International Year of Forests 2011

Congress Proceedings

Forestry for Better Living

The First Bangladesh Forestry Congress 2011

Dhaka, Bangladesh
19-21 April 2011

Organized by : Bangladesh Forest Department
Ministry of Environment and Forest

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First Bangladesh Forestry Congress 2011

Congress Proceedings

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FIRST BANGLADESH FORESTRY CONGRESS 2011

FOREWORDS

The United Nations General Assembly in its resolution 61/193 declared 2011 as the International Year of Forests (IYF). The secretariat of the United Nations Forum of Forests (UNFF) was requested to serve as the focal point for the implementation of activities linked to this milestone. All the stakeholders (governments, civil societies and communities etc,) were expected to use this occasion to raise awareness about the value of forests and how these can be conserved as well as sustainably managed. Bangladesh Forest Department in collaboration with the relevant stakeholders is going to organize Forestry Congress 2011 during 19 – 21 April in Dhaka. The Forestry Congress aims at raising awareness of the important roles of forest in national economy, welfare of rural population and environmental protection; as well as informing the public on the need of sustainable management, conservation and development of all types of forests.

Bangladesh falls in two of the twenty global ecological zones, namely Tropical Rain Forest (Tar) and Tropical Moist Deciduous Forest (Tawa). Based on ecological characters six forest types have been recognized in Bangladesh, namely Tropical Wet Evergreen Forest, Tropical Semi Evergreen Forest, Tropical Moist Deciduous Forest, Tidal Swamp Forest, Tropical Fresh Water Swamp Forest and Littoral Forest by Champion (1935).

Forests of Bangladesh are generally dense, uneven aged and multi storied with rich biodiversity. According to height of trees and floristic composition the forest is divided into top storey, middle storey and species growing on the forest floor.

In old days, forests were viewed as wilderness areas full of ferocious wild animals away from human settlements and people in general used to avoid it. The beneficial services of forests such as the crucial role of forests to serve as watersheds ensuring flow of water in streams, canals and rivers at downstream, the importance of forest in maintaining balance of environment etc. were not recognized in those days. Clearing of forests principally for agriculture, development of homesteads and shifting cultivation were the usual practice. The agrarian civilization indeed was flourished concurrently with the clearing of forests. During Mughal rule incentives were provided for expansion of agricultural land by clearing forest. During the rule of East India Company practice of conversion of forest to agricultural land continued or even accelerated by Zamindars (Feudal Lords). The area of the Sundarban Forest reduced to half during the eighteenth and first half of the nineteenth century.

Scientific management of forest began when the British government directly took the power to rule India from the East India Company in 1857. The Forest Department was created and Sir Dietrich Brandis a German forester was appointed as the first Inspector General of Forests of India in 1862. Development of plantation by involving shifting cultivators popularly known as 'Taungia System', creation of Indian Imperial Forest Service, reservation of forest tracts, preparation of Forest Policy in 1894, enactment of the Forest Act 1927, preparation of forest management plans for different forests were some of the important landmarks in the history of forest management during the British Regime.

Forest based industries were developed during Pakistan regime and heavy extraction was carried out during that period by clear felling of natural forests mainly to supply raw materials to those industries. Plantations were developed in clear felled areas mainly by teak. Introduction of forest extension by establishment of two Forest Extension Divisions and ten forest extension nurseries as well as commencement of coastal afforestation by creating four Coastal Afforestation Divisions were important breakthroughs in the forest management of the sub-continent during that period.

After liberation of Bangladesh in1971 extensive development activities have been undertaken in all the sectors and also extended to rural areas. As the symbol of transformation from mere administrative unit to development hub Thana was renamed as Upazilla, Municipalities have been established in all Upazillas and in some cases at Union levels also. With this transformation coupled with high growth of population, tremendous pressure has been developed on forest land and forest resources. To cope with the changed socio-economic scenario, Bangladesh Forest Department and the Government of Bangladesh have been undertaken many innovative management initiatives in the forestry sector. Strengthening of forest extension activities outside forest, introduction of social forestry involving local people in planning and implementation of plantation development process as well as sharing of benefits, successful accomplishment of a number of social forestry projects, framing of social forestry rules; strengthening of coastal afforestation activities, development of mass scale mangrove plantations along the coasts and thereby reclamation of big chunks of land from the Bay of Bengal, imposition of moratorium on felling of trees in the natural forests, promulgation of The Bangladesh Wildlife Preservation Act, 1974; declaration of Protected Areas, introduction of Protected Area Co management system, adoption of Forest Policy 1979 and its subsequent modification in 1994 are some of the major accomplishments of the Forest Department and the Government of Bangladesh in the forestry sector.

To create awareness among the people about the importance of forest conservation and development and to familiarize about various program and projects in this sector Forest Department has organized training program, seminars, workshops, meetings; drama, talk shows on radio and television; published books, manuals, booklets and journals; displayed posters, billboards, signboards; TV advertisement, documentary films etc. Tree fairs have been organized every year at the national, division, district and upazilla level. In consequence, overall participation of mass people in growing tress has got momentum resulting in substantial increase of tree resources particularly in rural areas. National forest and tree resources assessment 2005-2007 report indicates that, almost 50% of the area of Bangladesh has some kind of tree cover (Altrell et. al. 2007). 140 million cubic metre of total gross volume of trees has been reported in rural areas of Bangladesh in 2005-06 (Altrell at el. 2007) which is 255% more than that of 54.8 million cubic meters estimated in the village forest inventory report of 1981 by Hammermaster. 85,910 social forestry participants earned an amount of Taka 1,323.86 million as their benefit of participation in social forestry in previous 10 years up to June 2010.

Although notable success has been achieved to increase tree resources outside the forest particularly in rural areas with the support of motivated citizen, the protection of forest land and conservation of forest is still remained challenging. Prevailing land tenure and land record system are instrumental in destruction of forest. Elite section of the society and the policy makers are not much aware about the nature and scale of challenges in forest conservation and development. It is no denying fact that conservation and development of forests and matters relating to forestry is considered one of the least priority issues to policy makers in Bangladesh. Now a days climate change has appeared as a matter of concern to world leaders that Bangladesh is one of the most vulnerable countries of climate change in the world is recognized in the United Nations Framework on Climate Change Conference (UNFCCC) COP 15 held in Copenhagen in December 2009. The Honorable Prime Minister Sheikh Hasina and the Honorable State Minister for Ministry of Environment and Forests Dr. Hasan Mahmud of Bangladesh raised their voices and underscored that it was the responsibility of the developed countries to take initiative to reduce carbon emission and assist the vulnerable countries for mitigation and adaptation to climate change. Since deforestation and degradation of forest is responsible for nearly 18 percent increase of atmospheric carbon thereby global worming necessity for conservation and development forest in the country is of utmost importance.

After independence the first National Forestry Conference was held in1977 and the second one was held in 1982. These National Conferences helped awareness development and bringing together different stakeholders working in the field of forestry. Long time has been passed afterwards and no conference as such could be organized. Ultimately, discussing with different stakeholders we could decide to organize the first Bangladesh Forestry Congress from 19–21 April 2011. Forestry for better living is the theme of the Congress. The forestry congress envisages bring together all the stakeholders involved in forest conservation and development in order to document the lessons learned which can be useful in future planning of forest and biodiversity conservation management and research. The Forestry Congress will also create exposure for stakeholders to share their experiences on opportunities and challenges in the field of forest and biodiversity conservation and development.

The major objectives of the congress are as follows:

1. To bring together all the stakeholders such as forest managers, researchers, academicians, policy planners, development partners, civil society organizations and relevant community representatives involved in forest management to share their experiences and knowledge in promoting forest conservation in Bangladesh.

2. To develop national network of communities involved in collaborative forest management.

3. To identify strength and weakness of present management system and identify areas those need research.

4. To raise mass awareness for conservation of forests and biodiversity including wildlife

5. To develop recommendations for improving forest management system for sustainable use of ecological services.

Mr. A.M.A. Muhith MP, Honorable Minister, Ministry of Finance despite of his busy schedule has kindly consented to inaugurate the Bangladesh Forestry Congress as the Chief Guest which encouraged us to undertake this laudable task. **Dr. Hasan Mahmud** MP, Honorable State Minister, Ministry of Environment and Forest has been all along a source of inspiration without whose guidance organization of the congress was not possible. **Mr. Abdul Momin Talukdar** MP, Honorable Chairman, Parliamentary Standing Committee for Ministry of Environment and Forest and the Honorable members of the Standing Committee were always supportive to organize the Congress. We express our heartiest gratitude to them. We express our gratitude to **Mr. Mesbah ul Alam**, Secretary, Ministry of Environment and Forest for providing us valuable suggestions in organizing the Congress and also to the distinguished scholars in their own field who kindly agreed to Chair the technical sessions. We express our sincere thanks to **UNDP, IPAC, GIZ** and **IUCN** for providing us technical and logistic support in organizing the Congress. We are also thankful to Rapporteurs, session coordinators, distinguished personality who sent their papers for the Congress. We are also thankful to our team members of different sub committee, all officers and staff of the Ministry of Environment and Forest and Forest Department for their unwearying efforts to organize the Congress.

Md. Ali Kabir Haider
Deputy Chief Conservator of Forests
Convener, Bangladesh Forestry Congress 2011

Ishtiaq Uddin Ahmad
Chief Conservator of Forests
Bana Bhaban, Agargaon, Dhaka

Minister, Ministry of Finance

Message

I am happy to know that the Forest Department is going to organize the First Bangladesh Forestry Congress, 2011.

Today global warming and climate change is a challenge for the world. The importance of forestation is endless in the context of maintaining the balance of natural environment and facing the risk of climate change. The negative impact of climate change may be reduced significantly by massive tree plantation and forestation.

According to the declaration of the United Nations' General Assembly, the year 2011 is observed as the year of forestry. To specially emphasize worldwide forest conservation, management and development and to increase awareness at all levels as part of the UN declaration the arrangement of forestry congress by the Forest Department is highly appreciable. The main theme of the congress is "Forestry for better living". The role of forest is indispensible in building a beautiful, comfortable and livable habitat by creating a well balanced environment. Forestry also plays important role in economic development, poverty alleviation and employment generation.

Bangladesh is one of the most vulnerable countries from an ecological point of view. Climate change is posing a serious threat to our lifestyle and living conditions. We have necessarily mainstreamed climate change into our planning process. We have developed climate change strategy and created Trust Fund to tackle climate change impact. And now we are consolidating an overall climate change development plan. Forestry issues along with water resource issues are in forefront in climate change planning.

At this time Forestry Congress is most welcome. I hope, it will provide helpful guidelines in our endeavor to meet the problem of climate change.

I wish the Congress every success.

10 April 2011

(Abul Maal A. Muhith)

State Minister
Ministry of Environment and Forests

Message

It gives me immense pleasure to know that the First Bangladesh Forestry Congress, 2011 is going to be held on 19-21 April. I congratulate all the participants of this august event.

Forest is the part and parcel of the natural environment. The role of forest is very significant in maintaining the ecological balance of nature. These days, forest resources of Bangladesh are at a stake with multifaceted problems due to increased demand for fuel and timber, crop production, industry, urbanization and infrastructure development. In addition, global climate change impacts further add to the problem. Bangladesh is extremely vulnerable to the adverse impact of climate change because of its geographical position and huge population size. As a result of global climate change, the nature and magnitude of natural disasters such as cyclone, tidal surge, drought, flood etc have been changed causing severe damage our lives and livelihood. The present Government under the leadership of Honorable Prime Minister Sheikh Hasina has put enormous emphasis on environmental conservation and climate change issues. I hope the upcoming Forestry Congress will help create strong commitments among the environmental professionals of the country for implementing various government policies and programs.

The main theme of the First Bangladesh Forestry Congress is "Forestry for Better Living". Afforestation and environment conservation are essential to ensure our safe environment and livable habitat. I believe the First Forestry Congress will focus on the issues of global climate change and environmental conservation to ensure better quality of life of the people of Bangladesh.

Participants from home and abroad including foresters, forestry development workers, environmentalists, researchers, scientists, academicians, development partners, social elites and members of the civil society will exchange their views and experiences in this three-day long congress. I hope valuable suggestions will come up from the experts for conserving the natural environment of the country.

I offer my heartfelt thanks to the organizer of the First Bangladesh Forestry Congress for their excellent initiative and wish this event a grand success.

(Dr. Hasan Mahmud)

Chairman
Parliamentary Standing Committee
Ministry of Environment and Forest

Message

I am very pleased to know that the Forest Department is organizing the First Bangladesh Forestry Congress.

Our country is at a vulnerable position due to global warming and climate change. Large scale plantation and forest conservation may help in environmental balance and may reduce the vulnerability caused by climate change. Side by side the forestry also plays very important role in economic prosperity, poverty alleviation, and employment generation and in meeting the basic needs such as food, cloth, shelter etc.

Worldwide forestation and forest conservation is getting priority day by day. The year 2011 has been declared as the year of forestry by United Nations. Keeping pace with international cognition the organization of Bangladesh Forestry Congress by the Forest Department is a very much important and opportune effort. Moreover, Bangladesh is susceptible to hazard caused by climate change and global warming. Afforestation is considered as the most effective step to face this hazard. Saving the environment and creation of countrywide green belt by extensive plantation activities is urgently needed. Afforestation, forest conservation, forest administration and management, capacity building in the conservation activities, ensuring the peoples' participation in conservation processes and facing the impact of climate change and adaptability will be addressed, discussed and opined with valuable suggestions and future plans in the Forestry Congress to be held. I hope, through this congress it will be possible to come out with genuine and effective suggestions for legislation of future action plan and strategy.

I wish the overall success of the First Bangladesh Forestry Congress 2011.

Mamomen
06.04.2011

(Abdul Momin Talukdar)

Secretary, Ministry of Environment and Forest

Message

It is a great initiative by the Bangladesh Forest Department to arrange Bangladesh Forestry Congress for the first time ever in Bangladesh. I appreciate the endeavor.

The Bangladesh Forest Department is responsible of forest management since more than 150 years. In course of time the motive and pattern of forest management has been changed. What we need during the International Year of Forests is to emphasize the connection between people and forests, and the benefits that can accrue when forests are managed by local people in sustainable and innovative ways. Reserved forest land for forestry practice has been reoriented towards peoples' forestry. As a victim of global consequences due to hazardous effects of global climate change Bangladesh is also one of the most susceptible countries. These hazards are to be confronted to provide the next generation a healthy and safe habitat. The role of forest is endless in this issue. Forest acts as carbon sinks; effective forest management may help facing the jeopardizing effects of climate change.

I hope the Congress will provide an opportunity to learn about the diverse ecosystems in various regions of the world and for representatives of various organizations and stakeholders, including academics, forest producers, environmentalists, rural and indigenous people, forest managers, technical experts and policy makers, to share ideas on forestry. I believe through the organization of such an event the Forest Department will be honored with excellence.

I wish entire success of the First Bangladesh Forestry Congress 2011.

Mesbah

(Mesbah Ul Alam)

Country Director, UNDP Bangladesh

Message

Recognizing that forest and sustainable forest management can contribute significantly to sustainable development, poverty eradication and the achievement of internationally agreed development goals, including the Millenium Development Goals, the United Nations adopted a resolution to declare 2011 as the International Year of Forests.

It can be recalled that 2010 was the UN International Year of Biodiversity. The UN took these resolutions to articulate the urgency of biodiversity conservation as it has direct linkage with sustainable development. Changes in the availability and quality of biodiversity and ecosystem services minimize resources for the poor and vulnerable, and threaten ecosystems (such as Sundarbans in Bangladesh) that can protect the most vulnerable from natural disasters.

Emphasis for reversing the loss biodiversity has been an explicit part of the MDG agenda since 2006. The loss of provisioning resources, such as food, has been a contributing factor in intensifying poverty and hunger around the world. The degradation of regulating functions and services that ecosystems provide has afected the health of millions as air becomes toxic and water too poluted to drink. Therefore, the loss of biodiversity has a detrimental effect on the progress of MDGs.

Nationally, the MDG Country Analysis revealed that Bangladesh has made good achievement in terms of social forestry. It has contributed in income generation and poverty reduction. Social forestry has become a national movement in Bangladesh. However, natural forest ecosystems are struggling for its survival as these have been subject to continuous deforestation and encroachments since 70s. An effective forest ecosystem management system is yet to be in place with enabling policies and legal instruments.

A large number of people in Bangladesh depends on forests ecosystems in diverse ways such as liveliood, protection from cyclones, tidal surges, and building materials. Forests provide goods such as timber, food, fuel, and bio-products. In addition, functions of forest ecosystems are crucial for a healthy environment. Major functions including carbon storage, nutrient cycling, water and air purification, and habitats for biodiversity. All of these environmental and developmental aspects can be found in the Sundarbans, a World Heritage site and the largest mangrove ecosystem in the world.

UNDP is happy to partner with the Government of Bangladesh in organizing the Forsetry Congress 2011. I hope that this will raise awareness amongst policy makers, the general public, and the private sector of the importance of biodiversity in general and forests ecosystems in particular to development and the consequences of its loss. Concerted efforts should focus on raising awareness at all levels to strengthen the sustainable management, conservation and sustainable development of all types of forests for the benefit of current and future generation of Bangladesh.

(Stefan Priesner)

Director, Office of Economic Growth, USAID

Message

USAID is proud to work with the Government of Bangladesh and other partners to host the Bangladesh Forestry Congress 2011 to commemorate the International Year of Forests 2011 and celebrate people's actions to sustainably manage their forests. The Bangladesh Forestry Congress takes place at an opportune time. Bringing together forest managers and stakeholders from government and civil society, the Congress provides an opportunity to take stock of recent progress toward forest conservation and sustainable forest co-management, as well as to assess current challenges including climate change adaptation and mitigation. Most important, in the spirit of co-management, the Bangladesh Forestry Congress 2011 provides a forum for forest stakeholders to share their experience, enrich their knowledge, and build a powerful network to achieve even greater progress in forest conservation and sustainable management.

USAID has been supporting forest conservation and sustainable landscapes management in Bangladesh for more than a decade. This started with the Nishorgo Support Project, a pilot project that demonstrated the effectiveness of co-management for Protected Areas conservation in 5 sites. Now the IPAC project is working with the Government of Bangladesh to scale-up a national network of integrated forest and wetland protected areas conserved through co-management through the Nishorgo Network. An increasingly strong policy umbrella for Protected Area co-management is in place, and government and community stakeholders are working in 25 Protected Areas to strengthen conservation through co-management. Additionally, USAID support for the Arannayk Foundation provides an endowment fund to sustain long-term efforts in tropical forest conservation.

Forest conservation and sustainable forest management is essential for Bangladesh's long-term poverty alleviation plan. Healthy forests contribute to climate change adaptation by buffering vulnerable coastal communities from cyclones and tidal surges, and regulate water flow so essential for irrigation, home and industrial needs. Forest conservation and reforestation initiatives also mitigate impact of climate change by reducing carbon emissions into the atmosphere. The environmental services of healthy forests, especially water and biodiversity, provide a solid foundation of resilience for food security.

USAID is proud of its collaboration with the Government and people of Bangladesh and other donor partners to achieve positive results in forest conservation and sustainable natural resources management through co-management. The spirit of the Bangladesh Forestry Congress 2011 and the International Year of Forests celebrates the importance of co-management. Let's take a moment to be proud of our achievements, and then commit to working even harder to ensure healthy forests continue to contribute to the long-term development of Bangladesh.

Naren Chanmugam

Country Director, GIZ- Bangladesh

Message

The United Nation's General Assembly declared the year2011 as the International Year of the Forests to raise awareness on sustainable management, conservation and sustainable development of forests. We are delighted to see that Bangladesh Forest Department under the Ministry of Environment and Forest is organizing the "First Bangladesh National Forestry Congress-2011" to commemorate this great event.

As an international cooperation enterprise for sustainable development with worldwide operations, the federally owned Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH supports the German Government in achieving its development-policy objectives. It provides viable, forward-looking solutions for political, economic, ecological and social development in a globalized world. GIZ promotes complex reforms and change processes. Its corporate objective is to improve people's living conditions on a sustainable basis.

German Development Cooperation with Bangladesh has a long tradition and was initiated in 1972. Today the German Development Cooperation is focusing on three priority areas- health, renewable energy & energy efficiency and governance & local development, with increasing efforts to support their government partners in ecosystem rehabilitation in different parts of Bangladesh for the benefit of and with the support of the local resource users. GIZ involvement in Bangladesh is increasing rapidly as our cooperation with the Government of Bangladesh on behalf of the German Government has grown and expanded outside the priority areas like climate change mitigation and adaptation through several projects and programs. The Wetland Biodiversity Rehabilitation Project (WBRP) is introducing a improved natural resource management system including establishment of wetland sanctuaries, re-excavation of silted water bodies and reintroduction of lost riparian and swamp trees and other aquatic plants. The Resource Conservation through Community Reforestation and Forest Management Project (RCCR-Chunati) is supporting the Forest Department together with USAID funded IPAC project in setting up a sustainable forest co-management system in the Chunati Wildlife Sanctuary. Local communities are involved in the efforts to conserve and reforest the area which will help to trap carbon dioxide and thus reduce green house gas emission, protect endangered species and conserve water supply of the region. A new project of the Forest Department, the Sustainable Development and Biodiversity Conservation in Coastal Protection Forest (Sunderbans), will build the capacities of the authorities responsible at district and sub-district level and of the local people to improve biodiversity conservation and manage the ecologically critical zones of the Sundarbans.

The Forest Department plays a key role in conservation efforts. It is of utmost importance that lessons learnt and roadmaps are reflected through the conduct of this congress. This initiative complements our ongoing work with the Forest Department to address biodiversity and conservation issues.

I hope that the "First Bangladesh National Forestry Congress-2011" will be a very successful one and it will give new directions to Bangladesh Forest Department in managing its forest resources in a sustainable manner for the wellbeing of the Bangladeshi people.

Olaf Handloegten

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Theme-1:
Forests and climate change focusing on adaptation, mitigation and REDD+

Collaborative REED+ Program In Bangldesh

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Abstract

Bangladesh has a favourable and enanbling environment for the restoration and conservation of forests and wetlands through developing gainful partnerships with local communities. A vast majority of these communities depend on adjoining natural resources for meeting their subsistence needs including conservation-linked livelihoods. Being a densely populated delta with predominantly natural resources-based economy, the country's vulnerability to climate change is very high. Natural resources including cultivable land, forests and wetlands are getting degraded mainly due to heavy biotic pressure created by huge population concentrated in comparatively small geographic area. The forests in general and the coastal mangroves in particular, are ensuring substantial sequestration and storage of carbon. But avoiding the release of carbon dioxide resulting through deforestation and forests degradation is even more important. Nearly one-fifth of the total carbon is released globally due to deforestation activities that are currently occurring in many developing countries including Bangladesh. In addition to afforestation and reforestation, diminution of deforestation and forests degradation is, therefore, regarded as a third category of forest-based activity and qualified for conservation financing under international compliance and voluntary markets. Reduction of emissions through deforestation and forests degradation (REDD+) is one such emerging mechanism that is particularly suitable for the country's forests including the Sundarbans mangroves. REDD+ has particularly been focused in compliance of the decisions of the Conferences of Parties held at Bali, 2008; Copenhagen, 2009; Cancun, 2010 and Durban, 2011.

Minimisation of deforestation offers an excellent opportunity for achieving national environmental goals by mitigating Green House Gas emissions as well as conserving biodiversity and alleviating rural poverty locally. Greening of the country through community conservation activities with a view to reducing deforestation will also result in empowering local communities, thereby contributing in improved environmental governance. Many of the community activities in reducing forest degradation are cost effective, efficient, less lobor intensive and equitable with large employment and income gains to neighboring poor community. In the process, local surplus labors and resources may be utilized in restoring the degraded forest landscape of Bangladesh thereby generating substantial carbon credits. Accordingly, the Forest Department and the Ministry of Environment and Forests have initiated a number of policy and operational steps for implementing a REDD+ program.

A number of important issues are identified in this paper for taking up effective steps under REDD+ readiness program. The ongoing REDD+ program would go a long way in both climate change mitigation and adaptation of local ecosystems and community. However, a number of important policy and operational interventions, as identified in this paper, are needed to **be put in place both at the government and civil society levels.**

Key words : REDD+, AFOLU, Climate change, Green house gases, Protected area, Improved forests management

Introduction

Bangladesh is a low-carbon emitting country mainly due to low level of industrialization. But being a densely populated delta, its vulnerability to climate changes is very high. For instance, a sea-level rise of 1-2 meter would inundate the country's substantial area including the Sundarbans, thereby adversely affecting a large poor coastal population. In Bangladesh, the per capita carbon dioxide (CO_2) emission is estimated to be as 0.2 ton/year. This is much lower compared to 1.6 ton/year in other developing countries and 15-20 ton/year in some developed countries. However, the consumption of fossil fuels in the country is growing by more than 5% per year and motor traffic in big cities such as Dhaka and Chittagong is increasingly causing environmental pollution. Natural resources including forests are being severely degraded mainly due to heavy biotic interference by huge population concentrated in comparatively small geographic area. The forests in general, and the Sundarbans mangroves in particular are fortunately ensuring substantial sequestration and storage of carbon dioxide. But avoiding the release of carbon dioxide resulting through deforestation and forests degradation is even more important. Nearly one-fifth of the total carbon is released due to global deforestation activities that are currently occurring in many developing countries including Bangladesh. In addition to afforestation and reforestation, diminution of deforestation and forests degradation is, therefore, considered as a third category of forest-based activity qualified for conservation financing under compliance and voluntary markets. Reduction of emissions through deforestation and forests degradation (REDD$^+$) is an emerging mechanism that is particularly suitable for the country's forests including the Sundarbans mangroves.

Peoples Forestry

The neglect of existing forests due to lack of funding and inadequate management resulted in degradation of natural forests, particularly in the semi-evergreen and evergreen forests located in the country's hilly region, the mangroves in the Sundarbans and the sal forests in the central and northern regions. Anthropogenic pressures including increased commercial extraction of forest produce, brought by swelling human population, led to widespread shrinkage and deforestation of natural forests. With a view to reduce deforestation that took place earlier, the Government of Bangladesh declared some natural forests as Wildlife Sanctuaries (e.g. East, West and South sanctuaries in the Sundarbans Reserved Forests (SRF)) and National Parks through gazette notifications .

The Forestry Master Plan, prepared in 1993 with the assistance from Asian Development Bank (ADB), led to the promulgation of the people-oriented Forestry Policy of 1994, which ***inter-alia*** emphasized people's gainful participation in sustainable management of forests. Accordingly, emphasis of forests management gradually shifted from timber production to meeting bonafide consumption needs of local people. As a result, social forestry was included in the revised Forest Act of 2000 and Social Forestry Rules, 2004 and 2010 were formulated in order to implement the policy recommendations. In 2004 the Forest Department (FD) launched the Nishorgo Program, supported by Nishorgo Support Project (NSP) that aimed to improve the conservation of forests and other biodiversity in the Protected Areas (PAs)_ managed by FD. The ongoing Integrated Protected Area Co-Management (IPAC) Project is a follow on project to NSP and includes 19 forests PAs being co-managed by the FD.

Carbon Forestry

Global warming has adversely affected earth's climate, with significant consequences for natural resources including water, soil, forests and air. Land Use, Land Use Change and Forestry (LULUCF) sector has been identified as an important land-based sector that mitigates climate change as defined in the Climate Conventions. Forestry, broadly included under LULUCF sector, provides low cost mitigation opportunities to combat climate change either by diminishing greenhouse gases (GHGs) from the atmosphere through forests/plantations to act as carbon sinks or by reducing GHG emissions through avoiding deforestation and forests degradation. Till now only reforestation and afforestation are two eligible activities under Article 12 for non-Annex-I countries such as Bangladesh. Avoiding of deforestation and forests degradation have now been focused in compliance of the decision in the Bali, 2008; Copenhagen, 2009; Cancun, 2010 and Durban Conferences.

By conserving forests and developing plantations, landscape degradation can be halted. Additionally, biodiversity and water conserved *in-situ*, and community biomass needs can be met by utilizing surplus labour. Besides, sustainable forests management opportunities would have significant potential to transfer investment funds and technology, and upgrade institutional capacity of FD field staff and local community organizations for biodiversity conservation, forests landscape restoration and bio-energy. The revenue generated by carbon forest trade will help re-vegetate the degraded landscape through *in-situ* biodiversity conservation. The role of forests in carbon cycle is vital as they account for approximately 80% of CO_2 exchanged between land and atmosphere through the process of photosynthesis. As trees grow, the carbon is stored in biomass by converting CO_2 and water (by using solar energy) into sugars and oxygen (released through the leaves). Forests also release CO_2 during the process of respiration. However, a forest that is growing (i.e., increasing in biomass) will absorb more CO_2 than it releases. So the sequestration and storage potential depends on growing and sustaining forests.

In addition, sustainable forests management in densely populated countries such as Bangladesh would have high socio-environmental benefits for local communities, who are mainly subsistence farmers and laborers. So the development and sustainable management of forest carbon sinks will benefit local community by contributing to poverty alleviation through their enhanced income generation and better quality of life. There is substantial economic potential for the mitigation of global GHG emissions over the coming decades that could offset the projected growth of global emissions or reduce emissions below current levels.

Although climate change, as a public good and service, is global in its causes and consequences. Its adverse impacts are being borne inequitably in different regions and communities. Bangladesh, a riparian country very near to sea level, and the coastal poor dependent on adjoining biodiversity are being particularly affected adversely (FD, 2010). Avoiding of deforestation offers an excellent opportunity for achieving global environmental goals by mitigating GHG emissions while conserving biodiversity and alleviating rural poverty locally. Greening of the country through community conservation activities necessary for reducing deforestation also will result in empowering local communities, thereby contributing in improved environmental governance. Many of the community activities helpful in reducing forest degradation are cost effective, efficient, lobor intensive and equitable with large employment and income gains to neighboring poor communities. In the process, local surplus labors and other resources can be utilized in restoring the degraded forest landscape of Bangladesh and also generate substantial carbon credits.

Avoiding of deforestation and forest degradation is in line with the Poverty Reduction Strategy Paper (PRSP) of the Government of Bangladesh and especially with the measures envisaged in the Partnerships for the Global Environment; it supports the Millennium Development Goal No. 7, Ensuring Environmental Sustainability and the Millenium Development Goal No. 1 by addressing rural poverty alleviation. Scaling up flows of carbon finance to developing countries to support effective policies and programs for reducing emissions would accelerate the transition to a low-carbon economy. Avoided deforestation will sequester GHG emissions, and generate global environmental benefits and would conserve biodiversity and alleviate rural poverty locally.

According to the statistics of FAO, the deforestation rate in Bangladesh is estimated as 3.3% of the forest area (quoted in the Asia Pacific Forestry Sector Study, 2008 conducted jointly by FAO and Bangladesh Forest Department). Although deforestation rate is a function of the total forest area that has continuously declined in Bangladesh, it is assumed to be 3.3% for the purposes of this estimation. Forest Resource Assessment, 2000 of the FAO has estimated the total forest area (under the category of forests and plantations) as 952,000 ha in the reference year 1996. As per the Forest Carbon Study conducted jointly by Forest Department and Bangladesh Forest Research Institute (2008) the growing stock (average volume in m^3) in reasonably well stocked forests of sal and garjan is estimated on an average as 196 m^3/ha. So in 1996 the total growing stock in the country's forests amounts to around 18.66 million m^3. The annual loss of forests (@3.3% per annum) during the period 1996-97, therefore, computes to be 0.62 million m^3 (or 0.67x0.62 = 0.42 million metric ton). With a conversion factor of 0.5 , the total carbon tonnage lost annually during the period of 1996-97 is estimated as 0.21 million metric ton.

Carbon sequestration in planted forests was assessed by taking two biomass sample plots in mature plantations (12 years old) of high biomass yielding tree species that were planted in Chunoti forestland under Forestry Sector Project. According to the Chunoti Forest Carbon Study, the total forest plantation carbon sequestration rate works out as an average of 3.6 ton /ha/year of carbon. Assuming that most of the plantations being raised presently by FD are of fast growing tree species, an average of 36 ton/ha of carbon will, therefore, be impounded over a period 10 year rotation. The documents of FD reveal that the total plantations raised by FD during period 1991-2003 amounts to 48,000 ha, thereby giving an annual average of 3,700 ha approximately. Further assuming that this level of planting efforts will continue in future, it can be estimated that on an average 13,320 ton of carbon will be sequestrated annually as a result of forest plantations to be established by FD in each planting year. This shows that the present level of planting efforts will not be able to compensate for the deforestation rate and consequent loss of carbon.

Identifying REDD+ Issues

In order to improve the above-described carbon forestry situation, the following issues are identified for taking up effective steps under an appropriate REDD+ program:

Expanding and restoring protected areas: In order to save natural forests from further degradation, good natural forests may be considered for bringing under PA network. Accordingly, Government of Bangladesh (GOB) has recently declared eight new PAs representing different forest types. The protection and sustainable management of existing natural forests and PAs will improve forests quality and their ability to sequester and store carbon. This is necessary for the success of REDD+ initiatives that will focus on carbon sequestration and storage in forests. In view of small area under natural forests, it is of vital importance to expand forest area through eco-restoration wherever regenerative rootstock can be recovered, and by enrichment planting of indigenous tree species in other degraded forest areas. Suitable benefits/incentives may, however, be necessary for the poor community that renders special efforts to control deforestation and forests degradation through joint community patrolling.

Linking climate change initiatives with rural poverty alleviation : In Bangladesh the principal cause of deforestation/degradation is widespread poverty that results in over-exploitation of natural resources including forests and wetlands. Climate change due to deforestation is taking place in many tropical countries including Bangladesh where poverty is severe. This situation can be improved lucratively by involving rural poor in the protection, and sustainable use and management of forests by using capital gained through sale of carbon credits that may accrue to poor countries under REDD+ mechanism. Both climate change mitigation issues (through avoided deforestation and forests degradation) and adaptation issues (reducing the vulnerability of local community by involving them gainfully in forests protection and sustainable co-management) can be addressed by developing a REDD+ strategy within the framework of the national action plan for climate change that has been recently framed by the Ministry of Environment and Forest (MOEF) within the national development goals of Bangladesh. The strategy will focus on identifying conservation options that will result in retaining forests as beneficial to local community.

Sustainable conservation financing : Developing appropriate conservation financing mechanisms and frameworks is necessary for carrying out forests-based climate change mitigation and adaptation activities. Suitable incentives need to be worked out and paid to the communities and countries which are able to protect their forests beyond an agreed cut off period. Similarly, conserving forests on a progressive sustained yield basis should be well compensated through financial incentives that can be ploughed back in forest restoration, achieved by employing co-management initiatives/activities. As carbon credit market develops in Bangladesh, it may be necessary to develop a National REDD+ Trust Fund exclusively for addressing forests-based climate change mitigation and adaptation issues.

Forests protection : In a densely populous and poor country such as Bangladesh, effective protection of dispersed and mosaic forests is not possible without active partnerships of local community. Climate change mitigation from forests conservation is important in addition to controlling deforestation. Such a co-management initiative has proved successful as evident from the Integrated Protected Area Co-management (IPAC) and the Nishorgo Network of the Bangladesh Government. This is a good example, proving that conservation of forests is necessary for the forests landscape restoration by involving local community. The forests under community protection can be sustainably co-managed locally by sharing benefits accrued as a result of enhanced forests productivity. It should be possible to equitably distribute forests-based benefits to participating communities as naturally regenerating forests would require canopy opening through silvicultral interventions, thereby providing yield as a byproduct. As regenerating forests (either through natural regeneration and/or aided regeneration) sequestrate more carbon than mature standing forests, it may be necessary to take recourse of silvicultural thinning by following selection system for encouraging natural regeneration in mature forests.

Temporal assessment of deforestation and forests degradation: International negotiations on forest reference levels, agreed levels for transition point, long-term responsibility, definitions, incentives, etc., are in progress. Such actions are being taken in response to the decisions in the Copenhegan and Cancun COP conferences in view of the Bali decision that refers to incremental changes and enhancement of stocks linked to sustainable forest management and conservation. National baselines and emission reference levels, forest stock changes and time series analyses will be required for assessing historical trends of de-generating and/or re-generating forests. Forests under conservation and sustainable management will need to be assessed, inventoried and accounted for at the national and sub-national levels using inter-governmental panel on climate change (IPCC) guidelines in order to be assigned REDD credits for carbon trading. Monitoring of forests carbon stocks and assessing leakage and permanence would be required regularly. Access to remote sensing technology will be helpful but needs to be supplemented by ground truthing to be conducted regularly both at national and local levels.

Increment of carbon stock can be assessed by using scientific data collected from the identified permanent and temporary sample plots. Knowledge of technology particularly from relevant tropical countries would be helpful in conducting not only national inventory and carbon credit assessments but also maintaining sustainable management of natural forests that have degraded severely due to lack of resources. Bangladesh does not currently have a regular forest inventory mechanism. Thus, developing national forest inventory institutions (e.g. RIMS can be updated as Forest Survey Wing within the Forest Department are necessary) for objectively assessing baseline scenarios and emission reference levels.

Forest carbon assessment : It is important to develop an appropriate methodology for objectively assessing enhancement of forest carbon stocks as a consequence of conservation and sustainable management of natural forests in Bangladesh. Forest carbon assessment methods as approved by the clean development mechanism (CDM) Executive Board would require updating in view of local forests situation. Chunoti forests carbon project (FD, 2008) and Collaborative REDD+IFM Sundarbans Project (FD, 2011) have included some of these adaptations for assessing forests carbon pools (above-ground carbon, on-ground carbon and below-ground carbon, forest soil carbon). Scientific data showing the increment of carbon stocks in PAs and natural forests will be required. More work is, therefore, required, particularly for the temporal assessment of natural forests stocking that will include an accurate assessment of deforestation/forests degradation rates. Suitable modalities and procedures for transparent and verifiable assessment of forests changes need to be developed. This also will require developing a suitable common strategy, approach and modality for assessing positive and negative impacts of changes of forests over a period of time.

REDD+ Readiness Program

In order to be ready for tapping climate change funds under REDD+ mechanism, it is important that the GOB develops a REDD+ readiness program that will include :

- Preparing an effective REDD strategy to be developed in consultation with relevant stakeholders
- In-house capacity building in GOB Departments that deal with natural resources including Forest Department, Department of Environment (DOE) and Department of Fisheries (DOF).
- Designing and implementing a suitable monitoring, reporting and verification (MRV) system for forests carbon accounting
- Developing baseline scenarios and assessing historical rates for deforestation and forest degradation
- Community benefits sharing mechanism and enabling legal framework
- Enabling framework for carbon ownership rights, forest land tenure and contractual arrangements. Establishing separable and transferable rights
- Identifying role of private sector under public- private partnerships arrangements
- Establishing a national carbon registry

Ongoing REDD+ Program

The following REDD+ related activities have been completed under IPAC:

- Carbon forest inventory methods have been tested, designed and validated for assessing benchmark carbon stocks in identified carbon forest pools
- Carbon forest growing stocks modeling has been attempted
- Participatory monitoring indicators have been identified
- Carbon stocks have been assessed in Chunoti and the Sundarbans mangrove forests
- A major carbon policy workshop has been organized for senior policy makers and planners
- Two capacity building workshops have been organized for imparting to the field staff of FD, DOF and DOE, and the students from national universities
- Carbon forest field inventory has been completed in the Sundarbans mangrove forests and 6 PAs
- A writeshop has been conducted for writing carbon project proposals for the Sundarbans Reserve Forests and 6 PAs (Teknaf, Inani, Medhakachpia, Fasiakhali, Dudpukria-Dhopachari and Sitakunda)

- The GOB has initiated its intent for sharing carbon revenue with local community in the Sundarbans
- Collaborative REDD+ Improved Forests Management Sundarbans Project (CRISP) document has been drafted.

Collaborative REDD+ IFM Sundarbans Program (CRISP)

A concept note for a proposed reduced emission from deforestation and degradation and improved forests management (IFM) project (hereafter referred as Collaborative REDD+IFM Sundarbans Project, CRISP) was developed for the Sundarbans mangrove ecosystem. It is a precursor to a formal Project Design Document (PDD) that will be submitted for validation under one or more of the international carbon standards being used for greenhouse gas (GHG) emissions reduction or removal within the frameworks of voluntary or (eventual) compliance markets for carbon offsets. Further development of the initial design presented in this Concept Note requires broader stakeholder consensus (including civil society and co-management committees) on proposed project activities, monitoring systems, and finalization of benefits distribution mechanisms and participatory monitoring processes.

The overall aims of the program are to achieve, through avoided deforestation and degradation, and improved forest management activities in the Sundarbans Reserve Forest (SRF), carbon sequestration with livelihoods improvements through community participation in forestry activities as well as conservation of flora and fauna species through measures including habitat protection and improvement The emissions reductions will be achieved through avoided deforestation along the frontier borders of the Sundarbans Reserve Forest and avoided forests degradation in selected forests areas subjected to mosaic deforestation and forest degradation. Improved forests management through conversion of logged forests including protecting logged or degraded forests from further logging will help reduce GHG emissions. CRISP has three objectives as follows:

- **Improvement of Climate:** This will address mitigation of greenhouse gases both through emissions reduction and enhanced removal of carbon dioxide from the atmosphere. That means to slow or reverse documented deforestation and forest degradation, and making higher carbon sequestration per hectare and across more area through improved forests management.

- **Livelihood Improvement of Community:** This will assist the communities living within the 10 km zone of the periphery (hereafter referred to as the reference region or interface landscape zone) of the project area. The communities will be provided with alternative livelihood options and motivated to conservation-linked value chain development activities to reduce forest dependency for daily needs, ensure awareness raising through education facilities for adults and children on the importance of forests as well as carbon reserve for climate change mitigation and adaptation.

- **Biodiversity Conservation :** The objective is to conserve the habitat for several red- listed endangered species, including Royal Bengal tiger (*Panthera tigris tigris*), Irrawaddy river dolphin (*Orcaella brevirostris*), crab-eating macaque (*Macaca fascicularis*), and other important species of bird, fish, reptile, and other wildlife.

The CRISP is an agriculture, forestry and other land uses (AFOLU) project consisting of activities related to REDD and IFM in the project area. The activities will involve avoiding unplanned frontier deforestation and degradation, and improved forests management through conversion of logged forests to protected forests including protecting currently logged or degraded forests from further logging. CRISP will sequester an average of 213,115 tons CO_2e annually in the project area of 412,000 ha, over a 30-year project period. The total project emissions reduction will amount to 6,393,452 tons CO_2e during 30 years with an average of 15.52 tons per hectare.

The CRISP is a project designed to meet the requirements of an AFOLU project. Specifically, CRISP is expected to qualify for consideration under the REDD category of eligible activities. In this case, the activities are aimed to avoiding unplanned frontier deforestation and degradation. In IFM category, the activities are aimed to conversion of logged forests to protected forests including protecting currently logged or degraded forests from further logging as defined in the Voluntary Carbon Standards (VCS) 2007.1 and VCS Tool for AFOLU Methodological Issues (published on 18 November 2008). This document is developed by largely following the approved VCS methodology : VCS Methodology VM0006 – Methodology for Carbon Accounting in Project Activities that Reduce Emissions from Mosaic Deforestation and Degradation. The CRISP is not being designed as a Grouped Project as defined in the VCS 2007.1.

The project area is entirely owned by the State, with the Forest Department bearing responsibility for its management and conservation under the Forest Act of 1927 and its amendments thereof. As part of nationwide efforts to implement new co-management approach, forestry officials have established community co-management councils and committees (CMCs vide the Government of Bangladesh Order No. Pa Ba Ma/Parisha-4/Nishorgo/105/Sting/398 dated 23 November, 2009) with the neighboring populations along the northern and eastern boundaries of the Sundarbans Reserved Forests (SRF).

The CRIRP is anticipated to make greenhouse gas (GHG) emissions reduction or GHG removal totaling 6,393,452 tons of carbon dioxide equivalent (CO_2e) during 30 years of project implementation, compared to the baseline scenario. This equates to an average of 213,115 tons CO_2e annually. Therefore, the CRISP meets neither the requirements for a micro project as defined in the VCS 2007.1, due to the annual emissions reduction in excess of 5,000 tons CO_2e, nor the requirements for a mega project as defined in the VCS 2007.1 because annual emissions reduction are less than the 1,000,000 tons CO_2e threshold for mega projects.

The host party for the CRISP is the Government of Bangladesh, represented by the Forest Department, the statutory body authorized, empowered, and accountable for management of forests and forest lands held by the State. The Forest Department is one of the two technical departments within the Ministry of Environment and Forests (MOEF), established in 1865 under the Forest Act of 1865 for scientifically managing the government forests including the Sundarbans, which was designated as Reserved Forest (hereafter referred to as Sundarbans Reserved Forests, SRF) in 1875 under the Act.

Carbon sequestration and emission reduction benefits, leading to improved forests management, will be attained through a suite of forests protection and conservation activities in the SRF. To demonstrate the benefit of the proposed project, the project test under the Clean Development Mechanism and the Voluntary Carbon Standard is utilized. The CRISP is not mandated by any enforced law, statute or other regulatory framework. Due to resource constraints, there are not likely to be substantial initiatives on the part of the GOB to sustain and enhance the forest reserve. In terms of investment barriers, the GOB currently lacks access to the international forest carbon markets. In addition to overcoming investment barriers, the project would generate livelihoods benefits for the local communities through participation in forests conservation and monitoring activities, as well as enhance the biodiversity of the forest ecosystems by promoting the habitats of unique flora and fauna.

The Government has declared the co-management approach for managing protected areas through co-management councils and committees (CMCs). The CMC is an authorized entity established from among nearby residents and other key stakeholders for the purpose of management of the Sundarbans. Members of the CMC are drawn from different strata of society, including local government, public representatives, concerned GOB departments, and others. The CMCs will have resource management planning and conservation responsibility. The CMCs are working under a national network of protected areas known as "Nishorgo Network" with technical support from the USAID funded Integrated Protected Area Co-management project. Other donor projects are supporting the network in establishing co-management and scaling up natural resources co-management in the Sundarbans and other forest and wetlands. Thus, the CMCs are going to have some resource conservation and local development rights.

Project activities will take place in the SRF and its surrounding 10-km wide landscape located in the southwestern portions of the country (Fig.1). The Sundarbans is the world's largest mangrove forests, spanning a total of about one million hectares from the Ganges-Brahmaputra-Meghna estuary in Bangladesh to the South 24 Parganas area of West Bengal. It lies between latitudes 21°27'30" and 22°30'00" N and longitudes 89°02'00" and 89°55'00" E. The Sundarbans delta is the northern coast of the Bay of Bengal in the Indian Ocean. More than 60% of the Sundarbans ecosystem lies within Bangladesh, consisting of about 600,386 ha, of which about 411,227 ha are land with 189,159 ha of water courses. The area's protected status dates back to 1875 when it was designated as Reserved Forests (with 55 compartments) under the Forest Act, 1875, with three Wildlife Sanctuaries established in 1977 and expanded in 1996 to 139,698 ha under the Wildlife (Preservation) Amendment Act, 1974. The 4,112.27 km^2 of terrestrial forests legally classified as Reserved Forests form the project area (subdivided into the Satkhira, Khulna, Chandpai, and Sarankhola Forest Ranges).

Monitoring of both project parameters and carbon sequestered will be conducted in order to gauge the effectiveness and impacts of project activities; to measure forest carbon; and to inform any adjustments needed to ensure the efficacy of methodologies, implementation activities, or the monitoring plan itself. Key aspects of the project to be monitored include: project boundaries; forest protection; forest management; carbon stock changes; and leakage. It is envisioned that the CMCs, together with the FD, will play a central role in participatory monitoring, with assistance from relevant NGOs in the areas of administrative, managerial, and financial monitoring.

Several aspects of the project will be monitored to ensure that project activities are successfully carried out and adhere to conservation principles. Although the boundaries of SRF are clearly defined in the field and on maps as per GOB notification, periodic monitoring of the boundaries of the project areas will be conducted. This will be accomplished through the use of appropriate technologies, such as remote sensing with assistance from the FD's Resources Information Management System (RIMS) unit, as well as through monitoring and ground-truthing in the field. Maps will be updated regularly to ensure that monitoring is based on the most current situation. The capacity of institutions such as the CMCs and the FD to understand and utilize monitoring technologies and techniques will be strengthened through targeted trainings primarily during the first three to five years of the project, with follow-up trainings as necessary.

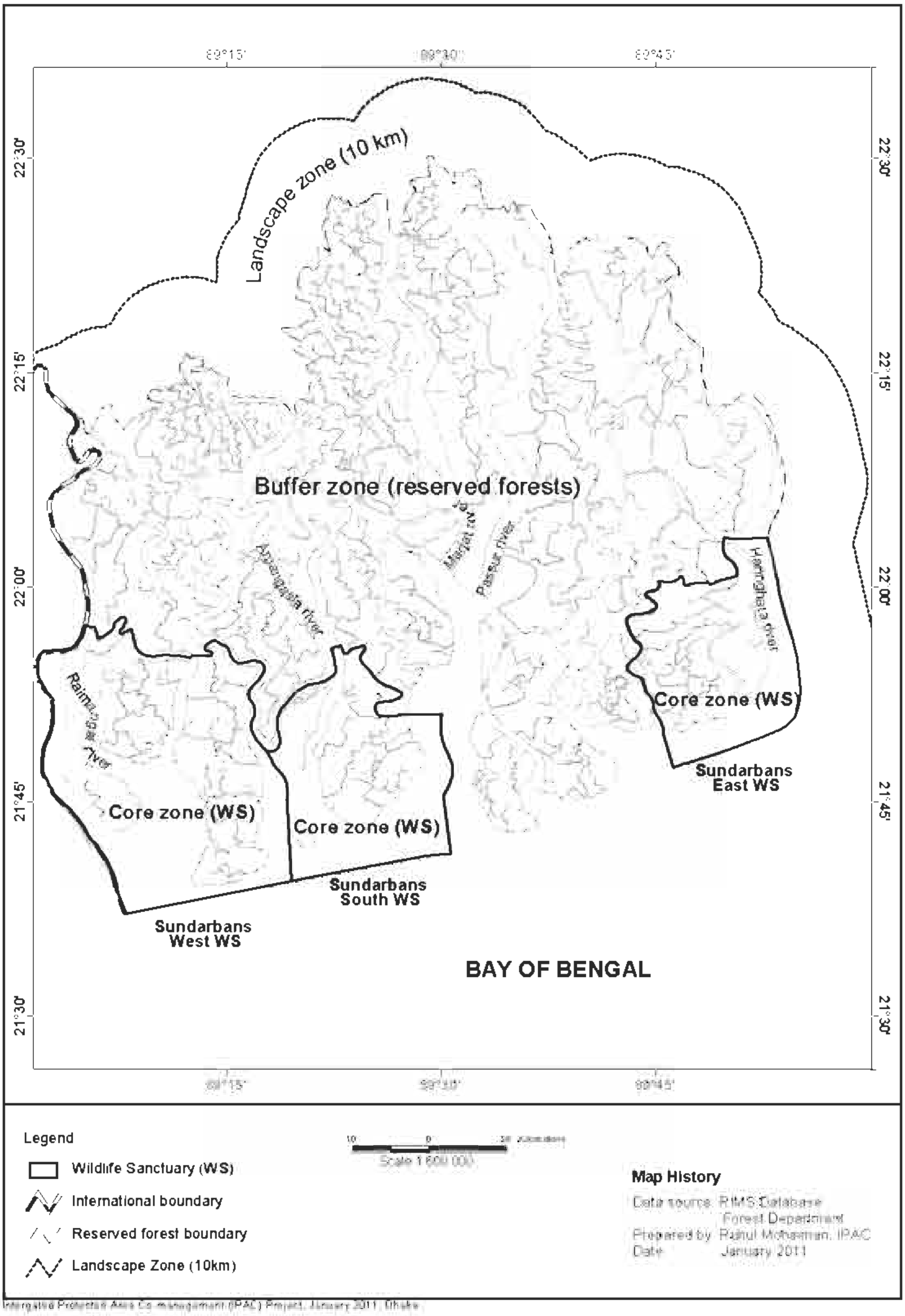

Fig. 1. The Sundarbans Reserved Forests

Measuring of soil carbon as well as below- and above-ground carbon and biomass will be carried out through permanent sample plots determined by systematic random sampling developed during the initial field inventory. The dominant pools of biomass and carbon stock (i.e., trees) will be measured every five years, along with periodic independent verification. Measurement of pools that comprise a less significant portion of the overall carbon stock or that are likely to change more slowly, such as soil carbon, may be measured less frequently, for instance every ten years. Best practices such as remote sensing and field methods will be employed to learn the land use categorizations that are used in measuring and monitoring changes in biomass and carbon. Similar to the case of the project parameters, carbon stock monitoring will be carried out largely by the CMCs through the CPGs, with the FD providing guidance on field inventory protocols. To ensure that they are equipped with the necessary knowledge and skills for carbon stock monitoring, NGOs and other relevant institutions such as the FD's RIMS unit will be brought in during the first three to five years to provide training-of-trainers to FD field staff as well as the CPGs on the use of remote sensing and field inventory technologies. Targeted follow-up training will be offered, particularly if technologies used change.

Main elements of a feasible monitoring, reporting and verification (MRV) system will be identified. Sundarbans mangrove forests form an important bio-geographical zone (the country's other such strata/zones include hill forests, sal forests, social forests and homestead forests) and shall thus form a stratum when a national MRV system is designed and implemented. Within the two Sundarbans Forest Divisions (East and West) and four field Forest Ranges, sample plots (temporary and permanent) will be laid out by estimating appropriate sampling design, sampling intensity, number and location of sample plots on a grid, and the methodology adopted as above for establishing baseline is recommended for application. A two year cycle inventory will be carried out in the sample plots laid out as per the grid by marking them in the field. Mangrove, forests of the Sundarbans will be categorized in the following 4 categories:

- Dense forests (more than 70% crown density)
- Moderately dense forests (30-70% crown density)
- Open forests (10-30% crown density)
- Scrub forests (less than 10% crown density)

Carbon gain-loss method estimates net balance of addition to and removal from a carbon stock (based on annual growth rates), whereas the carbon stock change method estimates the difference in carbon stocks at two periods. As the temporal inventories for the SRF provide time series data on growing stock, particularly for trees, the later method is suitable for carbon monitoring and reporting. The following carbon pools will be estimated:

- Above-ground carbon (tree, sapling, seedling, bamboo, cane, crown foliage, branches)
- On-ground carbon (woody debris, dead trees, leaf litter, grass)
- Below-ground carbon (soils, roots)

Average carbon stock for each of the above-identified stratum will be estimated by following the carbon inventory methods described in the Inventory Manual (IPAC, 2010). Species specific volume equations and specific gravity will be used in estimating carbon stock. Historical deforestation and degradation rates will be assessed either by employing temporal inventory data and/or temporal analyses of imageries such as LANDSAT/IRS. Maps will be generated by using facilities of RIMS of FD and/or SPARSO. Base maps of the LGED available at 1:50,000 scale will be helpful in generating these maps. However, it is important to know that carbon inventory and mapping pose some challenges as forests inventory are generally characterized by uncertainty and data limitations. Emission factors are neither available for the country nor for the Sundarbans. Land-use changes in Bangladesh are happening very fast due to heavy biotic pressure. RIMS of FD requires equipping with the latest equipment and technology, and manned with trained staff .

Conclusion

Bangladesh has a favourable and enanbling environment for the restoration and conservation of forests and wetlands through developing partnership with local communities. A vast majority of these communities depend on adjoining natural resources for meeting their subsistence needs including livelihoods. The country is particularly prone to negative consequences of global climate change that need to be mitigated by protecting and conserving forests through REDD+ initiatives. The ongoing REDD+ program would go a long way in both climate change mitigation and adaptation of local ecosystems and community. A number of important policy and operational interventions are suggested, which need to be put in place both at the Government and civil society level.

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Climate Change Impacts and Adaptation of the Local Community and Forest Ecosystems In Bangldesh

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Abstract

The ecosystems of Bangladesh, including forests and wetlands, provide socio-economic and ecological services in terms of life supporting, provisioning and regulating functions. These have tremendous impacts on the climate change adaptation of local community. The role of forests in carbon cycle is particularly vital as they account for approximately 80% of CO_2 exchanged between land and atmosphere through the process of photosynthesis. The climate change mitigation role of forests and wetlands ecosystems in terms of sequestration and storage potential of the CO_2 depends on their growth, conservation and sustenance. The climate change adaptation role of the country's ecosystems stems from the fact that huge number of local people depend on them for resilience functions by providing a coping mechanism.

Climate change projections include sea level rise, temperature rise, and increased frequency of droughts, cyclones, storms and other water-induced extreme events. The country's coasts have a gentle topography and are so more vulnerable to sea-rise and the adverse impacts of cyclones. Climate change impacts are expected to be substantial in the country's predominantly agrarian economy, as a large majority of her population is reliant on land-based primary production as a major source of income. Many ecosystems including forests and wetlands are able to tolerate some level of climate change, and so will continue to persist in short-term as they have done in the past. However, in long-term whether their resilience will be sufficient enough to tolerate future anthropogenic climate change is not known.

There is a likely link between biodiversity and ecosystem functioning in the maintenance of ecosystem services, and thus extinctions critical for ecosystem functioning may reduce societal options for adaptation responses. Sea-level rise would submerge the coastal ecosystems such as mangroves but would also increase the salinity of wetlands. This would favor salinity tolerant plants but may reduce the terrestrial and aquatic biodiversity. On the other hand, increased snow melt in the Himalayan glaciers (releasing more water in a drought year and less water in a flood year) could bring large quantity of fresh water, with consequences for the composition of the coastal vegetation including mangroves, and fisheries, favoring species that have the least tolerance to salinity.

Although climate change, as global public good and service, is global in its causes and consequences, its adverse impacts are being borne inequitably in different regions and communities of Bangladesh. Climate change thus has potential of altering the configuration by impacting both the ecosystems and the landscape human population. Adapting to climate change would involve reducing exposure and sensitivity, and increasing adaptive capacity of local community. Mainstreaming climatic variability and change, while designing and implementing forestry and wetlands programs, will enhance ecosystem health and benefit local community.

Key words : Climate change, Green house gases, Co-management

Introduction

The land-based natural resources such as forests and wetlands in Bangladesh have traditionally been intimate interspersion of human habitations with the neighboring community's dependency for their livelihood in a largely agrarian economy. Community forestry projects have been implemented in Bangladesh, particularly since 1981 when donor support was provided to the Forest Department (FD) for establishing short-rotation plantations mainly on unutilized public land not covered under forest category. As a result, natural forests including protected areas (PAs) could not get the benefits of enhanced funding and participation of local community. Although natural forests were included in Forestry Sector Project (1999-2006), main emphasis continued on raising plantations as more than two-third of the total budget was spent for planting activities mainly on non-forest land.

Inadequate management of natural forests due to lack of funding and increasing biotic pressure resulted in natural forests degradation, particularly in the semi-evergreen and evergreen forests located in the country's hilly region, and sal forests in central and northern regions. Anthropogenic pressures including increased commercial extraction of forest produce, brought by manifold increase in human population, led to deforestation and degradation of natural forests. The Government of Bangladesh (GOB) designated some natural forests as Wildlife Sanctuaries and National Parks through gazette notification mainly to conserve degraded forests; but the situation improved only marginally as large extent of natural forests remained virtually unprotected.

The Forestry Master Plan completed in 1993 led to the promulgation of the people-oriented Forestry Policy of 1994 which *inter-alia* emphasized peoples' participation in the sustainable forests management. Accordingly, the emphasis of forests management gradually shifted from timber production to meeting bonafide consumption needs of local people. As a result, social forestry was included in the revised Forest Act of 2000 and Social Forestry Rules, 2004 and 2010 were formulated in order to implement the peoples oriented policy recommendations. In 2004 the FD launched the Nishorgo program that aimed to improve the conservation of forests and other biodiversity by co-managing the PAs through co-management councils and committees set up as per the gazette notification of the GOB. Vital role of forests ecosystems has been analyzed in this paper in order to mainstream forestry in national and international climate change mitigation and adaptation programs.

Forests Scenario

The forests of the present day Bangladesh were brought under scientific management by Forest Department when the first Forest Act was enacted in 1865. Large tracts of well stocked forests including Sundarbans and hills of Sylhet and Chittagong were declared as reserved forests (RFs) in the late 19th and early 20th century. Of the total 2.53 million (m) hectares (ha) of forests land (17.5% of the country's total geographical area), the FD manages 1.53 m ha (10.5% of the geographical area), whereas 0.73 m ha is categorized as un-classsed state forests and 0.27 m ha as village forests. FD managed forest land is further classified as hill forests (0.67 m ha) mainly in greater Sylhet, Chittagong, Cox's Bazar and Chittagong Hill Tracts (CHT); natural mangrove forests (0.60 m ha) in the Sundarbans; coastal mangrove plantations (0.14 m ha); and sal forests (0.12 m ha) in central and northern regions.

FAO (2010) has recently conducted a national inventory, estimating 48% of the country's geographical area with some vegetation (including homesteads and other private tree growing). Tree coverage estimated under different categories in this inventory is reproduced as below:

No tree cover	7.60 million (m) hectare (ha)
Less than 5% tree cover	2.89 m ha
5-10% tree cover	1.43 m ha
10-30% tree cover	1.27 m ha
30-70% tree cover	1.23 m ha
Over 70% tree cover	0.33 m ha
Total Tree Cover	14.75 m ha

Hill forests classified into tropical wet evergreen and semi-evergreen forests are biodiversity rich, located as they are in the mega-biodiversity north-eastern subcontinent. The Sundarbans, the world's largest mangrove forests, is the home of Royal Bengal Tiger (FD, 2010a). Mangrove plantations have been raised along the coast. Sal forests, classified as tropical moist deciduous forests, have become severely degraded, and the deforested forest land has been brought under social forestry based on participatory benefits sharing agreements that have been signed with participants as per the social forestry rules, 2004. As representatives of the country's four bio-geographic zones, 27 national parks and wildlife sanctuaries have been established as per the provisions of the Wildlife Act of 1974.

Over the period the natural forests have depleted and as per the UNDP supported National Biodiversity Strategy and Action Plan (MOEF, 2006) of the Government of Bangladesh, the country's forests cover has declined from 10 to 6% of the total geographical area. The evergreen and semi-evergreen hill forests could not be protected mainly due to lack of resources, and clear felling of natural hill forests for raising commercially valuable plantations such as teak resulted in loss of ecologically diverse forests. Plantation activities declined substantially particularly after 1985 and so could not compensate a high rate of deforestation and degradation of natural forests.

The private forests (e.g., sal forests of Modhugarh and Bowalgarh) under the management of local rulers and landlords, though brought under the control of FD by enacting the State Acquisition and Tenancy Act, 1953, could not be effectively protected mainly due to lack of their proper reservation and management under the Forest Act. Being near to urban centers with dense population, sal forests particularly have came under large scale encroachment mainly for cultivation and settlement. The forests not under the management of FD (e.g., unclassed state forests in CHT) suffered heavily as no agency was responsible for their management. Such forest areas do not have good forest cover and the current presence of grasses indicates the extent of site degradation that has taken place over the period. In a land scarce country, the diversion of forest land for non-forestry purposes still continues. As per an estimate of Asian Development Bank, nearly 61,000 ha of forest lands have been transferred for various purposes since 1984.

Despite numerous challenges, a number of achievements have been made by FD and need to be mentioned. Firstly, the Sundarbans' sanctity has been maintained in terms of both the conservation of forest land and forests cover. The recently completed mangrove forests inventory (FD, 2010b) reveals that the growing stock have off late has increased since the previously conducted forests inventory (Ravilla, 1996) FD has been able to keep the forest land free from encroachment and deforestation has been effectively avoided.

Second important achievement of the FD relates to successful implementation of social forestry programs initiated since 1981 when community forestry was started in north Bangladesh by involving rural poor. This pilot social forestry program has now been institutionalized by enacting the amended Forest Act of 2000 under which social forestry rules were framed in 2004 and amended in 2010. For instance, during 2000-09 nearly 84,000 participants received Tk. 1,250 million as beneficiaries of social forestry programs that were implemented by FD. The achievement includes forestry sector and coastal green projects under which large scale coastal plantations were raised to act as protection belts from coastal tidal surges and storms. Additionally, a large number of rural poor were gainfully employed in raising social forestry plantations and received minimum wages for their labor. Social forestry has become a peoples movement and is now being expanded as private tree growing and also on non-forest *khas* lands.

Thirdly, important peoples oriented policy measure initiated since 2003 (in five PAs : Lawachara, National Park, Satchari National Park, Rema-Kalenga Wildlife Sanctuary, Teknaf Wildlife Sanctuary and Chunoti Wildlife Sanctuary) is co-management approach that has been now formalized in 19 forest PAs where co-management councils and committees, formed under the gazette notification, are protecting forests and wildlife in gainful partnerships with local community. The roles and responsibilities of such committees are listed in the GOB gazette and a legal backing is being provided under the draft revised forest and wildlife acts.

Climate Change Impacts

The forest ecosystems of Bangladesh provide socio-economic and ecological services in terms of life supporting, provisioning and regulating functions and so have tremendous impacts on the climate change adaptation of local community. The role of forests in carbon cycle is vital as they account for approximately 80% of CO_2 exchanged between land and atmosphere through the process of photosynthesis. As terrestrial and aquatic vegetation grow, the carbon is stored in biomass by converting

CO_2 and water (by using solar energy) into sugars and oxygen (released through leaves). Forests also release CO_2 during the process of respiration. However, forests that are growing (increasing in biomass) will absorb more CO_2 than they release. So the climate change mitigation role of forests and wetlands ecosystems in terms of sequestration and storage potential of the CO_2 depends on growing, conserving and sustaining them.

The climate change adaptation role of the country's forest ecosystems stems from the fact that large number of local people depend on them for their resilience functions but also for livelihoods, thereby reducing their vulnerability by providing a coping mechanism: The forests and wetlands provide biodiversity and life supporting eco-system services to local people and beyond. The population of the landscapes of vast forest and wetland ecosystems depends on climate-dependent land-based activities such as fisheries, agriculture and forestry. The country's socio-ecological systems are complex due mainly to an intimate interplay of climate change, environment, ecological, oceanographic and socio-economic factors. Ecological resilience implies the extent to which an ecosystem can recover from natural and human disturbances without losing their functions or shifting into alternate states. The ecosystems are particularly important for providing goods and services that are essential for local people. It is thus imperative to improve their resilience to climate change. Social resilience is the capacity of the affected coastal people to withstand and recover from disasters such as *Sidr* and *Aila*. Socio-ecological resilience will thus encompass both ecosystems and local community.

Bangladesh has a unique climate system dominated by monsoon, and the major physiographic features that drive this monsoon are its location (in terms of latitude, longitude and altitude). The Himalayas and the Bay of Bengal (in the Indian ocean), have significant influence on the climate of Bangladesh. Climate change (green house gases and their concentration are one of the main drivers of climate change) impacts on forests have been highlighted in a number of studies including various reports of the Inter-governmental Panel of Climate Change (IPCC, 2010). Climate change projections include sea level rise, temperature rise, and increased frequency of drought, cyclones, storms and other water-induced extreme events. Bangladesh has a long coastline where the impacts of climate change occur at medium-term and long-term scales. As a result of climate change, the sea-level may rise and there may be changes in the occurrence of frequency and intensity of storm surges. Recently the country experienced *Sidr* and *Aila* cyclones, indicating that the committed (as a result of past changes in green house gas concentration) climate change is already impacting it and future climate change will further aggravate this bleak situation (FD, 2010a).

The regional variations in sea-level rise in Bangladesh with respect to global sea-level rise are manifestations of tectonic changes and ocean density. For instance, a significant number of cyclones have occurred in the Bay of Bengal as compared to the Arabian Sea (at the ratio of 4 to 1). The cyclonic disturbances are 5 to 6 times more frequent over the Bay of Bengal than over the Arabian Sea, and one third of the Bay disturbances and half of the Arabian Sea disturbances intensify into tropical storms. This may be due to the fact that the surface sea temperature over the Arabian Sea is cooler than over the Bay of Bengal. The shallow depth of the Bay of Bengal and the low flat coastal terrain produce much larger storm surges and take a very heavy toll of human and animal life. Moreover, the country's coasts have a gentle topography and are so more vulnerable to sea-rise and the adverse impacts of cyclones.

Important changes in the coasts may be due to their location but more importantly due to high sensitivity of natural ecosystems, including forests and wetlands, to temperature rise. Possible changes may include shifts in forests and wetlands boundary, changes in species assemblage or types of forests and wetlands, changes in net productivity of forests and wetlands, forest die back, and loss of forest and wetland biodiversity. Although enhanced level of CO_2 in the atmosphere may increase net productivity over forests and wetlands, but the forests biomes may be vulnerable to climate change, as a result of which the existing vegetation may be less than optimally adapted to its existing location, thereby making it more vulnerable to the adverse climate conditions as well as to the increased biotic stresses. Climate change impacts are expected to be substantial in the country's predominantly agrarian economy, as a large majority of its population is reliant on land-based primary production as a major source of income.

Conspicuous changes in annual trends in both minimum and maximum temperatures have already been noticed both globally and nationally. Variability in monsoon rainfall has been recorded in recent years. Most of the observed increase in global average temperature is due to the observed increase in anthropogenic GHG emissions (IPCC, 2010). A study by the Indian Network for Climate Change Assessment (MOEF, 2010) concludes that discernable human influences now extend to other aspects of climate including ocean warming, continental average temperatures, temperature extremes and wind patterns. Global mean sea level change results mainly from two processes, mostly related to recent climate change, that alter the volume of water in the global ocean : i) thermal expansion, and ii) the exchange of water between oceans and other reservoirs (glaciers and ice caps, ice sheets, other land water reservoirs) including through anthropogenic change in land hydrology, and the atmosphere. Regionally, oceanographic factors such as changes in ocean circulation or atmospheric pressure cause changes in sea level. In addition, sedimentation and vertical land movements influence local level sea variations.

Fisheries including wetlands of the Sundarbans play an important role in food supply, food security and livelihood security of the country's millions of fishermen and other stakeholders. Temperature is known to affect fish distribution and migration. Increasing temperatures may have negative impacts on the physiology of fish because oxygen transport to tissues will be limited at higher temperatures, and this constraint in physiology will result in changes in distribution, recruitment and abundance. Fish have strong temperature preferences to spawning as the process of spawning is known to be triggered by pivotal temperatures. Phonological changes are expected with climate change, and species with short life spans and rapid turnover of generations such as planktons and small pelagic fish are most likely to face such changes.

The changes in distributions, recruitment and abundance of many species will be acute at the extremes of species' ranges. Changes in abundance will alter the species' composition and result in changes in the structure and functions of the ecosystems. Changes in the net primary production and its transfer to higher trophic levels are possible. The eggs of most of the fish species are pelagic, directly exposed to higher temperatures and currents. With temperatures increase, the development duration of eggs and larvae size decrease. The adults may grow faster in warmer years but afterwards the growth rates would start decreasing as metabolic cost continue to increase. The more mobile species will be able to adjust their ranges over time, but less mobile and sedentary fish species may not. Depending on the species, the area it occupies may expand, shrink or be located and this will include increases, decreases and shifts in the distribution of the Sundarbans fish including marine fish, with some areas benefiting while others losing.

Forests ecosystem are generally able to tolerate some level of climate change and so will continue to persist in short-term as they have done in the past. However, in long-term weather their resilience will be sufficient enough to tolerate future anthropogenic climate change is not known. The implications of possibly transient increases in productivity for resilience are also very important and these may occur through likely atmospheric CO_2 fertilization effects and/or modest warming, and as a consequence of increased radiation due to reduced cloudiness. The understanding of time-lags in ecosystem responses is not adequate, and they may take several centuries before responses to climate change are played out. However, there is a likely link between biodiversity and ecosystem functioning in the maintenance of ecosystem services, and thus extinctions critical for ecosystem functioning may reduce societal options for adaptation responses.

Sea-level rise may submerge the coastal ecosystems such as mangroves but would certainly increase the salinity of wetlands. This would favor salinity tolerant plants but may reduce the vegetation and aquatic diversity. On the other hand, increased snow melt in the Himalayan glaciers (releasing more water in a drought year and less water in a flood year) could bring large quantity of fresh water, with consequences for the composition of the mangroves and fisheries, favoring species that have the least tolerance to salinity. Changes in local temperature and rainfall will also influence the wetlands salinity and aquatic plant composition.

Climate Change Adaptation

Climate change adaptation is important for improved ecosystem management ensuring economic and climate change resilience benefits to local community. This means that main climate change adaptation programs would comprise ecosystem management and developing appropriate value chains and conservation linked livelihood options that will be implemented in gainful partnerships of local community. The climate change adaptation role of an ecosystem including forests and wetlands stems from the fact that local people depend on nearby ecosystems for their resilience functions but also for their livelihoods, thereby reducing their vulnerability by providing a coping mechanism. A large portion of the landscape population around many important ecosystems such as the Sundarbans is dependent on climate-dependent activities such as fisheries, agriculture and forestry.

Although climate change, as global public good and service, is global in its causes and consequences. Its adverse impacts are being borne inequitably by poor communities. Climate change thus has potential of altering the configuration by impacting both an ecosystems and its landscape human population and so it is important to understand vulnerability and adaptation issues arising as a result of climate change. Vulnerability to the impacts of climate change is a function of exposure to climate variables, sensitivity to those variables and the adaptive capacity of the affected ecosystem and community. Adapting to climate change would involve reducing exposure and sensitivity and increasing adaptive capacity.

Forests and wetlands provide livelihoods to local economy. Additional benefits mobilized through off-PA activities including value chain development and alternative income generation activities generate both wage and self-employment. A number of livelihoods opportunities can be identified and conservation-linked interventions designed for providing alternative income to local community in order to reduce extractive harvesting from ecosystems. Value chains mapping can be done by identifying all possible actors and factors. The increased population with few alternative livelihood opportunities poses a serious threat to many ecosystems.

The livelihood dependence of local people on many ecosystems is high and in future this dependence will increase. There are a large number of people directly involved with the resources extraction from many ecosystems. The pressure for resources extraction has increased tremendously as the number of collectors has increased many fold over the last decades, resulting in huge reduction in per capita resource collection. Land-based value chains (e.g., fisheries and tree nursery) may be designed for their implementation as climate change adaptation initiatives in the landscape villages. Additionally, a number of adaptation policy measures may be suggested for taking up appropriate interventions by different government agencies including FD. Such interventions may require a multi-sectoral approach wherein resources would be ploughed in from different funding sources.

The country's forests ecosystems are primary producers and protectors of various natural and human resources. Forests not only maintain and improve moisture regime and provide clean air but also produce humus and maintain soil fertility. These are vitally important for maintaining and regulating water flows and sub-soil water regimes because of thick humus layer, loose soil and soil-retaining powers of tree roots. The relationships between forest ecosystems and hydrology form vital ecological connections and interactions that sustain the country predominantly agrarian economy and populace. Main life supporting functions and services flow due to the very existence of forests ecosystems for ecological, hydrological and food security, and include water and air purification, evapo-transpiration and rapid runoff moderation and water storage, biodiversity conservation and repository of gene pool, nutrient cycling, carbon sequestration and storage, habitats for wildlife, etc.

The country's forests ecosystems and their natural processes recharge aquifers, maintain water regimes and moderate the impact natural disasters including floods, droughts and cyclones, thereby ensuring food security and regulating climate change. Water and fertile soil, two main prerequisites of the country's food security, are irrevocably linked with forests and their watershed conservation functions. Forests reduce air temperature and wind velocity and increase relative humidity that helps in reducing evaporation and in improving moisture balance in adjoining agricultural fields, creating a favorable climate for better production. Viable populations of fauna and flora by their independent collective activities, ensure that the quality of natural systems is kept at levels that maintain their life-giving quality for all life forms. Forests clean the environment by muffling noises, buffering strong winds and storms, and trapping dust and gases.

Natural vegetation in forests, wetlands and grasslands is the prime conserver of soil and the provider of nutrients and humus. Many forests, named after the rivers originating and flowing from them, have been historically designated as headwaters reserves (e.g. Matamuhuri and Sangu headwater RFs). Forests are living sponges of water which they hold in vast amount in the soil they shade, in their trunks, branches and leaves, and via transpiration in the air around and above them. The thermal stability of water stored in the forests of the sub-continent in general and Bangladesh in particular is the fundamental stability factor of sub-continental climates. Therefore, unique and representative ecosystems and biotypes should be effectively preserved and allowed to progress to their climax vegetation level as maximum biodiversity is manifested only in a climax if not pristine biomes. Such forest areas (as CO_2 sinks, O_2 and gene banks, and biodiversity pools) need to be treasured as national natural heritages under the aegis of National Nishorgo Network of PAs.

Water flow, both quantitative and qualitative, may be regarded as the single greatest function of forests, since most of the country's rivers and wetlands emanate from forests that constitute the upper catchments of these water bodies. These wetlands, though are a rich repository of biodiversity and provide waste-dissipative and aquifer services to the nation and are closely intertwined with forests (e.g., the Sundarbans), are under serious threat due to encroachment, over-extraction and environmental pollution. However, the beneficial effects of forests and wetlands depend on their size, location, composition, structure, etc.

Provisioning functions and services from forests are due to the fact that a number of economic goods such as timber, fuelwood, food, fibre, and non-timber forests products (NTFPs) and social benefits due to coastal protection from tidal surges, storms and cyclones. Substantial social forestry benefits accrue to local community. The wild counterpart food plants and livestock, and medicinal plants occur in forests. Main food collected from forests includes fruits, flowers, tubers, vegetables, bamboo shoots, honey, mushrooms, etc. Cultural values of forests include recreation and eco-tourism, and forests being abode of cultural festivals (Rash Mela in the Sundarbans RF) and temples (e.g. Sitakunda temple inside the Sitakunda RF) culminate in spirituality. These events provide recreation and aesthetic refreshment for people.

Recommendations and Conclusions

Vital life supporting and provisioning role of forests ecosystems need to be properly understood by policy makers in order to be mainstreamed in the national planning and decision-making. By conserving forests and developing plantations, forests landscape degradation can be halted, biodiversity and water conserved ***in-situ***, and community benefited through gainful partnerships. Besides, sustainable forests management opportunities would have significant potential to upgrade institutional capacity of FD field staff and local community organizations for biodiversity conservation, forests restoration and bio-energy. Sustainable forests management in densely populated countries such as Bangladesh would have substantial socio-environmental and economic benefits for local communities, who are mainly subsistence farmers and laborers.

The development and sustainable management of forests will benefit local community by contributing to poverty alleviation through their enhanced income generation and better quality of life. Greening of the country through community activities necessary for reducing deforestation also will result in empowering local community, thereby contribute in improved environmental governance. Many of the community activities helpful in reducing forest degradation are cost effective, efficient and equitable with large employment and income gains expected to accrue to local communities. In the process local surplus labor and other resources will be utilized in restoring the degraded forest landscape.

In a populous and poor country such as Bangladesh effective forests protection is not possible without gainful partnership of local community. Such a co-management initiative has proved successful as evident from the Nishorgo program of FD. The forests under community protection can be sustainably co-managed locally by sharing benefits accrued as a result of enhanced forests productivity. It should be possible to equitably distribute forests-based benefits to participating community as naturally regenerating forests would require canopy opening thereby providing yield as a byproduct. Forests should no more be treated as revenue generators because substantial benefits of forests are due to their existence value in terms of services and functions they provide as explained above. Resilience-based management is needed for enhancing the capacity of both ecosystems and local community to adopt together and be resilient to changes and disturbances.

Due to failure in valuing intangible socio-economic benefits of forests, their significant contribution in social welfare has not yet been captured. This means more research is needed in quantifying and monetizing vital values and services of forests to local community and beyond. As in many other countries, the senior FD officials should be involved in policy making and implementation at the level of different land-based ministries including the ministry of environment and forests (MOEF). In addition to short and medium-term donor funding, the GOB should provide both revenue and development budget to important FD programs that can be sustained for maximum impacts. The current state of forestry research needs strengthening, particularly in view of significant global interest that has generated recently due to climate change functions and services of forests ecosystems.

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Afforestation / Reforestation CDM or REDD Plus in Bangladesh : The Way Forward

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Abstract

Global climate change is a serious concern now-a-days. To effectively address the climate change, reducing greenhouse gas (GHG) emission was recognized importantly by the Kyoto Protocol. As climate change mitigation options, the Afforestation/Reforestation (A/R) Clean Development Mechanism (CDM) under the Kyoto Protocol allows Bangladesh to receive investments from developed countries wishing to offset their GHG emissions. Bangladesh has a special interest in strategies for mitigating global climate change because of its large areas to be planted that represent a potentially large carbon sink. A/R CDM offers opportunities for carbon credits for the uptake of atmospheric carbon in forest biomass. Reducing Emissions from Deforestation and forest Degradation, conserving and enhancing forest carbon stocks, and sustainable managing of forests (REDD+) has been proposed as a global climate change response option for the bigger benefits in the short-term, while the A/R CDM can give credits in the long-term. The literature illustrates the potentialities of A/R CDM and REDD+ in Bangladesh. This study finds that Bangladesh forestland has a good inherent capacity to mitigate global climate change. But lack of capacity dealing with the CDM hinders the potentials. The paper also finds that not only Bangladesh but also other developing countries face global constraints and uncertainties hindering the potentialities of A/R CDM. It shows that REDD+ can be a prospective option in Bangladesh for mitigating climate change and forest ecosystem conservation. The presentation discusses the limitation and the way forward of REDD+ in Bangladesh. The paper finally highlights the future policy options of the forestry sector of Bangladesh to mitigate the global climate change and to obtain carbon credits. The study concludes that the future policy/approach of the forestry sector in Bangladesh should be oriented to retard the deforestation, reforest the degraded forestlands and afforest the newly accreted lands. The study is expected to contribute to the global climate change mitigation and forestry development in Bangladesh.

Key words: Avoided deforestation, Global climate change, Sustainable forest management, Land-use change

Introduction

Global warming has been identified as the cause of anthropogenic greenhouse gas (GHG) emissions, principally carbon dioxide (CO_2) in the atmosphere due to the industrial activities and combustion of fossil fuels for non-industrial activities; deforestation and other land-use changes (Fearnside 2006; Houghton 2005; Nordell 2003). Mayaux *et al.* (2005) and Achard *et al.* (2002) reported that world's humid tropical forests were disappearing at a rate of about 5.8 (±1.4) m ha
yr^{-1}, with a further 2.3 (±0.7) m ha yr^{-1} of forests visibly degraded between 1990 and 1997.

Kram *et al.* (2000) noted that the distribution of both income and GHG emissions is very unbalanced between various global regions. The relative importance of individual gases and sources of emissions differ from region to region. Kram *et al.* analyzed that currently developing countries account for about 46% of all emissions, but by 2100 these countries will emit no less than 67-76% of the global total. In the Protocol, which was adopted in Kyoto, Japan, in 1997, industrialized countries committed themselves to reduce their combined GHG emissions by more than 5% in the period between 2008 and 2012 relative to the level in 1990,. The Kyoto Protocol recognizes forestry and land-use change activities as sinks and sources for atmospheric carbon. In a special report on land use, land-use change and forestry (LULUCF), the Intergovernmental Panel on Climate Change (IPCC) concludes that activities in the realm of land-use change and forestry provide an opportunity to affect the carbon cycle positively (IPCC 2000). FAO (2001) proposes three possible strategies for the management of forest carbon. The first is to increase the amount or rate of carbon accumulation by creating or enhancing carbon sinks. The second is to prevent or reduce the rate of release of carbon already fixed in existing carbon sinks. The third strategy is to reduce the demand for fossil fuels by increasing the use of wood, either for durable wood products (i.e., substitution of energy-intensive materials such as steel and concrete) or for biofuel (carbon substitution).

Carbon sequestered by the national forests and afforestation/reforestation (A/R) projects were well identified by Hansen *et al.* (2004), Cannell (2003), Pussinen *et al.* (1997), Karjalainen (Karjalainen 1996), Ravindranath and Somashekhar (1995) and Ismail (1995), etc. The carbon sequestration potential of forests is specific to the species, site and management involved, and it is therefore very variable. Assuming a global land availability of 345 m ha for A/R and agroforestry activities, Brown *et al.* (1996) estimated that approximately 38 Gt of carbon could be sequestered over the next 50 years ,i.e., 31 Gt by A/R and 7 Gt through the increased adoption of agroforestry practices. Reducing emissions from deforestation and forest degradation plus (REDD+) is now a central topic of research and discussion in the arena of climate change mitigation and forest conservation. The financial incentives for REDD+ in many pilot projects established in several countries have been found to alter the drivers of land use changes by reducing opportunity costs of retaining forest cover, and as multifarious solutions that not only generate profits and reduce carbon emissions, but also provide benefits to human development and biodiversity (Carlson and Curran 2009).

The implication of the legal frameworks of the Clean Development Mechanism (CDM) of the Kyoto Protocol is important for creating CDM forests in Bangladesh and to achieve the 'Certified Emission Reduction' (CER). Defining REDD+ activities in Bangladesh and her preparedness for operating this, is also important for Bangladesh. Through reviewing literatures, the study discusses the implications of the Kyoto Protocol and its CDM and proposed REDD+ in Bangladesh; potentialities of Bangladesh forestry sector to mitigate global climate change with its different land uses. It also discusses the policy issues to expedite the development of the CDM and REDD+ forests in Bangladesh. The findings of this study would be useful for the policy makers, environmentalists and the investors to the CDM and REDD+ forests.

Kyoto Protocol to Mitigate Climate Change

The Kyoto Protocol was the product of the COP 3 (Conference of the Parties) of the UNFCCC (United Nations Framework Convention on Climate Change) with the target of 'stabilization of GHG concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system'. The Protocol sets specific reduction targets and timetables for reducing net GHG emissions from the Annex I (Industrialized) countries. It calls for Parties to reduce their annual emissions 5% below 1990 emissions (UNFCCC 2011a). The Protocol with the ratification of Russian Federation came into force on February 16, 2005. As of March 2011, 193 Parties (192 States and 1 regional economic integration organization) have deposited instruments of ratifications, accessions, approvals or acceptances (UNFCCC 2011b). The Article 4 of the UNFCCC obligates the developed nations to assist developing nations through funding for emissions reductions, funding for adaptation to adverse effects and transfer of environmentally sound technology (Rosenbaum *et al.* 2004). A total of 38 Annex I and 155 Non-Annex I Parties compose this Kyoto Protocol Parties. The total percentage of the Annex I Parties emissions is 63.7% (UNFCCC 2011b).

CDM to mitigate climate change

The Article 12 of the Kyoto Protocol introduces the CDM, originally a part of AIJ (Activities Implemented Jointly). The CDM is an instrument under the authority of the COP and supervised by an Executive Board (EB). CDM projects typically involve Annex I countries as investors and Non-Annex I countries as hosts, essentially joint ventures between developed and developing countries (UNFCCC 2011a). Reductions resulting from these projects, beginning in the year 2000, count towards satisfying an Annex I country's obligations to reduce aggregate emissions during the years 2008 to 2012 (First commitment period). An 'operational entity' accredited by the COP must validate the project before implementation and verify the project's emission reductions before the EB can issue credits for the emission reductions achieved. CDM projects are expected to derive the sustainable development in the Non-Annex I countries. The development must be in the social, environmental and economic arena of a country. The possible carbon sequestration, carbon combustion efficiency and carbon substitution projects are expected to derive lots of impacts on the overall of a host country (Silveira 2005).

Bangladesh and Its Forests

Bangladesh is located in the South Asia ranged between 20°34/ to 26°38/ N latitude and 88°01/ to 92°42/ E longitude with a geographical coverage of 14.76 m ha with three broad categories of land-hills, uplifted land blocks and alluvial plains. The country is characterized by low per capita gross national product; low natural resource base; high population density, and high incidence of natural disasters. The climate is subtropical, characterized by high temperature, heavy rainfall, often excessive humidity, and fairly marked seasonal variations. Though more than half of the area is located in the north of the tropics, the effect of the Himalayan mountain chain makes the climate more or less tropical throughout the year (MoEF 2005). The mean annual rainfall varies widely within the country, according to geographical location, ranging from 1200 mm in the extreme west to 5800 mm in the east and northeast (MoEF 2005). In June 2009, the population of the country was about 156 m with a growth rate of 1.3% (USCB 2009). Among the total population, 77% live in rural areas. The main crops grown in the country are rice and jute. Per capita GDP (ppp) was US$ 1,155 in 2005 with the annual growth rate 6.6 (FAO 2009).

Forestry contributed about 1.84% of the country's GDP and 10.2% of the agriculture income in 2003/2004. The annual GDP of this sector in 2003/2004 was 4.48% (GOB 2004). Iftekhar (2006) reports that 'if environmental services and contribution in people's livelihood could have been properly accounted for, then the share of the forestry sector would have been much more'. Forestlands make up almost 18%, agricultural lands 64% and urban areas 8% of the total lands in Bangladesh (FAO 1998). Other land uses account for the remainder. Total forestland area is 2.56 m ha, including officially classified and unclassified state lands, village forests and tea/rubber gardens. Most of the state forestland is degraded. Classified and unclassified forestland signifies an administrative or legal category, not necessarily areas with forest cover. The natural forest accounts for about 31% and forest plantations 13% of total forest areas. Shifting cultivation, illegal occupation and unproductive areas account for the remaining forestland (FAO 1998). Presently, protected areas represent just over 5% of forestland. The FD is controlling 65% of state forestland while the other forestlands are administered by local District Commissioners (DC). The better quality natural forests and plantations in the government forestlands, excluding parks and sanctuaries (medium to good density), makes up around 0.8 m ha, which is 5.8% of Bangladesh's total area. The area included in the present protected area network is 0.12 m ha, equal to 5.2% of state forestland or less than 1% of Bangladesh's total area (FAO 1998). In 2005, forest area per 1000 people was 6 ha. The mean annual change rate between 2000 and 2005 was -0.3%.

Ali (Ali 2002a) describes that illegal harvesting; encroachment and shifting cultivation are the important problems in forest land-use in Bangladesh. In Bangladesh, individual offences related to illegal harvesting are mostly for fuelwood, home, and farm implements or for the sale of goods in the market for personal daily livelihood requirements. Although per capita fuelwood consumption of Bangladesh is one of the lowest in the subcontinent, fuel wood supply from the state forests of Bangladesh has not been enough to meet the demand of the whole population (GOB 2008). Official fuelwood supply from the forest (1985-90) was only 0.7 m m^3 yr^{-1}, whereas the demand was about 7.0 m m^3. The case for timber was similar. The average supply from the forest was 1.09 m m^3, whereas the demand was 2.42 m m^3. As the gap between supply and demand continued to grow, illegal harvesting was reported to increase. As a result of forest clearance, encroachment is one of the worst problems of Bangladesh forest land-use. Once the forest is cleared and left un-forested, people start to invade and claim the land as their own. Ali (2002b) describes that about 62,000 ha of national forest land has been encroached up to December 1980, and more than 88,000 people were living inside forests. Moreover, there were about 5,000 forest villagers living inside forests legally, whose number was also increasing.

Forests in Bangladesh Reducing Atmospheric Carbon

Overall carbon conservation

Owning to diversified forest ecosystems, i.e., wet forest lands, rain forests, moist deciduous forest, semi-arid areas and mangroves, Bangladesh forestry sector is acting as an important carbon sink. It has been estimated that about 5,000 species of higher plants with thick foliage and species diversity occur in Bangladesh. On an average, 92 tC ha^{-1} (Table 1) is stored by the existing tree tissues in the forests of Bangladesh (Shin *et al.* 2007). Among them, closed large-crown forests 121 tC ha^{-1}, closed small-crown forests 87 tC ha^{-1}, disturbed closed forests 110 tC ha^{-1} and disturbed open 49 tC ha^{-1}. ESSD (ESSD 1998) reports that forest soils in Bangladesh store carbon at a rate of 115 tC ha^{-1},100 tC ha^{-1} and 60 tC ha^{-1} in moist, seasonal and dry soils, respectively. But Shin *et al.* (2007) commented that due to the over extraction of the forest resources and encroachment in the forests, soil carbon reduces fast.

For the forests with high standing biomass and low future growth rates, the best choice for the carbon emission reduction is simply to conserve the existing forest stand. Thus, the 1.05 m ha of forestlands would fall in this category, simply requiring protection and enrichment. These lands include medium to good density natural forest areas (0.20 m ha), established and proposed protected areas (0.15 m ha), plantations (0.25 m ha) and other forest areas (0.45 m ha). A total of 15 formally protected forest areas in Bangladesh occupy about 0.75% of the total land area of the country. The situation of these protected areas is being quickly deteriorated as the pressure is being mounted from poaching, logging, and land conversion for shrimp farming. So, slowing down the deforestation is the most important issue to preserve the forests and enhance the carbon sinks.

Table 1. Biomass and carbon density in the forests of Bangladesh (Shin *et al.* 2007)

Forest types	Aboveground biomass tdm ha^{-1}	Underground biomass tdm ha^{-1}	Total biomass tdm ha^{-1}	Carbon stock t C ha^{-1}
Closed large-crowns	206-210	32	242	121
Closed small-crowns	150	23	173	87
Disturbed closed	190	29	219	110
Disturbed open	85	13	98	49
Average				92

Specific carbon sequestration through A/R

According to the modalities of the CDM adopted at COP7 in Marrakesh, Morocco, in November 2001(Marrakesh Accords), it can allow projects both in LULUCF and energy sectors. In the first commitment period, CDM restricts the LULUCF projects only to A/R which comply with the SBSTA (Subsidiary Body for Scientific and Technological Advice) recommendations adopted in COP9 (Decision 19/CP.9). Shin *et al.* (2007) estimated the carbon sinks through A/R including the 13 plantation tree species of ages ranging from 6 to 23 years in the tropical semi-evergreen forest zone in the Chittagong region of Bangladesh. It was found that 190 tC ha^{-1} exist in the forests including above-ground, under-ground tree tissues and soils through A/R. The average highest biomass carbon content (145 tC ha^{-1}, S.E*. 7.73) was found in the *Aphanamixis polystachya* stands, and the lowest (43 tC ha^{-1}, S.E. 7.70) was found in the *Swietenia mahagoni* stands. The average highest soil (including humus) carbon content (113 tC ha^{-1}, S.E. 5.39) was found in the *Lagerstroemia speciosa* stands, while the lowest was found in the *Pinus caribaea* plantation (83 tC ha^{-1}, S.E. 6.93). A net 4 (S.E. 0.31) tC $ha^{-1}yr^{-1}$ increment in the plantations was found, considering productivity and loss of litter and fuel wood from the plantation. The highest net mean annual increment (MAI) in carbon stock was found to be 9.83 (S.E. 1.50) tC $ha^{-1}yr^{-1}$ in the *Eucalyptus camaldulensis* stands, followed by *Acacia mangium* (7.48 tC $ha^{-1}yr^{-1}$, S.E. 0.66) while the lowest was in the *Gmelina arborea*, at 0.25 tC $ha^{-1}yr^{-1}$ (S.E. 0.64). However, there can be four approaches increasing the

* Standard error of mean

carbon pool in the forests of Bangladesh, i.e., a) Conservation of forests and carbon sinks; b)reforestation in previously forested barren lands and afforestation in newly accreted lands; c) enrichment o the existing 'poor tree cover' forest lands with reforestation, and d)enforcement of the forestry acts and regulations (FAO 2009). All of these approaches are expected to achieve the objectives of forest resources development and abatement of GHG emissions.

CDM Projects in Global Context and Its Position in Bangladesh

The major goal of the CDM projects in the host countries is to derive sustainable development (UNFCCC 2011a). Although Misana and Karlson (2001) and Olmos (2011) found a strong relationship between CDM project and sustainable development in the developing countries, Sutter and Parreño (2007) concluded that less than 1% CDM projects are likely to contribute significantly to sustainable development (in terms of contribution to employment generation, equal distribution of CDM returns, and improvement of local air quality) in the host countries. However, they found a large part, 72% of the projects are likely to represent real and measurable CERs. Furthermore, Sutter and Parreño (2007) found from the registered CDM projects (registered at UNFCCC as of August 30, 2005) that there was no project that is likely to fulfill the Kyoto Protocol's two fold objectives of simultaneously obtaining CERs and sustainable development. Caparros and Jacquemont (2003) and Mattheus *et al.* (2002) argue that A/R CDM may have negative impact on forest biodiversity. As CDM does not allow credits for avoided deforestation, so A/R CDM may enhance the deforestation and invite the alien invasive species having higher biomass growth. As CDM is an offsetting mechanism, it does not contribute to any net reduction of total global emissions, since the reduction achieved in CDM projects are used to offset emissions made in developed countries (Paulsson 2009; Schneider 1989). It may even increase in total global emissions, if more CERs are issued than emissions are reduced (Paulsson 2009). Up to February 1, 2010, the total number of registered CDM projects is 2,029 (IGES 2010). Among them, small-scale projects are 44% and the large-scale projects are 56%. A/R CDM projects only represent 0.64% enumerating only 13 among the registered CDM projects (IGES 2010).

The most important constraint to Bangladesh's participation in carbon trading is the lack of capacity to host CDM projects. Here, the term 'capacity' is defined as the abilities, skills, understandings, attitude, values, relationships, knowledge, conditions and behaviors which enable organizations, groups and individuals in a society to generate development benefits and achieve their objectives over time (Morgan 1999). CDM projects are expected to meet a set of requirements prior to the issuance of CERs by the CDM Executive Board (UNFCCC 2011a). Additionality, acceptability, externalities and certification must be demonstrated in the Project Design Document (PDD) (Minang *et al.* 2007). Project developers are required to put forth arguments and supporting evidence for each CDM requirement in a PDD. Planning, coordination, and management skills are also required in the project development process (Minang *et al.* 2007). Poor capacity, as defined above, hampers CDM activities in Bangladesh. Notwithstanding the institutional set-up of CDM, Bangladesh has not shown a significant capacity to deal with CDM projects, especially in the forestry sector of Bangladesh. As of July 2010, only two CDM projects for Bangladesh have been registered: (i) Composting of organic waste in Dhaka (0169[1]) and (ii) Landfill gas extraction and utilization at the Matuail landfill site, Dhaka (0078) (IGES 2010). The former is for methane avoidance and the latter is for methane recovery and utilization. The annual capacity of emission reductions (ERs) from these projects are 89,259 tCO_2 and 80,000 tCO_2, respectively. Total ERs by 2012 are estimated at 624,816 tCO_2 and 566,001 tCO_2, respectively. Another CDM project entitled 'Improved cooking stoves in Bangladesh' has been validated, but not yet registered (UNFCCC 2010). Its estimated annual ERs are 43,022 tCO_2. ADB (1998) reports the potential of emission reductions from least-cost GHG mitigation projects in the energy sector of Bangladesh. Based on the analysis of ALGAS (Asia Least-cost Greenhouse Gas Abatement project) (ADB 1998), presently registered CDM projects in Bangladesh to reduce GHGs are quite insignificant in comparison to the total potential of the energy sector. On the other hand, the neighboring country, India, had a total of 171 CDM projects on biomass and 66 on energy efficiency as of July 2010 (IGES 2010). The average annual ERs from the biomass-based CDM projects have been estimated at 38,328 tCO_2, with a total of 40,599,196 tCO_2 by 2012. For

[1] CDM EB Reference

the energy efficiency CDM projects, the average annual ERs are 81,095 tCO_2, with a total of 15,622,287 tCO_2 by 2012.

Most of the plantations in Bangladesh have been established by community participation in the encroached forest areas in Bangladesh. In future, it may also be expected that most plantations will be established by community participation. However, there may be some uncertainty for raising plantations. Insecure land tenure, unfavorable policies such as bureaucratic restrictions and intersectoral conflicts may hamper plantation establishment at the community level (Khan 1998; Muhammed *et al.* 2005). The higher opportunity cost of land on small farms may increase the cost of carbon sequestration by community plantations more than that of agricultural production (Smith 2002). Higher transaction costs may also discourage community plantations (Smith 2002). If population growth cannot be reduced and vertical development in the agricultural sector does not occur, then CDM forests will obviously conflict with the agricultural sector.

REDD+ a New Mechanism to Mitigate Climate Change

Provision in 2007 COP 13 in Bali for reducing emissions from deforestation and forest degradation, conserving and enhancing forest carbon stocks, and sustainably managing forests (REDD+) on receiving GHG benefits from slowing down deforestation became a central topic of discussion. The same was true for 2008 COP 14 in Poznan. It is expected that REDD+ will be the central forestry activities (slowing deforestation) in the tropical developing countries after 2012 (Skutsch and Trines 2008). The financial incentives for REDD+ in the pilot projects established in tropical and sub-tropical areas in Asia, Africa and South America have been found to alter the drivers of land use changes by reducing opportunity costs of retaining forest cover, and are often promoted as multipartite solutions that not only generate profits and reduce carbon emissions, but also provide benefits for human development and biodiversity (Carlson and Curran 2009). India and Costa Rica have already had success with programs to restore their forests and they feel they should receive compensation for these early conservation efforts (Trivedi *et al.* 2009). The Democratic Republic of the Congo has large areas assigned to logging concession and is keen for REDD+ to support sustainable forest management (UNFCCC 2007). Stickler *et al.* (2009) found that nations in the Amazon region can potentially participate in REDD+ by slowing clear-cutting of mature tropical forests, slowing or decreasing the impact of selective logging, promoting forest regeneration and restoration, and expanding A/R. Possible REDD+ program interventions in a large-scale Amazon landscape indicate that even modest flows of forest carbon funding can provide substantial co-benefits for aquatic ecosystems; but the functional integrity of the landscape's myriad small watersheds would be best protected under a more even spatial distribution of forests. As ecosystem services derived from REDD+ projects will have a global interest, it could access a large pool of global stakeholders willing to pay to maintain carbon in forests. Calling to low-biomass in Indian forests, Singh (2008) confirms that appropriately designed community-based forest management under REDD+ can provide a means to sustain and strengthen community livelihoods and at the same time avoid deforestation, restore forest cover and density, provide carbon mitigation and create rural assets.

However, before adopting REDD+ as an effective deforestation-reduction mechanism, decisions on the nature of carbon buyers and sellers, financing mode, compensation scheme, and type of land use to be targeted should be made (Oestreicher *et al.* 2009). However, good governance and political endeavor are also important to make this program successful (Melick 2010).

Future Policy/Approaches of the Forestry Sector

To mitigate the climate change through forestry practice, the future policy/approach of the forestry sector should be oriented to reforest the degraded forestlands, and afforest the newly accreted lands as well as to retard the deforestation. The general objectives of the forestry sector should be conservation of biodiversity; mitigation of global climate change; and alleviation of poverty. To reorient the forestry sector in that way, both physical and institutional measures are needed. Development of coastal green belts, agro-forestry and social forestry may be included in the physical measures. Institutional measures may include integrated ecosystem planning and management, management of ecosystem in the reserved/protected areas, and reduction of habitat fragmentation. The participatory forestry approach should be re-oriented with proper benefit sharing by the local participants with clear land tenure and keeping the idea of sustainability and biodiversity. The forestry sector of Bangladesh still does not have any A/R CDM project. The global scenarios of the partially implemented CDM projects, the ratio of A/R CDM among the total projects registered by the UNFCCC shows that REDD+ are more potential than A/R CDM in terms of biodiversity conservation and poverty alleviation. While A/R CDM offers carbon credits in the long-term, REDD+ can flow credits in the short term as its crediting starts just at the point of avoiding deforestation. Hence, Bangladesh should have more attention on REDD+ than A/R CDM. However, this article does not attempt to screen out one mechanism over other.

Bangladesh, a non-Annex I Party, ratified the Kyoto Protocol on 22 October 2001. Therefore, Bangladesh is eligible to be a host country for CDM and the expected REDD+ activities. Furthermore, Bangladesh signed the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) in 1973; UNFCCC in 1992; and the Convention on Biological Diversity (CBD) in 1992. It is a signatory to the Ramsar Convention and the World Heritage Convention. The Bangladesh Wildlife (preservation) Act, 1974; the Forest Act, 1927 (amended in 1989); the Fish Act, 1950; and the Environment Protection Act, 1995, provide legal support for forest and biodiversity conservation in Bangladesh. The present "National Forest Policy 1994" also supports the mass reforestation activities throughout the country. However, it is necessary to adjust or pinpoint the objectives of the forest policy, national renewable energy policy, and national energy policy, all of which should be compliant with the biodiversity conservation of the forests and thus reduce GHGs.

Although the present national forest policy emphasizes on retarding deforestation and promoting biodiversity conservation (Muhammed *et al.* 2008), it does not have any openings for accepting economic flexible mechanisms like CDM and REDD+. In the global climate-change perspective, Bangladesh forest policy should be reoriented to mitigate the climate change retarding deforestation. The present "Renewable Energy Policy 2008" of Bangladesh has an important objective of promoting clean energy through CDM (GOB 2008), but there are no strong guidelines for CDM activities. As the CDM forest can give birth to huge carbon credit (Silveira 2005), the attitudes of the rural peoples can be altered towards maintaining the sustainability of the forest biomass through the encouragement of small-scale CDM in the homestead forests. The present renewable energy policy has marked the importance of biomass for producing electricity through biomass gasification. This importance can be linked with CDM. As carbon sequestration and carbon substitution are the most important approaches for mitigating climate change (Shin *et al.* 2008), sustainable production of biomass and its conversion to secondary clean energy, i.e., electricity, can be useful for both the economic development of rural livelihoods and environmental amelioration. The most useful form of commercial energy is electricity, which can be produced from both renewable and non-renewable resources. The present "National Energy Policy (Draft), 2008" should emphasize the use of renewable resources for producing electricity. Of these renewables, biomass has the added advantage of being able to be set up on a small scale to provide power and electricity to villages and small clusters or on a large scale for electrical power generation to be fed to the national grid. Thus, there is a need to produce woody biomass not only as fuel but also as a means to address climate change-related issues and socio-economic problems.

To retard the deforestation/degradation of the forestlands, governance is a key issue (Shin *et al.* 2008). Elimination of corruption in the forest department and ensuring political commitment to preserving the forests is vital in order to achieve the effective implementation of policy and strategies. Governance in the arena of bridging gaps between policy, science and practice, is also important. Resolution of inter-sectoral conflicts among the forestry, agriculture, environment, land, wildlife and energy sectors is another important governance issue. There is a serious gap in terms of coordination between economic and environmental objectives. The gap is more serious in the case of the understanding and coordination of the linkages between GHG abatement activities and measures. Filling this gap is of immense importance for retarding deforestation through the undertaking of CDM and REDD+ activities in Bangladesh.

Conclusion

The paper shows that forestlands in Bangladesh are potential to sequester carbon to mitigate global climate change. The discussion addresses the larger potentialities of REDD+ over A/R CDM in

Bangladesh. Policy changes are expected to have the greatest potential effect in this arena. Slowing down deforestation has been found as an important global climate change response option that can gain potential carbon benefits as expected in the second commitment period of the Kyoto Protocol. A/R is much closer to offering eligible projects for investment. But it has the principal barriers that are social in most cases in Bangladesh. Steps should be undertaken to ensure that unacceptable social impacts do not derive from the plantation expansion programs. The study finds the most important constraints to Bangladesh's participation in carbon trading as the lack of capacities to deal with the CDM and other UNFCCC mechanisms. Therefore, capacity building should be prioritized to host the CDM/REDD+ projects in the country as early as possible.

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Climate Change Negotiation and Finacing REDD+

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The impacts of climate change are already being felt in many developing countries particularly the least developed countries and small island states. Yet these countries have not been the primary cause of it. It is becoming clear that the necessary actions to halt climate change and the ways in which all nations whether developed or developing, least developed or emerging or polluter developing or small island states should be the part in addressing the overall solution. What requires further clarification is how these actions should be financed, who should shoulder the responsibility and who should receive the benefits.

Deep cuts from industrialized nations are vital, but they are not enough; these countries must also bear their historical responsibility for causing climate change by providing adequate, predictable and sustainable finance for developing countries. Climate finance will give urgent support needed by the developing world to take immediate steps to move on to a low carbon development pathway. It can also enable the most vulnerable countries including the least developed countries like Bangladesh and small island developing states to adapt to the effects of climate change.

Forests offer a one-time opportunity to mitigate and adapt to climate change. According to Intergovernmental Panel on Climate Change (IPCC, 2007) , approximately 25-40% of the emissions reduction is needed by 2020 to prevent global temperatures rising above 2^0C. It can not be achieved without addressing emissions reduction from deforestation and degradation, conserving forest carbon stock and enhancing forest carbon stock through afforestation and reforestation. Forests are also providing ecosystem services such as biodiversity conservation. They underpin food and energy security and cool the land surface by pumping moisture and transferring heat. In addition, forests deliver a natural carbon capture and storage service, removing approximately 1 billion tones of carbon from the atmosphere annually –at no cost.

Forests also directly or indirectly support the livelihoods of 1.4 billion people (World Bank, 2004). Local communities depend on forests as a source of fuel, food, medicines and shelter. The loss of forests,Therefore, jeopardizes the livelihoods of the poor and the ability of the world's poorest to adapt to climate change. Maintaining the resilience of this ecosystem is a major opportunity for forest growing nations to adapt to climate change. Poorer nations will not to do this with adequate and predictable financing at scale to move to an alternative low carbon development path. Equitable, transparent and effective distribution of funds for these purposes, taking into account the needs of local peoples, will be crucial to its success.

An agreement was adopted in COP 16 in Cancun, Mexico on reducing emissions from deforestation and forest degradation (REDD+) in a future climate change regime that will guide the various pilot initiatives taking place around the world. The term REDD first defined under the paragraph 1b (iii) of the Bali Action Plan (2007) refers to "Policy approaches and positive incentives on issues relating to reducing emissions from deforestation and forest degradation in developing countries; and the role of conservation, sustainable management of forests and enhancement of forest carbon stocks in developing countries;

Last year in Copenhagen there was no substantial outcome. However, a political declaration called Copenhagen Accord was adopted. Out of 194 parties 140 parties associated themselves with this accord including USA, Canada, EU, India, China, Japan, Australia, Brazil, south Africa, Bangladesh ,etc. Bangladesh made a key role to formulate that accord. In that accord allocation of first start financing of 30 billion USD was made for adaptation, mitigation and REDD+ from 2010 to 2012. At least 4 billion

USD from this fast start financing was allocated for REDD+ activities. Multilateral programs include the World Bank's Forest Carbon Partnership Facility. These programs incorporate 37 developing counters and their Forest Investment Programs that have identified eight pilot developing countries. the United Nations Collaborative Programme on REDD (UN-REDD) is working on the ground in twelve pilot countries and the Global Environment Facility has over 40 REDD- related projects in developing countries round the world . All these countries will be benefited from these funds. At least a dozen developed countries have directed bilateral funding to REDD+ related activities. Norway is pioneer in this regard and providing support to Brazil, Tanzania, Guyana, Mozambique and the Congo Basin, in addition to proving funding for the various multilateral initiatives. However, financing for REDD+ has typically been under funded and poorly coordinated. Outside the proposed first start financing for REDD+, altogether 4.12 billion USD are generated. Maximum amount of these money are pledged and negligible amount are disbursed (Angelsen et al., 2009; World Bank, 2009). There is a clear shortfall in current commitments and the scale of funding required, estimated to be between 17-33 billion USD per year. Another big question is whether it is over and above ODA or not. Official Development Assistance (ODA) is defined as official financing from general budgetary expenditure given by national governments to developing countries to promote and implement development. The use of ODA for climate change particularly in relation to adaptation finance is controversial due to concerns over the additionality of finance. If climate finance is additional, it must generate revenue over and above existing and committed volumes of ODA, to ensure that neither the goals of development and nor those of climate finance are compromised.

A consensus is emerging within international climate change negotiations that REDD+ will pass though a series of phases that encourage countries to progress form initial capacity building activities toward achieving long-term emissions reductions in measurable, reportable, and verifiable (MRV) way. Phases in implementation are likely to correspond to various mechanisms and initiatives providing financial support to REDD countries. The phases are:

Phase 1: National REDD strategy development and capacity building: in many countries like Bangladesh support would begin with capacity building, institutional strengthening, and the building of monitoring capacitates.

Phase 2: Implementation of national REDD policies and measures:

Phase 2a: The implementation policies addressing the drivers of deforestation would create the enabling environment for REDD+. REDD+ countries could receive performance based support triggered by the achievement of agreed indicators.

Phase 2b: As soon as the countries have the relevant data and capacities, they could also adopt a national reference level that allows for accounting for GHG benefits. During the period in which a country lacks the capacity to account for fully measured tons of GHG reductions, climate benefits could be estimated based on the basis of proxy indicators for reduced deforestation.

Phase 3: Full scale implementation: This could rely on a results-based compensation mechanism for fully measured, reported, and verified emission reductions and removals from the forestry sector. The last phase could also receive funding through the marketing of carbon units on international carbon market.

Bangladesh is in its initial stage for REDD+ preparedness. Bangladesh already made progress to prepare carbon accounting for the Sundarbans. Bangladesh should harness its activities and capacities for strategy development and will increase the communication with United Nations Framework Convention on Climate Change (UNFCCC) and other international funding bodies to get fund both from bilateral and multilateral sources. Bangladesh has already made the National Advisory Committee and National Technical Committee for REDD+ with the involvement of government officials, experts, and academics. Forest Department (FD) is the lead organization for the REDD+ related activities. FD is working for REDD+ strategy development and making national baseline for the forestry sector. Bangladesh applied for the membership of UN-REDD and got the observer status. It is expected that more funds will be generated for future mitigation actions especially in the forestry sector.So, Bangladesh should work actively and diligently to get substantial amount of funds from the bilateral and multilateral funding sources as the country is most vulnerable to climate change and deserves to get justice from the future international funding mechanism to address the adverse impact of climate change

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Deforestation Affects Global Warming and Climate Change in Bangladesh

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Abstract

The relationship between tropical forests and climate has become an important issue in recent years. Global warming, in particular, is perceived as a product of tropical deforestation and a threat to the environment of small coastal, riverine country like Bangladesh. In this study the deforestation of two different forest areas in Bangladesh are investigated using remote sensing (RS) and geographic information system (GIS) technologies, specifically the coastal forest of the Chakoria Sunderbans and the inland Sal forest of Dinajpur. This study documents that about 70,000 hectares (ha) of these two forests have been cut and burned and, in the process, approximately 6581.0 gigagram (Gg) of carbon dioxide have been released into the atmosphere. An image-mosaic of Bangladesh was prepared from Landsat TM data showing the forests of Bangladesh and these two study areas. A brief description of these forests and the causes of their deforestation are included. Deforestation map of each study area is provided.

The total standing timber volume of the Dinajpur Sal forest was calculated to be 466,395 m^3 in 2002. This standing volume was estimated to represent 116.6 Gg of carbon. The annual uptake of CO_2 is estimated to be 109 Gg. The CO_2 released from the Dinajpur Sal Forest and the Chakoria Sunderbans due to deforestation were estimated to be 7310 Gg and 210 Gg, respectively. The net emission of CO_2 that has entered the atmosphere as a result of the deforestation of these two sources is estimated to be 6,581 Gg. By contrast, if these two forests had not been damaged, they would have taken up an additional 22,877 Gg of CO_2 annually from the atmosphere.

The historical record shows massive deforestation in Bangladesh during and immediately following the Liberation War (1971). Here, we may see a coincidence between massive deforestation and abrupt increases of temperature, rainfall and flooding. It is speculated that tropical deforestation, both in Bangladesh and in the larger South Asian sub-region, has influenced ambient air temperatures and contributed to local temperature increases and precipitation-related disasters. However the correlations are not definitive, further studies are called for. This study suggests that tropical deforestation has had a profound effect on the local and regional climate and climate-related disasters in Bangladesh.

Key words: Deforestation, Climate change , Green house gases, Geographical information system

Introduction

Deforestation is a land use and land cover problem. It is the permanent change from forest to non-forest such as agriculture, human settlement, and grazing land. The Food and Agriculture Organization (FAO) estimates that some 135,680 sq. km of tropical forest have been destroyed each year since the 1980s. Deforestation and the destruction of other vegetation increase the amount of carbon dioxide (CO_2) and other green house gases in the atmosphere. When a forest is cleared to establish cropland or for other uses, the carbon stored in the biomass is released into the atmosphere as CO_2.

Most scientists assume that global warming is caused by burning oil and gas. But in fact between 25 and 30 percent of the greenhouse gases released into the atmosphere each year amounting about 1.6 billion tones – is caused by deforestation. Trees are considered to store about 50 percent carbon. When they are felled or burned, the CO_2 they store escapes back into the air. According to FAO figures, some 13 million ha of forests worldwide are lost every year, almost entirely in the tropics. Deforestation remains high in Africa, Latin America and Southeast Asia.

The forest ecosystem in Bangladesh has been severely damaged by the destructive anthropogenic and natural impacts coupled with overexploitation of forest resources (Rahman et al.,2010). Of the total area in Bangladesh, forest lands account for approximately 2.52 million hectares (m ha), which is about 17.08% of the country counting all the public forestland, unclassed state forests and village forests together (Forest Department 2010). The forests of Bangladesh fall broadly into 3 major types. These are (i) the semi-evergreen forests occurring in the eastern hills of Chittagong, the Chittagong Hill Tracts (CHT) and the Sylhet District (hill forest) and comprise roughly 50% of the total forest area where main prevailing species are natural Dipterocarpus and associated species; (ii) the deciduous Sal (*Shoria robusta*) forests on the central and northwestern terraces in the districts of Dhaka, Tangail, Mymensingh and Dinajpur constitute a mere 10% of the remaining forest area of Bangladesh; and (iii) the extensive littoral Mangrove forest adjacent to the Bay of Bengal, the Sunderbans, the world's largest mangrove forest. Being at the mouth of the great Ganges-Brahmaputra-Meghna river system, the Sunderbans is the tidal swamp of a vast delta. The Bangladesh portion of the Sunderbans stands within the districts of Barisal, Patuakhali, Bagherhat and Khulna. Its total area is 6,000 sq. km, of which 4,200 sq km are forest covered and remaining 1,800 sq kmare water Bodies. Its average elevation above mean sea level is only about 1.5 meters.

Evidently all forest areas in Bangladesh are suffering from clear-cutting and degradation, and are contributing tGHG emission. Other sources of GHG emissions include grazing animals, land cultivation, fossil fuel burning, marshland destruction, industrial wastes, brickfield kilns, and rural chulas for cooking, natural gas combustion by industries, animal and other wastes.

This paper is limited to describing forestry practices and deforestation. The objectives are to quantify the deforestation of the Dinajpur Sal forest and Chakoria Sunderbans,and to estimate the timber volume using remote sensing and GIS technologies. Subsequently these data were used to estimate carbon release and the net flux from the forest ecosystem.

It is known that the forests of Bangladesh are distributed throughout the country. They are of various kinds. In this study two major types of forests, namely,Dinajpur Sal Forest and Chakoria Sunderbans Mangrove Forest have been selected as the study area because they are in serious deforestation process.

Objectives of the Study

The main objectives of the study is to find the total deforestation and estimate the carbon release into the atmosphere. Remote sensing and GIS techniques in combination with *in situ* ground reference data have been used in this study. The specific tasks of this research are as follows:

- Prepare a digital deforestation map of Dinajpur Sal Forest and the Chakoria Sunderbansestimate the deforestation area,
- Estimate the above ground carbon stock in the study area;
- Estimate the carbon release due to deforestation and its contribution to global warming, climate change and disaster in Bangladesh.

Materials and Methods

Remote sensing data

The remote sensing data for this study included Black-and-White, 1:30,000 scale aerial photographs taken in 1975 by Capital Air Survey Ltd., Canada; selected color-infrared (CIR), 1:50,000 scale aerial photographs taken in 1984 by IGN, France; digital Landsat MSS from 1987, digital Landsat TM data from 1997, and digital data from 1:25000 scale photos collected by Kevron, Australia, in 2000.

Ancillary data

Topographic maps of 1:50,000 scale of the study area were obtained from the Survey of Bangladesh (SOB), Map of the Dinajpur Sal forests prepared in 1977 was obtained from the Bangladesh Forest Department (BFD), and all supporting published and unpublished documents have been used wherever possible.

Instruments and software

During the field survey forestry equipment like Sunto clinometer, Blum Leiss hypsometer, Spigel relaskop, diameter tape, prismatic compass, ranging rods, etc., were used for standing volume inventory. For image processing and analysis software like ERDAS Imagine, Imagine OrthoBase, ArcGIS: ArcInfo were used. SPARRSO Bangladesh and IGRE USA laboratory were used during the study.

Ground data collection

Following a standard sampling design, a number of sample plots were located on the maps and photographs for the collection of biomass inventory data. GPS readings of the center of all sample plots were recorded. Average stand height, dominant and co-dominant height and diameter at breast height (dbh) of all living trees in the sample plots were measured. Tree species regeneration data were recorded for each sample plot. Height and dbh were measured for the preparation of allometric regression equation for the timber volume estimation. Using the allometric regression equation, a local volume table was prepared to estimate the total standing volume and biomass of each study area. This table was compared with the Volume Table of Sal prepared by Forest Research Institute (FRI), Chittagong (Das *et al.*,1992).

Image classification and volume estimation

Supervised and unsupervised classifications were conducted on remotely sensed imagery to stratify the forest of the study area. The landuse stratification reduced sampling errors and the standard error of estimate. Two dates of remote sensing data were superimposed to identify and measure the areas of deforestation for the study areas. The timber volume and biomass per unit area obtained from field survey was multiplied by the total area deforested to obtain a figure for the carbon released (assuming substantial forest combustion). Finally the total CO_2 flux to the atmosphere due to this deforestation was estimated according to standard procedure. The international procedures for GHG inventory have been followed for this work.

Timber volume Inventory in the Dinajpur Sal Forest

To carrying out timber volume inventory of the year 2000 of Dinajpur Sal forest, 74 sample plots were randomly selected from the ortho-photomaps. The starting points, bearings, and distance to reach the centre of the sample plots were marked on the photographs. With the help of a prismatic compass and ranging rods, the field crews located the centres of the sample plots. For each plot, tree diameters at breast height (dbh) and overall tree heights were obtained using a Spiegel relaskop with BAF 4. The dbh of all living trees and the heights of dominant and co-dominant trees were measured and recorded. The Sal Volume Table prepared by Forest Research Institute (FRI), Chittagong, has been used in computing our plot volumes (Das *et al.*,1992) After statistical calculation, the average volume/ha was calculated to be 130 m^3/ha for Sal forest. Accordingly the total standing volume of the Sal forest was found to be 245,000 m^3.

Results and Discussion

The deforestation in Dinajpur Sal Forest

The deforestation was estimated on the basis of the quantitative changes in the forest cover between two dates. Forest type maps were prepared from the remote sensing data for two different years. The maps were then digitally superimposed upon one another for showing and measuring the changes in colors and patterns. The aerial difference was computed from the vector attribute table. One deforestation map was prepared using the 1976 and 2000 digital data shown in Fig. 1. It was found that 61,342 ha of Sal forest have been deforested over last 25 year period.

Most of the sal forest floor is now open and cleared of undergrowth as a result of grazing and vegetation collecting. Natural regeneration of the sal coppice has been stopped. Under these conditions, the Sal forest could not regenerate. Most of the people living here are very poor and living below the poverty line. They collect timber, the natural regeneration of Sal coppice, and the leaves and branches of trees. They use them to make household furnishings, house construction, fuel for cooking, and feed for livestock. They also sell forest products in the marketplace. Uncontrolled grazing and livestock husbandry are practiced in the forest. With the increasing population pressure, the forest is highly depleted, a process that is still in progress. Obviously the timber stock and the general condition of the forest are very poor (Islam ,2002).

In an effort to improve the Dinajpur forests and forest productivity, the Bangladesh Forest Department (BFD) is undertaking large scale "social and agroforestry programs" on a community participatory basis (Mahboob). This program involves the local community in the reforestation of local areas. Local communities take part in raising, tending and maintaining nearby plantations in close cooperation with the BFD. They will get part of the income raised from these plantations. As a result their economic status improves and their dependency on the forest decreases (Forest Department ,2001).

Fig. 1. Deforestation in Dinajpur sal forest in 1976~2000

Deforestation in Chakoria Sundarbans

The total area of the Chakoria Sundarbans is 8,500 ha. Once it was a fully stocked mangrove forest. Widespread clear cutting was first noticed on aerial photographs of 1981. Stereoscopic examination of these photographs showed that about 2,104 ha of the mangrove forest have been cleared for shrimp farming. Subsequent studies from aerial photographs and Landsat imagery showed that the forest was completely removed and shrimp farms have been established in its place. The total area of the forest is now under shrimp farming; the mangrove forest is completely lost (Warick and Ahmad, 1996). The entire area of mangrove measured 8,500 ha and has been completely deforested except for some narrow patches of non-woody mangrove vegetation. There are many causes for the deforestation of the Chakoria Sunderbans. The most important cause is poor management and control, and the extreme poverty of the people living around the forest. Natural disasters such as tropical cyclones with accompanying storm surges have contributed but the breaches of the forest laws and illicit timber removal are the most significant **Error! Reference source not found.**.

Total Carbon Release in the Study Area

i. Carbon Release in Sal Forest Area:
Total mature and degraded sal forest area = 1,883 ha
Average Timber volume/ha = 130 m^3/ha
Therefore the total standing timber volume = 244,790 m^3

ii. Total Woodlot and Social forestry plantation:
Forestry Areas= 3,548 ha
Average Volume/ha = 62.4 m3/ha
And the total standing volume is = 221,395 m^3
Total standing volume of sal forest

Woodlots, social and community forestr = 466,185 m^3

iii. Present Carbon Stock
Present Carbon Stock = Total standing Volume * BCR * CFD. Where, BCR (Biomass Conversion/Expansion Ratio) = 0.5 and CFD (Carbon Fraction of Dry Biomass) = 0.5, therefore, Present Carbon Stock = 466.185 (000m3)*0.5*0.5 = 116.5 Gg of Carbon (C).

iv. Carbon Dioxide Uptake in the Dinajpur Sal Forest
Carbon Uptake = AF * AG * CFD
Where AF is the Area of the Forest = 5.431 kha,
AG is the Annual growth in tdm/ha/year (tdm is ton dry mass) = 10.7 and CFD is the Carbon Fraction of Dry biomass = 0.5
Therefore, Carbon Uptake
= 5.5552 kha * 10.7 tdm/ha/year * 0.5
= 29.7203 Gg/yr which is equivalent to 29.72o3 * 3.666
= 108.95 Gg of CO2/yr

v. Carbon Released (CR) from the deforested Area
CR = Total volume of Deforested Areas * vol/ha * BCR * CFD
Where, BCR and CFD have their usual significance.
= 61.342 * 130 * BCR * CFD
= 61.342 * 130 * 0.5 * 0.5
= 1993.615 Gg of Carbon which is equivalent to
= 1993.6 * 3.6667 (IPCC) = 7309.92 Gg of CO2

Total carbon released from the deforested area is 1993.6Gg and the total uptake of Carbon is 222.7 Gg. There is a net carbon emission of 1771 Gg which is equivalent to 6493.5203 Gg of CO_2. If there had been no deforestation, the forest could have taken up following amount of CO_2 from the Atmosphere: Uptake of Carbon = AF * AG * CFD where AF = Area of the forest, AG is the Annual Biomass growth and CFD is the Carbon Fraction of the Dry Matter = 61.342 9 (kha) * 7.26*.5 = 222.67 Gg of Carbon which is equivalent to 816.47 Gg of CO_2 In 25 years this forest could uptake 816.47*25 = 20412.0 Gg of CO_2 from the atmosphere.

vi. Carbon Released from Chakoria Sunderbans
The average standing volume of the Chakoria Sunderbans was estimated to be 26.9 m^3/ha. Therefore the total commercial volume of the Chakoria Sunderbans was 8500* 27 = 226173 m3 = 226 (000m^3). Carbon Released (CR) from the forest was CR = CH* BCR* CFD where CH is the Commercial Harvest and BCR and CFD have their significance. Therefore CR = 226 * 0.5 * 0.5 = 56.5 Gg of carbon, which is equivalent to 210.40 Gg of CO_2 that has been released to the atmosphere from the forest.

If this Mangrove ecosystem was not deforested it could have taken up 8.500 (kha) * 7.91 * 0.5 = 33.6 Gg of Carbon which is equivalent to 123.26 Gg of CO_2. The forest has been denuded for 20 years. So by this time it could absorb 123.3 * 20 = 2465.0 Gg of CO_2 from the atmosphere and could reduce the greenhouse effect and consequently global warming. It is found that the total carbon released by deforestation in this area is 56.5 Gg and the total annual uptake is 33.617Gg. Thus there is a net annual carbon release of 23.0 Gg which is equivalent to 84.4Gg of CO_2 emissions.

vii. Net Emission of CO_2 from the two Study areas

The net emission of CO_2 from the deforestation of the Chakoria mangrove forest and the Dinajpur Sal forest is 23.0*3.6667 + 1771* 3.6667 = 84.0+ 6494.0 = 6578.0 Gg. This huge amount of CO_2 has contributed to greenhouse effect and Global Warming. If the two forest had not been deforested they could uptake about 20,412 +2,465 = 22,877 Gg of CO_2 from the atmosphere. In that case, uptake would have been more than emission (positive), reducing the GHGs in the atmosphere.

Conclution and Recommendation

Reducing Emission through Deforestation and Degradation is a significant task for the world community. Clearly, tropical deforestation and global warming are important environmental issues that must be of concern to the society. Deforestation appears to be contributing to global warming which isimparting direct adverse impacts on Bangladesh now. It is also clear that increasing GHG emissions to the atmosphere have been concurrent with global warming and with Bangladesh's changing temperature and weather patterns in the recent past. Bangladesh's coastal and deltaic location, low lying terrain, and high population density makes it uniquely vulnerable to global warming and sea level rise.

The study makes the following specific recommendations:

The historical record shows massive deforestation in Bangladesh during and immediately following the Liberation War (1971). It is observed a coincidence between massive deforestation and abrupt increases of temperature, rainfal and flooding. It is speculated that tropical deforestation, both in Bangladesh and in the larger South Asian sub-region, has influenced ambient air temperatures and contributed to local temperature increases and precipitation-related disasters. However the correlations are not definitive, and further studies are called for. This study suggests that tropical deforestation has a profound effect on the local and regional climate and climate-related disasters in Bangladesh. The recommendations include:

(1) Deforested mangrove ecosystem of Bangladesh should be restored with artificial plantations to take up CO_2 from the atmosphere and reduce greenhouse gas emissions;
(2) Integrated shrimp–mangrove farming systems should be rapidly introduced to economically restore the Chakoria Sunderbans and develop a sustainable mangrove management system;
(3) All ongoing deforestation, whether for commercial purposes or as a consequence of expandinghuman settlement, should be stopped completely;
(4) Greenhouse gas emissions and the forest uptake of CO_2 in Bangladesh should continue to be assessed using remote sensing and GIS technologies. Such biomass inventories would provide an objective basis for assessing the nature and directions of ongoing forest changes;
(5) Wherever possible, the area of Bangladesh's forests must be increased and managed on the sustaining yield basis;
(6) The ongoing "Community and Agroforestry Plantation Program" should be expanded to insure that local people are active participants and beneficiaries in reducing deforestation;
(7) Intensive study is to be undertaken on the coincidence of deforestation and the increasing trend of climatic conditions and severity of natural disasters in Bangladesh as observed in the present study;
(8) The Government and the people of Bangladesh must come together to stop the deforestation and degradation processes that are currently on going and address the upcoming disasters that are already a product of global warming;
(9) International society should show their readiness to act on deforestation, major portion of which is due to increased farmland to feed growing population. Agricultural productivity should be increased so that there is less demand to convert forest into farmland. But financial assistance is needed from developed countries to conserve forests. Such incentives could come in the form of

carbon credits as further action under the Kyoto Protocol.

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Forest management for biodiversity conservation and climate adaptation : revisiting Bangladesh initiatives

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Abstract

The once biodiversity-rich forests of Bangladesh have undergone massive deforestation and degradation due to high population pressure and lack of proper management. Consequently many native species of plants and wildlife of Bangladesh have become extinct and many of the remaining ones are threatened or endangered. On the other hand, Bangladesh is one of the worst affected victims of climate change. In order to stop and reverse the trend of deforestation, forest degradation and biodiversity loss and to adapt to the impacts of climate change, the Government and concerned other organizations of Bangladesh have undertaken various initiatives in the recent years in connection with the international initiatives on biodiversity conservation and climate change mitigation and adaptation. This paper presents a brief account of such initiatives with analysis of the gaps and bottlenecks therein and recommends strategies and actions to ensure more effective conservation of the existing forests and biodiversity resources. It particularly highlights that the current forest conservation efforts are undermined by illicit extraction of fuelwood, timber and bamboo due to huge demand of such goods for household fuel requirements, brick manufacturing, furniture making, construction work and cultivation of certain agricultural crops (country bean, betel leaf) and stresses upon developing alternative means to minimize requirements of such forest products. The other recommendations include strengthening research, monitoring and documentation activities on the remaining biodiversity resources, strengthening habitat restoration program for endangered wildlife species and developing REDD project(s) based on the village forests which account for 65% of total carbon stock in all the forests and plantations in Bangladesh.

Key words: *Climate change; biodiversity conservation; sustainable forest management;* REDD

Introduction

Bangladesh has 2.53 million hectare forest lands: 1.40 million hectares of tropical evergreen and semi-evergreen forests in the hilly regions in the east and south-east of the country (Hill forests), 0.74 million hectares of mangrove and coastal forests in the coastal belt in the south, 0.12 million hectares of moist deciduous *Shorea robusta* (Sal) forests in the central and northern regions and 0.27 million hectares of village (homestead) forests scattered throughout the country. All the mangrove forests, all the Sal forests and 0.67 million hectares of the hill forests are managed by Bangladesh Forest Department (FD), while another 0.73 million hectares of hill forests in the Chittagong Hill Tract (CHT), called un-classed state forests (USF), are managed by the district civil administration and the homestead forests are owned by private individuals (Roy, 2005).

Being a part of the bio-diversity rich Indo-Burma region, Bangladesh is endowed with rich floral and faunal biodiversity. Its flora includes 5,700 species of angiosperms including 68 woody legume species, 130 fire-yielding species, 3 species of gymnosperms and 1700 pteridophytes. Its fauna includes 113 species of mammals, 628 species of birds, 126 species of reptiles, 22 species of amphibians and 708 marine and freshwater fishes (Mukul et al. 2008). But due to high population pressure (0.017 hectares of per capita forest land), there has been a high rate of deforestation and forest degradation resulting in a continuous loss of biodiversity. The recent (2005-2007) National Forest and Tree Resources Assessment recoded only 1.442 million hectares of land i.e., 10% of the country's total surface area under forest cover (Altrell et al., 2007).

Due to the deforestation and degradation of forests, 10% of native species of plants of Bangladesh are already extinct and 167 species are vulnerable or endangered (Mukul, 2008). For the same reason, it has lost 13 vertebrate fauna species (10 mammals, 2 birds, 1 reptile), while another 147 species are vulnerable to extinction of which 52 species are critically endangered (Mukul et al. 2008).

In the above backdrop, the Government of Bangladesh and concerned other organizations have undertaken several initiatives in order to conserve the remaining biodiversity resources of the Bangladesh forests.

On the other hand, Bangladesh is one of the worst affected victims of climate change. The Intergovernmental Panel on Climate Change (IPCC) has predicted that, by 2050 the water level of the Bay of Bengal might rise by 15 – 50 cm, inundating about 120,000 square kilometer area of the country. Due to accelerated rate of melting of the ice cover of the Himalayan mountains and increased monsoon rainfall, about 4,000 km^2 area in the northeast and 1400 km^2 area in the southeast of the country might experience more frequent flash floods. On the other hand, the frequency of droughts in the dry season, especially in the northwest region of the country might increase. In fact, such climate change impacts are taking place in Bangladesh in a progressive fashion. Land inundation and salinity intrusion have already been spreading to more and more areas in the coastal belt every year affecting biodiversity of the region and compelling people to replace rice cultivation with shrimp farming. Frequencies of cyclones and storm surges in the coastal region of Bangladesh have increased to the extent that while only 3 major cyclones occurred in every 50 years from 1785 to 1896 and 13 major cyclones during 1897 – 1947, the number dramatically increased to 51 during 1948 – 1980 (Falguni, 2011). Frequency of major floods in the floodplain areas and that of early flash flood in the haor (basin) areas in the northeast of the country have also increased.

The climate-change-induced natural hazards have been affecting every sector, including forestry. For example, the two devastating cyclones, *Sidr* in 2007 and *Aila* in 2009, not only killed thousands of people and damaged their houses, but have also caused extensive and severe damage to the mangrove stands in the Sundarbans and killed hundreds of spotted deer and other wildlife. Thus the increased frequency of strong cyclones is also becoming a threat to the sustainability of the forest stands and the wildlife resources of the Sundarbans. Due to increased salinity (and silting up of the forest floor) the survival and growth of some of the important tree species of the Sundarbans are being affected.

To deal with the climate change impacts, Bangladesh has undertaken various programs and projects in different sectors based on its own resources as well as support from international donor agencies. In consideration of its vulnerability to climate change impacts, Bangladesh is treated as a priority country for adaptation support by the international communities – both under the United Nations Framework Convention on Climate Change (UNFCCC) and bilateral aid programs of donor countries.

As a least developed country with negligible contribution to the global green house gas emission (only 0.14%), Bangladesh does not have the international obligation as yet to undertake emission reduction measures. Nevertheless, it has undertaken certain initiatives to reduce its emissions as voluntary measures and to exploit the opportunity of earning revenue by selling carbon credits to developed countries under the Clean Development Mechanism (CDM) and the Reducing Emissions from Deforestation and Forest Degradation (REDD) programs of the UNFCCC.

This paper describes Bangladesh's contemporary forest management policies and programs aiming at biodiversity conservation and climate change adaptation and mitigation.

Forest Biodiversity Conservation Initiatives

Regulatory measures to preventing loss of biodiversity has been embedded in the Forest Act of 1927 that has governed forest management in Bangladesh for more than a century now, but that did not work due to several factors mentioned earlier. After the independence In Bangladesh, biodiversity conservation efforts began in 1973 through the promulgation of the Bangladesh Wildlife (Preservation) Act 1973, which entitled the FD to establish National Parks, Wildlife Sanctuaries and Game Reserves (i.e., Protected Areas) and to regulate hunting, farming and trading of wildlife. In 1976, a 'Wildlife Circle' was created in the Forest Department in order to implement wildlife conservation activities, which was abolished in 1983 due to shortage of fund but reestablished in 1994 under a development project and subsequently revamped and named as 'Wildlife Management and Nature Conservation Circle (WMNCC) under revenue budget of the FD. As of now, 28 Protected Forest Areas (15 National Parks and 13 Wildlife Sanctuaries) have been established in Bangladesh. The total area of the 28 PFAs is 268,961 hectares, which is 10.67% of total forest lands and 1.82 % of the country's total area (Forest Department, 2010a).

Bangladesh Government signed the UN Convention on Biological Diversity (CBD) in 1992 (ratified in 1994) and subsequently developed and adopted the National Biodiversity Strategy and Action Plan (NBSAP) in 2004. The NBSAP outlined short-term (up to 3 years), medium-term (4-7 years) and long-term (8-10 years) interventions toward conservation, restoration, protection and sustainable use of the ecosystems, species and genetic pool of Bangladesh including the institutional arrangements and procedures for implementation and monitoring of the proposed interventions. It recommended co-management approach for the management of the Protected Areas (PAs).

In 2003, the Forest Department undertook a pilot project through financial support from the USAID called 'Nishorgo Support Project (NSP: www.nishorgo.org)' which tested a collaborative management system (co-management) in five protected forest areas. In the co-management model, the management of a protected area is vested to a local Co-management Council composed of representatives of local communities, relevant government line agencies and local government bodies including the local Member of the Parliament (MP) and the Divisional Forest Officer (DFO) as advisers. The FD officer in charge of the respective forest area act as the Member Secretary of the executive committee of the Co-management Council, called Co-management Committee (CMC). The CMC and the technical experts of the FD jointly develop a development and management plan for the PA and its surrounding landscape, which includes aspects of forest protection, biodiversity conservation and social forestry activities in the buffer zone. Community Petrol Groups (CPG) involving poor forest dependent people are established for patrolling the forests jointly with the Forest Guards of the FD. The Government has created the legal provision by which the CMC can retain 50% of the entry fee collected from the PA visitors for local development activities. The NSP provided training and input support on alternative income generating (AIG) activities to the poor forest dependent people.

Based on positive results of the NSP, the co-management approach is now being adopted in all the 28 notified national parks and wildlife sanctuaries (i.e., PA) of Bangladesh by the FD under a subsequent USAID-supported project called Integrated Protected Area Co-management Project (IPAC). The IPAC project (2008 – 2013) activities include establishment and capacity development of the co-management organizations, training of forest dependent people on AIG activities, promotion of value chain of the products produced by the forest dependent communities, and promotion of ecotourism. IPAC has also been measuring carbon stock in the protected areas with a plan to develop REDD projects. It has also arranged training on REDD project proposal development for FD staff.

In 2003, the Governments of Bangladesh and USA jointly established the Bangladesh Tropical Forest Conservation Foundation, called Arannayk Foundation (based on the provisions of the US Tropical Forest Conservation Act, 1998) as an independent institution to provide financial and technical support to NGOs, community based organizations, forestry research and academic institutions as well as relevant government agencies for important forest and biodiversity conservation activities in Bangladesh.

Arannayk Foundation supports forest and biodiversity conservation projects on PAs as well as in community conserved forests in the CHT and homestead forests in different regions of the country. In PFAs as well as in reserve forests, it supports establishment of co-management systems following the same model as IPAC and promotes AIG activities through training, market linkage development and creation of access to capital.

The AF sponsored projects follow a unique approach in order to create access of the poor project participants to capital. It provides a grant to the organized groups of project participants to use as revolving fund for AIG activities. The group members apply for loans (BDT 3000 – 10,000) to the executive committee of their organization along with their business plans. The executive committee assess the feasibility of the business plans in order to approve the loan. The loan is generally interest free but the incumbents are required to plant 3-5 saplings of endangered native tree species in their homesteads or farm lands at their own cost as a condition of the loan. Some of the community based organizations (CBO) however levy a low rate of interest, determined in a democratic manner, for the revolving loan considering the time value of money. The repayment schedule is based on the enterprise concerned.

Based on local context, a wide range of AIG activities are done by the project participants using the revolving fund. The most common ones include vegetable cultivation in homesteads, leasing in land for cultivation of profitable crops, cow rearing, goat rearing, poultry rearing, beef fattening, handicrafts making, value addition to crops through primary processing, grocery shop and other petty businesses. The project participants also contribute to increasing their revolving fund through monthly saving contributions. The results of the revolving fund schemes are very encouraging and it contributes to the development of group cohesion and sense of ownership among the participants (Arannayk Foundation, 2010). Recently AF and IPAC has initiated a collaborative program to extend the Arannayk revolving fund support to the forest dependent groups of the IPAC-supported co-managed protected forest areas.

In each of the AF-sponsored project, the baseline biodiversity profile of the project area has been prepared through field surveys with the help of professional experts (botanists and wildlife biologists).

Through an AF grant, the Institute of Forestry and Environmental Sciences, Chittagong University (IFESCU) has undertaken a program of restoring and conserving critically endangered native tree species of Bangladesh forests by identifying the remaining (mother) trees, developing propagation technique, establishing seed orchards and planting them in forests and conservation sites.

From December 2010, a joint team of Wildlife scientists from Jahangirnagar University and Botanists from Dhaka University has initiated a project of surveying and documenting the floral and faunal biodiversity of the protected areas under the jurisdiction of the FD as well as that of the community conserved forests in the CHT. This project will establish a national database of the biodiversity resources in the forests of Bangladesh.

Climate Change Adaptation Initiatives

The Government of Bangladesh signed the UNFCC in 1992 and ratified the same in 1994, enabling the country to benefit from the UNFCCC sponsored initiatives on climate change mitigation and adaptation programs.

In 2005, the Government of Bangladesh launched the National Adaptation Plan of Action (NAPA), which identified 15 priority activities, to combat climate change impacts in Bangladesh, including general awareness raising, technical capacity building and implementation of projects in vulnerable areas. The Bangladesh NAPA included priority actions for all relevant sectors: agriculture, fisheries, forestry, water development, health, infrastructure development, communication, and food security and disaster management. The planned forestry sector activity included reducing climate change hazards through coastal afforestation with community participation (MOEF, 2005).

In 2009, the Bangladesh Government prepared the Bangladesh Climate Change Strategy and Action Plan (BCCSAP). The BCCSAP is a 10-year program to build capacity and resilience within the country to meet climate change challenges over the next 20-25 years in 6 thematic areas, namely (a) food security, social protection and health, (b) comprehensive disaster management, (c) infrastructure development, (d) research and knowledge management, (e) mitigation and low carbon development, and (f) capacity building and institutional strengthening (MOEF, 2009).

Based on NAPA and BCCSAP, concerned agencies of the Government have undertaken various programs and projects on climate change adaptation. The adaptation activities include establishing/strengthening systems for early warning information dissemination among vulnerable communities, establishment of multi-purpose flood/cyclone shelters in vulnerable areas, raising up of homesteads in char areas, strengthening of research and extension program on developing saline, flash flood, drought crop varieties and cropping systems. Aside from the government agencies, NGOs are involved in such activities that are supported by a number of donor agencies.

In 2009, Bangladesh has established a Tk 7.0 billion Climate Change Trust Fund from its own source for the implementation of the BCCSAP. The Trust Fund is managed by the Ministry of Environment and Forests.

In June 2010, the Government of Bangladesh has established a multi-donor trust fund, called 'Bangladesh Climate Change Resilience Fund' with an initial amount of $ 110.2 million contributed by the United Kingdom ($86.7 M), Sweden ($11.5 M), EU (10.4 M) and Denmark (1.6 M). The Fund will support implementation of the BCCSAP by supporting vulnerable communities in adapting to greater climate uncertainty and changing agricultural conditions with technical support to be provided by the World Bank. The latter has pledged to provide approximately $ 800 million in the next four years for Bangladesh's Climate Change Strategy and Action Plan, especially for investments in water resource management (embankments, river conservation, etc), agricultural adaptation, emissions reduction, and disaster preparedness. The World Bank has already made a number of large scale investments in climate change-related operations which are owned and implemented by the government of Bangladesh like the Emergency Cyclone Recovery Project (establishment of embankments, cyclone shelters and warning systems) and National Agriculture Technology Project, which is focused on agricultural adaptation (The Daily Ittefaq: 2 June, 2010).

In the forestry sector, the Forest Department undertook the first climate change adaptation project in connection with the NAPA in 2009. The project titled, 'Community based adaptation to climate change through coastal afforestation', funded by UNDP-Global Environment Facility (GEF), seeks to reduce vulnerability of coastal communities to impacts of climate induced risks in 4 pilot sites (sub-districts) in the coastal districts of Barguna, Bhola, Noakhali and Chittagong. The project, implemented by the FD in partnership with local NGOs, has the plan to establish 7,000 hectares of mangrove and non-mangrove plantations, which will sequester 610,000 tons of carbon and will diversify livelihood of about 85,000 people through cash-for-work and training on nursery and plantation work.

In fact, the Forest Department has been establishing coastal plantations with the objective of saving lives and properties from tidal surges and cyclones in the costal frontline of Bangladesh since 1960's. By 2007, the FD made a total of 151,000 hectares of coastal plantations (under different projects) along 610 km coastline, of which 45,000 ha were surviving in 2007 (FAO, 2007).

Climate Change Mitigation And Carbon Forestry Initiatives

As a least developed country with negligible contribution to global GHG emission (only 0.14%) Bangladesh does not have legal obligation to undertake mitigation measures. However, it has undertaken a number of voluntary measures, some of which are aimed at exploiting the carbon trading opportunities provided by the UNFCC initiatives namely the Clean Development Mechanism (CDM) and Reducing Emissions through Deforestation and Forest Degradation (REDD).

Since 2004, the Designated National Authority (DNA) for CDM projects in Bangladesh has approved eight projects, of which only two have got CDM registration. The two registered CDM projects (each with eight years duration) are on organic composting of municipal wastes, implemented by the Waste Concern of Bangladesh and financed by the Worldwide Recycling (WWR) of the Netherlands. The projects in pipeline are on landfill gas recovery, promotion of solar home systems (SHS), promotion of energy-efficient compact fluorescent lamps, and reducing electric energy consumption in industries (http://cdmbangladesh.net; Enayetullah & Sinha, 2010).

Despite having a vibrant afforestation program, unfortunately Bangladesh does not have any afforestation-based CDM project as yet. However, it is registered for the UN-REDD program and the Forest Department (under IPAC project) is currently developing three forest carbon investment projects aiming to access the REDD facilities (IPAC, 2011). The projects are: (a) the Sundarbans REDD+ Project, (b) the Chunati Wildlife Sanctuary Reforestation Project; and (c) an innovative forest carbon sequestration initiative that bundles efforts in seven protected areas into a single project.

The Sundarbans REDD+ project involves conservation of 412,000 hectares of natural mangrove forests with an emission reduction target of 52 million tons of carbon.

The Chunati Wildlife Sanctuary has an area of 9000 hectares and the project will involve restoration of degraded areas of the forest through participatory afforestation, establishment of a sustainable management plan for the forest, promotion of AIG activities among the communities living around the protected area and carbon trading under the REDD facility (Forest Department, 2011). The project targets to increase carbon stock of the forest by about 43,000 tons per year.

The project on carbon sequestration in seven co-managed protected areas (Dudpukuria-Dhopachari Wildlife Sanctuary, Fasiakhali WS, Teknaf WS, Rema-Kalenga WS, Inanai National Park, Medhakachapia NP and Sitakunda Botanical Garden & Eco-park) involves a bundle of activities including reforestation, livelihood improvement trough community participation in forestry activities and conservation of flora and fauna through various measures including habitat improvement.

Presently, the Chunati Project is co-financed by the German Development Cooperation Agency, GIZ and the USAID-funded IPAC project, while the other two projects are funded by the IPAC project.

In 2010, the Forest Department has undertaken seven projects, worth Tk 778.5 million (USD 11.12 million), using the Climate Change Trust Fund of the Bangladesh Government. The projects include: (a) planting material production for afforestation and reforestation activities, (b) buffer zone plantation in the protected forest areas in the central zone, (c) restoration of degraded forests through participatory reforestation, (d) embankment and *charland* plantation in coastal areas, (e) conservation of Sundarbans and promotion of its ecotourism demand, (f) forest information generation and networking system establishment and (g) establishment of a Botanical Garden (in Chittagong) for carbon sequestration.

Integrated Resource Management Approach

With necessary technical support mobilized under the IPAC project, the Forest Department has developed a draft 'Integrated resources management plans for the Sundarbans'. This plan covers the entire Sundarbans including the three protected areas, the remaining parts of the reserved forests and the buffer landscape zone (10 km strip bordering the protected areas and reserved forests). It includes aspects of biodiversity conservation as well as sustainable harvest of timber and non-timber forest products, enhanced protection measures and capacity development of the FD. Considering the livelihood requirements of the one million poor people that are directly dependent on the Sundarbans for their livelihood, the integrated resources management plan includes social forestry and fisheries activities in the landscape zone as well as various social safety-net programs (VGD, VGF, Food for Work, etc.) that the government has been implementing for the extreme poor and distressed people of vulnerable areas. The management plan prescribes Annual Allowable Cut, silvicultural system, length of rotation, minimum diameter size of harvestable trees and the number of seed trees to be left per hectare for different mangrove species and for the mixed stands. The management plan has also recoded the carbon stock in the Sundarban in 1997 (31.4 million tons of Carbon or 115 million tons of CO_2 equivalent) and 2010 (31.4 million tons of Carbon or 115 million tons of CO_2 equivalent) for potential use in developing a REDD+ project (FD, 2010b).

Gaps And Bottlenecks In Current Initiatives

All the policies and plans made by the Government in order to better conserve the forest biodiversity resources look very good but there has been very little positive impact in the field due to lack of proper implementation of the policies and plans. In most of the state owned forests, including the protected areas, illicit extraction of timber, bamboo and other minor forest products, and incidence of forest fire have remained high. Constraints of the FD such as inadequate staff and logistic facilities are recognized as the main causes of such failure in forest protection. In fact these are not the only causes, but there are also other systemic causes which are not generally taken into consideration. The most important gap in the problem analysis and development planning is not duly addressing the demand and market factors that contribute to illicit extraction of forest products.

For example, in Chittagong and Cox's Bazar forest divisions, country bean and betel leaf are cultivated very extensively and both require huge quantities of bamboo or wood sticks providing a vibrant market for such materials and the thousands of poor people living near the forest collect such materials from the forests and sell that in the local market on a daily basis. Due to heavy competition, they harvest immature culms of bamboos, which leads to permanent loss of the groves and people need to travel deeper and deeper into the forest in search of remaining groves. They also cut saplings of naturally regenerating trees as well as those in young plantations of the Forest Department for the same reason. Moreover, the booming brick manufacturing industry of this region provides a big market for fuelwood, which allures poor people to extract fuelwood from the forests, often by destroying planted and naturally regenerating saplings. As such, afforestation and forest conservation efforts hardly succeed in this region. Participatory forest conservation and social forestry activities generally create alternative livelihood opportunities for a very limited number of households and the non-participants continue to rely on their illicit forest product extraction activities for their livelihood based on the unmet demands of the market.

It is realized that until effective alternative materials or technologies are available to the country bean and betel leaf farmers and brick kiln owners, it would be very difficult to restore and conserve the forests of the Chittagong and Cox's Bazar regions. Agricultural research and extension interventions are needed in order to identify and promote alternative cropping systems (which should be more profitable than the mentioned existing cropping practices). Alternatively, application of preservative treatment to the bamboo and wooden sticks used by the country bean and betel leaf farmers should be vigorously promoted in the said region. This technology is already available with the Bangladesh Forest Research Institute. Similarly, manufacturing of concrete building blocks may be promoted in the region in order to replace the demands for bricks in order to reduce demands for fuel wood. Such solutions involve decision making at the highest level of the government and inter-agency collaboration and coordination at the implementation level.

In case of the REDD project planning initiatives, the efforts are limited to protected areas. On the other hand, the village forests (homestead forests and trees on cultivated lands) hold much more amount of carbon (277 million tons) than the state forests (139 million tons) (FAO, 2007). The National Forest Assessment Process may provide the basis for planning the REDD project on village forests as it would provide periodic data on the carbon sock in different types of forests including the village forests.

Conclusion

The CDM and REDD programs provide the opportunity to earn foreign currency through selling of carbon credits but the processes are quite complicated and involve high transaction costs due to the requirement of engaging designated specialized organizations (independent operational entities) for the validation of project proposals and verification project implementation processes and outputs. Therefore the financial viability of REDD projects is yet to be ascertained. Nonetheless, the remaining forests of Bangladesh need to be conserved for sustaining the various ecosystem services and livelihood support the forests provide to the local communities and to the nation at large. Accordingly, sustainable multiple use and biodiversity conservation should be the main objective of forest management plans although carbon trading opportunities should also be pursued for added benefit.

The integrated resource management plan developed by the Bangladesh Forest Department for the Sundarban forests might be a good model of sustainable multiple-use forest management. However, the success of the plan will depend on a number of factors such as necessary capacity development (staff, logistics) of the Forest Department, collaboration of other agencies and peoples' representatives and, above all, political will of the government towards establishing good governance and enabling environment.

The co-management system being tried in Bangladesh would hopefully be effective in sustainable management of the protected areas as it involves local communities as well as administrative, law enforcement, technical support agencies and market actors in the forest management activities and it also focuses on developing alternative livelihood opportunities for the forest dependent people. The creation of community's 'Revolving Fund', as done by the Arannayk Foundation, is an effective strategy of motivating and enabling the forest dependent people to support forest conservation. However, more financial resources are needed for this purpose.

Moreover, the government and concerned other development organizations should undertake/strengthen a number of other initiatives in order to ensure long-term sustainability of the forest biodiversity resources of the country such as the following:

- Strengthening research, monitoring and documentation activities on biodiversity resources in the forests of Bangladesh;
- Strengthening habitat restoration program for the endangered wildlife species of Bangladesh;
- Joint planning, technical collaboration and coordinated program implementation with neighboring countries (India, Myanmar) for the conservation of tiger, elephant and other wildlife species having trans-boundary habitat;
- Promulgation of laws providing perpetual right to the concerned indigenous communities of the CHT to conserve the community conserved forests;
- Promoting use of metals (steel, aluminum) and plastic in building construction and furniture making;
- Promoting manufacturing and marketing of concrete blocks, in addition to stricter control of brick manufacturing, in the forest zones;
- Extension of appropriate technologies such as preservative treatment of bamboo and wood and alternative crops and cultivation technologies in order to reduce use of bamboo and wood (poles, sticks) in agricultural activities in the forest zones; and
- Extending education and family planning programs among the communities living in and around the forests in order to lessen extraction pressure on the forests in the long run.

Last but not the least, the carbon forestry initiatives should include exploring the possibilities of developing a REDD project on the village forests, which constitute the biggest repository of carbon (65% of total stock) in Bangladesh and are managed in a sustainable manner by the owner households.

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Congress Proceedings

Theme-2:
Collaborative management of protected areas community based conservation of forests and biodiversity

The Nishorgo Network Strategy and Action Plan: Collaborative Management of Bangladesh's Natural Protected Areas

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Abstract

The welfare of rural and urban population of Bangladesh has been closely associated with the blessings of the nature for centuries. An abundance of native fish fed the growing population. Forests and upland vegetation provided wood as raw material to industries, for furniture making, as construction material and fuel for daily necessities, and ensured a stable supply of clean water, steadily flowing rivers, protection from storms, etc. These gifts of the nature are presently in jeopardy through over exploitation, illegal human interference, poor management and many other ruthless activities. This document gives a strategy of the collaborative management of the natural protecting areas in Bangladesh. It identifies an action plan for establishing an effective, co-managed and integrated protective area network in Bangladesh that contributes to sustainable development objectives especially related to food security, climate change adaptation and mitigation, and poverty alleviation.

Key words: Biodiversity, Collaborative management, Natural protected area, Nishorgo

Introduction

Context and Need

Mach e Bhat e Bangali	*Fish and Rice makes a real Bengali*
Tu lal paharer deshe ja	*People of forests and hills*
Rangamati r desh e ja,	*return to your red earth*
Hethai tore mania sena go	*The chaos of the concrete world is no match to*
Ekkebare mania se na go	*your nature's heaven*

The well-being of Bangladesh's rural and urban population has been closely associated with the bounty of nature for centuries. An abundance of native fish fed the growing population, while forests and upland vegetation ensured a stable supply of clean water, steadily flowing rivers, and protection from storms. The diversity of wildlife – most notably the Bengal Tiger –is embedded within both Bengali culture and the other diverse cultures that make up Bangladesh today.

In recent decades, the native fish from open waters has given way to commercial species cultivated in ponds. These ponds have become more productive, and generated revenue for rich land-owners. Thus, the productivity and richness of open waters has declined. In absence of observed rules to regulate fishing, native fish has been over-extracted to the point of disappearance.

The richness of forest lands have also suffered. Outside of the Sundarbans, large blocks of contiguous forest throughout the country have given way to degraded forests. Wildlife once common is now rare. The poor that maintained their livelihoods by supplementing income and fuel wood from forest lands are now increasingly cut off from a fallback.

As wild natural resources of forest and water have succumbed to the pressures of Bangladesh's economy, the culture of the country has come under threat. Rural festivals that were closely associated with animals, fish and other wildlife are changing in response to loss of nature. The diversity of indigenous cultures associated with our forests loses their links to the forest. The loss of wild and open water and forests, therefore, bring with them a direct threat to the cultures of Bangladesh.

The Nishorgo Strategy and Action Plan

In response to these threats, communities, NGOs, the private sector and the Government have undertaken efforts to find ways to conserve the very nature from which food, fish, livelihoods and culture have been provided. Cultural norms of the past have been combined with management models from today to find new ways to conserve nature. Indeed, Bangladesh has become a global leader for embracing co-management, bringing together a diversity of stakeholders and perspectives to ensure sustainable development is built on a foundation of ecological conservation.

This Nishorgo Network Strategy and Action Plan for Bangladesh has been prepared with the Forest Department (FD) and Department of Environment (DoE) of the Ministry of Environment and Forests(MOEF), and with the Department of Fisheries (DoF) of the Ministry of Fisheries and Animal Resources, to support their efforts to strengthen, scale-up and institutionalize a national and collaboratively managed network of ecologically significant wetlands and forests.

The strategy has been further strengthened based on the inputs of a wide range of interested stakeholders, forming an informal network of conservation partners committed to benefitting people through the conservation of biodiversity, environmental protection and sustainable use of natural resources in Bangladesh.

The protection, conservation and improved management of ecologically and economically significant landscapes is of vital importance to stakeholders across Bangladesh, including rural communities and natural resource user groups dependent on wetland and forest resources, local government officials and technical services. These stakeholders have the mandate to serve the needs of people, alleviate rural poverty and conserve the environment. The government officials and aid agencies are also providing leadership to address climate change, biodiversity conservation, food security and poverty reduction. University faculty and researchers, NGO and business leaders, students and the general public also have a stake in raising awareness about the consequences of continued degradation and loss of natural forests and wetlands, and in fostering effective interventions to maintain ecosystem services, support sustainable economic development and secure a better future for the people of Bangladesh.

This Strategy and Action Plan is intended to help articulate a common vision and to orient needed interventions by these stakeholders to capitalize on the potential benefits to be gained from the improved, collaborative management of a network of protected wetlands and natural forests ecosystems in Bangladesh. The strategy aims to address the current gaps and overcome the policy and regulatory barriers, institutional capacity constraints and other obstacles to more effective conservation of a scaled up, institutionalized and integrated national Protected Area system. In preparing this strategy, particular efforts have been made to capitalize on the lessons learned and good practices emerging from the pilot experiences of community based, co-management of wetlands and inland capture fisheries, protected forests and Ecologically Critically Areas, piloted by CBFM, MACH, NSP, CWBMP, Arannayk Foundation, IUCN and others. The strategy is also designed to build upon recent advances in conservation financing, and to ensure the long term sustainability of the emerging "Nishorgo Network" of co-managed protected areas through innovative carbon financing as well as revenue sharing and promotion of public-private partnerships.

While Bangladesh has made great progress towards sustainable development since independence in 1971, substantial challenges still exist. \The pace of economic growth and poverty reduction have become overshadowed by negative impacts of global climate change. Bangladesh is already experiencing erratic weather patterns resulting in increased incidence of flooding and drought, as well as increased incidence and severity of cyclones and other natural disasters. Continued success toward achieving sustainable development in Bangladesh requires ensuring that economic growth is build upon a solid foundation of ecological and economic resilience. Key to this is an effectively managed and integrated Protected Area (PA) network. Incorporated as a centerpiece to the national development strategy, an effectively managed PA network provides a foundation for food security, climate change adaptation and mitigation, and poverty alleviation. This PA network will provide a buffer against climate change impact, and contribute to the stabilization of environmental services – especially water flow – that so many Bangladeshis rely on for their day-to-day survival and long-term well-being.

This strategy document presents a vision and action plan toward mainstreaming the conservation of an integrated PA network for Bangladesh into the country's national sustainable development strategy. Most important, it serves as a rally cry and call-to-action for government and other stakeholders to work together, and to invest financial and other resources to achieve ambitious integrated PA management objectives that contribute to Bangladesh achieving its 2021 Vision of sustainable development in the face of growing global climate change and food security challenges.

The goal of this strategy document is to establish the steps needed to put in place a national network of conservation areas that provide for the neighboring populations, protect against impending climate change, and ensure the continuity of those cultural elements associated with nature, for the good of all citizens.

In order to achieve that goal, this document identifies an action plan for establishing an effective, co-managed and integrated PA network in Bangladesh that contributes to sustainable development objectives especially related to food security, climate change adaptation and mitigation, and poverty alleviation. Specific *objectives* of this strategy include the following:

- Identification of key forests, wetlands, marine and environmentally-critical areas (ECAs) and landscapes for inclusion in an integrated PA network;
- Clarification of the policy framework to harmonize co-management efforts and activities;
- Strengthen institutional capacity among government, community and other stakeholders necessary to effectively co-manage this integrated PA network;
- Establish a long-term financing plan to fund effective co-management of this PA network;
- Demonstrate tangible and intangible economic/financial/livelihoods benefits to PA-dependent communities, especially the poor;
- Implement a comprehensive monitoring and evaluation system to ensure efficient investment of limited financial and technical resources achieves the greatest positive impact in terms of PA conservation.

Achieving this goal and objectives requires a clear set of principles and approaches to move forward. These are described below in terms of three main *Principles* and five *Pillars* required to achieve an effective national PA network for Bangladesh.

Principles of this integrated PA network include:

- An integrated network of ecologically as well as economically-significant natural areas (or PA) should represent key forest and wetland ecosystems across Bangladesh and should build ecological and economic resilience by conserving biodiversity and stabilizing critical environmental services (especially water);
- Effective management of ecologically-significant natural areas (or PA) is predicated upon the institutionalization of co-management among key stakeholders, including various government agencies, local communities, NGOs, universities, the donor community and the private sector;

- Integrated conservation area management (or PA management) should be considered a centerpiece of Bangladesh's sustainable development strategy, providing meaningful livelihoods development opportunities for people living adjacent to and dependent upon PA resources.

This national integrated PA strategy is based on five main *pillars*:

- *National-level policy and legal framework* that formally establishes a robust network of forest, wetland and other PAs as a centerpiece of the national sustainable development strategy; harmonizes policies amongst various government agencies to most effectively support integrated PA co-management; and communicates the significance of integrated PA co-management to long-term sustainable development;

- *Landscape-based co-management of forest, wetland and other PAs* based on low-emission development plans that integrate PA conservation with sustainable livelihoods development particularly for poor people living adjacent to and dependent on PA resources;
- *Institutional strengthening and human resource capacity building* to strengthen effective co-management of PAs. This includes but is not limited to the effective facilitation of co-management approach and activities that lead to conservation of PAs, low emission development for poor people living adjacent to and dependent on PA resources, and elucidation of the significant role of a PA network for national sustainable development. This also includes the facilitation of public-private partnerships to leverage additional financial, in-kind and technical resources required for effective PA conservation co-management;
- *Marshaling of science and community involvement for monitoring and evaluation.* The best evidence based science needs to be brought to bear to ensure adequate selection of PAs in the national network, and then to ensure that environmental, and socio-economic objectives are being adequately met, especially in light of expected changes due to climate change and resulting food insecurity;
- *Sustainable conservation financing* to establish, grow and manage a robust PA network. This includes financing for co-managed conservation of PAs, low emission development initiatives for the poor living adjacent to and dependent on PA resources, and public outreach to build national-level awareness of and commitment to Bangladesh's PA network. It requires an integrated financing approach to include GoB recurrent and development budget allocations, and alternative conservation financing generated from Payment for Environmental Services (PES), especially water and carbon, as well as various user fees, debt-for-nature swaps, etc.

This strategy document is structured into five key chapters including this introduction as follows:

Background of PA management in Bangladesh includes a brief account of the history of PA management in Bangladesh (and around the world); the legal basis for PA management, including international conventions and national policies; and the institutional basis for co-management of various kinds of PAs.

Snapshot of Bangladesh's PA system today includes a map (or maps) of various PAs that are coded by type. The section also includes a matrix summarizing key features of Bangladesh's current PAs.

PA management challenges and opportunities starts with a brief threats assessment, identifying direct and indirect drivers that threaten PA conservation. The section then looks at the management of ecological services, focusing especially on water, carbon and biodiversity. This is followed by a brief assessment of global climate change adaptation and mitigation approaches. Finally, the section looks at a sustainable landscape approach to pro-poor low-carbon development to generate support from communities living adjacent to and dependent on PA resources.

Action plan for the Bangladesh Nishorgo PA network , broken down by pillar (national-level policy framework; landscape-based co-management of PAs; institutional strengthening and human resource capacity building; monitoring and evaluation; and sustainable financing), specific activities and actions are presented in order to move this integrated PA network forward as effectively and efficiently as possible.

Background of Protected Area Management in Bangladesh

Efforts to establish a national protected areas system in Bangladesh commenced in the 1960s with creation of a number of National Parks and Wildlife Sanctuaries. The conservation movement received a push in the 1980s and then expanded rapidly into the 1990s. Concentrating almost entirely on protected areas under management of the Forest Department, this interest in the 1980s correlated with global trends for terrestrial protected areas and nature conservation.

Early PA Management: An Enforcement Approach

Managed by the Forest Department, initial PA conservation management was based on an enforcement approach as per the Forest Act of 1927 and the Wildlife Preservation Act of 1974. This included the designation of protected areas, appointment of field staff, and enforcement efforts to keep people out of protected areas in order to reduce incidence of illegal logging and forest encroachment. In Bangladesh, like other densely populated developing countries, the enforcement approach to PA management proved inefficient and costly. Forest Department could not provide enough field staff to significantly reduce threats to PA resources. Moreover, the enforcement approach proved to be a heavy financial burden on limited budget. Forest Department was not endowed with sufficient human or financial resources necessary to effectively manage a growing PA system, and the pressures being put upon it by a growing population and economy

Integrated Conservation and Development

By the 1990s, Bangladesh joined other developing countries in evolving the Integrated Conservation and Development Project, or ICDP, approach to conservation. The ICDP approach shifted objectives of PA management from strict conservation within PAs to a more positive and integrated strategy of generating support for conservation by providing development benefits to communities living adjacent to PAs. While enforcement activities continued, Forest Department began working with other stakeholders striving to provide economic development opportunities to communities living in the buffer zones of PAs.

The ICDP approach to PA management improved efforts to better conserve Bangladesh's PAs, but faced problems and inefficiencies. Development activities, while often appreciated by the beneficiaries, did not necessarily correlate to threats reduction. Beneficiaries often were not the ones encroaching on PAs, and the level of economic benefits was insufficient to sway people away from illegal encroachment activities. The ICDP approach required strong facilitation skills and human resources that were not sufficiently available within the Forest Department. Meaningful development activities required a budget that far exceeded the regular budget of the Forest Department. The ICDP approach could be beneficial on a project basis, with significant human and financial resources made available over a fixed period of time. Conservation objectives might be achieved during the life of the project, but long-term sustainability of PA conservation remained questionable. In fact, in Bangladesh and around the world, once ICDP projects ended, project beneficiaries became disenchanted and threats to conservation quickly began to increase. ICDPs provided a band-aid but lacked sustainability.

Sustainable Landscape Conservation and Co-management

Over the past decade, PA conservation management in Bangladesh has evolved to a landscape-based co-management approach. Drawing lessons learned from successful PA management around the developing world, co-management shares the responsibilities and rights of PA conservation management with all responsible stakeholders. This includes broad-based and equitable engagement of government agencies at all levels and communities dependent on PA resources, as well as relevant private sector, university, and NGO partners. It involves building awareness of the long-term economic development benefits that effective PA conservation provides, and then working together at a landscape level to balance conservation and with long-term, equitable and sustainable development.

While ICDP activities were project-based, co-management for PA conservation is an entire paradigm shift in governance. The government shares management rights and responsibilities for conservation with PA-dependent communities. These communities actively support conservation management through participation in joint patrols and committing to development activities based on conservation or sustainable resource utilization. Government and community work together to identify and develop economic opportunities that enhance PA conservation (ecotourism, forest rehabilitation) and reduce dependence on PAs (intensifying agriculture, agroforestry and fisheries value chains through both intensifying and diversifying production on land outside of PAs).

The Vision for Nishorgo Network in Bangladesh

Nishorgo Network is the affiliated network of co-managed protected forest, wetland and ECAs throughout the country. With the assistance of Bangladesh Government, communities are working with the Government to conserve bio-diversity of the protected forest, wetlands and ECAs through co-management organizations. Co-management Organizations (CMO) in forest and wetlands represent the participation of local community and government agencies in a new structure for protected area governance. The enthusiasm of the local community to participate and work for conservation with government agencies represents a significant paradigm shift.

USAID's Nishorgo Support Project, MACH and IPAC projects expanded the co-management approach in different PAs. As a result, CMOs have been developed and organized in those Protected Areas and Wetlands. To date 16 CMOs in forest PAs and 17 CMOs in wetlands have been established and actively working in management process. Most of the CMOs are registered from the Department of Social Welfare and have their own identity. They have management plan according to the nature and features of the PAs and yearly activity plan based on the management plan.

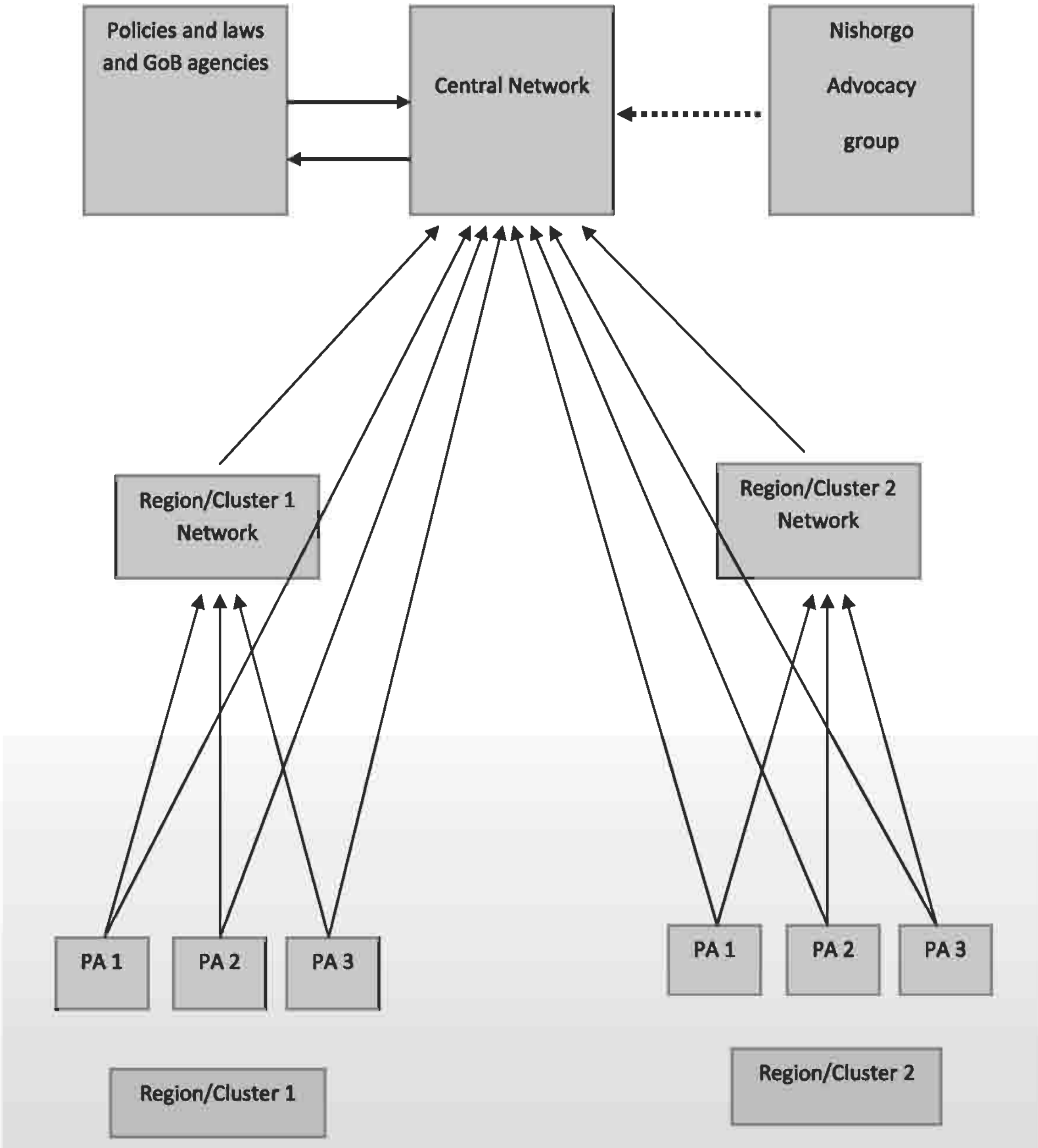
Although, there are many differences of the PAs, challenges and threats are almost common. Bangladesh is a highly populated country with high density. In Bangladesh there are tremendous pressures on land and at the same time poverty is the important issue to address. Due to poverty, people living adjacent to the natural resources are highly dependent on resources. Climate refugees are dependent on forest land for their habitat.

To address the challenges and threats of biodiversity conservation is difficult for individual CMOs because of the magnitude of the issues. It needs huge mobilization of community people at the same time other partner organizations like GoB agencies and organizations working for conservation purpose. As example we can note here the issue of water pollution in Mokosh Beel, which is still unresolved. However, to promote larger campaign within the country in favour of conservation and building constituency, initiate and hold advocacy with policy makers for influencing them, ensure rigorous community mobilization, need united effort of the CMOs. Need regional and central forum of CMOs where they can share their experiences and move jointly to address and influence the challenges.

What would be the vision of Nishorgo network in Bangladesh? The basic perception of the network is a collective response to the demand of the environmental eco-system which is in vulnerable situation. This is an approach to work jointly by the community and government through co-management organizations for revering the present trend. Focusing the conservation, collaborative management and pro-poor activities are the main principles of the network.

Today, climate change is not only important but urgent issue to address by the Government for the community living around the forest, wetland and ECAs. People are becoming vulnerable day by day due climate change. Reduction of vulnerability climate change mitigation and adaptation is necessary and at the same time need to mainstream the issue of these areas with our national development agenda.

Diagram 1: The diagram below is the vision of the future Nishorgo Network in Bangladesh



Co-Management Initiatives in Bangladesh

Bangladesh has developed effective co-management approaches in both forest and wetland ecosystems. Initially implemented at a pilot scale, Bangladesh is now working with the international donor community to bring co-management for PA conservation to scale. Examples of important co-management initiatives include the following:

The Arannayk Foundation

The Arannayk Foundation, also known as the Bangladesh Tropical Forest Conservation Foundation, facilitates the conservation, protection, restoration and sustainable use and management of tropical forests in Bangladesh. The Arannayk Foundation serves as a catalyst for the protection and sustainability of forest biodiversity in Bangladesh. It adopts an ecosystem approach and considers the entire range of possible goods and services in order to optimize the mix of benefits for a given ecosystem.

The Foundation provides grants and other technical support to NGOs, community organizations, universities and research institutions, and other organizations working to conserve forest biodiversity in Bangladesh. The foundation incorporates rigorous monitoring and evaluation to ensure effectiveness of its projects, and develops forward looking assessments to incorporate lessons learned and guide future initiatives.

The Arannayk Foundation is a strong proponent of co-management for effective conservation of forests in Bangladesh. For example, Arannayk Foundation has facilitated the formation of a co-management committee (CMC) in the proposed Inani National Park near Cox's Bazar. This has generated significant support from both the Forest Department as well as the local community for the conservation of this important area. Additionally, Arannnayk Foundation is providing grants to co-management committees for existing Protected Areas to support integrated conservation and development.

IUCN Bangladesh's Initiative in Chittagong Hill Tracts (CHT)

The IUCN Bangladesh Country Office (IUCNB) initiated a program in 2000 to link people with nature conservation in the hilly areas of southeast Bangladesh. The goal of the program was to develop a socially acceptable, economically viable and "biodiversity friendly" development model for a given landscape in which the ethnic people of the CHT can live "in harmony with nature". The expected outputs of the program include: (i) awareness raising of local people on sustainable use of natural resources, (ii) building capacity at local level for conservation and sustainable development, (iii) development and implementation of sustainable land use plans, (iv) ecological regeneration of depleted tropical forests, (v) support to rural livelihoods by increasing productivity of their farming systems, and (vi) making provision for alternative income generating activities (IUCNB 2003).

Krykhong Para, one of the villages of *Mouza* Hafaikhong in the Baderban Hill District, was selected as the pilot area. A Village Development Committee (VDC) was established to manage all activities of the program with technical support from IUCNB. The participatory and capacity building approaches of the pilot initiatives have been well accepted by the community as well as the district council and district administration. Ethnic people from other villages of the same *Mouza* as well as nearby areas approached the project for assistance with undertaking similar programs in their villages (IUCNB 2003).

UNDP-GEF Coastal and Wetland Biodiversity Management Project

The Coastal and Wetland Biodiversity Management Project (CWBMP) is a UNDP-GEF funded project implemented by the Department of Environment (DoE) under the Ministry of Environment and Forests, working to conserve wetlands in Cox's Bazar and Hakaluki Haor.

It is designed to establish and demonstrate an innovative system for management of Ecologically Critical Areas (ECAs) in Bangladesh that will have a significant and positive impact on the long term viability of the country's biodiversity resources. Among the eight ECA sites declared under the Bangladesh Environment Conservation Act 1995, CWBMP is working on four of them. The project supports DoE to operate the ECA concept at two main geographical areas. One area (which includes three ECA sites) is the country's biodiversity rich long coastal zone and the other is the largest and most important inland freshwater wetlands of the country.

USAID Support for Co-Management: MACH, Nishorgo Support Project and IPAC

USAID has worked with the Government of Bangladesh since 1998 to develop effective pilot-level co-management approaches to wetlands and forest PAs through the respective MACH and Nishorgo Support Project (NSP), and then to support the development of an overall PA co-management strategy through IPAC since 2008.

The MACH and NSP pilot efforts focused on 3 freshwater wetland sites and 5 forest protected areas covering about 45,000 hectares and affecting the lives of several hundred thousand people in three areas of the country (central region north of Dhaka, northeast region around Srimongal and southeast Teknaf peninsula). Both projects developed a model for co-management, and tested this approach through support for a number of best practices that proved effective in conserving biodiversity while increasing local socio-economic benefits. A variety of community based organizations (CBOs) including resource user groups and resource management organizations were established and supported with revolving funds, access to credit, training and technical support. Upazila Fisheries Committees, Co-management Committees and Councils and other forms of co-management organizations (CMO) were also organized, and endowment funds were established to support UFC and revenue sharing agreements were developed to help support CMC.

These projects contributed to a reduction in the loss of biodiversity in wetlands and forests, the productivity of the local fisheries was increased, local communities became engaged in working collaboratively with local government authorities and GoB technical services. Based on the experiences, considerable socio-economic benefits were documented, particularly on households engaged in wetland restoration and community-based fisheries management, and ecotourism developments associated with protected forests.

As MACH and NSP project assistance ended in 2008, USAID and the Government of Bangladesh launched IPAC to support bringing these pilot projects to scale. It was anticipated that the three concerned technical departments would work together to consolidate and harmonize their approaches for community based, collaborative management of these PA landscapes, and integrate the network of declared PA into a national system, jointly supervised by the Dept of Fisheries, Forest Dept and Dept of Environment. IPAC was funded to provide assistance in key areas, including the strengthening of a favorable policy and legal framework, development of communications and outreach, increased support for training and capacity building, and increased support for site level implementation of PA co-management

National Program & Strategies Supporting and to be Supported by the Nishorgo National PA Network

To be effective, the Nishorgo National PA Network strategy must recognize, support and be supported by a number of national programs, strategies and action plans with overlapping interests. Espousing its co-management values, it is critical that this new Nishorgo National PA Strategy leads to greater cohesiveness among national programs, strategies and action plans related to conservation, sustainable natural resources management, poverty alleviation, food security, and global climate change adaptation and mitigation. Some of the key programs, strategies and action plans include the following:

Poverty Reduction Strategy

One of the most important strategies for Bangladesh that has relevance to all sustainable development activities undertaken in the country is the National Strategy for Accelerated Poverty Reduction. The poverty reduction strategy paper (PRSP) for Bangladesh is based on a road map that addresses the multiple dimensions of poverty reduction while "unlocking the potential" from an optimal mix of public action, private initiatives and community mobilization. There are eight specific avenues outlined, including at least three of direct relevance to the scope and objectives of the Nishorgo Network: participation and empowerment of the poor, especially women, ethnic minorities and other marginalized or ecologically vulnerable groups; promoting good governance; and caring for the environment and its sustainability.

The PRSP explicitly recognizes that:

"human lives and livelihoods in Bangladesh are intricately intertwined with nature. Consequently, no process of development and eradication of poverty can be conceived of without putting care for environment and sustainable development at the centre-stage. On the other hand, as the poor depend heavily on nature for their livelihood, without the whole-hearted involvement of the poor, caring for environment becomes an extremely difficult task….it is important to keep in mind that in a country where the majority of the poor are highly dependent on natural resources, the improved management of natural resources is a prerequisite for poverty reduction….the linkage between poverty and conservation of natural resources is a mutually reinforcing process….Thus conservation and regeneration of natural resources through appropriate intervention, investment and management have to be ensured so that the poor and vulnerable communities can depend on the use of natural resources on a sustainable basis."[1]

The PRSP recognizes that biodiversity is an asset for the nation, and that the economic well-being of the country is being negatively impacted by the continued degradation and loss of biodiversity. Furthermore, it notes that the improvement of biodiversity will benefit the poor, especially in terms of fisheries given the large numbers that depend on fishing for income generation and also as a source of protein. It also recognizes that dependence on land and other natural resources is increasing, not decreasing; and that the yields, productivity and economic contributions of these natural resources must increase, not decrease if poverty is to be reduced. More effective conservation of biodiversity and improved management of public commons or common property resources such as open water resources in wetlands, forests, khas and grazing lands, and the rivers and open seas are critically important to maintain a safety net for the poor. The PRSP recommends that specific measures should be taken to prevent the capture and exploitation of the highest quality public commons by the Government and/or local elites so as to exclude the poor.

In view of the foregoing, the PRSP recommends that

"the Government should improve and systematize access of the poor to the natural commons and introduce community-based participatory natural resource management; in this respect, enacting laws and regulatory frameworks and recognizing the rights of the ethnic minority and rural people to local

[1] Bangladesh Unlocking the Potential – National Strategy for Accelerated Poverty Reduction. General Economics Division, Planning Commission, Government of People's Republic of Bangladesh, October 16, 2005. p. 177.

common property resources are essential. The conservation of nature needs to include the goal of ensuring sustainable livelihood for the poor."[2]

National Biodiversity Strategy and Action Plan

The Convention on Biodiversity Conservation includes 11 broad goals relevant to the goals and objectives of a national Protected Area system, including promotion of conservation, reduction of species loss, conservation of genetic diversity, promotion of sustainable resource use, reduction of habitat loss, control of alien species, addressing threats to biodiversity from pollution and climate change and ensuring equitable benefit sharing. In 2005, Bangladesh formulated its National Biodiversity Strategy and Action Plan (NBSAP), with 5 pillars, 16 strategies and 128 action programs to ensure better protection of biological resources in Bangladesh. The NBSAP takes account of the institutional complexity and notes the complicated legal regime related to biodiversity conservation, and cites relevant policies and strategies in the forest, environment, fisheries and other sectors, as well as a number of project interventions that have supported biodiversity conservation in one manner or another. By 2009, the fourth national report on NBSAP status and implementation had been prepared, and in 2010 a major assessment and program of action to the year 2020 was carried out as a milestone event for the International Year of Biodiversity. The assessment highlights the major threats or drivers of biodiversity loss, and reviews progress made so far in achieving its 2010 targets under seven focal areas related to the NBSAP and associated projects. The assessment also includes an analysis of the linkages between NBSAP and the programs outlined in the Bangladesh Climate Change Strategy and Action Plan (BCCSAP), and complementarities and conflicts between NBSAP and Poverty Reduction Strategy Paper. By and large, there has been progress and some accomplishments on many fronts, although the 2010 report notes that many challenges exist to mainstream and successfully implement NBSAP, including:

- weak inter-sectoral coordination

- lack of momentum in policy level endorsement to back conservation of biodiversity; negligible efforts to enhance policy level understanding of the importance of biodiversity conservation

- legal and institutional framework not supportive of biodiversity conservation; inadequate implementation of existing legislation to halt conversion of forest lands

- negative impacts of climate change on conservation

- inadequate financial and technical capacity of concerned organizations to implement NBSAP strategies and action plans

Taking into account the latest assessment, a participatory process was organized to identify the short and long term programs to be undertaken for nine focal areas of biodiversity conservation in Bangladesh, including the conservation of coastal areas, wetlands and fisheries, landscapes, forests and wildlife. Some of the recommended activities from the recently adopted Biodiversity Programme of Action 2020 (BPA 2020) that are most pertinent to the strengthening and scaling up of the Nishorgo Network include:

- updated survey of wetlands to declare and conserve important areas
- development of guidelines and rules for wetland ecosystem management
- provision for community based wetland management
- community based conservation of riverine habitats to conserve cetaceans
- community based management of medicinal plants in CHT
- development of guidelines and monitoring indicators to apply ecosystem approach towards forest biodiversity conservation

[2] Ibid, 2005. pp. 181

- updated inventory and demarcation of forest areas
- development of REDD+ projects with communities in suitable areas
- development of conservation based forest management system
- conduct study to identify biodiversity rich forest ecosystems to be declared and managed as protected areas
- develop a handbook on best practices in management of ecosystems in relation to wildlife, cultural heritage and landscape conservation

Forest Department's 'Vision 2010'

In 2003, the Forest Department developed a "Vision 2010" to identify the major challenges to improved PA management in the medium term. As per that Vision, the major trends that could be expected to affect PA management in Bangladesh included:

- The number of tourists visiting protected areas and other nature sites will continue to increase
- NGOs, academics and the international community will put steadily increasing pressure on the FD to manage protected areas in a more sustainable way
- It will be increasingly difficult to adhere to the international Conventions that the country is bound to uphold
- At the local level, the demands on Protected Areas will increase
- Forest Department will manage Protected Areas in a more sustainable way
- Protected Areas will see increasing intractable social conflicts
- The economics of land prices and competing development plans, based on increasing demand for land, will put an extra pressure on the Protected Area system

As a response to these coming challenges and trends, the FD will need to master a new approach to PA conservation, as called for under the Nishorgo Program. Nishorgo must find ways to get "buy-in" or consensus from local stakeholders who can serve as a counterweight to special interests far away from PAs and adjacent lands. "Vision 2010" states that FD will need new approaches for PA management, including several issues:

- PA managers would need to continue to focus on and master forest and ecosystem management
- The Wildlife and Nature Conservation Circle, and its mandate and processes, would need to be modified to be in line with the overall goals of Nishorgo. In effect, the Circle would need to be strengthened and its processes reviewed
- A co-management approach should be adopted
- To extend the reach and effectiveness of the PA managers, an active local PA management committee, composed of an appropriate but small number of local stakeholders, will be essential
- The role of the DFO(Wildlife), in particular, needs to be examined and clarified
- PA Managers can no longer manage their areas as islands cut off from the rest of society
- The FD must continue to improve its ability to manage the legal dimensions of land and resource conflicts

"Vision 2010" recognizes that PAs represent important economic opportunities and each PA will need to take appropriate steps to move toward financial self-sufficiency. To reach its goals, the Forest Department will also build its institutional, human and material capacity to meet these challenges. Formal structural changes must be made to the PA capacity-building efforts for PAs to become functional and operational. The movement towards a separate PA management system should be made slowly, allowing the national PA management institutions to gain ability in the process. The five pilot PAs that are the focus of NSP will produce models for PA management that can be extended to other PAs as a networked PA system.

National Fisheries Strategy and Action Plan

The National Fisheries Strategy and Action Plan was formulated to present new ways in which policies, in particular the National Fisheries policy, can be implemented and support can be offered to guide the sector, recognizing that over the next ten years the requirements of the sector are likely to change as development continues apace. It recognizes the need for more support for the capture fisheries, both marine and inland, to reduce the current decline and to prevent further biodiversity and wetlands losses. It also recognizes the increased support needed for both promoting aquaculture while also improving the regulatory framework to provide a structure for continued expansion. All of this must be done from severely constrained resources and so improved working relationships need to be fostered to encourage greater ownership and management by the fishers through community or co-management.

The Strategy and Action Plan represents the compilation of eight sub-strategies which have been formulated to provide specific direction in their areas. These were all prepared using a participatory approach with inputs from Department of Fisheries and other stakeholders from the private sector, research bodies, other government agencies, NGOs, and fish farmers and fishers. The work was facilitated by project staff but the ownership of the strategy lies with the Department of Fisheries which is responsible for coordinating the management of the sector. The building block sub-strategies include:

- Aquaculture Sub-strategy
- Aquaculture Extension Sub-strategy
- Inland Capture Fisheries Sub-strategy
- Marine Sector Sub-strategy
- Shrimp Sub-strategy
- Monitoring and Evaluation Sub-strategy
- Quality Control Sub-strategy
- Human Resource Development Sub-strategy

The Bangladesh Tiger Action Plan

The Bangladesh Tiger Action Plan (BTAP) marks the beginning of a structured approach to achieving long-term conservation of tigers in Bangladesh. The BTAP is a policy-level document that provides a vision, goals, and objectives to guide an integrated and focused tiger conservation program. The vision is to ensure protected tiger landscapes in Bangladesh, where wild tigers thrive at optimum carrying capacities and which continue to provide essential ecological services to mankind. The main goal for the next eight years is to stabilise or increase the Sundarbans tiger population. The Bangladesh Forest Department, under the Ministry of Environment and Forests, is the custodian of the forest and its wildlife, but one of the most important aspects of the BTAP is the recognition that the immense task of tiger conservation necessitates support and expertise outside the normal remit of forest management. Therefore, the establishment of a Forest Department-led platform that facilitates collaboration for the implementation of conservation activities will be fundamental to its success.

Tigers are directly threatened by poaching to supply the increasing demand for tiger products. In addition, Bangladesh suffers high levels of tiger-human conflict, manifested in human-killing, livestock depredation, and ultimately the retribution killings of tigers by affected local communities. Poaching of prey further reduces the capacity of the forest to support tigers, and unsustainable forest use and climate change threaten to reduce the area in which tigers can live. In building a successful tiger conservation effort, there are also a range of challenges that need to be dealt with relating to: (1) institutional development and policy, (2) forest protection and law enforcement, (3) education and awareness, (4) research and monitoring, and (5) the need for collaboration.

Climate Change Strategy and Action Plan

In seeking to address the threat of Global Climate Change, Bangladesh has also developed strategies and programs that are relevant to the goals of the Nishorgo Network. In 2005, a National Adaptation Programme for Action (NAPA) with a view towards identifying projects to strengthen adaptive capacities and increase resiliency among the most vulnerable populations in coastal areas and elsewhere. Focal points were identified in relevant ministries to support the implementation of prioritized actions, including coastal afforestation with community participation, provision of drinking water supplies to coastal communities, capacity building to integrate climate change in development planning, awareness raising and assistance in coping with recurrent floods.

In 2008-2009, the overall Climate Change Strategy and Action Plan was developed with the leadership of the Department of Environment and Ministry of Environment and Forests, and Climate Change cells and units have been established in DoE and MoEF to support the implementation of the BCCSAP. The strategy includes a number of pillars related to food security, disaster management, infrastructure development, research and knowledge management, low carbon development and capacity building. The potentially negative impacts of climate change on biodiversity as well as on livelihoods, food supplies and the incidence of disease are noted. The opportunity and potential benefits from programs aimed at mitigation and carbon sequestration, including CDM initiatives, Afforestation / Reforestation and REDD+ in association with Protected Area co-management are also cited. The protection of livelihoods in ECA, and contribution to food security and adaptation from improved fisheries management is also noted.

The Bangladesh PA System Today

Bangladesh was originally a country of rich wetlands and tropical forests, but those vast expanses of wetland and forest habitat have been largely converted to agricultural fields, human settlements and fish and shrimp firms, particularly during the last fifty years. Some idea of the vegetation and geography of this area are available from the experiences of early visitors. A Chinese traveler named Xuanzang (also spelled as Hieun Tsans) who visited this area around 630 A.D. found it very marshy. The British surveyor Francis Buchannan, who surveyed the southeastern Bangladesh in 1798 to identify areas suitable for the cultivation of spices, saw most of the area covered by dense forests. Lord Guy Mounfort, who flew as a Royal Air Force pilot in the Second World War and then returned in 1969 to lead a World Wildlife Fund expedition, noted that the nearly continuous hill forests of Greater Sylhet from the 1940s had been decimated in the intervening years. The rich wetlands of the country are, in some areas, still quite in their original state, but forests have suffered severely from overexploitation.

Four main wildlife habitats in Bangladesh include forests; wetlands; bushy, grassy and bamboo-covered areas; and homestead vegetation. These are described below.

Forests

There are three types of forests in Bangladesh, i.e., mangrove, mixed evergreen, and deciduous forests One-tenth (9.8 percent, or 1.45 million ha) of the country's surface area is under the forest belts, but the actual coverage of natural forests is lower than this, with most of this accounted for by the Sundarbans mangrove forest. Bangladesh has one of the world's lowest forest-to-population ratios (<0.02 ha per person). The natural forests are the most important wildlife habitats since most of the flagship and threatened species are found there.

The mangrove forests (including coastal plantations) cover an area of 0.71 million ha along the coast, with most of this (0.58 million ha) accounted for by the Sundarbans – the largest and least disturbed forest of Bangladesh. The Bangladesh and Indian Sundarbans together form the largest single mangrove forest in the world accounting for 6 percent of all mangroves on earth. The mangrove forests are characterized by unique plants that grow below the high tide level and can survive through the use of various types of aerial roots. The vegetation is mainly composed of mangrove trees such as *Heritiera fomes*(sundri, sundari), *Excoecaria agallocha* (gewa), *Sonneratia apetala* (keora), *Sonneratia caseolaris* (chila/ora) , *Avicennia* spp. (baen), and smaller plants such as *ceriops* spp. (goran), *Phoenix paludosa* (hental), *Nypa fruticans* (Nipa palm, golpata), *Acanthus ilicifolius* (hargoza), *Imperata* spp. (sungrass, chhan) and *Typha* spp. (hogla).

The mixed evergreen forests have become heavily fragmented but together cover an area of 0.55 million ha in the southeast and northeast of Bangladesh. Some relatively large patches of mixed evergreen forests still exist in the Chittagong Hill Tracts in the southeast. The two best mixed evergreen forests in the northeast are found within Rema-Kalenga Wildlife Sanctuary and Lawachara National Park. The mixed evergreen forests are dominated by evergreen trees, but also have some deciduous trees. The principal tree species include *Artocarpus chaplasha* (chapalish), *Dipterocarpus* spp. (garzan), *Swintonia floribunda* (civit), *Bombax* spp.(shimul), *Michelia champacea* (champa) *Syzygium* spp. (jam), *Mangifrea longipes* (wild mangoo, ury-aam), *Albizia* spp. (koroi), *Dillenia pentagyna* (hargaza/azuli), *Lagerstroemia* spp. (jarul) and *Ficus* spp. (bot). Other common plants include differenct species of bamboo (*Bambusa* spp., *Melocann* spp., etc.), epiphytes (*Vanda* spp., *Dendrobium* spp., etc.), climbers and ferns, including the Tree-fern (*Alsophila* sp.).

The deciduous forest have also become largely fragmented and degraded throughout the country. The 0.12 million ha of deciduous forests are distributed in the central, northern and northwestern parts of the country. Only in the Madhupur Tract relatively large areas of forests still exist, although they are not in a primary state. The most dominant tree species of the forest is *Shorea robusta* (sal, shal), which forms 80 percent of the trees, but mature sal trees in the forest are now extremely rare. Other patches that form the vegetation include trees such as *Dillienia pentagyna* (hargaza/azuli), *Adina cordifolia* (kaikka), *Ficus* spp. (bot) and *Syzygium* spp. (Jam), and plants including *Zizyphus* spp. (bon-boroi), *Spondias mangifrea* (bon-amra), *Phyllanthus embelica* (amloki), *Gloriosa superba* (ulotchondal), *Curcuma* spp. (shoti), *Bambusa* spp.) (bamboo and *Lantana camrara*. The deciduous forests have many large grassland pockets, dominated by *imperata* grasses.

Wetlands

Bangladesh is a country of wetlands, with 7 percent (1.03 million ha) of the country permanently always under water, 21 percent (3.09 million ha) deeply flooded and 35 percent (5.16 million ha) experiencing shallow inundation. The five most important wetland areas are Haor Basin in the northeast, the Sundarbans in the southwest, the Meghna River estuary in the south, Kaptai Lake in the southeast, and the coastal areas adjacent to St. Martin's island and the Teknaf Peninsula in the far southeast. Two sites have been recognized as internationally important wetlands under the Convention on Wetlands of International Importance especially as Waterfowl Habitats ("Ramsar" Convention). These two "Ramsar" sites include Tanguar Haor and the Sundarbans. The riverbeds of large rivers like the Jamuna, Padma and Meghna, together with their tributaries, are good habitats for many wetland birds. The sandflats, mudflats, and grassy areas along the coast are also important for coastal and marine birds and other wildlife. Moreover, the Bay of Bengal provides habitats for marine wildlife. The common vegetation of the wetlands are reeds like *Saccharum* (kansh) and *Phragmites* (nol), and other plants such as *Barringtonia racemosa* (hijal), *Eichhornia crassipes* (water hyacinth , kochuri pana), *Lemna* spp. (khudi pana), *Chara* spp., *Nitella* spp. *Saggitaria* spp., *Ipomoea* spp. (kolmi), and *Nymphaea nouchali* (water lily , shapla). One special wetland plant of the country is the *Rosa involucrate* (wild rose , guzar kanta) that grows only in the Haor Basin. Some species like *Myriostachya wightiana* (dhanshi/ury ghash) and *Typha* spp.(hogla) grow only in the coastal wetlands.

Bushy, Grassy and Bamboo-Covered Areas

The hilly areas in the southeast, particularly the Chittagong Hill Tracts, and in the northeast, have vast hilly areas covered by dwarf vegetation. The total of such areas is 5 percent (0.80 million ha) of the country's total area, most of which (0.73 million ha) are found in the Chittagong Hill Tracts and legally designated as "unclassed state forests". Common bushy plants such as *Lantana camara, Eupatorium* sp., *Clerodendrum* spp., *Melastoma* spp., many species of bamboo (*Melocanna bambusoides, Bambusa* spp., *Oxytenanthera* spp., *Teinostachyum griffithi, Neohouzeaua dullooa*, etc.) and grass (*Imperata* spp., *Phragmites* spp., etc.) grow in these areas. Some of the areas previously had good forest cover, but once the trees were logged the areas were occupied by bushes, grasses and bamboo.

Homestead Vegetation

Most villages in Bangladesh are lush with vegetation. The backyards of village homes often have dense growth of planted and natural vegetation, and are particularly important in supporting a number of wildlife. These wildlife use the homestead vegetation and surrounding crop fields (rice, wheat, jute, etc.) for their food and shelter. Homesteads account 27 percent (4.0 million ha) of the country's total area. The common vegetation of the villages include the trees like *Magnifera indica* (mango , aam), Artocarpus heterophyllus (jackfruit , kanthal), *Syzygium* spp. (Jam), *Lichi chinensis* (litchi , lichu), *Zizyphus mauritiana* (boroi), *Dyospyros peregrine* (Gaab), *Tamarindus indica* (tamarind, tentul), *Bombax ceiba* (silk cotton , shimul), *Anthocephalus cadamba* (kadam), *Albizia* spp. (koroi), and other plants like *Bambusa* spp. (bamboo , bansh), *Musa spp.* (banana, kola), *Phoenix sylvestris* (date palm , khejur), *Borassus flabellifer* (palmyra , Tal), *Cocos nucifera* (coconut , narikel), *Barringtonia racemosa* (hijal), Ficus spp. (fig , dumur), *Citus aurantifolia* (lime, lebu), *Calotropis gigantean* (akand), *Ricinus communis* (bherenda), *Cassia* spp., *Clerodendrum inerme* (bhant) and *Coccinia grandis* (telakucha).

Protected Areas and Wildlife Conservation

Bangladesh has a network of designated Protected Areas, primarily for the conservation of wildlife. While some of these were declared in the 1960s, the history of forest management by the state goes back at least to the Mughal era. During the Mughal Empire and the rulings of the local kings there were areas preserved for sport-hunting for the elites. During the colonial era, forests were brought under the Government's jurisdiction and parts of the forests were declared as Reserves where logging was not permitted. In 1793, the Government of British India officially took control of the forest, and in 1865 the Forest Department was created and the first Forest Act was promulgated.

A significant improvement in the legal status of the Protected Areas occurred after the independence of Bangladesh through the formulation and implementation of Bangladesh Wildlife Order in 1973, which was refined as Bangladesh Wildlife Preservation Act, 1974. According to this Act there are three defined types of Protected Areas: National Parks, Wildlife Sanctuaries and Game Reserves.

The National Park is defined as "comparatively large areas of outstanding scenic and natural beauty with the primary object of protection and preservation of scenery, flora and fauna in the natural state to which access for public recreation and education and research may be allowed".

The Wildlife Sanctuary is defined as "an area closed to hunting, shooting or trapping of wild animals and declared as under Article 23 by the Government as undisturbed breeding ground, primarily for the protection of wildlife, inclusive of all natural resources, such as vegetation, soil, and water".

The Game Reserve is quite similar to that of Wildlife Sanctuary except for the provision of hunting permit., and is defined as "an area declared by the Government as such for the protection of wildlife and increase in the population of important species wherein capturing of wild animals shall be unlawful".

In recent years, the Forest Department has declared a number of sites as "Eco-Parks" and "Safari Parks". Although these declarations have no legal basis in the Act, they are distinguished by being smaller in size than the other Protected Areas and generally organized and managed to support recreational visitation rather than conservation. The one Safari Park (at Dulahazra north of Cox's Bazar) includes a collection of different wild animals kept in relative large enclosures.

In light of continued loss of forest habitat throughout the country, the Forest Department has in recent years experimented with modified approaches to management of Protected Areas. The Department's Nishorgo Program for Protected Area Management, created in 2003, has shifted the historical emphasis on exclusive Government control of Protected Areas towards an active engagement with local and national stakeholders. At five pilot sites, the Department has been testing "collaborative management" models and a wide range of complementary activities, including ecosystem restoration, nature interpretation, key species monitoring, support to conservation enterprises and more. The program has received financing principally from the Government of Bangladesh and United States Agency for International Development, with additional support provided by the German Agency for Technical Cooperation and the Asian Development Bank.

Using birds as bio-indicators, systematic monitoring and evaluation indicate that the conditions of forest understories have improved. Although evidence indicates that illegal felling has slowed, it has yet to be stopped. Moreover, there is a positive change in the mindset of the local communities regarding conservation, primarily thorough their involvement in "Co-Management Councils" which are now legally recognized and formally engaged in management decision-making, as well as through their involvement in the form of patrolling, working as paid nature guides and other activities.

Today, there are 19 Protected Areas and 6 other conservation sites in Bangladesh with a total area of 252,835 ha or 2,528.35 km^2, covering only 1.7 percent of the total area of Bangladesh. All these Protected Areas are forests or bushy and bamboo-covered area under the jurisdiction of the Forest Department, despite the fact that there area many rich wetlands in the country that require legal protection. Notably, the Government has declared Hakaluki Haor (in northeast), Teknaf Peninsula (in far southeast), St. Martin's Island (in far southeast) and a few other areas as Ecologically Critical Areas. The legal protection, however, does not necessarily ensure actual protection, but one big step on the road to protection.

The existing Protected Areas are the remnants of luxuriant natural forests that once existed and serve as the last strongholds of most of the charismatic wildlife of the country. Sadly, however, most of the Protected Areas are very small and disturbed, with in sufficient management. These areas must be protected from further degradation and initiatives should be taken to improve the health of the wilderness and biodiversity.

Bangladesh is also managing about 85,000 hectares of wetlands and more than 44,000 hectares of ecologically critical areas (ECAs) as Protected Areas. Wetlands and ECAs represent an important expansion of Bangladesh's PA system, especially with regard to addressing food security and Global Climate Change Adaptation. Managing wetlands as protected areas ensures that vast wetland areas stabilize surface water flow, reducing incidence of flooding in the wet season and storing water deep into the dry season. Moreover, protected wetlands result in increased fish catch for communities dependent on wetlands for their livelihoods. ECAs help buffer against natural disasters, providing sizable PAs to absorb the shock and thus lessen the impact of cyclones and floods. Details of the Protected Areas ,Wetlands and ECAs are given in Table 1. Fig. 1 portrays the locations of these Areas in the map of Bangladesh.

Table 1. Bangladesh's Protected Areas as of November 2010

No.	Protected Area	Habitat Type	Location	Area (Ha)	Established (Extended)
A. National Parks					
1	Modhupur NP	Sal forest	Tangail/Mymensingh	8,436.13	1962 (1982)
2	Bhawal NP	Sal forest	Gazipur	5,022.27	1974 (1982)
3	Himchari NP	Hill forest	Cox's Bazar	1,729	1980
4	Lawachara NP	Hill forest	Maulvibazar	1,250	1996
5	Kaptai NP	Hill forest	Chittagong Hill Tracts	5,464.78	1999
6	Ramsagar NP	Sal forest	Dinajpur	27.75	2001
7	Nijhum Dweep NP	Mangrove	Noakhali	16,352.23	2001
8	Medha Kachapia NP	Hill forest	Cox's Bazar	395.92	2004
9	Satchari NP	Hill forest	Habiganj	242.91	2005
10	Khadimnagar NP	Hill forest	Sylhet	678.80	2006
11	Baryadhala NP	Hill forest	Chittagong	2,933.61	2010
12	Kadigar NP	Sal forest	Mymensingh	344.13	2010
13	Sinra NP	Sal forest	Dinajpur	305.69	2010
14	Nabab Gonj NP	Sal forest	Dinajpur	517.61	2010
15	Kuakata NP	Mangrove	Patuakhali	1,613	2010
B. Wildlife Sanctuaries					
11	Char Kukri-Mukri WS	Marine, Intertidal	Bhola	40.00	1981
12	Rema-Kalenga WS	Hill Forest	Hobigonj	1,795.55	1981 (1996)
13	Pablakhali WS	Hill Forest	Chittagong Hill Tracts	42,087.00	1983
14	Chunati WS	Hill Forest	Chittagong	7,763.97	1996
15	Teknaf WS	Hill Forest	Cox's Bazar	11,614.57	1983 (2010)
16	Sundarbans East WS	Mangrove	Bagerhat	31,226.94	1996
17	Sundarbans West WS	Mangrove	Sathkhira	71,502.10	1996
18	Sundarbans South WS	Mangrove	Khulna	36,970.46	1996
19	Fasiakhali WS	Hill Forest	Cox's Bazar	1,302.43	2007
20	Hazarikhil WS	Hill Forest	Chittagong	1,177.53	2010
21	Dudpukuria Dhopachari WS	Hill Forest	Chittagong	4,716.57	2010
22	Sangu WS	Hill Forest	Bandarbon	2,331.98	2010
23	Tangragiri WS	Mangrove	Barguna	4,048.58	2010
D. Wetland PA					
24	Hakaluki Haor	Wetland	Moulvibazar	18,383	1999
25	Tanguar Haor (Ramsar)	Wetland	Sunamgonj	9,727	1999
26	Marjat Baor, Jhenaidah	Oxbow Lake	Jessore	200	1999
27	Gulshan-Baridhara Lake	Urban Wetland	Dhaka		2001
28	Hail Haor		Moulvibazar	3,000-12,000	
29	Baikka Beel (sanctuary)	Wetland	Moulvibazar	100	2003
E. Ecologically Critical Areas (ECA)					
30	Teknaf Peninsula	Sandy Beach	Cox's Bazar	10,465	1999
31	Sundarbans (10 km periphery buffer around the forest)	Mangrove			1999
32	St. Martins Island	Coral Ecosystem	Cox's Bazar	590	1999
	Hakaluki Haor	Wetland	Moulvibazar	18,383	1999
33	Sonadia Island	Sand Dunes	Cox's Bazar	4,916	1999
	Tanguar Haor (Ramsar)	Wetland	Moulvibazar	9,727	1999
	Marjat Baor, Jhenaidah	Oxbow Lake	Jessore	200	1999
	Gulshan-Baridhara Lake	Urban Wetland	Dhaka		2001
34	Rivers (Buriganga, Turag, Sitalakhya and Balu) around Dhaka city	River			2009

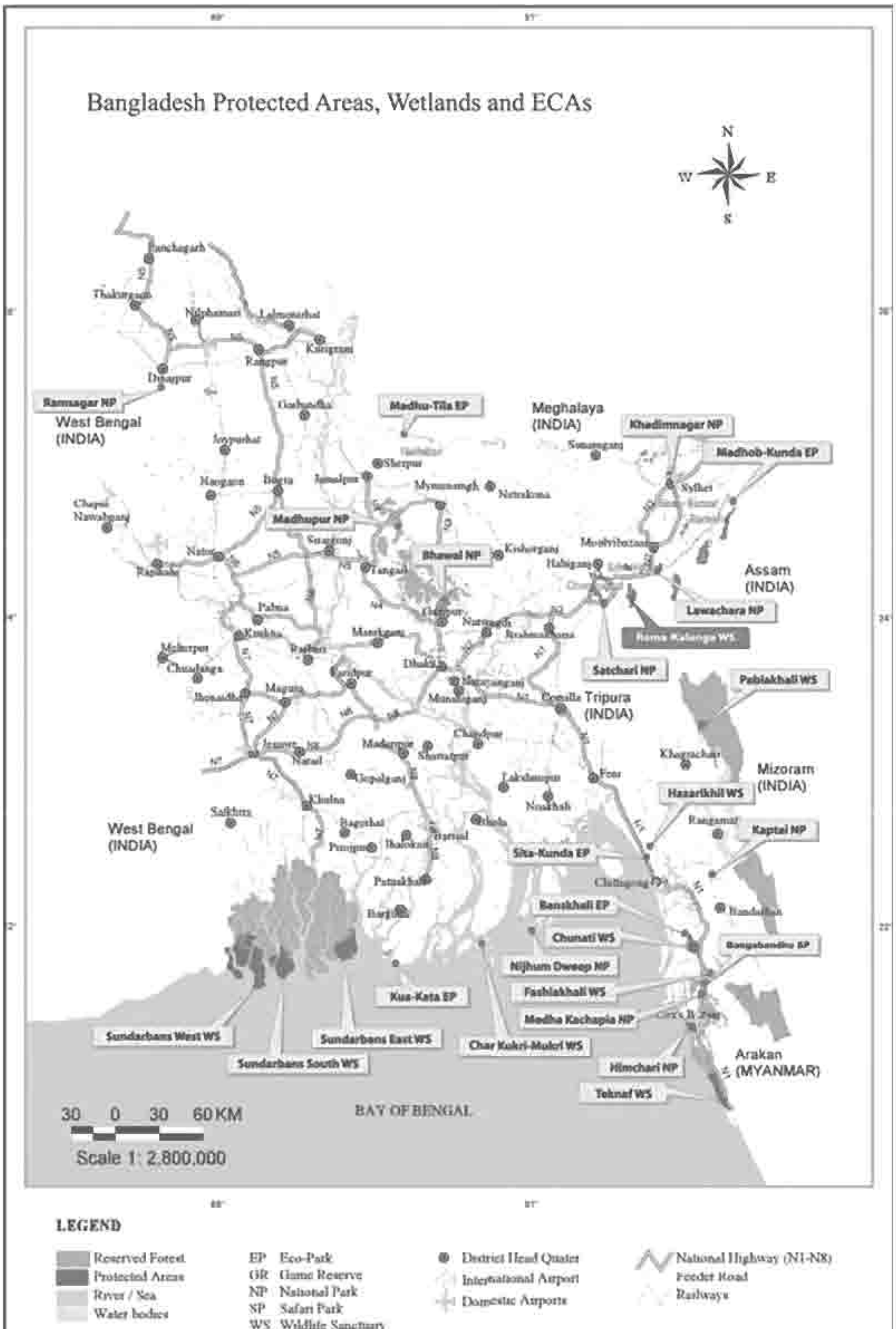


Fig.1. Locations of Protected Areas, Wetlands and ECA in Bangladesh

The types and area of types of Protected Areas in Bangladesh is given in Table 2.

Table 2. Types of Protected Areas in Bangladesh, and Area per Type

Type of PA	*Targeted ecosystem*	*Number declared*	*Estimated Area (ha)*
National Parks	Forests, wetlands, mangrove	15	45,313.83
Wildlife Sanctuaries	Mangrove, char, forest	13	216,577.68
Ecoparks, Safari Parks, Botanical Gardens	Mixed evergreen, high hill and deciduous forest	7	5,202
Fish Sanctuaries	Wetlands, open water bodies, rivers	Over 300	85,000
Ecologically Critical Areas	Mangrove, beach, corals, wetlands, rivers	12	44,281
Community Conserved Areas	Forested catchment areas, wetlands	Over 100	5,000-10,000
Total		400-500	300,000 – 350,000

Protected Area Management Challenges and Opportunities

Bangladesh's Protected Areas present a paradox. A well-managed Protected Area system can contribute to the long-term and sustainable development of Bangladesh while simultaneously providing safe-guards and buffers to negative impacts of food security and Global Climate Change. In many respects, Bangladesh's future rests on managing densely populated rural landscapes as mosaics integrating protection and rehabilitation of Protected Areas to safeguard ecosystem functions and environmental services with sustainable utilization of adjacent agricultural land and wetlands.

Bangladesh's PA Threats Assessment

The main drivers threatening Bangladesh's Protected Areas are *high population and poverty*. Resulting from this is lack of access to land or employment opportunities; as well as lack of access to affordable building materials and cooking fuel.

Additional drivers include lack of *government financial and human resources* to adequately manage the current and expanding Protected Area system. Government budgets are limited, often prioritizing more immediate challenges in disaster relief or health services delivery. Poorly resources staffing is inadequate to effectively manage large, often remote Protected Areas.

Increasingly, *Global Climate Change* is a main driver threatening Bangladesh's Protected Areas. Sea level rise and increased salinity is likely changing the habitat structure of the Sundarbans mangrove forest, drawing more salt-tolerant tree species deeper inland. Increased incidence of cyclones and other natural disasters is leading to more significant tree loss and subsequent vegetative change. Change in temperatures and rainfall seasonality is likely impacting forest and wetland flora and fauna resources, exacerbating the negative impact of ongoing PA encroachment and weakening the resilience of PA ecosystems to adapt and bounce back.

There are a number of secondary drivers associated with the primary drivers threatening Bangladesh's PA system and thus Bangladesh's ability to ensure food security and adapt to Global Climate Change. This includes but is not limited to lack of awareness, lack of clear tenure for forest-dependent communities, and various limitations on government to effectively manage a sprawling and often isolated PA system. Yet addressing secondary drivers without addressing the underlying primary drivers is inefficient in the short-run and ineffective in the long-run. Only by addressing primary drivers as they relate to Bangladesh's overall development and Global Climate Change strategies can Bangladesh's PA system contribute resilience, sustainability and adaptation.

Co-Management: Turning Threats into Opportunity

Co-management provides Bangladesh the single greatest opportunity for effectively managing an expanding PA system in a manner that contributes significantly to resilience-based development, food security and Global Climate Change adaptation and mitigation. Co-management offers a management paradigm that harnesses the primary drivers currently threatening the conservation of Protected Areas and turns them into our greatest resources for success.

Most fundamentally, co-management shares management responsibilities and rights for the conservation of Protected Areas between key stakeholders that include government agencies at various levels, communities dependent on PA resources for their livelihoods, and other private sector, university and NGO institutions that have a stake in the management and/or resources of a specific Protected Area. Taking a landscape approach, co-management stakeholders work together to manage a broad landscape for integrated conservation and sustainable development objectives. Protected Areas are managed as core conservation zones, with management activities limited to ecosystem and environmental services conservation, rehabilitation, restoration, and sustainable natural resources management. Broader landscapes adjacent to and beyond Protected Areas are managed for low-emissions based sustainable development based on the intensification of agriculture, fisheries, agro-forestry and other sustainably-managed value chains.

Key to effective co-management in Bangladesh is the rapid and significant demonstration of livelihoods benefits for poor people living adjacent to and dependent on forest and/or wetland Protected Areas. Such benefits can be financial, including sustainable development initiatives based on the intensification of economic activities in the landscape beyond the Protected Area. Financial benefits can also be based on effective conservation and restoration of Protected Areas, through ecotourism development or social forestry critical land restoration. Benefits are also generated from improved and enhanced environmental services from conserved Protected Areas. This includes increased fish catch from around wetland PAs, improved access to stabilized water resources from well-managed forest protected areas, and sharing of payments for environmental services possibly from carbon sequestration and water resource management. Many economic benefits of PAs may not be accrued for many years to come. Importantly, given the extreme level of poverty in Bangladesh, effective co-management requires the demonstration of economic benefits today as we build the momentum for more and broader based benefits tomorrow. Without demonstrating meaningful benefits today, we will lose the opportunity to reap greater rewards tomorrow.

Co-management mobilizes a cadre of PA managers that far exceeds the capacity of government, and also necessitates government changing its approach to interacting with PA stakeholders. While enforcement must continue, government can draw on community patrol groups to strengthen numbers in the field and lessen the financial and human resource burden. Government must also re-orient human resources toward a more significant role as facilitator. Government leadership in co-management requires the ability to clearly communicate a vision for shared conservation and development, and then the skills to facilitate this. The co-management paradigm requires significantly less management of natural resources and significantly more management of people.

Co-management can clearly address the primary drivers threatening Bangladesh's PAs today, turning threats into opportunities. It mobilizes the rural poor to become partners, thus reducing strain on government budgets. Implemented at a landscape level, incorporating PA conservation with low emissions development in the buffer areas, it contributes to Global Climate Change adaptation and mitigation.

Just as there are many secondary drivers threatening Bangladesh's PAs, there are many secondary drivers that will enhance conservation of these PAs. Awareness campaigns will raise interest in and commitment to effectively managed PAs. Addressing land tenure issues in forest and wetland PAs will strengthen the sense of ownership among stakeholders. Yet these secondary drivers cannot have sustainable impact without fully embracing co-management as a means to mobilize the poor, demonstrate immediate economic benefits of integrated conservation and development to the, offset human and financial resource demands from the government, and integrate global climate change adaptation and mitigation into a landscape-based approach to PA conservation.

Bangladesh Nishorgo Protected Area Network Action Plan

This national integrated PA network is based on five main *pillars*:

- *National-level policy framework* that formally establishes a comprehensive network of forest, wetland, marine and other PAs as a centerpiece of the national sustainable development strategy; harmonizes policies amongst various government agencies to most effectively support integrated PA co-management; and communicates the significance of integrated PA co-management to long-term sustainable development;

- *Landscape-based co-management of forest, wetland and other PAs* based on low-carbon development plans that integrate PA conservation with sustainable livelihoods development of poor people living adjacent to and dependent on PA resources;

- *Institutional strengthening and human resource capacity building* to strengthen effective co-management of PAs. This includes but is not limited to the effective facilitation of co-management activities that lead to conservation of PAs, low carbon development for poor people living adjacent to and dependent on PA resources, and elucidation of the significant role of a PA network for national sustainable development. This also includes the facilitation of Public-Private Partnerships (PPPs) to leverage additional financial, in-kind and technical resources required for effective PA conservation co-management;

- *Monitoring and evaluation* to support adequate selection of PAs in the national network, and then to ensure that environmental, economic and social objectives are being adequately met, especially in light of expected changes due to climate change;

- *Sustainable financing* to establish, grow and manage a robust PA network. This includes financing for co-managed conservation of PAs, low-carbon development initiatives for the poor living adjacent to and dependent on PA resources, and public outreach to build national-level awareness of and commitment to Bangladesh's PA network. It requires an integrated financing approach to include GoB budget allocations, donor support, and alternative conservation financing generated from Payment for Environmental Services (PES), especially water and carbon, as well as various user fees, debt-for-nature swaps, etc.

Specific action plans for each of these pillars are as follows:

Enabling Policy and Legal Framework

- PA policy assessment identifying gaps in policy and related legal framework, especially related to types of PAs, co-management principles and an overall, integrated PA system.
- Policy harmonization review, ensuring the national PA strategy synergizes with related national strategies most notably dealing with food security and Global Climate Change
- Development of national PA policy statement embracing the establishment of a national integrated PA system based on co-management and sustainable land-use including forest, wetland and ECAs, and focused on supporting food security as well as GCC A&M, and in line with the relevant international conventions to which the GOB is signatory.
- Establishment of national-level PA co-management board/council/oversight committee under the leadership of the Prime Minister and with representation from relevant government agencies and civil society organizations in order to ensure inter-sectoral and inter-departmental coordination for policy implementation.
- Roll-out national Nishorgo Network communications campaign to build awareness of and support for Bangladesh's integrated PA network.

Landscape-based Co-Management of forest, wetland and ECA Protected Areas

- Integration of PA conservation management within broader sustainable development planning including their contribution in food, water and environmental security.
- Facilitation of on-going landscape-based co-management planning and field implementation initiatives in existing PAs, focusing on achievement of significant economic benefits to poor community dependent on PAs based on conservation-linked value chain and livelihoods interventions.
- As representatives of selected biogeographic regions, declaration of suitable forests and wetlands as PAs and identification of their multi-use interface landscape zones and buffer zones for co-management with neighboring community.
- Identification of corridors that link the country's comparatively small PAs and declaration of such corridors as ECAs in order to provide adequate protection for ensuring their long-term conservation values.
- Expansion of co-management of PAs through a strategic and systematic expansion of co-management into newly-declared PAs and under-represented PAs.
- Mobilizing local community including women by following the approved co-management approach and providing for their sustainability through capacity building, capitalization and sustainable financing including revolving funds.
- Naturally regenerating degraded forests and wetlands PAs in gainful partnerships with the local community by equitably sharing benefits that will accrue as a result of enhanced productivity of restored ecosystems.

Institutional Strengthening and Human Resource Capacity Development

- Based on sectoral reviews, strengthen capacity for PA co-management possibly through establishment or redeployment of PA wings/divisions in the concerned departments for ensuring strengthened staff recruitment, posting, performance review and promotion, and implementing in-service refreshers courses on PA co-management and conservation biology.
- Prepare and implement Institutional Development Frameworks to guide and measure progress on profound institutional changes required at the national level in government agencies and at the PA site-based level for co-management organizations.
- Prepare and implement human resource training programs for government officials to build skills in facilitation and people-management, and for NGOs and community partners on co-

management, low emissions conservation and development, and global climate change adaptation and mitigation.

- Biannually prepare a PA status and performance report that will be presented to the national parliament for national debate and consequent corrective measures.

Monitoring and Evaluation

- Prepare and implement a comprehensive monitoring and evaluation protocol that measures and provides guidance toward resource allocation to achieve environmental, social and economic objectives of PA co-management.
- Prepare and implement site-specific participatory monitoring protocols that measure and provide guidance for understanding and responding to impacts of Global Climate Change.

Sustainable Financing

- Prepare and implement a PA co-management sustainable financing plan that integrates efficient use of on-line government budget with an integrated alternative conservation financing strategy that leverages donor resources, debt-for-nature swaps, forest-carbon financing, payment for environmental services, user fees, and public-private partnerships.
- Develop a national strategy and pursue on-going forest-carbon financing opportunities for Sundarbans, Chunati and 'bundled' PA conservation and reforestation.
- Conduct economic valuation studies for each of the co-managed PAs in order to assess their potential contribution to the society in general and the neighboring community in particular.
- Bring maximum number of PAs under co-management and implement the approved entry fee guidelines for community benefits sharing in all the co-managed PAs
- Develop suitable guidelines for generating revenue and ensuring community benefits sharing from carbon credits from the co-managed PAs.

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Annex 1:

Modalities of Nishorgo Network:

1. Name and Status of the Network

- Name
  The name of the network is "Nishorgo Network"

- Status
  This is a regional and national network of Co Management Organizations (CMO) which are representing the Protected Areas working in (forest, wetland and ECA) in Bangladesh to support bio-diversity conservation.

2. Objectives of the network

- To serve as an apex body of the CMOs for the enhancement of knowledge and awareness of the forest, wetland protected areas and ECAs.
- To encourage regional cooperation and collaboration among CMOs and other organizations working for conservation;
- To promote/develop cooperation with government agencies to receive support for bio-diversity conservation;
- To link and liaise with donors and international bodies to receive fund or donation for conservation and community benefit;
- To gather experiences from other countries through collaborating with the organization working for the same purpose;
- To develop and maintain wide relation with academics, researchers and students for research purpose;
- To organize lectures, meetings, seminars, workshops and conference on issues related to protection and conservation;
- To maintain a website for benefit of PAs;
- Publish booklets, brushier, and other promotional materials for enhancing bio-diversity conservation;

3. Principle of network

- Conservation focused
- Collaborative management or co management
- Pro-poor

4. Membership

- Co management organizations working for bio diversity conservation in forest, wetlands and ECAs are the member of the network.
- Membership is voluntary and must submit an application to the network.
- Members should have the commitment to the objectives of the network,
- Membership shall be terminated for breach of conduct or for acting against the principle and interest of the network.
- President of CMOs will represent their organizations.

5. Rights and responsibilities of members

- To take part in event organized by the network
- To vote in elections, be elected, to official bodies of the network
- To contribute through opinions and comments to the work carried out by the network

- To promote and maintain reputation of the network
- To help the network to accomplish the activities decided by the general council or executive committee
- To help the network to achieve the objectives decided earlier by the general council
- To share the best practices of individual member with other members

6. Structure and Governance

- The network will consist of –

a) An central apex body – to organize and manage all activities under the aegis of the network as well as monitor and coordinate the activities of all regions/clusters created under its jurisdiction
b) Regions/clusters body created and managed by local members of the network

6.1 At the central level, the organizational structure of the network shall comprise of the following:

- The general council
- The executive committee

6.2 The general council

- The general council is the highest official body of the network and is composed of all the members of the network – both at large and regional/ cluster members. A minimum of two-third of all members coming together at one particular time shall constitute a quorum. All duly registered members of the network have the right to vote at a general meeting.
- The General Council will meet once in a year, normally as part of Annual general meeting. Notice of the General meeting will be served at least one month in advance by the President and Secretary of the Network.
- A special/extra ordinary GM could be convened at the request of two-third members of the General Council. Notice of the special/extra ordinary meeting shall be serves at least two months in advance.
- The President of the Executive Committee or in his /her absence Vice- President shall preside all sessions of a GM.
- Any issue shall be decided by simple majority of the votes cast in GM with the president abstaining. In case of a tie the President has the casting vote.
- To audit the finance of network two auditors shall be selected by the general Meeting. At least once in a year the accounts of the network shall be audited. An auditor's report shall be presented at the General meeting. Members' of the Executive Committee are not eligible for selection as auditors.

6.3 The executive committee

- An Executive Committee will be formed to administer day to day activities and administrative affairs of the network.
- The Executive Committee shall consist of
- President
- Vice president
- Member Secretary
- Joint Secretary
- Treasurer
- 5 Members
- One representative from each region/cluster

Two Third of the EC members shall constitute a quorum

- The members of the executive committee shall be elected by the votes of members in GM.
- Members of the EC shall be elected for three years term. Re-Election is possible but only for two terms. After two terms new members will be elected for EC.
- There shall be at least quarterly meeting of the EC or whenever needs arises. Place and date will be determined by Member Secretary in consultation with President and at least one month notice will be served to each members of the EC. EC members are entitled to participate in and vote at the meetings of the EC.
- The day to day activities will be dealt by the Member Secretary with help of other EC members.

6.4 Election of the office bearers

- The Members of the General Council shall elect the members of the Executive Committee. The five members of the EC must come from different regions/clusters. Regional/Cluster network will elect one person for regular position of EC. The EC members will elect office bearers of the EC.
- The President of the EC will serve as president of the General Council.
- All members of EC shall be elected for three-year-term. They shall be eligible only for second term re-election.
- If there is vacancy arises in EC before expiration of a member's term, EC has the power to fill the vacancy by co-option.
- The Member Secretary shall keep the records of proceedings and the treasurer shall keep the book of accounts.
- The main tasks of the EC are:
- To determine the activities of the network;
- To implement the daily activities of the network;
- To prepare the report of the activities for General Council;
- To prepare a activity plan with budget;
- To maintain contacts with Regions/Clusters;
- To liaise with donors, Government Agencies and other stakeholders;

7. Region/Cluster network

- The CMOs situated in the same region/cluster shall form a Region/Cluster network.
- President and Member Secretary of each CMO will be the member of the Region/Cluster network.
- The region/cluster network shall keep the executive committee informed of all their activities and will work with close collaboration of the EC.
- Each region/cluster network shall be free to prepare their activity plan and budget, raise fund for implementing the activities.
- A minimum of two-third of all members coming together at one particular time shall constitute a quorum.

8. Financial management

- The Network is an independent legal entity that finances its activities through membership fees as well as donation/grant from Government and other donors.
- There shall be a bank account in national bank of the Network; President, member secretary and Treasurer shall be the signatory of the account. But any two of the signatory can draw an amount from the bank with the decision of Executive committee.

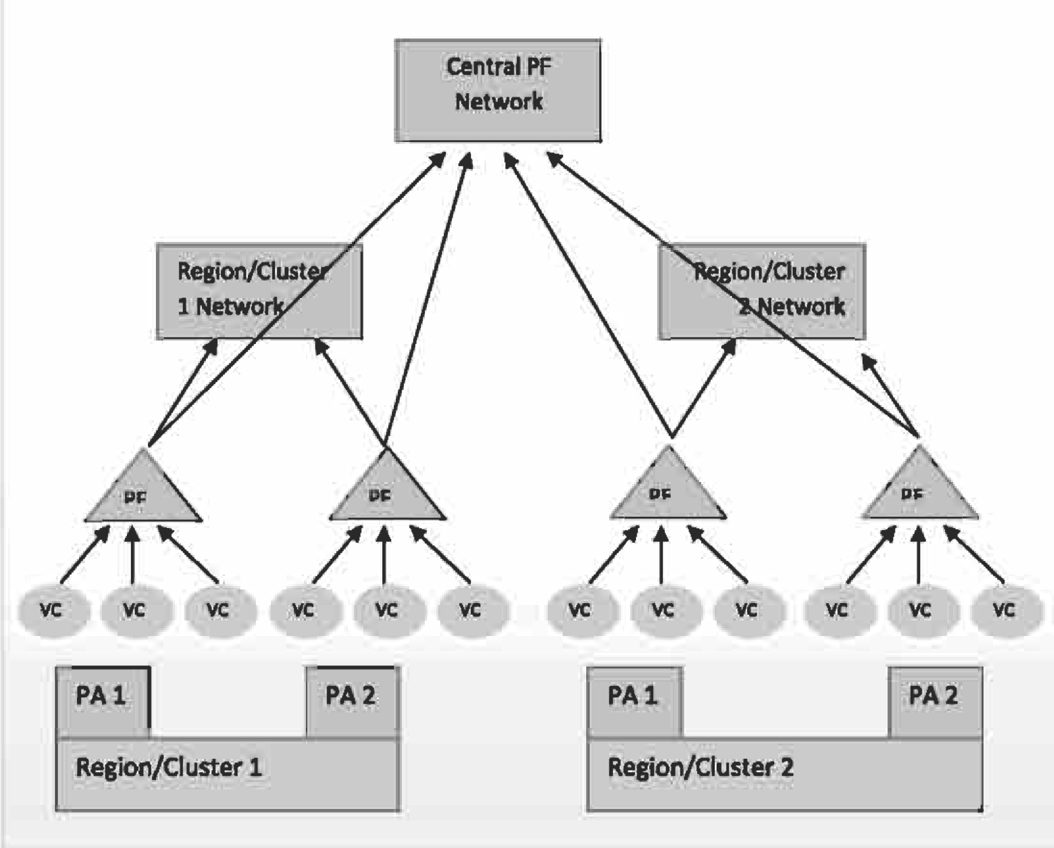
9. Dissolution of the network

- The termination of the existence of the Network shall result from a motion to that affect by the General Council being passed by a two-thirds majority of all members.

10. These rules may be amended by a two-third majority of members in a general meeting, due notice of the proposed amendment have been given to all members at least six weeks in advance.

At the same time, IPAC has organized the poor and ultra poor resource users through Village conservation and peoples Forum. Peoples Forum is the platform of the poor and ultra poor resource users living in and around the protected areas. These people have no voice in conservation and decision making forum for conservation. Hence, Peoples Forum will play the role of VOICE (Villagers Opinion for Integrating Conservation and Economic improvement) of poor in conservation. They also need to be united through apex body to raise the VOICE loudly and strongly. The modalities would be redesigned later on. (The diagram is attached as annex)

Diagram 2: Modalities of Nishorgo Network



Challenge of Forest Law Enforcement in Bangladesh with Special Reference to Proposed Inani National Park

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Abstract

Crime is a part of the forest setting. Crime and acts of violence make the work of forest managers more hazardous and jeopardize the safety of forest resources and wildlife. To understand and respond appropriately to current and future needs of the Forest Department to address issues related to crime and violence on forests and wild lives, it is important to interact with the stakeholders. Specific research objectives were to- gather information on what crimes are occurring, the extent of crimes, and the impacts they have on forest land management .In this study focus group discussions were applied and interviews of key informants were conducted for data collection. The study was carried in Inani National Park during July to December 2010. The Inani National Park and adjoining forest area (12,000 ha) is manned by only 18 forest guards /foresters (of which 30 percent are physically unfit) to enforce forest law against forest illicit, wild life poaching and forest land encroachment distributed into 8 Forest Beat . On average, 2,000 law breakers enter into the forest of which only 1(one) is recorded by the Forest Department .The department cannot make significant number of arrests and very unsuccessful in prosecution of forest offences. Given this situation coupled with lack of public respect in FD, lack of ownership and participation of police, administration and politicians, lawlessness is the order of the day in the forest area. To reverse the situation strengthening Forest Department capacity is imperative towards successful forest law enforcement to ensure forest conservation.

Key words: Forest crime, Forest law enforcement, Forest conservation

Introduction

Crime is a part of the forest setting. Crime and acts of violence make the work of forest managers more hazardous and jeopardize the safety of forest resources and wildlife. To understand and respond appropriately to current and future needs of forestry, it is important to closely interact with the forest officers, police officers, magistrates and politicians who are most closely associated with those issues in order to mitigate the problems related to crime and violence on forests and wild lives.
, One objective for conducting this study was to supplement the needs of Forest Department's (FD) initiative for Protected Area (PA) management. As a consequence of poor budgets and competing demands for Annual Development Plan, the FD is not adequately equipped to demonstrate its accountability to the Government and the general public. Nevertheless the FD must be accountable for its level of performance. Under the aegis of credibility through Performance Audit, FD Law Enforcement should be tasked with developing and implementing performance outcome measures. This is the first study of its kind needed to address the law enforcement performance of Bangladesh FD.

Research on national forest crime is totally absent in Bangladesh. In USA, research efforts focused on vandalism (Christensen and Clark ,1978). More recently, Munson (1995) noted problems such as the dumping of garbage and toxic chemicals, vandalism, marijuana cultivation, and timber thefts in the forest. Marosi (1999) found that national forests were being used as a dumping ground for murders committed elsewhere, especially in urban-proximate forests . Pendleton (1996) found a 100-percent increase in national forest crime from 1989 to 1992. Chavez and Tynon (2000) reported on crime in a study conducted at eight USFS sites in four USFS regions. The kinds of crime taking place at these sites were sorted into the following crime categories: urban-associated crime,assault , drug activity ; and takeover or violence perpetrated by members of extremist and nontraditional groups . Later research at other USFS sites lent support to those findings (Chavez et al. 2004, Tynon and Chavez 2006).

In Bangladesh, offence registrar, maintained at Forest Beat Office/Forest Range Office/Divisional Forest Office, remains the only available source of crime statistics of the forest; but it does not capture all the crime or incidents that are occurring. The crime or incident data collected by non-FD law enforcement personnel are not specifically entered to the register. Therefore, survey to obtain incomplete records of actual crimes was incorporated in this study . Research in USA suggested that officers with several years of on-the-job experience might best know about crime and how crime and incidents have changed over time.

Specific research objectives were to:

- To gather information on what crimes are occurring, the extent of crimes, and the impacts they have on forest land management
- To ascertain whether acts of crime and violence are changing, and if so, why
- To determine the impacts of crime and violence to forest conservation

Methods

The study was carried out in Inani National Park(proposed) Focus group discussion , key informants' interview and field visit were conducted for data collection. Ten focus group discussions (FGD) were carried out with forest dependent peoples/village conservation groups. Participants as key informant (KI) included 10 forest beat officers, 2 forest range officers, 10 forest guards, 10 forest malies, 10 forest village headmen, 5 police sub-inspectors and 1 police inspector as officer in charge (OC)of Ukhia Thana, The Upazilla Nirbahi Officer (UNO), the Upazilla Chairman, 10 political leaders (treasury bench and opposition), 10 civil society members were also interviewed . Face to face interview througha semi-structured questionnaire was made between July to October 2010. The questionnaire consisted questions, both closed- and open-ended, seeking information about crime and violence that had occurred within the past year on each respective administrative unit. Four questions measured experience levels of respondents. Specifically, the respondents were asked about their tenure in law enforcement , FD, or as government officers, and also tenure at their current duty station. Questions were focused on respondents' areas of responsibility , the number of acres the respondents normally patrol as well as the number for which they're responsible, the patrol setting and the number of incidents in which they were personally involved. They were also asked to characterize their most common public contacts and to describe how they communicate with others in the FD.

A series of information related to enforcement levels on an average day was collected . This included questions about cooperation with other agencies and groups and perceptions about the adequacy of that coverage. Questions also addressed on perceptions about authority and jurisdiction as well as resources necessary to do the job. Questions that focused on respondents' roles in the FD were asked as to how their job fits into the FD, what they perceived as their highest priority of work, what they believe on the relationship of FD with the rest of the government law enforcement system, and where FD fits within the organization and programs. To get the information on the issues FD officers deal with, we asked them if different types of crime, law enforcement violations, and other patrol activities had increased, decreased, or remained about the same from fiscal year (FY) 2008 to 2009. We asked FD officers to identify activities that were more common during the week, during daytime hours, or when areas were more crowded. We also asked forest officers if they had ever been threatened or attacked because of their nature of job. We asked two open-ended questions about priorities. In the first, we asked about priority issues facing the law enforcement profession in the FD today.

In another question we asked about the media portrayal of crimes. We used several open-ended questions to identify measures of law enforcement success, including what the orest officers believed to be well effective and what they tried that didn't work. We asked respondents/participants to characterize a successful law enforcement program nationally, regionally, and locally. The final section of the survey contained a number of socio-demographic questions. The forest officers/stakeholders also had an opportunity to add final thoughts.

Results

Forest Law Enforcement Administration

Inani National Park (proposed) is the part of The Ukhiar Ghat Reserve Forest (12,606ha). Forest law enforcement administration is headed by an Assistant Conservator of Forests (ACF) under the jurisdiction of Cox's Bazar South Forest Division. He is assisted by 2 forest range officers (2 Forest Ranger),8 forest beat officers(1deputy ranger/7forester),10 forest guards. The team has been supported by only one age old pick-up vehice and 10 fire arms. So, the mean forest area of a forest beat is 1576ha, which is guarded by 2 numbers of forest personnel. Forest officials now working for Ukhiar Ghat Reserve forest has an average age of 43 years , mean length of service 16.8 years. On an average, they are working in forest law enforcement for about 9.4 years, although their length of service at present duty station is 10.5 months. Thirty percent of the forest personnel working in the study area are not medically fit for forest law enforcement due to ailments such- as heart diseases, diabetes, liver disorder, jaundice, impaired vision, asthma ,etc,leading to inability in walking and running through hilly terrain in the tropical forest. The people who are unfit for working in the hilly forest fall in the age range of 40 to 50 years , and their mean age since joining in the forest department is 20.20 years. The forest area under Inani forest beat and Thain khali forest beat are very large. Forest workforce here, cannot enjoy weekly holiday, they work for 16 hours on average each day. According to them the priority of their work is combating forest illicit and forest encroachment and they extend 100% of their working time in these activities . They cannot enjoy 20 days casual leave they are entitled to in each calendar year. The offices/residential buildings lack basic civic facilities (shortage of water, absence of electricity, and regular maintenance). It is noteworthy to mention that the DFO was stripped of with the authority to evict any encroachment in forest land ,and the authority was then vested with the District Magistrate.

Practice in Forest law Enforcement

Crime preventive measures

According to prevailing norms usually, forest guards and forest villagers (5 to 10 in each group) carry on foot patrol (led by forest beat officer) in the forest in day time. However, they also go on road patrolling during night .Night patrolling into the forests have remained absent totally for the last five years. Forest officers go on patrolling the roads to check movement of forest products. It is found that one beat office can organize 2 patrol team each day; compared to the need for 8 patrols, opined the forest beat officers.

Crime controlling measures

Having information from different sources on stock of illegally collected forest produce/intrusion of armed loggers in the forest/organized attempt to cut trees or conversion of forest land, forest officials submit requisitions for police forces to the Ukhia police station and or nearby boarder outpost of Boarder Guard Bangladesh (BGB). One in every five requisitions for police forces has been responded by the police authority. The police department was unable to send police forces due to busy schedule with their regular duty of law and order maintenance. The statement of the OC of Ukhia police station was supported by Upazilla chairman, UNO and ASP, Ukhia. It is keenly felt that presence of an executive magistrate is necessary for inspection of saw-mills, brick kilns and major market locations, to offset interventions of local elites. Capacity and public respect of FD is so poor that forest department cannot enforce any law provisions without the help of police department. In one very un-fortunate occasion in 2010, the then range officer of Ukhia with 5 staff and 5 forest villagers, tried to stop a jeep loaded with illicit timber. Taking the advantage of absence of police force, The RO was beaten mercilessly by the hoodlums; to the most terrible, one forest staff was hit at the head with lethal weapon while others were injured with various kind of severity. Table-1 gives a summary of FIR/GD lodged with Ukhia Police Station regarding encounters between Forest officers and unruly illicit fellers/ forest land encroachers. During 2010, FD submitted 28 FIR of which only 10 were recorded and others recorded as GD. The KI informants (political leaders, ASP, UNO, Upazilla chairman and forest officers) do perceive that police authority cannot work without the interventions of vested interest group usually coming from ruling party- leading to the triumph of deforestation and forestation. In 2010 FD carried out 42 Taskforce (joint team of executive magistrate, police, BGB and FD) operations in which police participation was available in 15 events. However, BGB participation was remarkably high (27 events). According to FD sources, BGB forces are easy to convince to join in operations to combat breach in forest law.

Table 1 . 2010 FIR/GD/Charge Sheet in INP- 2010

Item	Submitted	Recorded
FIR(first information report)	28	10
GD(general diary)	4	22
Total	32	32
Charge sheet		6

Forest neighborhood characteristics

The Ukhia Upazilla is the poorest in Bangladesh (WFP 2005). Villages in and around the reserve forest has a population of 76,986 consisting of 12,000 households of which 3900 households live within forest covering an area of 1,000ha. Villagers use the reserve forest as grazing ground for 81,468 cattle heads, 1,576 buffaloes and 42,376 goats.

The forest has very easy access by motor able roads from all directions. Through FGD and KI 57entry points have been identified to the reserve forest; of which 20 are water bound and 37facilitated by rural roads developed by Local Government Engineering Department. Fig. 1 shows 32 entry points on the map.popularly used for forest illicit and the villages of origin of illicit wood cutters (annex-1). It is estimated that on average, as many as 2000 people trespass into the forest boundary for a variety of purposes in a normal day. The Upazilla chairman of Ukhia, who is a lawyer, observed that FD has no matching capacity to make deterrence against such a large number of law breakers. The mean number of offender for each beat is about 250 with 7 access points. The wrong doers come from 63 villages, of which 5 are under Teknaf Upazilla. The villages are located on forest boundary to as distant as 20km. People of Pinojir kul, Lombori para, Sonarpar, Folia para, Jalia para, Painnyasia, Nedania, Shaplapur, Shilkhali, Jahazpura travel long distance and avail public transport to reach the access points. However, criminals of Folia para, Horinmara, Modhur chara, Hazir para, Telkhola, Painnyasia, Sonaichari, Chakkata , Madarbunia chakma para, Monkhali chakma para, are violent and commonly use lethal arms against forest workforce. Law breakers entering into the forest, all concentrating into Swankhali beat, Inani beat and Thainkhali beat for cutting trees; and for all forest beats for grabbing forest lands.

Identification of forest crime

Forest related crimes might occur in the forest or outside the forest. The main target point is in the forest as all natural resources like tree or timber or forest produces remain there. Here we are concerned about crimes in the reserved forest. The Forest Act establishes three categories of forests: *Reserve Forest, Protected Forest and Un-classed State Forest* in addition to *Village Forest.* The most restricted category is "reserved forest". Generally speaking, in reserved forests, most uses by local people are prohibited unless specifically allowed by a forest officer in the course of settlement. In the reserved forest crimes may be identified by the forest officials only, as entry of general people is an offence (section 26(1) of the Forest Act 1927).

Usually it appears that the forest officials identify crimes relating reserved forest when they are informed about commission of an offence or when they go for regular patrol duty. In a very few cases (8.9%) the officials are able to arrest the accused persons with the wood and wood cutting tools, and in most of the cases (91.3%) they failed to detect the accused and thus failed to arrest (Table 2). However, of all the offences identified, only one-fourth (24.98%) were detected. All undetected offence reports (UDOR) involve collection of forest products, of which 40% occur outside forest boundary and 60% occur inside the forest.

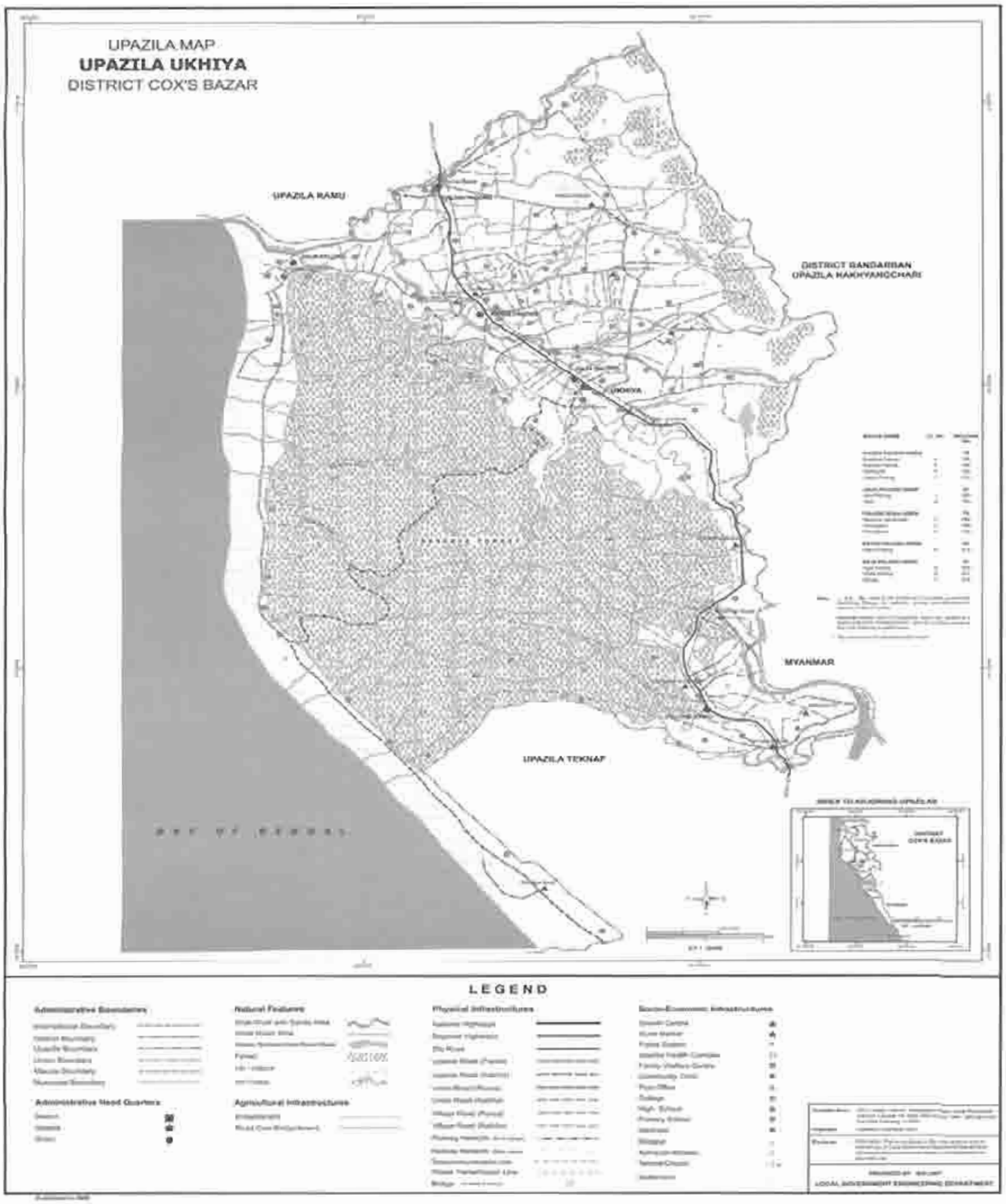

Fig.1. Map of Ukhya Upazila

Table-2. Identification forest offences in INP from 2005-06 to 2010

Year	POR with arrest (no)	POR without arrest (Number)	Total POR (Number)	UDOR (Number)	POR + UDOR (Number)
2009-10	4	96	100	251	351
2008-09	7	46	53	198	251
2007-08	8	49	57	573	630
2006-07	7	86	93	280	373
2005-06	8	80	88	263	351
TOTAL	34	357	391	1565	1956
average	6.8	71.4	78	313	391.2

As per section 52 of the Forest Act, 1927 when there is reason to believe that a forest-offence has been committed in respect of any forest-produce, such produce together with all tools, vessels, carts, or cattle used in committing any such offence, may be seized by any Forest-officer or police-officer, or any other officer authorized in this behalf by or under any other law in force. Analyzing section 52 we find that a forest offence could be detected outside the forest when there is reasons to believe about commission of the offence.

Inquiry/Investigation of a forest offence

Section 5(2) of the code of criminal procedure reads as all offences under any other law shall be investigated, inquired into, tried, and otherwise dealt with according to the same provisions, but subject to any enactment for the time being in force regulating the manner or place of investigating, inquiring into, trying or otherwise dealing with such offences. Section 72 of the Forest Act 1927 reads as government may invest any forest officer with all or any of the following powers, that is to say- 72(d) gives power to hold an inquiry into forest-offences, and, in the course of such inquiry, to receive and record evidence.

It is also stated in sub section (2) that any evidence recorded under clause (d) of sub section (1) shall be admissible in any subsequent trial before a Magistrate, provided that it has been taken in the presence of the accused persons.

Analyzing the provisions stated in the Criminal Procedure Code (CrPC) -1898 and the Forest Act 1927 it appears that in the forest offences there is provision for inquiry by the forest officers when the government permits them in this regard. But there is also scope for investigation when the Magistrate permits them to do so under section 202 of the CrPC.

Filing of a case before the court

After identification and inquiry of a offence , the informant files the case before the court. Section 52 of the Forest Act 1927 authorizes the prosecution officer to submit a report before the Magistrate having jurisdiction to try the forest offences. The report is known as Prosecution Offence Report (POR). For the POR there is a prescribed form, i.e., Bangladesh Form no. 1646 . For the seizure list , there is also a prescribed form ,i.e. ,Bangladesh Form no. 1648. The case is usually filed by the Forest Beat Officer of the concerned beat forwarded by the Range officer, and finally submitted before the court after the due approval of the concerned Divisional Forest Officer. It is written in the form that the case has to be filed within 24 hours of the commission of the occurrence. In the cases of accused caught red handed, the provision is applicable. But in most of the cases the accused are not arrested red handed (Table 2). Table 3 classifies nature of forest offences in INP (proposed) for the last five year. It is observed that around one-third of the POR were related to forest land conversion and encroachment.

Table 3. POR According to nature of offences (2005-6 to 2010) in INP

Item	Forest products collection					Forest land conversion			
	Cutting Tree seedlings	Collection of poles/ timber	Collection of Fuel-wood	Collection of bamboos	Collection of canes	Expansion of occupied plot	Making new plot	House construction	Jhumm ing
number	51	187	101	1	1	40	64	18	6
%	13.04	47.8	25.83	0.25	0.25	10.23	16.36	4.6	1.5
number	341					128			
%	87.17					32.69			

In most of the forest cases the language and pattern of the cases are the same or similar. That is the forest officials have gone for a patrol duty in the reserved or protected forest. Hearing the sound of wood cutting from a certain distance they could identify the location and went towards that location silently and could recognize the accused by their names, father's names and location. When they get close to the accused in order to arrest them, the accused fled away on seeing them. The forest guards ran towards the accused but could not arrest them. Returning to the place of occurrence (PO) they inquired the place and seized the articles fallen down and seized the articles by a seizure list. The accused disappears within the deep forest. The story is continuing over the decades as like as cut and paste just changing the names, addresses and date of the occurrence. The scenario is of such a nature that the offences are happening in the same way over the decades. This is like fairy tales though the actual scenario may be totally different.

The Forest Act 1927 has provided the necessary powers to the forest officials to fight against the offence and the offenders. To prevent forest crime, to protect forest from offenders there is enough provision in the Act. They are treated as public servant. There is provision to arrest without an warrant. According to CrPC the forest offences are cognizable offence, they can investigate forest offences after getting permission from the concerned Magistrate.

Pitfalls in filing: Role of the prosecution officer

While filing forest cases the prosecution officer should keep in mind that the case would go to his higher authority, i.e. Range Office and D.F.O. Then it would go to the court. In the court, it is scrutinized at different times and stages, i.e., at the time of bail hearing, charge hearing, taking evidence, at argument and finally at judgment. At these stages it undergoes different criticisms. So, a prosecution officer should keep in mind that a mistake or lacking or ignorance helps escaping an accused from the case. Thus, he should file the case on acquiring adequate knowledge of fact and related laws. The fact should attract the law and formulate in such a manner that all the legal necessities cover the ambit of law.

In most of the cases the POR is written very carelessly without mentioning the detail names of the accused or mentioning the nick names only. Supporting documents are not attached with the POR. The place of occurrence is a reserved forest but the gazette notification is submitted for the protected forest. The section mentioned by the prosecution officer does not match with that one written by the DFO. The trace map is not drawn properly or drawn to fulfill a duty but not to convict the accused. In the gazette notification the place of occurrence is not identified. In some cases the fact of the case does not cover the ambit of the law. The above lacking creates loopholes for which the accused escapes the convictions.

A prosecution officer should strictly follow the matters stated below while filing a case (Rahman 2002):

- To follow the provisions of the Forest Act, Evidence Act
- To file the case immediately after the commission of the offence
- To inquire a case properly before filing
- To write the proper names of the accused with their detail addresses
- To attach all the supporting relevant documents with the POR

- To mark the p.o. in the gazette notification
- To submit detail sketch map of the P.O. so that it clarifies the p.o.
- To involve local witnesses in the POR.

Role of the FCCO (forest case conducting officer)

Under section 69 of the Forest Act, 1927 the Government may empower any forestofficer not junior a Deputy Ranger to appear, plead and conduct the prosecution on behalf of the Government before any court in any case where a forest offence is under trial.

The FCCO has to play the following roles before the court:

- To maintain a POR registrar
- To oppose the petition for bail by the accused
- To help the court in case of charge hearing
- To produce before the court the complainant and the witnesses
- To pray for time for the witnesses
- To help adducing the examination in chief and cross-examination
- To defence the nervous witness
- To declare a witness hostile
- To argue for conviction of the accused
- To propose for revival, revision and appeal of a disposed of case
- To prefer a petition for transfer of a case
- To prefer for petition for withdrawal of a case
- To seek permission for selling of seized property
- To send copies of order or judgment
- To report the department about absence or hostility of a witness
- To maintain dignity of the court
- To maintain a self culture

In brief the FCCO has to play the role of watchdog regarding the forest cases. It is his duty to be present at every hearing of a forest case, he should note down the problems of a case specifically and then to consult with his superior officers to make up the problem. He has to think that he is the representative of his department before the court. He has to know everything related to forest. To keep up to date information and he should have a good communication skill. Ultimately at the time of criticism of forest department he becomes the main target of lawyers and the court also. For safeguard he should have proper knowledge on law and fact. It is pertinent to mention here that a FCCO should have proper training on conducting cases.

Disposal of POR

The maxim of law is that no innocent person should be convicted. Thousands of people may be acquitted by the loopholes of law but no innocent person should be convicted. The maxim is very much applicable in forest cases where remain many more opportunities for the accused to take the chance of acquittal. Even in some cases where accused are caught red handed in the forest can be acquitted by the help of taking opportunities of the weak prosecution. Again the weakness begins from the very root level to the court also. The prosecution officer to the FCCO, none of them have any practical or educational background or training to give input in order to confirm the conviction of such an accused. It is seen that the R.O and DFO okays the case written by a Forest Beat Officer. There is no special or general interference by any criminal expert. DFO okays as it is written by the Forest Beat officers and FCCO does not look at it, he just submits it before the court. The weakness and loopholes in the cases come out at the time of bail hearing, charge hearing and evidence taking stages. Even in the cases of red handed caught accused, if the case of occurrence becomes confusing or the section quoted is ambiguous, the trial becomes weak. We have to keep in mind the maxim written above. The FD should have special concentration on the cases where accused are arrested on the spot; because in such cases prima facie makes out in every one's mind even the advocate appearing for the accused become mentally weak to fight for an offender who has arrested on the spot with wood cutting weapons and wood have been seized from him. Special case should be taken by every authority. It is pertinent to mention here that for the lack of knowledge on law the forest beat officers write the cases as cut and paste. They hardly write up the actual facts or the true story; rather they write up the same known story. This is also a vital reason because everybody concerned with the court proceedings know the known story of forest department. They can write the true story following some guidelines. Special care should be taken about the time, place and manner which are known as pillars of a criminal case.

Time of occurrence

Regarding the time no confusion usually arises. The offence in forest may be committed at any time. When the offence is identified at night,the source of recognizing the accused should be mentioned.

Place of occurrence

One of the very important differentials is the place where the accused side takes the advantage ,and the prosecution side makes mistakes. The place should be matched with the section quoted. It should be written very clearly that the offence is committed at such places. It is usually written that the place of occurrence is a plantation of 1996 and reserved forest not mentioning how it is declared as reserved and by what gazette notification, that on that reserved a plantation of 20 thousands trees have been established on it and that the accused have committed an offence on such plantation. To confirm that the P.O. is a reserve or protected forest, the gazette notification should be mentioned about. The plot number if any should be mentioned clearly. The phrasing is usually that the offence has been committed in such a place of such a plot number of such a plantation of such year and the place is declared as reserved forest by the govt. by such a gazette notification dated......................, which is attached with the case.

Manner of occurance

Here also comes the same matter, i.e., the common story. Becoming very sincere not to acquit the accused, the FD officials discover a story which is known even by the habitual offenders thoroughly. They apply the story even in the cases of arrested accused. They seldom write the true story.

Reason for failure of the prosecution in maximum cases

Table 4 provides number of POR based on year of submission in Cognizance Court no. 5 in Cox's Bazar, which depicts that on an average 7.7 years have been elapsed since their filing. It is found that in the year 2010, the learned court disposed 35 PORs (Table 5) It took 7.9 years mean duration for disposal of a POR. A closer look into the prosecution process (Fig.-2) reveals that the prosecution side was not successful in case of 20% POR in framing charge against the accused. Large proportion (75%) of the offender obtained release from the court due to absence of prosecution witness, and only a very small percentage (6%) of POR disposed by the court through judgments ended with acquittal of the accused. This means that FD failed totally (100%) to award punishment to any accused.

Table 4. POR in Trial Process with Cox's Bazar Judicial Magistrate Cognizance Court no-5

Year	Number	Waiting period
1991	04	20
1997	09	14
1998	35	13
1999	13	12
2000	28	11
2001	09	10
2002	04	09
2003	03	08
2004	12	07
2005	12	06
2006	14	05
2007	14	04
2008	22	03
2009	42	02
2010	100	01
	Mean	7.7

Table 5. POR Disposed in 2010

Year of Submission	Number	Year Required
1991	3	18
1997	04	12
1998	07	11
1999	06	10
2000	11	9
2001	01	8
2004	02	5
2005	01	4
2008	01	1
2009	00	
	mean	7.9

Steps		Result	No of POR
Filing of POR ↓			
Cognizance ↓			
Ready for trial ↓			
Framing of charge ↓	⟶	Discharged (section 249)	07
Evidence taking ↓	⟶	Released (section 245)	26
Examination of accused ↓			
Arguments ↓			
Judgment	⟶	acquitted	02
TOTAL			35

Fig.1.Prosecution Process

In 90% of the forest cases , the prosecution fails because of the following reasons:

- Lack of care while filing the case by the concerned Forest Beat officer
- Lack of monitoring the prosecution by the higher officials above the Forest Beat Officer.
- Proper knowledge of administration of criminal justice by the forest officials
- Lack of training regarding the prosecution
- Reluctance of the FCCO while conducting forest cases
- Lack of law knowledge of the FCCO and selection of weak officers as FCCO
- Overall carelessness of the forest officials regarding forest cases
- Ambiguity of the existing Forest Act
- Reluctance of court regarding disposal of forest cases
- Lack of inquiry or investigation about the forest cases
- Misconception regarding forest law and rules by the prosecution officers

Discussion

Around the world in rural areas, people collect timber, fuel-wood, canes, bamboos and many others (fruits, tubers, medicines, vegetables) every day (World Resources Institute 2003). For centuries, the great quantity of trees preempted any need for people to control how quickly or how much they harvested. Outlooks changed in areas where overharvesting—driven by population growth, industrialization, and agricultural expansion, among other factors—began turning a renewable resource into an exhaustible one. Case studies tracking peoples' use of forests, from ancient times to the present, reveal that communities making and enforcing conservation-oriented rules tend to survive, indeed thrive, over the long term (Diamond, 2004; Ostrom, 1990).

Unfortunately, in many rural areas around the world, has adequate attention has not been paid to diminution of forests, living condition of forest-dependent peoples, and importance of forest in national and regional economies. There is considerable evidence that unsustainable harvesting of forests is the norm, rather than the exception. Unsound forest management techniques are often coupled with illegal practices in harvesting timber and other forest products. Not all overharvesting is illegal harvesting: bad forest management does not necessarily mean laws are broken. However, the law is broken in many instances, and where we find illegal logging and forest crime, fragile institutions are likely part of the equation. To wit, if forest law inspection is weak—if inspectors are spread too thin or are corrupted—forests are at risk. Similarly, when forest crime is discovered but not prosecuted, or is prosecuted but not sternly punished, illegal loggers and timber smugglers continue to exploit forest resources at unsustainable levels and in contravention of national laws. This is what has been running in government forest of Bangladesh.

In INP, forest workforce has been deployed very thinly to contain forest illicit and forest land encroachment but to no avail. The situation has been made further worst by the fact that powerful people are either patronizing the process or party to it. FGD participants and key informants exposed this fact . They also indicated the role of political families turned dynasty against forest conservation. The non-co-operation of police and district administration as well the conflict with land revenue administration adds fuel to forest conservation.

Forest officers are not always informative about forest crime, nor are detailed crime information readily available to them. Intelligence on illegal logging, forest smuggling, illicit trade, and their impacts are found most frequently in media reports. However the reliability of reports varies .

Forest Depletion and Deforestation

It is revealed that around 2000 people enter into the forest through 57 points every day, illegally. So, according to Section 26 of Forest Act 1927, 2000 offences have been occurring each day. Curiously, FD identified/recorded only one offence each day only during the study period in INP. Due to social resistance and absence of support from elites and other law enforcing agencies, the present ill equipped FD people evade enforcing law provisions against collection of fuel-wood and other NTFPs (mostly as head load and shoulder load) and grazing. However FGD participants have regarded these activities as top most agents of deforestation and forest degradation. It is also learnt from FGDs that armed groups (group 20-100) cut trees during nights and use pit saw within forest. They apprehend presence of pit saw in every charas (17). To sum up, forest of INP can be regarded as guardian less. They also termed the situation as institutional failure of FD. It is estimated that, each day 200 m^3 of wood have been removed which is equivalent to one ha of natural forest. It means natural forest of INP will be lost within next 10(ten) years.

During FGD participants observed that a comparatively few are making gains at the expense of the manyPoor people, who live in and near forests, are also involved in illegal logging. Many of them depend on the forest for their livelihood. In fact, these artisanal scale illegal loggers hurt their own long-term interests by degrading the resource base they rely on (Kaimowitz, 2003). The World Wildlife Fund observes, "While illicit forest practices may be a sole means of survival in the short term, the long-term impacts crippled economic growth and lost public revenues which result in declining health-care, sanitation and education opportunities" (WWF, 2005).

Depletion of forests cause the local communities to suffer and at the same time national interests are put to misery, too. Governments, which are usually the largest forestland owners in developing countries, lose revenues, royalties, and tax receipts that might otherwise fund public services and social wellbeing. On a global scale, the World Bank estimates that, each year, governments lose $5 billion in revenue to illegal logging and another $10 to $15 billion are lost to the economies of developing nations (World

Bank, 2002). The profound environmental, social, and economic consequences of illegal logging were noticeable to many nations by the 1990s, inspiring some donors to invest heavily in forest conservation, particularly in the tropics.

Forest Land Encroachment

It is observed that of all the offences recorded by FD, one-third is related with conversion of forest land to other purposes due to encroachment. 3,900 households live within forest encroached area of 1,000 ha. This investigation made it known that 90% of the encroachers are less than 25 years old. In most of the cases, FD submitted list of encroachers with request to evict the culprits out of forest land. However, the t Magistrates, over the years, have shown commendable reluctance in doing the job.Such reluctance was mainly due to political maneuvering. It is further uncovered that a plot of forest land can be sold/transferred by many: from a forest villager to forest ranger in FD, from a village leader to MP in political ring; and from surveyor to DC in administration.

Ownership and Partnership

According to the critics, the lack of clear regulation and the confusion over coordination lead to the fundamental question of ownership of the forest law enforcement processes. By ownership, it means taking responsibility to realize the objectives of the legal authority given by Forest Act 1927 and taking control over next steps. Agencies such as the DC and the police have been vocal against the inertia of FD to dislodge illicit wood cutters and encroachers. However, not all time show sense of ownership—their commitment may be somewhat hortatory, rather than action-oriented. Fostering ownership is especially important to the extent that this key agencies—both administration and police—are enthusiastic enough to apply their lawful authority in combating forest crime.

Many interviewees observed that it is vital for political authorities to be fully committed. There is no substitute to the resolve the issue by the Minister of MoEF and Secretary of MoEF, MPs and the DC. In recent times, monitoring of anti encroachment drive by the honorable Minister and his phone calls to DC prompted the taskforce operation to prevent forest land encroachment. Ownership can be nurtured by other stakeholders as well. In co-management setting in Teknaf Wildlife Sanctuary, CMC and CPG have been instrumental in creating opinions in favor of eviction of forest land encroachers. Participation of stakeholders does not mean just to attend meetings. They must participate directly to combat this crime. Civil society actors can participate directly in implementation, an approach that offers rich possibilities for public, private, and NGO partnerships

The Way Forward: Forest Crime Management

Crime results partly from the opportunities presented by physical environment. This being the case it should be possible to alter the physical environment so that crime is less likely to occur. Forest Crime Management is a core function of FD. Consequently, a significant proportion of FD resources should be allocated to this output. Crime Management consists of the initial response to crime by forest officers such as the detection of offenders, preliminary investigations, responding to neighborhood watch, the commencement of prosecutions and the investigation of major and serious crimes. Crime Management should also includes crime operations and criminal investigations conducted by specialist police officers.
Evaluation of the studies in USA resulted in identification of key characteristics of success in law enforcement. The key characteristics were:

- force of personalities (i.e., attention to an area depended upon individuals, not on policies),
- adequate resources (i.e., money and people),
- persistence (i.e., planning, consistency, and visibility),
- collaboration (i.e., within the Forest Service and with other law enforcement agencies, with community and volunteer groups, and recreation visitors and recreation clubs), and
- communication (e.g., a communication plan, getting the word out to the public, being reliable and being consistent).

Successful forest crime mitigation characteristics (e.g., force of personalities, adequate resources, persistence, collaboration, and communication) are not "business as usual" for law enforcement—they go beyond the co-operative agreements that already exist. To this end, opinions of KI and FGD participants were asked. Interestingly, all have viewed to increase the personnel capacity of FD in INP and suggested opening of more forest beat units at interval of five kilometers. It was agreed that Swankhali, Inani and Telkhola beat must be divided into two, each beat must be manned with at least 20 armed forest guards headed by a Deputy Ranger and and assisted by 2Forester. There must be one cook and one messenger for each beat. The forest beat administration will always not be able to resist forest land encroachment. To mitigate this problem, a reserve force of 20 members/FGs should be stationed at ACF office at Ukhia. They also suggested for provision of one pick-up vehicle for each forest range office to carry patrol duty at night. The FGD argued that FD must be trained to become capable of dispersing illegal crowd through using teargas shell, inquiry of forest offences and in maintaining intelligence. FD should take necessary action to conduct mobile court and taskforce led by executive magistrates at major market locations (Court bazar, Moricha bazaar, Ukhia, Pallongkhali, Thainkhali). However, availability of executive magistrate can only be ensured if there exists a permanent position of Executive Magistrate for each district within FD's organogram. Regarding prosecution of forest offences, most often forest officers are usually posted as FCCO with no knowledge and training on court process and relevant laws. The FCCO of such stature is a serious mismatch against trained and experienced lawyers of the offenders. As a result FD fails to win the prosecutions. So, FD must initiate a strong training program on law for its officers.

Conclusion

Illegal forest activities in INP have reached at an alarming state and have been the subject of national concern and discussions. Opening of LGED road and marine drive parallel to beach has made the forest very accessible. The marauders come from villages on the forest boundary as well as from far distant villages. The thinly deployed forest workforce cannot establish any deterrence, and forest crimes go unabated. Due to construction of new roads, land price jumped 10000 times compared to 2007. Only a highly strengthened FD can take the challenge of successful enforcement of forest law provisions. Failure to ensure required number of manpower and logistics will result in total loss of natural forest in INP within 10 years.

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Annex-1: List of entry points and villages of origin for forest illicit

Sl no	Name of point/village	No of forest products collector (daily average)	Village of origin	Village Conser-vation Group	Impact deforest ation
1	Musar khola forest office road (Adjacent to Sabbir Ahamed's house)	45	Pallongkhali, bottoli, anjuman para, musar khola, farirbil	Musar khola	**
2	Chitakhola bridge, goialmara road	40	do	do	*
3	Solaiman ghat (pallong khali khal)	120	Pallongkhali, bottoli, anjuman para, musar khola, karontoli,katakhali	do	***
4	End of Jamtoli road	35	Anjuman para, pallong khali, jamtola	Telkhola	*
5	Bagghona, Shafiullah kata road	50	Thainkhali, anjuman para, bagghona, shafiullah kata	do	**
6	Thainkhali-tanzimarkhola road	150	Thainkhali, east rahamaterbil, pallong khali, anjuman para, police beat para	do	***
7	Telkhola bazaar road(chakma para)	80	Tanzimarkhola, thainkhali, rahamaterbil		***
8	Folliapara masjid road	70	Patabari, shailardepha, shilerchara, folliapara, modhurchara	folliapara	****
9	Folliapara school road	85	Patabari, shailardepha, shilerchara, folliapara, modhurchara		***
10	Hazirpara maszid kaborstan road	55	Shikderbil, gururbazar, malvita, gilatoli, taipallong	Khoirati, Dochori	**
11	Khoiratikhal	150	Uallapallong, Kazipara,	Khoirati,	***
12	Khairatikhal-Dochori connecting road		Shikderbill, Gorubazar, malvita, ghillatoli, Taipallong	dochori	
13	Zadimura-hindupara road	55	Jamtoli, bottoli, uttarpukuria, mashiarbil, zadimura	Horinmara	**
14	Upazilla chairman bari road	35	Zadimura, malkachara, baruapara, hindupara, kumarpara	do	*
15	Hijolia Abulkashem High school road	40	Rajapalong, uttarpukuria, Daskhin pukuria, Hijolia, Horinmara	Tuturbil	*
16	Baruapara-Pinojirkul road nearby coatbazar	90	Sadrikata, Paglirbil, Ratnapallong, Sikderpara, Jhawtala Chy para, Hindupara, Pinojirkul	Pinojirkul	***

17	Rumkha bazaar road (adjacent to ASA Office)	45	Courtbazar, rumkha, Bhalukia	do	*
18	Jummapara road	65	Daskhin Painnyasia, Paschim painnyasis, Jaliapallong, Dalepara, Jummapara	Painnyasis	**
19	Painnyasia serang point road	55	Uttar Painnyasia, PURBO painnyasis, Chakkata, Lamboripara, Choudhurypara, Boruapara, Rejukhal		
20	Trail adjacent to Boro Inani khal	30	nani, Dalepara, Sonarpara, Jalipara, Tuturbil	Boro Inani	*
21	Boro Inani khal				
22	Choto Inani khal	70	Choto inani, Nidania, Sonarpara, Sonaichori, Dalepara	Choto Inani	***
23	Md Shafirbil- adjacent to Abdulkarimer Bari	60	Horinmara, Jalipallong, Pinojirkul, Md Shafirbil, Sonarpara, Courtbazar,	Md Shafirbil	***
24	Dakchara	75	Patuartek, Sonaichari, Lomboripara, Jaliapallong, Baruapara	Patuartek	***
25	Ruppoti- Cheng Chari Hill(near to the house of Chai cheng chakma)	40	Ruppoti, painnyasia, Sonarpara, Rejukhal, Nidania	Ruppoti	*
26	Ruppoti Chara and adjacent trail(near to the house of kabir headman)	85	Tuturbil, Khairati para, ruppoti, Barua para, lombori para, Jumma para		***
27	Ruppot chara				
28	Baillakhali Khal and adjacent foot trail	50	Ruppoti, Bailla khali, Pinojirkul, Horin mara, Painnyasia		**
29	Swankhali foot trail (north of swankhali forest beat office)	50	Imamer dale, Ruppoti, Monkhali, Dochori, Khairati para, swan khali		**
30	Maderbunia chakma mondir road	55	Maderbunia, swankhali, monkhali, Shaplapur, Shilkhali, Jahajpura, Telkhola, Musarkhola		**
31	Road at mid point of Madarbunua and Sepotkhali	80	Maderbunia, swankhali, monkhali, Shaplapur, Shilkhali, Jahajpura,		***
32	Monkhali chakma para road	95	monkhali, Shaplapur, Shilkhali, Jahajpura, Telkhola,musarkhola, Holbunia, telkhola, pallongkhali, thainkhali		***
		1955			

Forest Land Tenure System in Bangladesh

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Abstract

Land tenure in Bangladesh is generally categorized as: private, communal, open access and state owned. Forest land is an integral component of land tenure system of Bangladesh. It has evolved over centuries. Since forest land is the home to most of the terrestrial biodiversity and provides vital ecosystem services, measures must be taken to ensure that these critical environmental features are not jeopardized because of changes to land tenure. To this end, the capacity of the Forest Department must be strengthened so that it can safeguard these functions under the prevailing land tenure system of the country.

Key word: Biodiversity, Encroachment, Land use conversion, Land tenure

Introduction

Bangladesh is a sovereign country flanked by India on three sides except for a small border with Myanmar in the far south east. The Bay of Bengal is situated all along its southern border. Its geographical location is between 20° 34' and 26° 38' North latitude and between 88° 01' and 92° 41' East longitude. It is a tropical country which covers 147,570 square kilometers and experiences mild winters from October to January and hot and humid summers from March to June. The average annual rainfall is about 2,000 millimeters, concentrated during the monsoon months of May to September. Very often the country faces natural disasters, especially cyclones and tidal bores. Bangladesh is a low-lying deltaic country at the confluence of two mighty river systems, namely the Ganges and the Brahmaputra. The land is deep, fertile and mostly flat. Most parts are less than 12 m above the sea level while the highest point is about 1,052 m. It has a population of about 151.41 million (BBS, 2008) and an estimated per capita GDP of about USD 322.8 (Taka 22,597) in 2008(BBS, 2008). More than 20% of its population lives on a dollar a day (GED, GoB 2005).

Land tenure refers to the legal relationship or prevailing norms, between people and the land. It is also the association with a piece of land (including water found on it), either of the state or of a proprietor, under specific terms and conditions.
Land tenure is generally categorized as:

- **Private:** The assignment of rights is to a private party who may be an individual, a group of people, or an organization. For example, within a community, individual families may have exclusive rights to residential parcels, agricultural parcels or certain trees over a land parcel.
- **Communal:** Each member of a community has a right to use independently the holdings of the community, for example, the right to graze cattle on common pasture.
- **Open access:** Specific rights are not assigned to anyone and no one can be excluded. Examples are free access to the high seas, rangelands, and forests.
- **State:** Proprietary rights rest with the state.

Forest land generally refers to land that is either under tree cover or legally designated as such.

Historical Background

In the past, forest land was under the control of rulers but could be used by local people. Between 800 and 1400 A.D., Bengal (most of present day Bangladesh) came under the *Pal* dynasty when the Indo-Bangladesh region was divided into a large number of individual sovereign states (Dwivedi, 1980). Although forestry was administered at the state level at that time, the only function authorities performed was the collection of revenue from harvests. Throughout this period, forest land was converted to agricultural land. During the Mughal period (1526-1700), states were brought under central control and administered as *Suba.* The forest land tenure system continued as before, with agriculture taking priority.

At the fall of the Mughal dynasty, Britain ruled the Indo-Pak subcontinent from 1757 to 1947 AD. Initially, the forest land tenure system remained the same, where the goal was to collect royalties from the many forest toll stations placed along important river banks. The conversion for forest land to agriculture land continued as well, mostly through settlements granted to the public.

In 1793, Earl Charles Cornwallis brought about what is known as the permanent settlement of Bengal - a revolutionary change which granted chunks of land to *Zaminders* (landlords) for a fixed fee on a permanent basis. Forest land could now be owned privately. However, the tax or rent which a landlord paid to the Crown, was far more than what could be earned from the sale of forest products. Thus, the conversion of private forest land to agricultural land remained significant.

In the 18th century, vast tracts of present day Bangladesh had extensive forest cover, all of which was owned by the British Crown. Since people wanted to grow more crops and the Crown wanted to collect more tax, forests were destroyed to achieve these ends. Though the Government owned all land, the state recognized user rights, especially because it generated revenue through taxation. People were given forest land under the assumption they would convert them into agricultural land. Records indicate that the northern part of the Sundarban Reserved Forest was forest land even in the mid 19th century. However, it is now inhabited and has become agricultural land. Similarly, most of the greater Sylhet districts was forest land in 19th century but have since become tea estates and human habitations.

The British Crown promulgated Act VII in 1865 to establish a rule of law in the forest sector - a first in this part of the world. The Act declared many tracts of forest land as reserved forests under the management of the forest department. Most of the existing Sundarban was made into reserved forests in 1875-76 and forest land in the greater district of Sylhet received the same designation under Assam Forest Regulations. Much of the forest land of Chittagong and Chittagong Hill Tracts (CHT) followed suit in the early 20th century and tracts were managed by the British Government.

The Pakistan Government promulgated the State Acquisition and Tenancy Act 1950, which authorized the proprietary rights with regard to tenantancy and ownership of villages, market places, forest land, and *ghats* were vested to government from the landlords . Now all these non-retainable properties became the property *(khas)* of Government along with all forest land of more than 10 acres, including areas where trees were scattered. Government later decided to acquire this forest land through the forestry department. Small parts were later declared reserved forests and tenure arrangements changed accordingly.

Present day Bangladesh was under British rule from 1757 to 1947 after which time it became an independent country as Pakistan, of which present Bangladesh was a province known as East Pakistan. It emerged as a sovereign nation in 1971.

Drivers of Forest Land Tenure Change

The above historical background sheds light on changes to forest land tenure over the last few centuries. The balance of this report covers the drivers of reform during the last 50 to 60 years.

Prevailing Policy of the Government

Government promulgates a number of policies for the purpose of administration and control. Forest land tenure is largely affected by those related to land, land use, water and forestry.

In the 1940s and 50s, landlords paid a fixed amount of revenue to the Government. As noted earlier, because each unit of forest land fetched less income for the landlord than agricultural land, thereby large scale conversion took place Consequently, a significant change in tenure arrangements occurred.

In the 1950s and 60s, government policies, considered the leasing of forest land for other uses that could be more beneficial to the nation. Thus, much of the forest land administered by Government (*khas* land), but not under the control of the forestry department was leased out for agriculture, horticulture, and rubber gardens, for example.

In the 1970s, large chunks of unclassified state forests, especially in Chittagong Hill Tracts (CHT), were leased out for establishing rubber gardens. As of 2010, more than 13,660 ha were granted to individuals for this purpose, with the result that the status of this forest land changed from khas to private. Around the same time, many of the plain land people were allotted 5 acres per family of unclassified state forests to establish homesteads, orchards, gardens, and agricultural fields. Under this policy, the status of another 7,570 ha of forest land changed from khas to private and, in almost all cases, forest cover was lost. In addition, more than 14,575 ha of reserved forest were transferred to the Forest Industries Development Corporation in the 1970s and 1980s for rubber plantations.

All the newly accreted lands along the coast are '*khasland*[3]' as per the prevailing law of the land. In the 1980s, the Government undertook massive afforestation of these new accretions and more than 190 thousand ha were turned into forest land, 30% of which has been permanently designated as reserved forests. About 46 thousand ha of mature plantations are under process to be shifted to agricultural land by government. Moreover, the Government gave thousands of ha of reserved forests to the defense services.

When shrimp farming was lucrative in the 1970s and 80s, the Government leased out more than 8 thousand ha of reserved mangrove forests in Chokoria Sundarban to influential people, thereby changing their status to shrimp farms. It also leased out many *khasland* mangroves, especially in the greater districts of Chittagong and Noakhali, for the same purpose. These transactions involving *khasland* resulted in the further conversion of large chunks of forest land to farmland.

Administrative Decisions and Bureaucracy

The land use policy of 2001 prohibits the change of forest land to other uses but, in spite of these provisions, district administrations still lease the land for different purposes because it is considered *khasland*. The recent decision of the Government to release 50% of coastal forest land for agriculture contradicts the prevailing land use policy.

Economic perspectives

Infrastructure development, especially the construction of roads through forest land, makes this land more accessible and incites powerful people to grab it for establishing various industries, as happened in the Dhaka Forest Division where the status of more than 2,025 ha of forest land has changed. Several law suits in this regard are pending for settlement in the court of law.

Another cause of forest land conversion is the discovery of valuable mineral products . In these cases, authority over the land is transferred to different agencies. Examples of such occurrences include a gas field in Shahjir Bazar in the greater district of Sylhet and stone quarries in Sunamgonj also in greater district of Sylhet.

Population Pressure

Bangladesh has one of the highest population densities in the world and pressure on land is severe. The influx of people into forest land, especially after eroding of rivers, regularly results in encroachment because they have no alternative for shelter. Although the Government continues to own these sites, they

[3] "*Khasland*" is a legal term which means that, for the given parcel of land, government has title and holds all proprietary rights.

are converted to homesteads, agricultural fields, and orchards and lose their designation as forest land. At times, local influential people incite poor rural people to grab forest land for uses other than forestry and, over decades, thousands of people took over large chunks of the "Sal" forest land. To address this situation, the Government of Bangladesh launched a program of social forestry in Dhaka, Tangail, Mymensingh, Dinjpur and Rangpur districts , involving encroachers as participants. The program was highly successful and, in 10 to 12 years, more than 35,100 ha (PCR of FSP 2008) were brought back under tree cover, recovering its status of forest land.

Although population pressure is a common occurrence and a root cause of encroachment on forest land, it does not officially change the tenure status of the land. Rather, it is the land use pattern which changes.

Current Government Policies and Implementation of Forest Land Tenure

The designation of land as forest land refers either to how it is classified in official records or to the fact it is forested or under tree cover. Most forest land in Bangladesh is under the control of the Forest Department and is classified according to 8 legal categories, as indicated in the Table 1.

Table 1. Legal nomenclatures of forestlands

Sl. No.	Legal Nomenclature	Area in Million ha	Percent of Total Land Area of Bangladesh	Ownership vests with	Management vests with	Remarks
1	Reserved forest (RF)	1.246	8.476	Forest Department (Government)	Forest Department	No activity is allowed without prior permission of the FD
2	Notified forest (NF)	0.224	1.523	District Administration (Government)	Forest Department	Some tree species are declared reserved
3	Protected forest (PF)	0.037	0.251	District Administration (Government)	Forest Department	Not supposed to be leased out for a certain period
4	Acquired forest (AF)	0.008	0.054	District land Administration (Government)	Forest Department	Non retainable under SATA 1950. To be managed as RF & under the process of reservation
5	Vested forest (VF)	0.003	0.020	District Administration (Government)	Forest Department	
6	Unclassified state forest (USF)	0.730	4.965	District Administration (Government)	District Land Administration	Ethnic people have the right to practice slash and burn agriculture
7	Homestead forest (HF)	0.27	1.836	Private	Private	
8	Tea estate forest (TE)	0.070	0.476	Private	Private	
	Total	2.588	17.6			

Source: Management Planning Unit, Forest Department, Government of Bangladesh, June 2010

The major government policies that affect forest land tenure are

- Forest Policy
- Land Use Policy
- Industrial Policy
- Environment Policy
- Agriculture Extension Policy
- Water Policy

The prevailing Forest Policy was promulgated in 1994 and is well drafted. It incorporates all the necessary aspects for the improvement of forests and forestry in Bangladesh, including social and participatory forestry. Afforestation and enhancement of forest cover to 17.6% of the land area of the country are notable features.

The Land Use Policy of Bangladesh was declared on June 13, 2001. It is also well drafted and clearly opposes the conversion of forest land to other uses. Although it promotes the conservation of natural resources, very often it is not followed in that spirit, especially by Deputy Commissioners who use the bureaucratic hierarchy as a cover. (Biswas and Choudhury, 2004).

Even though the Industrial and Agricultural Policies do not conflict with forest land tenure per se, often this land is converted to industrial and/or agricultural uses.

Types of Forestland Tenure and Ownership

Ownership is the most important feature of tenure, and forest land tenure is no exception. However, communities, especially those involved in forest management, can accrue user rights over forest land that is owned by Government (FD) and, through agreements, can share in the benefits. In addition, other rights have been accepted in some forest land, such as the right to practice slash and burn agriculture in unclassified state forests, and the right of easement through forest land to farm land (as in many sal forestlands). Thus, there are two types of ownership of forest land: private and government.

Private ownership: Tenure over private forest land is clear and fully in favor of the individual or organization named in the land record. It extends, for example, to forest land for homesteads, rubber gardens, and tea estates.

Government ownership: According to records, proprietary rights over government owned forest land are not always completely in its favor. Local residents and communities living nearby for generations, develop unwritten rights which become especially significant when they participate in forestry operations under social forestry or co-management programs.

Impacts and Consequences of Forest Land Tenure System

In the past, the Crown controlled forest land but local people had user rights. In 1793, the British rulers in India introduced permanent settlement which took away the proprietary rights of cultivators and gave them to *Zamindars*. This new system relegated cultivators to tenants and, as a result, discontent and resentment grew among them. As noted earlier, the tax or rent which the landlord paid to the Crown amounted to more than earnings from the sale of forest products. Therefore, this private forest land was often converted to agricultural land.

To reduce conflict, Pakistani rulers introduced the State Acquisition and Tenancy Act (1950) which abolished private ownership of forest land and prohibited sub-letting. It charged rent to a number of intermediaries, including to the tenants cultivating the land. However, to avoid expropriation, some *Zaminders* cleared their forests and made it agricultural land.

Certain categories of land, including forest land, were managed by Government as *khas*. These lands were declared non-retainable by any tenant or ex-receiver of rent. Later on, however, *khas* land that was under the administrative control of Government, not the forestry department, was leased out for use other than forestry - a situation which changed the status of the tenure.

The land tenure system basically revolves around ownership and forest land tenure is no exception. As per prevailing regulations, Government maintains a record of rights (ROR) which it amends following new land transactions such as registration and transfer, as well as on the basis of physical field surveys.

The tenure of forest land, like the regular tenure system of the country, incorporates a use aspect - in this case, use associated with forests and forestry - but this dimension is often neglected when tenure is granted. In view of the fact that the Forest Policy (1994) and Land Use Policy (2001) call for special treatment of forest land, tenure aspects are expected to remain forestry based. However, increasing population pressure may hinder attempts at conservation and the consequences of maintaining the status quo with regard to forest land tenure are likely to be adverse.

Future Trends

Mustafa (2002) concluded that, in Bangladesh, two interrelated trends with respect to its Forest Policy are surfacing: state-sponsored commercialization of forestry and the alienation of forest communities from the management and use of forest resources. Since the policy is directly related to forest land tenure, the same trends are expected to emerge in this area as well.

The visible aspects of forest management and the hopes and aspirations of the people at large indicate that the following issues are eminent.

- Under social forestry, participants will give pressure for a bigger share of the benefits,
- As the co-management of protected areas (conservation sites) progresses, communities will attempt to secure total management of these locations and all benefits,
- Communities adjacent to forests that are not yet under co-management are likely to demand that Government hand over the management of these sites to them, especially with regard to revenue collected from recreational services.

Based on the above, forest land tenure in the future will accord increasingly more rights and privileges to adjoining communities, including participants engaged in social forestry.

Conclusion

Land tenure is an important issue in Bangladesh. The country's land tenure system, of which forest land is an integral component, has evolved over centuries. The forest land is under severe threat to conversion to many non-forestry activities. Since forest land is the home to most of the terrestrial biodiversity and gives very important ecosystem services, measures must be taken to ensure these critical environmental aspects are not jeopardized because of changes to land tenure.

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Community Based Sustainable Management of the Tanguar Haor - a Unique Initiative in Wetland Ecosystem Management

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Abstract

Tanguar *Haor* is a unique wetland ecosystem in northeastern part of Bangladesh with national and global significance. This wetland has been under a traditional leasing system since 1932. In consequence of over exploitation of natural resources during the leasing system it was declared as an Ecologically Critical Area in 1999 by the Government of Bangladesh. It was then designated as a Ramsar site (Wetland of International Importance) in 2000. Tanguar *Haor* plays a critical ecological and economic role in Bangladesh. The wetland supports freshwater fish spawning grounds for indigenous fish species and supports the livelihoods of over 56,000 people living on the periphery of this wetland. It contributes directly to national food production and security. Wetland resources, i.e. , mother fishery, swamp forests, water fowl, etc., were threatened due to over-exploitation and discriminate use of lands and forests for the different household purpose like cattle grazing, commercial duck farming, destruction of forest for fuel ,etc. IUCN Bangladesh on behalf of the Ministry of Environment and Forest has been working in this wetland since 2006 mainly to establish a community based co-management system to apply 'wise use' principles of Ramsar convention. In the mean time community people are organized having executive bodies in three tiers (at village, union and central level) within purview of that co-management model is now functioning well at expected level. The initiatives has increased the capacity of local communities to bargain, negotiate and effectively manage the wetland, and generated alternative income options to reduce dependency on natural resources. This has been considered as a historic milestone in the management of Tanguar Haor and its rich biodiversity. It is a 15 years project funded by the Swiss Agency for Development and Cooperation. The objective of the current phase is to establish a functional co-management system for conservation, stabilization and sustainable use of the natural resources of the wetlands that generates opportunities for significant improvements in the livelihoods of rural communities and contributes to the costs incurred by management.

Key words: Co-management **,** Community based management, Ecologically critical area, Tangoar haor, Wetland

Background

In 1999, the Government of Bangladesh, recognizing the ecological importance of the area and the over-exploitation of resources declared the Tanguar Haor (TH) an "Ecologically Critical Area" . In 2002 the Tanguar Haor was listed as the country's second RAMSAR site - wetland of international importance. Due to its status as an ECA and Ramsar site, the government of Bangladesh (GoB) has been keen to put in place a community based management system. In order to do that the ownership of TH has been transferred from Ministry of Land (MoL) to Ministry of Environment and Forest (MoEF) in 2001 and subsequently the lease system was banned effectively in 2003.

MoEF under the National Conservation Strategy Implementation project sponsored a number of studies to determine the potential in natural resources of haor and to identify the causes of observed resource depletion. These studies identified that lack of income and employment opportunities for the people of the basin (who live isolated on islands during the entire rainy season) as a major cause of resource depletion. The swamp forests have diminished as local people harvest wood for use as fuel, reed beds have depleted due to unsustainable harvesting practices and the fish stocks had been seriously diminished due to over-exploitation by leaseholders. The lack of any system for recognizing customary rights of use and related management schemes has alienated the haor residents and precluded the emergence of management schemes that could ensure that exploitation levels are sustainable.

With these observations, the Government of Bangladesh prepared a comprehensive management plan for Tanguar Haor, introducing the concept of "wise-use" of wetland resources based on the wise-use principles of the RAMSAR convention in 2005. The poverty situation in Tangaur haor is no doubt appalling and there is need to develop scopes for income and employment opportunities. However, high dependence on haor resources also highlights the need for sustaining the resource base for supporting the existing livelihoods. Intertwined approach to generate "income" and conserve the "ecology" is thus a more logical approach to address the complex management aspect of Tangaur haor. Looking back into the management history of Tangaur haor, it has always been subject to "elite capture" and rich and politically connected local elites used to control the resources excluding the local and poor. The resource was fiercely guarded which used to result in conflict and violence. Declaration of Tanguar Haor as the ECA and subsequently a Ramsar site provided opportunity to the government to test a new management paradigm. IUCN Bangladesh, on behalf of the MoEF, with its technical expertise continuing financial support from SDC, along with its partners (IC, CNRS, ERA and BELA) and with strong support from the Sunamganj District Administration led the process of initiating a co-management model in 2007 now being well functioned and established at ongoing second phase.

Hydro-geology of Tanguar Haor

Tanguar Haor is one of the largest wetlands of the country comprises 51 beels (people say 120) having a total area of 9,727 ha (24,026 acres) situated in 4 unions under two upazila named Tahirpur and Dharmapasha of Sunamgonj district (Figure 1). About 10,205 households in 88 villages comprising a population of 56,000 are believed to be dependent directly and indirectly for their livelihoods on the TH.

It is a globally significant wetland, in north-eastern part of Bangladesh, adjacent to the Indian border, is part of a wetland/floodplain complex of the river basin. Although several hundred kilometers from the sea, the haor is located at an elevation of only 2.5 – 5 meters above sea level, and water movement is generally sluggish. During the monsoon, it merged into one large body of water in a natural depression between the levees of several rivers. During this season (June - September), the *haor* is entirely under water except the villages whichmostly locate in the periphery, constructed on raised mounds, appear as small islands in this vast body of fresh water. In the dry season water recedes into the rivers and all that remain are some beels which cover about 25 - 30% of the area. These deeper bodies of water are heavily fished. They attract many waterfowl during the winter season. These are considered as an important breeding ground of many species of fish. Water in Tanguar Haor consist mainly of water backing up in the Surma river system, south of the *haor* although some water is received from streams flowing from the Meghalaya Hills in India to the North. Though rich in nutrients, water is generally clear, especially in the dry season. The Jadukata River, to the north-east, brings large amounts of sand to this part of the Sylhet basin.

Figure 1: Hydrological map of Tanguar Haor

Demography

Environment-poverty nexus can well be depicted in case of Sunamganj, in general and Tanguar haor, in particular. Flash flood is one of the major vulnerabilities that affects livelihood of all social classes. The people of Tanguar haor are more vulnerable and poor compared to rest of Sunamganj. The principal economic resource of Tanguar Haor is fish and agriculture, and people has very high dependency on the *haor* ecosystem. 93% of the households in the *haor* basin are involved in activities within the *haor* basin and nearly 76% of them are engaged in different forms of fishing activities. However, the resources are gradually declined due to overexploitation and mismanagement of the natural resources. Moreover, lack of access to Tanguar Haor resources has made people poor particularly the fishing communities. Besides, the people have also limited access to services provided by the government and NGOs. The average national household size is 4.9 (BBS 2007), however it is 5.94 in Tanguar haor. Education facilities are not widely accessible in this area. Almost more than half of the populations are illiterate and only 29 % receive primary education and 8% receive high school education.

Table I. Source wise distribution of the annual income of the households (Source: IUCN survey, 2008)

Source of Income	Percentage of HH	Annual Average income
Agriculture	67	21212
Day laborer	52	23300
Open access fisheries	38	21053
Culture fisheries	1	14417
Fish business	5	28143
Transportation	4	2544
Small business	18	32782
Remittance (inland and abroad)	3	20444
Others	21	16983
Total Income	**100**	**46769**
Income from Haor	95%	38059
Income from Haor (non agriculture)	72%	30553

Monthly income of the population is not at satisfactory level. Nearly 30% are earning Tk. 1500 – Tk. 3000 (US$ 22 – 44) in a month and 39% are earning Tk. 3000 – Tk. 5000 (US$ 44- 73) in a month. There are only 2.57% households that are earning more than Tk.10000 (US$145) and nearly 6% live with income less than Tk. 1500 per month (Figure 2). In terms of average income by occupational group, annual average income of the households is shown in Table 1. It shows that nearly 67% of the households receive income from agriculture. At the same time there is a large degree of variation in their income which shows the skewness of the distribution of income with few large farmers and a majority of them are rather small farmers. Table 1 further illustrates that nearly 95% of the households use *haor* as a resource to earn their living in the Tanguar Haor area. It is also evident from the survey data that nearly 72% of the households earn their living from the *haor* but it is not from agriculture rather it is from a) fishing b) fish trading, and c) boating. Their average income from these sources is about 65% of the total average income. Clearly, it shows the dependence of haor resources of the people of Tanguar villages.

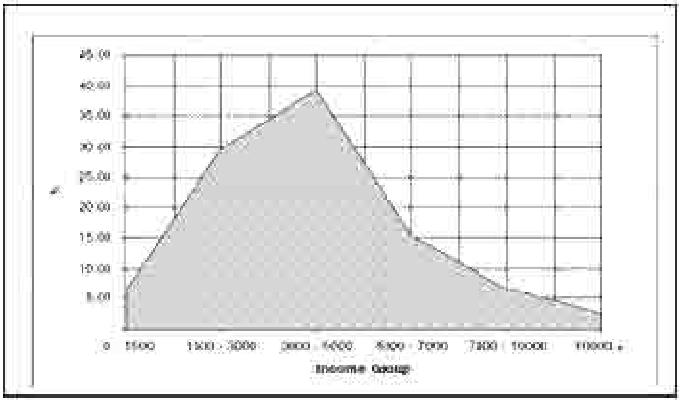

Figure 2: Income distribution (Source: IUCN Survey, 2008)

Considering the physical features, topography and geographic locations of different wetland projects in the country it has got some specific difference in the case of TH. Unlike other beels of different projects, all the beels of TH are situated in the same geographic location. Unlike hydrological setting, TH community is not organized institutionally as it exists in the case of GoB. Almost all the people in the periphery of TH can be categorized in two groups. The major portion is dependent on TH resources directly and the others are indirectly. Direct dependents are mostly migrants and constitute about 90% of the whole community. The local and elite are rich and play dominating role in the society, owing to the fact that they are the main employer in the territory and sources of help and assistance during natural disaster.

Co-management approaches in TH

The project has direct relevance to fulfill Bangladesh's commitment to Ramsar convention. Bangladesh ratified the convention in 1992 and declared the Tanguar Haor as the second Ramsar site in 2000. Through this declaration, Government of Bangladesh has committed to conserve and manage the Tangaur Haor in a sustainable way. However, through this project a sustainable management system will be developed and government's commitment to the convention will be fulfilled. The co-management system that is proposed for Tanuar Haor will contribute to generate significant improvements of the livelihoods of the rural communities around Haor as well as to the cost of management. A program conceptual frame is proposed based on the following **seven main approaches**.

- A model of *co-management approach* aiming at elaboration and establishment of a comprehensive management capacities of state, local government and communities in the periphery of Tanguar Haor;
- A *livelihoods approach*, aiming at increasing and valuing the human, social, financial, physical and natural capital, according to the choices of the beneficiaries. This approach will not only consider the needs of the beneficiaries, but also the *assets* from which this capital develops;
- An *ecosystem based approach* placing human needs at the centre of biodiversity management. It aims to manage the ecosystem, based on the multiple functions that ecosystems perform and the multiple uses that are made of these functions. The ecosystem approach does not aim for short-term economic gains, but aims to optimize the use of an ecosystem without damaging it. It was endorsed at the fifth Conference of the Parties to the Convention on Biological Diversity (CoP 5 in Nairobi, Kenya; May 2000/Decision V/6) as the primary framework for action under the Convention.
- A specific focus on *gender* aspects, which should ensure an equal participation of women and men through a strategy of gender mainstreaming at all levels;
- A *concept of capacity development* that is based on a deep and appropriate understanding of the nature of the learning challenge of all stakeholders it is addressing;
- A *public awareness* concerning the values (goods and services) of wetlands ecosystems should be promoted in parallel, through civil society organizations at local, regional and national levels. This is with a view to build public pressure for pro-poor sustainable management measures;
- A *market approach*, targeting pro-poor economic growth, with the development of opportunities (better access to market, new markets, etc) and of a socio-economic environment that benefits the poor.

The approach mentioned above has direct relevance to the PRSP in terms of poverty reduction, empowerment of the poor and overall governance. The model of Tangaur haor management will ultimately contribute in developing a roadmap for overall sustainable wetland management in Bangladesh. It is very important to note that 80% of the rural poor still depends on the wetland resources for meeting their subsistence needs. Sustainable wetland management is important to realize the PRSP targets. It thus also relates with the MDG 1 and MDG 7. Considering the current situation, following three strategic thrusts is targeted to address the issues in Tanguar Haor and in the larger context of wetland management in Bangladesh, viz.

- Community Management Structures, reinforcing capacity for resource use, access to markets, value addition of products, introducing participatory M&E processes to be conducted by the communities themselves;
- Establishing a Management Authority for Tanguar Haor with the active participation of district government agencies and stakeholders. Additionally, providing a knowledge base (sciences and traditional knowledge) to empower the stakeholders in decision-making;
- Introducing wetland management strategies; to develop approaches, tools, methods and partnerships that can be used for managing natural resources; and to use the lessons from Tanguar Haor in other floodplains in Bangladesh.

Expected outcome of TH co-management model

The project eventually, when will be implemented fully, will produce the following long-term (10-15 years) outcomes:

At Community level

- Communities of the Tanguar Haor are organised, structured and federated
- CBOs have developed the capacity and the internal organizational systems required to effectively collaborate with the District Administration of Sunamganj and local government entities in the management of Tanguar Haor
- CBOs are able to effectively participate in the assessment of the productive potential of natural resources on a pluri-annual basis, to allocate community access to natural resources and to organize sustainable levels of harvesting, to derive direct (subsistence) and indirect (cash) benefits from the use of natural resources, and to agree on the allocation of benefits amongst and within communities
- CBOs are able to formulate social and development priorities and to engage in negotiations with governmental and non-governmental service providers to acquire social and developmental services, including from micro-credit and credit providing organizations.

At national , local government, community co-management level

- A management authority for Tanguar Haor is established, adequately staffed and resourced through sustainable funding streams.
- The management authority is composed of representatives of the rural communities, of the District Administration – including representatives of relevant line Ministries; representatives of the concerned Upazillas, Unions and Wards; civil society organizations (advocacy and academic and scientific institutions).
- Deliberations and decisions of the management authority are informed by a comprehensive information system, based on science and traditional (community) knowledge, regularly updated through a combination of community based monitoring and scientific monitoring of key indicators.

In relation to sustainable use of wetland and floodplain resources in Bangladesh

- Methodologies and approaches for the management of wetland and floodplain resources in a protected area (Ramsar site) are documented and their pertinence for improved wetland and floodplain management in the rest of Bangladesh are assessed and their characteristics identified.
- Models of natural resources management that are based on Community responsibility and that generate significant livelihoods improvements are assessed and their characteristics identified.
- National wetlands and floodplain management policy, and natural resource management and revenue-generation practices are reviewed in the light of Tanguar Haor experiences.

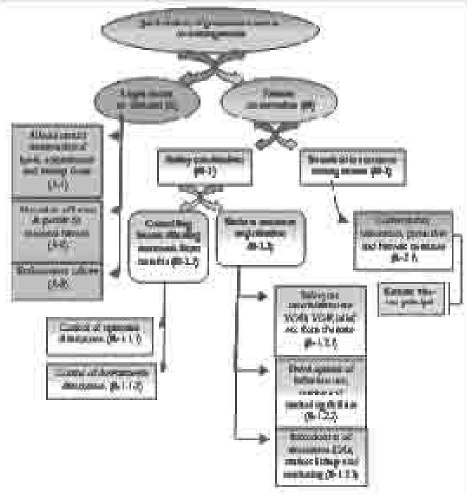

Figure 3: Showing essential issues related with co-management governance

Journey towards sustainable natural resource governance in TH

The project entry point was to develop a resource governance system (*illustrated in* Figure 3) for Tangaur Haor as it being a Protected Area of the Government of Bangladesh. For the governance system, the project intended to and as prioritized by the Government, would be a co-management system where local community is supported to develop organizations and capacity to negotiate "access right" to *haor* resources and support their livelihoods, and in other hand the government is also supportive and have instruments to recognize and realize this right of the Tangaur haor community. In other words, the co-management model will enable community and government to reach to same level for having discussion on resource conservation,

Table 2: Showing activity modality for community

	activities	[illegible]	[illegible]
1.	Annual General Meeting and Election	- Income and expenditure statement - Profit distribution - New leadership	May, June & July
2.	Participatory Resource Management Planning (PRMP)	- Annual plan organizational development, AIGs and resource management	August September & October
3.	Preparation for agriculture and commercial fish harvest	- Financial assistance to farmers and fishermen - Price fixation of fish through tender - License and permits	November & December
4.	Commercial fish harvest	- Income from resource management	January, February & March
5.	Review progress, enforcement and plan	- Experience capitalization - Next year plan	April

regeneration, responsible management, harvesting and selling, and finally on sharing of the benefits and costs among the stakeholders. The Governance mechanism of TH co-management has stepped into a new era by successfully facing the multidimensional socio-political crises by Tanguar Haor Management Committee (THMC) with leadership of District Commissioner, Sunamganj. The district administration demonstrated a splendid role in overcoming those exhausted situation. Other members of THMC have also played an active role. These activities have helped squeezing relationship between the district administration and the community. Local government representatives from the respective unions have also shown their comprehensible commitment towards establishing a co-management system in TH.

Democratic organizational structure at community level

An democratic organizational structure accommodating nine executive leaders at 3 tires of 76 village co-management committees (VCC), 4 union co-management committees (UCC) and central co-management committee (CCC) are established. Among the nine, five are representing five professional groups and the remaining four representing four required administrative portfolio as shown in Figure 4. Three (3) tires TH community organization is presented in Figure 5. Membership reached a total of 5,117 numbers of which 21.7% are females. Household (HH) coverage has reached to 55.8% with a total of 4,765. Increasing trends of progress has been noticed in leadership functionalities at different tiers. A total of 1,722 weekly VCC meetings were conducted by the village leaders with the support from the community facilitator during last six months period (Apr-Oct 2010). They have organized monthly meetings to review plans and progress as per yearly Participatory Resource Management Plan (PRMP). CCC organized 7 meetings to overcome the challenges evolved from the natural and manmade disaster. CCC managed to organize formal election in 67 villages fulfilling a condition of 100% updates with new portfolio. In general female leaders have acquired 23.18% seats. Percentage of elected women leaders in the VCCs by October 2010 is 22.72% in the administrative group and 23.86% in professional group.

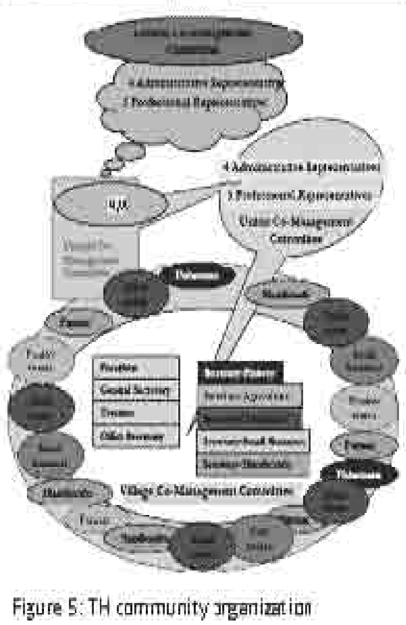

Figure 5: TH community organization

Community is being accustomed with TH activity modality

Community leaders came into a common consensus regarding some common modality of activities for all committees as detailed in Table 2. The community has also developed a common consensus in resource harvest modality for fish throughout the year considering Ramsar wise-use principle and the subsistence income for the underprivileged. According to this common modality, commercial fish harvest would be conducted for 3 months between

January and March, non commercial for 10 months from June to March following a banned period of 2 months during 15 April & 15 May every year. Community started to get accustomed with the resource harvest modality considering Ramsar wise-use principle and the subsistence income for the underprivileged.

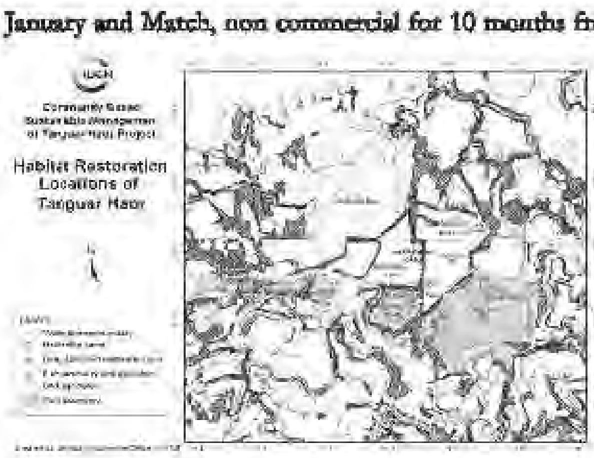

Figure 6 Habitat restoration locations of TH

Accumulation of social capital under SCM

A self running community savings system is established as a mobilization strategy of co-management since its initiation that leads the TH community to attain a social status of '*Crorpoti*'(multimillionaire). So far, collection of a total amount of BDT 13,241,581/= (as on 26 Feb 2011) by a community organization like TH has been recognized as one of the historic success in the field of social mobilization in Bangladesh and elsewhere in the world. Financial assistance provided to the members reached BDT 10,070,000/=. Selected underprivileged members constitute 75% of the total membership, where 40% members achieved to convince VCC leaders to receive financial assistance from the respective UCCs. A total of 590 women headed families were brought under the organizational platform.

Advancement of community people in taking control over TH resources

Community people organized three distinct groups, coined as 'forces', from the members to manage, guard and document commercial fish harvest events independently. These 'forces' were named interestingly as CAT, LION and TIGER on the basis of their responsibility and the nature of their job. Specific uniforms were delivered to these force members for easy identification. The community proposal of involving a community guard is under active consideration by the MoEF. Different initiatives and attitudes of district administration encouraged community leaders to take an active role to protest against fish poachers in TH. A total of 153 actions were taken by the community members to prevent fish poaching accomplished independently or jointly with project staff and assigned learned Magistrates.

Table 2: SCM account as on 26 Feb 2011

Sl	Head of Accounts	Total (BDT)
1	Admission Fee	100,540
2	**Subscription**	**776,325**
3	Savings	3,944,093
4	**Principal**	**7,628,123**
5	Interest	792,100
6	**Admission form**	**10,023**
7	Insurance	109,180
8	**Loan form**	**16,220**
9	Fine	1,145
10	**Pass book**	**60,970**
11	Total Collection	13,241,581
12	**Loan**	**10,070,000**
13	SW	741,987
14	**PW**	**194,454**
15	Total disbursement	11,006,441

Effective resource conservation strategies are established

Five fish and two bird sanctuaries are established in TH. 40% no-fishing zone in five fish sanctuaries are demarcated with joint effort of GoB representatives, community leaders, project staff and other local elites based on the fisheries resource study. Six fish species namely *Bagair, Chital, Nanid, Sharputi* (deshi), *Rita and Mohashol* are declared as endangered in TH and restricted for fishing. In addition, two months (15 April – 15 June) seasonal fishing ban imposed during major breeding season to allow substantial recruitment of fingerlings. Besides, 6 spots are declared as protected area for reeds those are essential habitats for maintaining TH ecosystem integrity. Figure 6 showing the locations of sanctuaries and habitat restoration areas of TH.

TH experienced a very successful breeding of some specific fish species that produced a huge numbers of fry and fingerlings that has spread in all the neighboring districts through the fish migratory route and rivers connected with TH. Some important species like *Boal, Kalibaus, Sharputi, Gonia, Gang Magur* and *Lacho* enjoyed a very successful breeding with low mortality rate in TH. Abundance of these species was also noticed in the market of Sunamganj, Kishorganj, Hobiganj and Netrokona districts. Community people and experts are recognizing this as a success of TH conservation strategy owing to the fact that all wetlands in Sunamganj and neighboring districts has been under leasing system where the lease holders did not maintain any conservation strategy to maximize harvest. Increased number of an endangered species *Chital* through restricted to fish was noticed in the local market.

A number of important habitats are restored

TH habitat improved in 16 perennial water bodies including five no-fishing zones through piling more bamboos and hijal tree branches (katha). Afforestation of hijol and koroch are accomplished in five spots. Plantation was made in two swamp forests with 25,000 koroch and 15000 hijal saplings. Important reed species – *nol* were transplanted in approxinmately 4 ha area of TH. All these activities resulted increasing abundance of both residence and non-residence wetland birds (waterfowl) significantly. A fish nursery to rear the fingerlings of rare species ,i.e. *Rita, Baghair, Nanid, Sarputi* (native), *Chital and Mohashoal* collecting from open water natural sources is established.

Ensured year round IGAs for fishermen members through govt. approved resource harvesting modalities

As a process of establishing access right into TH resources by organization members are accomplished through government gazette notification on fish harvest and sharing modality. This is a milestone achievement in the wetland resource management history in Bangladesh to influence policy makers to provide endorsement on the benefit sharing mechanism from harvest. The "fish resource sharing modality" agreed by the Government, the District Administration and the communities are: Harvesters-40% of the income; Community organization- 36% of the income; and Government-24% of the income (for reinvestment). This arrangement was supported by the THMC and the MoEF has endorsed the modality through a gazette notification in April 2008. Similar harvest modality for forest resources are proposed that has been endorsed by THMC. It is in the process of getting approval from MoEF after successful testing in TH. The proposed "Forest resource sharing modality" is: Harvesters-60% of the income; Community organization- 25% of the income; and Government-15% of the income (for reinvestment).

Table 4: Best livelihood practices in TH

Category	Profit/day (Tk.)			
	Avg	Min	Max	Rank
Fishing gear	1035.00	85.00	2487.00	1
Rice Business	906.00	180.00	1680.00	2
Fishing boat	755.00	725.00	785.00	3
Tea stall	554.78	255.00	1143.00	4
Hawker	385.38	30.00	963.00	5
Fish Business	281.88	50.00	795.00	6
Dry fish (shutki)	182.00	182.00	182.00	7
Sweet shop	163.50	94.00	233.00	8
Beetle leaf & nut	126.05	77.10	175.00	9
Grocer's Shop	119.10	8.00	500.00	10

Commercial fish harvest is arranged following the above mentioned agreed sharing modality at regular basis through permitting license by DC to the fishermen of TH during Jan-March of each year. Besides, a number of fishermen of TH are involved year round in different non-commercial fish harvest event given seasonally e.g. ,beel based chai (traditional fishing trap), daitta (traditional hook) fishing, lar (long line hooks) fishing, etc. Income from commercial fish harvest so far is BDT 6,850,805/= (April 2010) and non-commercial BDT 667,845/= (October 2010).

Alternative incomes generated for different profession members

CCC provided 3037 financial assistances (Feb '11) to its valid members of different occupation in 27 sub-domains. Among the small business categories best practices are identified to promote market and provide training to the members (Table 4).

Participatory Resource Management Plan (PRMP)

A legendary tool of participatory planning for resource management was established by the community themselves. They conduct PRMP for each VCCs using their skill through guidance of co-facilitators developed under project. It includes year round activities of all five profession groups of organization. They conduct PRMP at yearly basis soon after completion of election. An interactive PRMP calendar depicting all significant activities at VCC level with both Bangla and English dates is published for the year 2010. The calendar is first of its kind in Bangladesh in operation and executing by any community organization.

Major Challenges, Opportunities and the Road Ahead

Major constraints, challenges and opportunities identified are documented with possible strategic interventions in the table below-

Sl No	Constraints	Challenges	Opportunities	Way forward
1	Negative propaganda by the vested interest groups patronised by the previous leaseholders (who still remain active in the locality).	a. Changing mindset of the vested interest groups who do not believe co-management system. b. Developing confidence of the poor leaders that they will be the owner of Tanguar Haor collectively. c. Community people are still dependent on project staff psychologically. d. Developing managerial and accounting skill as the leaders remain busy most of the day time with their own business.	a. GoB commitment for Ramsar Site. b. Increased income from commercial and non commercial fish harvest. c. Increasing number of leaders from 5 to 9 in the VCC will allow more leaders both from professional and administrative groups. d. Increasing trends of membership among the community. e. More representation of women and poor in the co-management committees at different tires. f. Accumulation of more than 10 million BDT of social capital of the community g. Continuous support from district administration.	a. Increasing visibility of project activities through afforestation, re-excavation, habitat restoration and construction of UCC offices on khas lands. b. Organising civil society groups/Ramsar Committee at regional and national level. c. Inclusion of maximum GoB officials in different decision making bodies like THMC. d. More responsibility of community leaders to make decisions.

Conclusion

Establishment of a successful co-management may require a long period of time to be negotiated by the communities where the role of the project at initial stage is to convince GoB to show flexibility on issues not affecting the sustainability of stock. It is also required to aware the community about the rules and regulations resulted from the negotiation with the GoB. However, still there is need of long and sustained efforts of negotiation, coaching and capacity building of community as well as the implementing government instruments. The preparatory stage of the project (with its 1st and 2nd phases) successfully initiated the process by developing modalities for co-management through consultation with stakeholders at different tires, and getting necessary policy support to establish resource harvesting in convincing scale involving the community. It also supported livelihoods needs of the communities in villages.

The next phase would be its development stage of co-management through progression of the success and scaling up ongoing processes and also for initiation of replicating the Tanguar Haor Co-management model in sustaining other wetlands management in Bangladesh. This would be particularly important from the point of view of the current lease-holding arrangements prevailing for management of all other important wetlands of the country. A public awareness campaign concerning the values (goods and services) of wetlands and floodplain ecosystems should be promoted in parallel, through civil society organizations at local and national levels. Such an effort would serve to build public pressure for pro-poor sustainable management measures.

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Lessons Learned in Protected Area Co-management: Co-management Organization (CMO) Perspective

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Abstract

Bangladesh is a country with high population density Its protected area coverage per person is one of the lowest in the world. The country adopted its first Co-management Program towards conservation of natural resources through MACH project in 1998 funded by USAID. The MACH (Management of Aquatic Ecosystems through Community Husbandry), which ended in 2008, was developed with the aim of addressing poverty, declining fish stocks and wetland degradation in the northern region of Bangladesh.

In 2003, the forest co-management project (Co-management of Tropical Forest Resource in Bangladesh), named "Nishorgo Support Project (NSP)" was launched as an initiative of the Forest Department of Bangladesh \with the financial support from USAID. Five forests Protected Areas (PA) were included under this project in Northern and South-eastern parts of Bangladesh. The over all goal of the Nishorgo Support Project is to enhance biodiversity conservation in the target protected areas through the active and formal involvement of the local communities depending on the forest resources. This project concluded its term in October 2008.

Considering the lessons learned of MACH and NSP, the Integrated Protected Area Co-management (IPAC) Project has been lunched in November 2008 in Bangladesh for bio diversity conservation through co-management approach of 26 Forest PA, Wetlands and ECAs (Ecologically Critical Area). This project is also funded by USAID. The main goal and objective of IPAC Project is to conserve biodiversity through collaborative management with active participation of local community.

Now all the PAs have been managing under the leadership of CMOs (Co-management Organizations). And CMCs are taking the lead for the implementation of sustainable conservation activities under respective PA. Some CMCs have already registered the local CBOs with concerned authority of the Government. with a view to continuation of these organizations even after phasing out of IPAC Project. A healthy relation was thus created between CMCs and GoB department. Deferent field based stakeholder organization/group (VCF, PF, CPG, FCC) have been formed under the umbrella of CMCs. CMCs are taking participatory decision for conservation of forest, wetland and ECAs under their jurisdictions.

Key words: Co-management, Protected area, Biodiversity conservation

Introduction

Co-management: `*A situation in which two or more social actors negotiate, define and guarantee amongst themselves a fair sharing of the management functions, entitlements and responsibilities for a given territory , area or set natural resources'* (Borrini Feyerabund, IUCN 2000).

Co-management (Collaborative management) of protected areas is participatory an approach to environmental conservation that seeks to enhance both natural resources conservation and local livelihoods. This approach gives local residents both the responsibility to manage their natural resources effectively and opportunity to enjoy the benefits derived from them. Without the active involvement of local community there is little chance for reducing their dependence on forest and boosting the success of PA initiatives. A large number of environmentalists, non-governmental organizations and national governments worldwide have begun to emphasize the importance of local community's participation in decision-making and management of PAs (Svarstad *et al.*, 2006 cited in Agrawal and Gibson 1999;).

Bangladesh has faced significant loss in natural resources and biodiversity over the last few decades. This resulted severe degradation of the environment. A major reason for the environmental degradation is that many people have been left out of the conservation process. Not surprisingly, these people have decided not to cooperate with conservation efforts that they perceive could adversely affect their own livelihoods. To address the issue and to engage local stakeholders as partners in the management of Protected Areas, the Forest Department initiated a nationwide co-management program called Nishorgo Support Project (NSP). NSP worked in five (Teknaf GR, Chunoti WS, Lawachara NP, Satchari NP and Rema-Kalenga WS) forest protected areas as pilot from since 2004 to 2008 to involve local stakeholders that are directly and indirectly dependent on forest resources. The primary goal of NSP is to promote the conservation of biodiversity within the protected areas of Bangladesh through co-management approach.

After successful implementation of NSP and MACH, a new project named `Integrated Protected Area Co-management (IPAC) has been lunched in 2008 and implementing by the Ministry of Environment & Forest and Ministry of Fisheries & Animal Resources funded by USAID. IPAC Project has been implemented in 26 PAs in Bangladesh under five clusters (South-Eastern, Sundarbon, Sylhet, CHT and Central Cluster). The specific objectives and purpose of the IPAC Projects are:

- Provide technical advisory services Environment, Forestr and Fisheries departments of GoB to support further development of the natural resources sector and conservation of biological diversity;
- Develop a protected area strategy that applies to all ecologically and economically significant areas, including those outside freshwater and forest ecosystems;
- Build technical capacity within national and local level institutions for protected areas co-management;
- Expand the geographic area of Bangladesh under site-specific implementation of co-management to ensure long-term success of the co-management model and to extend socio-economic benefits to surrounding communities, including increased access to improved drinking water supplies and opportunities for alternative income generation
- Address within IPAC a series of short, medium and long-term climate change mitigation and adaptation issues.

Stakeholders and Composition of Co-management Organizations (CMOs)

Considering the importance of biodiversity and natural resources conservation, the Government of Bangladesh circulated a special gazette (Ref: PABAMA/PARESHA-4/NISHORGO/104/Sting/2006/398, dated: 23/11/2009). It is a remarkable decision by the Government that, all the PAs in Bangladesh will be managed as stated in this gazette. According to the gazette deferent levels of local stakeholders are the part of CMOs. The CMCs consist of a two tier structure. It has a general body, called Co-management Council and other is executive body, called Co-management Committee. The Council consists of 65 members and Committee consists of 29 members, elected by council.

The composition of Co-management Council is as follows:

Advisers (3): - Member of Parliament (Local MP)
- Upzila Chairman and
- Divisional Forest Officer (DFO)

Member (65): - Local Civil Society (Local elites, teacher, social workers, physicians, journalist, religious leader, freedom fighter) - 5

- Local Administration and Government (UNO, ACF, RO, BO and local other GOB Officials) - 16
- Local Community:
    - -Forest Resources Users Organization – 4
    - -Local Indigenous Community – 3
    - -Forest Conservation Club Member – 5
    - -Community Patrolling Group Member – 5
    - -People's Forum Representative/VCF Members – 22
- Other GOB Department: (Agriculture, DoE, DoF, YD, SW) - 5

Out of 65 members 15 must be women.

Co-management Committee consists of:

Advisers (2): - Divisional Forest Officer (DFO) and
- Upzila Nirbahi Officer (UNO)

Member (29): - Assistant Conservator of Forest (ACF) – 1
- Respective Range Officer (RO) – 1 (as Member Sectary of Council & Committee)

- Local Government Representative (at least one woman) - 2
- Local Civil Society Representative - 2
- People's Forum (PF) Representative – 6
- Forest Conservation Club Representative – 2
- Beat Officer/Station Officer of related PA - 5
    - Local indigenous Community representative – 2
    - Community Patrolling Group (CPG) representative - 3
    - Forest Resources Users Organization's representative – 1
- GoB Law & order department (Police, BGB, Coast Guard) - 2
- Other GOB Department: (Agriculture, DoE, DoF, YD, SW) - 1

Out of 29 members 5 must be women.

Co-management Organizations (CMOs) working under IPAC Southeastern Cluster (Chittagong and Cox's Bazar Districts)

Under IPAC Southeastern Cluster (Cox's Bazar and Chittagong Districts, the two southeastern district of Bangladesh), IPAC is working under 7 Protected Areas (6 Forest PA and 1 ECA) with 8 Co-management Organizations (Table 1). Out of eight CMOs five had been formed under NSP and rest of three has been formed under IPAC.

Table 1. Details of CMOs/PA

SL	Name of CMO/PA	Forest Range	Date of Formation	Date of Reformation	Remarks
1	Chunoti CMO - CWS	Chunoti	24.08.2005	28.06.2010	Formed under NSP
2	Jaldi CMO - CWS	Puichari	27.07.2006	11.07.2010	Formed under NSP
3	Teknaf CMO - TWS	Teknaf	06.08.2006	25.10.2010	Formed under NSP
4	Shilkhali CMO - TWS	Shilkhali	27.09.2006	18.08.2010	Formed under NSP
5	Whykhong CMO- TWS	Whykhong	29.05.2005	02.10.2010	Formed under NSP
6	Himchari CMO - HNP	Cox's Bazar	07.07.2010		
7	Medhakachapia CMO-MNP	Fhulchari	17.11.2009		
8	Fashiakhali CMO-FKWS	Fashiakhali	23.12.2009		

Some Achievements of CMOs

- COMs have been formed and reformed as per new gazette,
- A platform has been formed at the site level towards raising voice for natural resource conservations,
- Regular periodical meeting (Monthly Committee meeting and half-yearly Council meeting),
- Relation build up between local stakeholders and GOB officials,
- Encourage the participation of the local community in the management of natural resource conservations,
- CMC members are participating for local conflict regulation process,
- Increase interaction among local stakeholders,
- Participation at PA Management Plan preparation and Annual Development Plan (ADP) preparation,
- Formation of Village Conservation Forum, Peoples Forum, Forest Conservation Club, Community Patrolling Group as part of CMOs,
- CPGs members are taking part for forest patrolling along with local FD officials,
- Active involvement of CMC members during implementation of project activities,
- Some CMCs have taken registration from Social Welfare Department,
- Community development activities have been implemented through Landscape Development Fund (LDF),
- Entry Fees collection have been started in some PAs (Teknaf, Chunoti),
- Taking part in providing AIG support activities,
- Supervising and follow-up CPG activities,
- CMC members are taking part at various site level community awareness programs (day observation, drawing competition for students, scout hiking program, program with visitors, religious leader ,etc.)
- CMCs are playing a vital role to motivate the local community with this conservation activities,
- Related GOB departments are also willing to get support and cooperation from local stakeholders and their attitude is positive and increasing graduall.

Lessons Learned and Challenges

It is a great and effective initiative to introducing Co-management Approach for conservation of natural resources in Bangladesh. Respective CMOs are taking the lead as Co-Managers of PAs. Respective GoB departments are also part of CMOs. Now CMOs are able to set up themselves as a local platform and institution. Some of them already proved their competencies through their activities (for example – Chunoti, Teknaf, Shilkhali etc.). However, still the following issues need to be addressed:

- Population pressure to PAs,
- Rohinga Refuge issue at Cox's Bazar,
- Land encroachment,
- Capacity and capability enhancement of CMOs,
- Capacity and capability enhancement of Forest Departments (mainly insufficient staff, staff accommodation facility, logistic, vehicle and others)
- Training and orientation for CMOs and GOB officials at field level towards understanding the co-management approach and conservation,
- Set up CMO office space and other support,
- Create and accelerate eco-tourism opportunity at all PAs, so that CMOs can collect entry fees for their sustainability,
- Create more livelihood opportunity for PA dependent communities.

One of the overall lessons was thatwith diversity of interests, over exploitation (for example- around 50,000 people directly exploit Teknaf Wildlife Sanctuary alone), and limited benefits from conservation, it is difficult to achieve full success Conservation planner need to accept these structural conflicts are a part of conservation, and work to manage conflict in transparent process.

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Co-management in Sundarbans

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Abstract

The paper gives an idea of the status of co-management in the Sundarbans. It describes the constitution of co-management organization comprising of co-management council and co-managent committee. The co-management is mainly used for natural resource management and conservation in protected areas. Here, the management is shared between the Government and the relevant stakeholders. The key partners are the local resources users in co-management of protected areas. The co-management approach has been well accepted by the people living around Sundarbans. The assistance of Integrated Protected Area Co-management (IPAC) project has been well noted at community and other stakeholder levels. There has already been some improvement in the Sundarbans conservation in particular to reducing fishing by poisoning and deer poaching. However, several constraints are identified in co-management in the Sundarbans.

Key words: Co-management, Protected area, Sundarbans

The Co-management

Definition: "A situation in which two or more social actors negotiate, define and guarantee amongst themselves a fair sharing of the management functions, entitlements and responsibilities for a given territory, area or set of natural resources" (Borrini and Feyerbund, IUCN: 2000).

In simple word, the co-management is a method or approach used for the management of an area or natural resources. The participation of the resource users and other stakeholders are ensured, the decisions are made on a participatory approach taking into account the opinion of the stakeholders. The transparency and accountability is ensured, everyone gets responsibly in the management and conservation,and the benefit raised from the managed resources is shared among all stakeholders on an equitable basis.

Background

The Forest Department of Bangladesh is designated for the management of the forest of Bangladesh since the inception of the department. The management of forest lies with two major objectives of (a) proper utilization of natural forest and its resource and (b) revenue collection. It is now evident that the protection or management of the resource only by the Forest Department is not only difficult but almost impossible. This is due to the limitation of capacity and resources of the department. Apart from that, the experience of the other parts of the world reveals that without the collaboration and participation of the local people, the conservation and management of the resource only by the Government is impossible.

The Co-management is relatively a new concept in natural resource management. It has similarity with participatory management and community based management but not the same. In many countries of the world, the co-management approach has been tested for natural resource management and has given good success. Many countries of the world are now using the approach. In Bangladesh, two projects of Nishorgo Support Project (NSP) and Management of Aquatic Ecosystem through Community Husbandry (MACH,) were implemented through Co-management approach with the financial and technical assistance of the USAID. The NSP (2003-08) was in forest areas and MACH (1998-2005) in wetlands. The two projects had quite good success in resource management and conservation as well as benefiting the dependent people. The success of the two projects has encouraged the adoption of co-management in Bangladesh.

The co-management approach has been a fundamental recommendation of the past two World Parks Congresses, and is actively advocated by the IUCN.

Main Co-Management Values and Principles

- Recognise ***different values, interests and concerns*** involved in managing a territory, area or set of natural resources, both outside the local communities and within them
- Seek ***transparency*** and ***equity*** in natural resource management
- Allow the ***civil society*** to assume ever more important roles and responsibilities
- Co-Management Adoption by Bangladesh Government

Based on the success of MACH and NSP and taking account the limitation of forest conservation and management, the Government of Bangladesh (GOB) has decided to adopt the Co-management approach and involve local people in the natural resource conservation and management through collaboration and active participation. The basis of such collaboration and participation would be "equitable sharing of benefits".

The Legal Status

The Government of Bangladesh has accepted and legalized the co-management in Protected Areas (PA). The Ministry of Environment and Forest has issued Gazette notification (pabama/parisha/4/nishorgo/105/sting/2006/398, date 23/11/2009) in this regard. The Gazette has approved and made legal the formation of the co-management organizations. The government has also approved to provide 50% of the revenue raised from visitor entry fee from PAs to the Co-management Organization (CMC).

Co-Management Organization

The Co-Management Organization (CMO) is the organization involved in the management and conservation of natural resources and biodiversity in selective protected area through co-management approach. The CMO has two tires of (1) **Co-management Council** (called CMC-Council**)** and (2) **Co-management Committee (**called CMC-Committee**)**. The first one is the General Body for policy development and the second one is the Executive Body for implementing activities.

Member Eligible for the Council

As per the Gazette, the local Member of the Parliament (MP), Upazila Parishad Chairman and the Divisional Forest Officer are the advisors. The president and member secretary are the respective Upazila Nirbahi Officer (UNO) and the respective Forest Range Officer.

There are a total of 65 members (maximum) in the Council and at least 15 of them are females. The members of the council comprises of Assistant Conservator of Forest (ACF), beat/ Station Officer, adjacent Range Officer, people from civil society, local government & administration, law enforcement departments, local people, indigenous community, resource user institution/representative of the Peoples Forum, member of the Community Patrolling Group (CPG).

Out of several member-categories representing to the council, one key members-category is the **Peoples Forum (PF)**. All the resource users of the surrounding village under specific council/committee are members of the Village Conservation Forum (VCF). Two representatives from each resource user (VCF) of the surrounding village of the respective protected area under the forest Range forms a Peoples Forum. Twenty two representatives from the Peoples Forum represent in the Co-management Council. Among the 22 PF members, 33% are female.

It is noted that the "Peoples Forum" is the breeding platform between the poor people or the resource users and the co-management organization. In other words, the People Forum is the platform to speak for the general people.

Major Terms of Reference (TOR) of the Council

- The key role of the Council is to review and approve the Annual Development Plan (ADP)
- Monitor and evaluate the adopted activities and give guidance to the Co-management Committee
- The council will act as the guardian in implementing the co-management activities
- The Council members sit together at least two times in a year
- The Council is formed through election and its tenure is 4 years.

Member Eligible for the Co-management Committee

The maximum number of Committee member is 29 and at least 5 of them are females. The others members come from different Govt. organizations, elected representatives and different resource users groups. The Divisional Forest Officer and the Upzila Nirbahi Officer are the advisors and the respective Forest Range Officer is the member secretary by position. The president, one vice president and treasurer of the Committee are elected by the members of the Committee and its tenure is 2 years. The account is operated by the joint signature of treasurer and the member secretary of the Committee. Major Terms of Reference (TOR) of the Committee:

The activities of CMC committee include:

a) Implementation and monitoring of the daily activities of Protected Area
b) Preparation of Annual Development Plan (ADP) for each year and get approval by the Council for implementation
c) Implementation of the ADP of the Protected Area approved by the council
d) Select people from local area to perform the activities for the implementation of ADP
e) Ensure equitable distribution of goods and services to the stakeholders
f) Assist to the Forest Department in selecting participants in buffer zone plantation
g) Assist to the Forest Department in protecting the forest resources by forming Community Patrolling Group (CPG) from the members of Peoples Forum
h) Keep records of all incomes (comes from any sources) and expenditures.

Present Status of Co-Management in the Sundarbans

The Co-management activities have been initiated in Sundarbans in mid November 2008 through office set up and staff placement under IPAC project. The process got advancement through the "Consultative Meeting" held in Khulna on April 18, 2009 with participation of different stakeholders of higher level GOB (ministry) officials, personnel from Forest Department (FD), Department of Fisheries (DOF) & Department of Environment (DOE), US Ambassador, representative from USAID (the donor), IPAC and stakeholders from the Sundarbans area. The process was further advanced by the formal inception workshop of IPAC project held at Khulna on April 22, 2009.

Since then the process of co-management establishment in Sundarbans has been progressing. As per the gazette, four CMOs (4 CMC-Council and 4CMC-Committe) are to be formed under the four ranges of Sarankhola, Chandpai (East Division), Khulna and Satkhira (West Division). So far (as of March 2011), 2 CMOs (2 CMC-Council and 2 CMC-committee) have been formed in Chandpai and Sarankhola ranges under Sundarbans East Forest Division by mid of 2010. The names of the two formed committees are "Chandpai Co-Management Committee: and"Sarankhola Co-Management Committee". The formation of the other two Committees is in progress. The one in Satkhira Range will be formed very soon. The other one in Khulna range is being delayed considering the misery of the people and area caused by the cyclone AILA. The people are yet to recover and straggling for existence.

The CMCs of Chandpai and Sarankhola Ranges developed the ADP for 2010-11 and implementing the activities using the IPAC project fund. IPAC project is assisting the CMC in the implementation of activities. The CMCs are involved with activities like AIGA support, drinking water support, and training in NRM. However, the prime focus is in awareness raising program on the importance of Sundarbans, need for conservation, responsibility of local people to conserve the resources of Sundarbans.

Very recently (April 2011), the two CMCs of Chandpai and Sarankhola has received a fund of about Tk. 9 and 10 lacs respectively under the Landscape Development Fund (LDF) from the USAID. They will use the fund for AIG to 190 households and three pond renovation for drinking water.

The co-management approach has been well accepted by the people living around Sundarbans. The assistance of IPAC has been well noted at community and other stakeholder levels. There has been some improvement in the Sundarbans conservation in particular to reducing fishing by poisoning and deer poaching. There has been at least one incident of returning a deer to Sundarbans which came into the locality. The awareness sessions have contributed to this achievement. There were some mass gathering in the local area organized by the CMC where personnel like MPs, Upazila Chairmen, senior personnel from Forest Department, (Khulna circle) and Department of Fisheries (district level) participated.

Hon'able Member of Parliment Dr. Mozammel Hossain Bagerhat 4 delivering his speech at the CMC declaration meeting at Sarnkhola

Mr. Idris Ali Upa Zila Chairman Mongla, Bagerhat deliveringhis speech at the awareness program organized by CMC Chandpai

Hon'able Member of Parliament Begum Habibun Nahar Talukder Bagerhat 3 delivering her speech at the CMC awareness program, Chandpai

It is notable that, the Government, in principle has agreed establishing and promoting "Nishorgo Network", a platform or network of the co-management organizations. It is felt necessary for the sustainability and effective functioning of the co-management organization as well as protected area and biodiversity conservation.

Constraint for Co-management in Sundarbans

- As per the present co-management rules, the co-management council/committee will be formed with the people living in and around the protected areas. In case of Sundarbans, it does not fit properly as the protected areas are far away from the locality. So the existing co-management rules need to be amended accordingly. The present CMC has been formed with people of the landscape of each respective FD Range covering 5 km area
- A vast area (77%) of the total Sundarbans Reserve Forest (RF) falls outside co-management intervention as the Gazette is only for the management of PA. There is no scope of differentiate the Sundarbans ecologically from PA and other parts of the Reserve Forest (RF), that it is known as buffer zone of the PA. More importantly, the buffer zone is quite close to land and community than the PAs. The accessibility of the people is easier to buffer zone than the PA and by thus possibility of destructionof buffer zone is higher than the PA as the thumps rule
- The present circulation/ gazette for the entry fee sharing with CMC is also a constraints. The gazette allows 50% of the visitor entry fee income from the Protected Area. In case of Sundarbans, the visitor has no limit of visiting buffer zone or PA, and virtually visits occur in both the places. Thus the segregation of entry fee for only PA is almost impossible. This issues need to solved
- Presently the CMC's working area is 5km in the landscape. There are many people outside the area who are the dependent of the Sundarbans resource. They need to be brought under the co-management
- Under the present Gazette, the CMC will be formed Range-based. The area (landscape and the forest) under a range is huge which is difficult to manage for one CMC. There is high communication hazard in the landscape area of the Sundarbans. Traveling by the CMC members over the working area is time consuming and costly. The number within a Range is very high (45 for Satkhira within 5 km). Effective co-management is difficult in such situation. It is mentioned here that the CMC member has to provide volunteer service with no payment
- A large number of people are dependent on the resources of Sundarbans and the numbers are increasing day by day but the resources are not increasing to meet the need. The benefit raised from the Sundarbans will not fulfill the need of the dependent people and the dependency reduction will not reduce to a level that can significantly contribute to Sundarbans conservation
- Scope and options of large scale AIGs are limited around Sundarbans
- There is lack of coordination among the NGOs, projects and GOs working around Sundarbans with AIG
- Literacy rate of the people is very low
- The health, education, family planning and drinking water facilities are low.
- High rate of birth and child mortality
- The Government decision of spending 50% of revenue earned from Sundarbans for socio-economic development of local people through Co-Management Organization. The rules/guidelines are not yet formulated for execution of the Govt. decision.

Recommendations

- Amendment of the Co-management Gazette or a special circular for the Sundarbans considering above-mentioned limitations so that the co-management can function well and contribute to Sundarbans conservation and local development
- The whole Sundarbans (PA and buffer zone) should be brought under co-management
- At least 10 km landscape area should be brought under the working area of Co-management
- The number of Co-management organization should be two or more in one range. The basis of determining CMC number would be forest and landscape area coverage and number of villages and households in a range
- NGOs, projects and GO working in the 10km (in width from the periphery of SRF) for livelihoods and AIG should work in coordination with the Forest Department
- The CMC should be provided with the 50% of the income from minor forest produces including fish resources of the entire Sundarbans not only from the PA
- Quick arrangement of paying the 50% money of the income to the CMC should be made.
- More investment from GO, NGO and projects on livelihood and AIGA should be initiated for Sundarbans dependent people to stop or limited the dependency.

Conclusion

Forest Department has been managing the natural resources of Sundarbans since 1875. With change of time, the FD is facing many and new challenges in respect to protection and conservation of the Sundarbans. Sundarbans is a World Heritage and RAMSAR site and of international significance. It is one of the tiger-dense forests in the world .Out of 14 tiger range countries, Bangladesh is one. Sundarbans is the name that familiarizes Bangladesh to a huge international community. It is included in the list of seven Wonders out of 27. Millions of people depend on Sundarbans for their livelihood. In a scenario of climate change, the Sundarbans can play significant role in saving Bangladesh and people. The proper conservation of Sundarbans can earn money in two ways 1) carbon credit sale and 2) sustainable eco-tourism development. Without participation of local people, it is extremely difficult to manage the Sundarbans efficiently and ensuring long-term sustainability. It appears that through Co-management, it is possible to ensure the people's participation in Sundarbans recourses management.

It is hoped that the constraints of Co-management application for Sundarbans will be solved and an effective co-management practice will be established to function well. Then the people will be benefited and the Sundarbans will be conserved.

Plant Biodiversity of Fashiakhali Wildlife Sanctuary in Bangladesh

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Abstract

The article highlights plant biodiversity of Fashiakhali wildlife sanctuary which has been assessed on the basis of collected materials and observations made from October 2010 to March 2011. From this sanctuary, a total of 285 angiosperm species including cultivated and planted under 67 families have been documented. For each species scientific name, local name (wherever available), family and life forms are provided. The abundance of species in the family displays variation. Among them, 47% species are represented by ten families whereas 53% species by 56 families. In Magnoliopsida (Dicots), Fabaceae is the largest family represented by 30 species, while in Liliopsida (Monocots), Poaceae (Gramineae) is the largest family represented by 19 species. The most common ten families are Fabaceae (30), Poaceae (19), Euphorbiaceae (16), Rubiaceae (12), Verbenaceae (12), Mimosaceae (10), Arecaceae (9), Asteraceae (8), and Myrtaceae (7). Of 285 species recorded here, 88 species (31%) are represented by herbs, 66 (29%) by shrubs, 82 (23%) by trees, 41 (14%) by climbers and 8 (3%) by epiphytes. The common native tree species in the canopy are *Diptercarpus turbinatus, Dipterocarpus costatus, Dipterocarpus gracilis, Syzygium grandis, and Alstonia scholaris, Hopea odorata* and *Artocarpus chaplasha.* The presence of large number (82) of tree species in the area is indication of rich tropical forest. If managed properly it may restore their original climax condition though it is now a very disturbed area. The survey has also confirmed the occurrence of seven threatened angiosperm species and a good number of exotic species. These threatened plants are *Aquilaria agallocha, Bombax insigne, Calamus guruba, Cymbidum aloifolium, Mangifera sylvatica, Pterospermum semisagittatum* and *Swintonia floribunda.* The most extensive exotic invasive species are *Mikania scandens* and *Eupatorium odoratum.* It is observed that the regeneration of canopy trees of the area is in great challenges because of overexploitation by local people in the name of minor product collections. The study suggests for further long term research to focus all aspects of plant biodiversity to help in making proper management plan for this sanctuary.

Keywords: Plant biodiversity, Fashiakhali Wildlife sanctuary, Bangladesh

Introduction

Fashiakhali wildlife sanctuary is located in the south-eastern side of Chakaria Upazila headquarters under Cox's Bazar district. Fashiakhali forest range is spported by six forest bits including Fashiakhali, Dulhazara, Nalbila, Manikpur, Kakara and Bamu. Among the bits parts of Fashiakhali (also called ring bong block) and Dulhazara were declared as reserve forest during 1937. Very recently in 2007, to conserve the existing flora and fauna, especially the habitat of Asian Elephant, this area was declared as wildlife sanctuary under the wildlife (Preservation) (Amendment) Act 1974 with a total area of the sanctuary of 1302.43 ha (BFD, 2011). The area bounded by Chakaria Upazila headquarters to the north, Lama to the east, Chakaria Sundarban to the west and Dulhazara to the south. It can be reached in 1.5h ride by bus from Cox's Bazar and 2.5h ride from Chittagong city. The vegetation the area has been classified as tropical rain forest (Khan 1990) with the mixture of evergreen and deciduous trees (Uddin and Misbahuzzaman, 2007). The sanctuary area is undulating with several hill ranges of different heights. It also covers low valleys, streams and wetlands, thick bushy vegetation, plantation forest, small patches of natural forest and also the segment of Chakaria mangrove forest. The sanctuary and the nearby areas are similar in geological structure. It includes in the Pliocene era of the tertiary periods which was built-up 25 million years ago. It was under the Dupitilla series that was built-up with sandstones and shale (Uddin and Misbahuzzaman, 2007). The sanctuary area enjoys moist tropical maritime climate with 740.8mm mean annual rainfall, whereas the average annual humidity and mean annual temperature are 79.3% and 26.60°C respectively (Uddin and Misbahuzzaman ,2007).

A number of studies on the plant biodiversity of different protected areas of Bangladesh have already been reported, such as, Khan *et al.,* 1994; Rahman and Hassan, 1995; Uddin *et al.,* 1998; Uddin and Rahman, 1999; Khan and Huq, 2001; Uddin *et al.* ,2002; Uddin *et al.*, 2003; Uddin *et al.,* 2005; Uddin *et al.* ,2006; Rafiqul *et al.,* 2009; Tutul *et al.,* 2009;2010 and Uddin and Hassan, 2004; 2010. Such studies did not cover the plant biodiversity of Fashiakhali wildlife sanctuary. The Park supports a large number of native angiosperm species. Conservation significance of such species is very high because of the presence of Asian elephant in the area. Currently plant biodiversity of the sanctuary is under threat due to various pressure including anthropogenic activities. For the making proper management plan of the sanctuary, data on the plant biodiversity is essential. In order to provide such information, in the present study an attempt has been made to prepare the inventory of the plant biodiversity of Fashiakhali wildlife sanctuary.

Materials and methods

Floristic survey has been carried out in the Fashiakhali wildlife sanctuary at 2-months intervals between October 2010 and March 2011. The survey covered all habitats of the study area including hilltops, slopes, foothills, valleys and wet areas including mangrove patch. Special attention was given to locate the species already listed (Khan *et al.,* 2001) as threatened categories in the country. Flowering or fruiting specimens were collected and processed using standard herbarium techniques (Hyland ,1972; Alexiades; 1996). The specimens were identified consulting different flora, viz., Hooker 1872-1897; Prain, 1903; Uddin and Hassan, 2004; Siddiqui *et al.*,2007 and Ahmed *et al.,* 2008-2009; 2008a. Specimens available at Dhaka University Herbarium (DUH) and Bangladesh National Herbarium were consulted in identifying the collected plant specimens. The updated nomenclature of the species was followed according to Siddiqui *et al.,* 2007 and Ahmed *et al.,* 2008-2009; 2008a). Threatened categories of plants were confirmed with the help of Khan *et al.* (2001). Some noxious exotic plant species were also determined comparing with the reports of Islam *et al.* (2003), Hossain and Pasha (2004) and Akter and Zuberi (2009). Families are determined according to Cronquist (1981). Voucher specimens are deposited at DUH.

Results and Discussion

The present study has recorded of 285 angiospermic species including cultivated and planted under 66 families from the Fashiakhali wildlife sanctuary. For each species scientific name, local name (wherever available), family, and life forms are provided (Table 1).

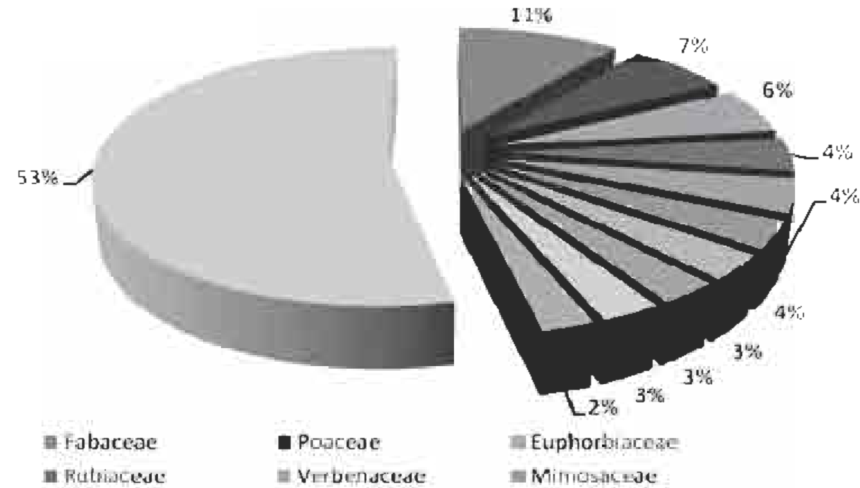

Figure 1: Abundance of species in the families

The abundance of species in the family displays variation. Among them, 47% species are represented by ten families whereas 53% species by 56 families (Figure1). In Magnoliopsida (Dicots), Fabaceae is the largest family represented by 30 species, while in Liliopsida (Monocots), Poaceae (Gramineae) is the largest family represented by 19 species. The most common ten families are Fabaceae (30), Poaceae (19), Euphorbiaceae (16), Rubiaceae (12), Verbenaceae (12), Mimosaceae (10), Arecaceae (9), Asteraceae (8), and Myrtaceae (7). Of 285 species recorded here, 88 species (31%) are represented by herbs, 66 (29%) by shrubs, 82 (23%) by trees, 41 (14%) by climbers and 8 (3%) by epiphytes (Figure 2). The presence of large number (82) of tree species in the area is an indication of rich tropical forest. If managed properly it may restore their original climax condition though it is now a very disturbed area. The survey has also confirmed the occurrence of seven threatened angiosperm species and a good number of exotic species. These threatened plants are *Aquilaria agallocha, Bombax insigne, Calamus guruba, Cymbidum aloifolium, Mangifera sylvatica, Pterospermum semisagittatum* and *Swintonia floribunda* whereas the most extensive noxious exotic invasive species are *Mikania scandens* and *Eupatorium odoratum.*

Fashiakhali protected area covers mainly plantation forest, natural bushy vegetation, small patch of natural forest, streams and wet valleys. Species distribution among these habitats displays variation. They also form vertical stratification. The top tree canopy includes *Dipterocarpus turbinatus, D. Costatus, D. gracilis, Syzygium grandis, Alstonia scholaris, Tectona grandis, Artocarpus chaplasha* and *Hopea odorata.* The middle strata of vegetation is dominated by the tree species particularly *Dipterocarpus* spp, *Syzygium garndis* (Dhakijam), *Aporosa dioica* (Kakra), *Quercus spicata* (Batana), *Alstonia scholarish* (Chatim), *Syzygium fruticosum* (Bhutijam), *Vitex peduncularis* (Awal), *Vitex altissima* (Badruk), *Pterospermum semisagittatum* (Bonaserd) and *Sterospermum personatum* (Goda). The most common shrub species are

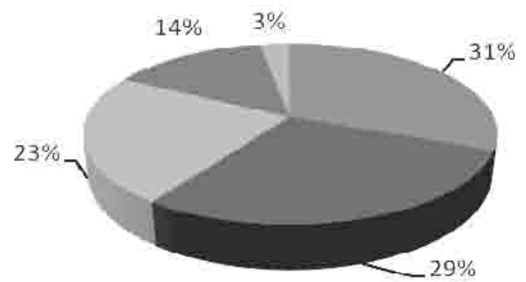

Figure 2: displaying life form patterns

■ Herbs ■ Trees ■ Shrubs ■ Climbers ■ Epiphytes

Morinda angustifolia, Ixora javanica, Antidsema ghaesembila, Psychortia fulva, Pterospermum semisagittatum, Glochidion multiloculare, Macaranga indica, Maesa indica, Grewia microcos, Glycosmis arborea, Clausena subfruticosa, Breynia retusa, Holarrhena antidysenterica, Dracaena spicata, Ardisia solanacea, Randia dumetorum, Erioglossum edulis, Dalbergia stipulacea, Sapindus danura, Deasmodium triquetrum. Forest floor, near streams and valleys are covered by member of Poaceae, Acanthaceae, Asteraceae, Zingiberaceae, Cyperacae, Araceae, Polygonaceae. Water bodies within the study area are dominated by free floating hydrophytes (e.g., *Nymphoides cristatum*), surface creepers (e.g., *Ludwigia repens*), emergents (e.g., *Eleochari acutangula*), other sedges, grasses and aroids. Native climbers are mainly the members of Combretaceae, Apocynaceae, Asclepiadaceae, Rubiacaeae, Vitaceae, Annonaceae, Cucurbitaceae and Dioscoreaceae. The most common epiphytes in the forest are met *Cymbidium aloifolium, Arides odorata, Bulbophyllum lilacinum, Vanda teres, Acampe premorsa, Dendrobium aphyllum* and *pholidota pallida.* Main exotic species are encountered in the disturbed forest areas including *Mikania scandens, Eupatorium odoratum, Croton bonplandianum, Lantana camara, Acacia auriculiformis, Eucalyptus camaldulensis* ,etc. Some enhancement plantations have also spotted in the sanctuary area and the species planted here are *Dipterocarpus turbinatus, Syzygium fruicosum, Hopoea odorata, Shorea robusta, Switenia mahagoni, Chukrasia tabularis, Terminalia chebula, Terminalia bellirica, Phyllanthus emblica, Azadirachta indica, Albizia procera, Artocarpus chaplasha* and *Terminalia arjuna.*

Currently regeneration of plant biodiversity of this sanctuary is in great risk because of many threats as observed during field works. The most commonly cited threats are forest minor product collections, illegal logging and forest fire during dry season. According to local information, the demand of small erect tree ,up to above man height, is very high in the local market. These products have several uses particularly in crop cultivations including betel leaf and bean. It is a fact that both of these crops need erect sticks on which they climb towards the light. Same scenario have been observed in other forests from where small trees were collecting to use in betel leaf cultivation. Though the plant diversity of the sanctuary is under *in situ* conservation plan, the management plan should be made based on local knowledge of plant biodiversity. As the sanctuary is the home for so many threatened plant species as well as for wildlife, distribution map of threatened plant species should be made on priority basis for the sake of better management option. Such map will facilitate accurate location and home range of threatened species in the sanctuary so that monitoring activities can be carried out easily. In severe cases, *ex situ* conservation for particular species may be followed to replicate their population number. Present management system should be strengthened by deploying relevant manpower including plant taxonomists for proper documentation and conservation and sustainable development of the Fashiakhali wildlife sanctuary.

Conclusion

Fashiakhali wildlife sanctuary is a newly declared protected area of Bangladesh. According to the literature no floristic works have so far been found for this area. The present list of plant biodiversity (285) is very preliminary. It is still believed that there might be some other species yet to be listed, and many specimens need to be identified. Based on the field observations and present preliminary results it may be concluded that the sanctuary is very rich in the plant diversity and the sanctuary is the home for so many threatened plant species in context of Bangladesh. From the field observation, it is also confirmed that the regeneration of tree species in the habitat is severely hampered because of minor product collections. Invasive species such as *Mikania scandens, Eupatorium odoratum,* etc.,are another challenge to future regeneration of forest trees in the disturbed area. The study suggests for further long term research to focus all aspects of plant biodiversity to help in making proper management plan for this sanctuary.

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Table 1: Plant biodiversity of Fashiakhali Wildlife Sanctuary. c=climber, h=herb, s=shrub, t=tree, e=epiphyte

Species name	Local name	Family	Habits
Abrus precatorius L.	Ratti	Fabaceae	c
Acacia concinna DC.	Kuchui	Mimosaceae	s
Acacia auriculiformis A. Cunn. *ex* Benth and Hook.	Akashmoni	Mimosaceae	t
Acampe premorsa (Roxb.) Blatter & Mcann	Rasna	Orchidaceae	h
Acanthus ilicifolius L.	Hergoza	Acanthaceae	s
Achyranthes aspera L.	Apang	Amaranthaceae	h
Actinodaphne angustifolia Nees	Modanmosta	Lauraceae	t
Aerides odorata Lour.	Porgasa	Orchidaceae	h
Ageratum conyzoides L.	Fulkuri	Asteraceae	h
Albizia lucidior (Steud) Nielsen	Sil-koroi	Mimosaceae	t
Albizia procera (Roxb.) Benth.	Koroi	Mimosaceae	t
Allophyllus cobbe L.	Chita	Sapindaceae	h
Alstonia scholaris L.	Chatim	Apocynaceae	t
Alternanthera sessilis (L.) R. Br. *ex* DC *ex* Roem & Schult.	Chanchi	Amaranthaceae	h
Ammannia multiflora Roxb.	-	Annonaceae	h
Anisomeles indica (L.) Kuntze	Gobura	Lamiaceae	h
Annona reticulata L.	Ata	Annonaceae	t
Anthocephalus chinensis (Lamk.) A. Rich *ex* Walp.	Kadam	Rubiaceae	t
Antidesma roxburghii Wall *ex* Tulasne	Chukka	Euphorbiaceae	s
Antidesma ghaesembilla Gaertn.	Khudijam	Euphorbiaceae	s
Aphania danura (Roxb.) Rodlk.	Danura	Sapindaceae	s
Aporosa oblonga (Wall.) Muell.-Arg.	Kakra	Euphorbiaceae	t
Aporosa dioica (Roxb.) Muell.-Arg.	Patakharolla	Euphorbiaceae	t
Aquilaria agallocha Roxb.	Agar	Thymeliaceae	t
Ardisia paniculata Roxb.	-	Myrsinaceae	s
Ardisia elliptica Thunb.	-	Myrsinaceae	s
Areca catechu L.	Supari	Arecaceae	t
Artocarpus chaplasha Roxb.	Chapalish	Moraceae	t
Artocarpus lacucha Roxb.	Deua	Moraceae	t
Artocarpus heterophyllus Lamk.	Kanthal	Moraceae	t
Arundinella bengalensis (Spreng.) Druce	Ganga bena	Poaceae	h
Axonopus compressus (Swartz.) P. Beauv.	Ghora dubo	Poaceae	t
Baccaurea ramiflora Lour.	Lotkon	Euphorbiaceae	t
Bambusa balcooa Roxb.	Barak bans	Poaceae	s
Bambusa vulgaris Schrad. *ex* Wendl.	Baijja	Poaceae	t
Blumea lacera (Burm.f.) DC.	Barokukshim	Asteracae	h
Bombax insigne Wall.	Bonshimul	Bombacaceae	t
Bombax ceiba L.	Shimul	Bombacaceae	t
Borassus flabellifer L.	Tal	Arecaceae	t
Breynia patens Benth.	Kakro	Euphorbiaceae	s

Species name	Local name	Family	Habits
Bridelia stipularis (L.) Bl.	pat Khowi	Euphorbiaceae	c
Brownlowia eleta Roxb.	Massjot	Sterculiaceae	t
Bulbophyllum lilacinum Ridl	Ishwarmul	Orchidaceae	h
Buttnera pilosa Roxb.	Hargoza Lota	Sterculiaceae	c
Caesalpinia bonduc (L.) Roxb.	Nata	Caesalpiniaceae	c
Cajanus cajan (L.) Millsp.	Orhor	Fabaceae	s
Calamus erectus Roxb.	Kadam bet	Arecaceae	s
Calamus tenuis Roxb.	Jayut Bet	Arecaceae	s
Calamus viminalis Wild.	Bara Bet	Arecaceae	s
Callicarpa arborea Roxb.	Bormala	Verbenaceae	t
Calopogonium mucunoides Desv.	-	Fabaceae	c
Calypcoteris floribunda (Roxb.) Lamk	Guachchalata	Combretaceae	c
Carallia brachhiata (Lour.) Merr.	Latkao	Rhizophoraceae	t
Cassia occidentalis L.	Eski	Caesalpiniaceae	s
Cassia sophera L.	Kalkesunde	Caesalpiniaceae	h
Cassia nodosa Buch.-Ham. *ex* Roxb	-	Cesalpiniaceae	t
Cassia siamea Lamk.	Minjori	Cesalpiniaceae	t
Ceiba pentandra (L.) Gaertn.	Bontula	Bombacaceae	t
Centella asiatica (L.) Urban.	Thankuni	Apiaceae	h
Chrysopogon aciculatus (Retz.) Trin.	Premkanta	Poaceae	h
Chukrasia tabularis A. Juss.	Chikrasi	Meliaceae	t
Cinnamomum iners Reinw *ex* Blume	-	Lauraceae	t
Cissus adnata Roxb.	Aliangalata	Vitaceae	c
Clausena heptaphylla (Roxb.) Wight & Arn. *ex* Steud.	Pomkafur	Rutaceae	h
Clerodendrum viscosum Vent.	Bhant	Verbenaceae	h
Clerodendrum indicum (L.) O. Kuntze	-	Verbenaceae	s
Clerodendrum serratum (L.) Moon.	Barangi	Verbenaceae	h
Clerodendrun inerme (L.) Gaertn.	-	Verbenaceae	s
Cocos nucifera L.	-	Arecaceae	t
Colocasia esculenta (L.) Schott	Kachu	Araceae	h
Combretum acuminatum Roxb.	Patuinia	Combretaceae	c
Costus speciosus (Koening *ex*. Retz.) Smith	Kura	Costaceae	h
Crotolaria pallida Ait.	Jhunjhni	Fabaceae	h
Croton bonplandianus Bail.	-	Euphorbiaceae	h
Curculigo orchioides Gaertn.	Talmuli	Liliaceae	h
Curcuma domestica Valet.	-	Zingiberaecae	h
Cyclea barbata Miers.	Patalpur	Menispermaceae	c
Cymbidium aloifolium (L.) Sw.	Porgasa	Orchidaceae	h
Cynodon dactylon L.	Durba	Poaceae	h
Cyperus pilosus Vahl	-	Cyperaceae	h
Daemonorops jenkinsiana (Griff.) Martius.	Golakbet	Arecaceae	c
Dalbergia spinosa Roxb.	-	Fabaceae	s
Dalbergia stipularis Roxb. & Baker	Dadbari	Fabaceae	c
Dalbergia volubilis Roxb.	Ankilata	Fabaceae	s

Species name	Local name	Family	Habits
Dehaasia kurzii King *ex* Hook. f.	Modonmosta	Lauraceae	t
Dendrobium aphyllum (Roxb.) Fisch.	-	Orchidaceae	h
Dendropthoe falcata (L. F.) Etting	Bandha	Loranthaceae	s
Derris monticola (Kurz.) Prain	-	Fabaceae	c
Derris scandens (Roxb.) Benth.	Kalilata	Fabaceae	c
Desmodium pulchellum (L.) Benth.	Jutasalpani	Fabaceae	s
Desmodium heterophyllum (Willd.) DC.	-	Fabaceae	h
Desmodium laxiflorum DC.	-	Fabaceae	h
Desmodium motorium (Houtt.) Merr.	Loncharal	Fabaceae	h
Desmodium Pulchellum (L.) Benth.	-	Fabaceae	h
Desmodium triflorum (L.) DC.	Kulalia	Fabaceae	h
Desmodium triquetrum (L) DC	-	Fabaceae	h
Digitaria ischaemum (Schreb.) Schreb *ex* Muhl.	-	Poaceae	h
Dillenia pentagyna Roxb.	Hargoza	Dilleniaceae	t
Dioscorea bulbifera L.	Ratalu	Dioscoreaceae	c
Dioscorea trinerva Roxb.	-	Dioscoreaceae	c
Dioscorea triphylla Wall.	-	Dioscoreaceae	c
Dipterocarpus costatus	Silgarjan	Dipterocarpaceae	t
Dipterocarpus gracilis Blume.	Dhuligarjan	Dipterocarpaceae	t
Dipterocarpus turbinatus Gaertn.	Kaligarjan	Dipterocarpaceae	t
Dischidia nummularia R.Br.	-	Asclepiadaceae	c
Dracaena spicata Roxb.	Dracaena	Liliaceae	h
Elaeocarpus floribundus Blume.	Belphoi	Elaeocarpaceae	t
Elaeocarpus rugosus Roxb. *ex* G.Don.	-	Elaeocarpaceae	t
Elaeocarpus robustus Roxb.	Jolpai	Elaeocarpaceae	t
Eleocharis acutangula (Roxb.) Schult.	-	Cyperaeaceae	h
Eleocharis palustris (L.) R. Br.	-	Cyperaeaceae	h
Elephantopus scaber L.	-	Asteracae	h
Eleusine indica (L.) Gaertin.	-	Poaceae	h
Engelhardtia spicata Lesch.	Zalna	Guglandaceae	t
Eragrostis coarctata Stapf.	-	Poaceae	h
Eragrostis diplachroides Steud.	-	Poaceae	h
Eriocaulon xeranthemum Mart.	-	Cyperaeaceae	h
Erioglossum rubiginosum Blume.	Appaingota	Sapindaceae	s
Ervatamia coronaria (Jacq.) Stapf.	Togor	Apocynaceae	s
Erythrina ovalifolia Roxb.	Mandar	Fabaceae	t
Eucalyptus camaldulensis Dehnhardt.	Malaria Tree	Rutaceae	t
Eupatorium odoratum L.	Assamlata	Asteraceae	s
Ficus hispida L. f.	Dumur	Moraceae	h
Ficus retusa L.	Jir	Moraceae	s
Ficus altissima Blume	Bot	Moraceae	s
Ficus curtipes Corner	Swet bot	Moraceae	s
ficus infectoria Roxb.	Pakur	Moraceae	t
Flemingia macrophylla (Wlld.) O. Kuntze *ex* Merr.	Bara shapla	Fabaceae	s

Species name	Local name	Family	Habits
Garcinia pedunculata Roxb *ex* Buch.-ham	-	Clusiaceae	t
Garcinia cowa Roxb *ex* DC.	Kau	Clusiaceae	t
Gardenia coronaria Buch.-Ham.	Koinar	Rubiaceae	s
Geissapsis cristata Wight & Arn.	-	Fabaceae	h
Glochidion multiloculare (Roxb. *ex* Willd) Muell.-Arg.	Kakra	Euphorbiaceae	s
Glycosmis arborea Roxb.	Datmajan	Rutacae	s
Gmelina arborea (Roxb.) A.DC.	Gamari	Verbenaceae	t
Grewia microcos L.	Assar	Tiliaceae	s
Hedyotis verticillata (L.) Lamk	-	Rubiaceae	h
Hemidesmus indicus (L.) R. Br.	Anantamul	Asclepiadaceae	c
Heritiera fomes Buch.-Ham.	Sundari	Sterculiaceae	t
Heterophragma adenophyllum (Wall. *ex* G. Don) Benth.	-	Bignoniacae	t
Hevea brasiliensis (Willd *ex* A Juss.) Muell.-Arg.	Rubber	Euphorbiaceae	t
Holarrhena antidysenterica (L.) Wall. *ex* Decne.	Kurchi	Apocynaceae	s
Hopea odorata Roxb.	Telsur	Dipterocarpaceae	t
Hoya parasitica (Roxb.) Wall *ex* Wight.	Pargacha	Asclepiadaceae	c
Hyptis suaveolens (L.) Poit.	Tokma	Lamiaceae	h
Ichnocarpus frutescens (L.) R. Br.	Shamalata	Apocynaceae	c
Imperata cylindrica (L.) P. Beauv.	Ulu	Poaceae	h
Ipomoea fistulosa Mart. *ex* Choisy	Dholkalmi	Convovulaceae	s
Ixora javanica DC .	Rongong	Rubiaceae	s
Jasminum sambac (L.) Ait.	Beli	Oleaceae	S
Jasminum scandens Vahl.	jasmin	Oleaceae	C
Justicia gendarussa burm.f..	Nilnishinda	Acanthaceae	S
Lagerstroemia speciosa (L.) Pers.	Jarul	Lythraceae	T
Lannea coromandelica (Houtt.) Merr.	Jiga	Anacardiaceae	T
Lantana camara L.	Lantana	Verbenaceae	H
Laportea crenulata (Roxb.) Wedd.	Agnichutra	Urticaceae	c
Leea crispa L.	Banchilata	Leeaceae	S
Leea acuminata Wall.	phupharia	Leeaceae	H
Lepidagathis linearis T. Anders.	-	Acanthaceae	H
Leucas lavandulaefolia Sm.	Gaochia	Lamiaceae	H
Limnophila heterophylla (Roxb.) Benth.	-	Scrophulariaceae	H
Limnophila indica (L.) Druce.	-	Scrophulariaceae	H
Limnophila sessilifolia (Vahl) Blume	-	Scrophulariaceae	H
Litsea monopetala (Roxb.) Pers.	Akorma	Lauraceae	T
Litsea glutinosa (Lour.) Robinson	Kukurchita	Lauraceae	T
Ludwigia adscendens (L.) Hara	-	Onagraceae	H
Ludwigia hyssopifolia (G. Don) Exdell apud A. & R. Fernades	-	Onagraceae	H
Ludwigia prostrata Roxb.	-	Onagraceae	H
Ludwigia repens Forst	Mulsi	Onagraceae	H
Macaranga indica Wight	-	Euphorbiaceae	S
Macaranga denticulata (Bl.) Muell.-Arg.	Bura	Euphorbiaceae	S

Species name	Local name	Family	Habits
Maesa ramentacea (Roxb.) A. DC..	Maricha	Myrsinaceae	S
Maesa indica Wt.	Ramjoni	Myrsinaceae	S
Mangifera sylvatica Roxb.	Jangliam	Anacardiaceae	T
Mangifera indica L.	Aam	Anacardiaceae	t
Mangifera sylvatica Roxb.	Uriam	Anacardiaceae	t
Melastoma malabathricum L.	Datrangan	Melastomaceae	h
Merremia umbellata (L.) Hallier f.	Sadakalmi	Convolvulaceae	c
Mesua ferrea L.	Nageshor	Guttferae	t
Michelia champaca L.	Champa	Magnoliaceae	t
Mikania cordata (Burm. f.) Robinson	Assamlata	Asteraceae	c
Miliusa globosa (DC) G. Panigr. & Mishra	-	Annonaceae	c
Mimosa pudica L.	Lajjabati	Mimosaceae	h
Mimosa diplotricha C. Wright *ex* Sauv	-	Mimosaceae	h
Mimosa intisia L.	-	Mimosaceae	s
Morinda angustifolia Roxb.	Ranggach	Rubiaceae	s
Mucuna nigricans (Lour) Steud.	-	Fabaceae	c
Mucuna pruiens (L.) DC.	Alkushi	Fabaceae	c
Myxopyrum smilacifolium (Wall.) Blume..	-	Oleaceae	h
Nymphoides cristatum (Roxb.) O. Kuntze.	-	Manyanthaceae	h
Oplismenus burmanii (Retz.) P. Beauv.	-	Poaceae	h
Ormosia robusta (Roxb.) Baker	-	Fabaceae	t
Oroxylum indicum (L.) Kurz.	Thona	Bignoniaceae	t
Osbeckia chinensis L.	-	Melastomaceae	h
Oxyceros kunstleri (King & Ganmble) Tirveng	-	Rubiaceae	c
Paedaria foetida L.	Gandhabadhuli	Rubiaceae	c
Pandanus foetidus Roxb.	Keyakanta	Pandanaceae	s
Passiflora foetida L.	jhumka-lata	Passifloraceae	c
Pericampyeus glaucus (Lamk.) Merr.	Guria lata	Menispermaceae	c
Persicaria flaccida (Meissn) H. Gross *ex* Loesen	Lal-bishkatali	Polygonaceae	h
Phoenix sylvestris Roxb.	Khejur	Arecaceae	t
Phragmitis karka (Retz.) Trin. *ex* Steud.	-	Poaceae	h
Phyllanthus emblica L.	Amlaki	Euphorbiaceae	t
Phyllanthus reticulatus Poir.	Chitki	Euphorbiaceae	s
Phyllanthus amarus Schumacher & Thonn.	-	Euphorbiaceae	h
Piper longum L.	Pepul	Piperaceae	h
Pithecellobium angulatum Benth.	Kurmar	Mimosaceae	s
Pithecellobium dulce (Roxb.) Benth.	Khai-babla	Mimosaceae	t
Pogonatherum crinitum (Thunb.) Kunth	-	Poaceae	h
Pogonatherum paniceum (Lamk.) Hack.	choto bush	Poaceae	h
Pothos scandens L.	Batilata	Araceae	c
Premna esculenta Roxb.	Lallong	Verbenaceae	s
Psidium guajava L.	Peara	Myrtaceae	t
Psychortia denticulata Wall *ex* Roxb.	-	Rubiaceae	s
Psychotria fulva Wall.	-	Rubiaceae	s

Species name	Local name	Family	Habits
Pterospermum acerifolium (L.) Willd.	Kanakchampa	Sterculiaceae	t
Pterospermum semisagittatum Buch.-Ham. *ex* Roxb.	Banassar	Sterculiaceae	s
Pueraria phaseoloides (Roxb.) Benth.	-	Fabaceae	c
Quercus spicata Smith	Batna	Fabaceae	t
Quercus gomeziana A. Camus	Dholia-batna	Fabaceae	t
Randia dumetorum Lamk.	Mankanta	Rubiaceae	s
Ricardia scabra L.	-	Rubiaceae	h
Rotala densiflora (Roth. *ex* R.&S) Koehne	-	Lythraceae	h
Rotala indica (Wild) Koehne	-	Lythraceae	h
Saccharum spontaneum L.	Kash	Poaceae	h
Saccharum arundinaceum Retz.	teng	Poaceae	h
Samanea saman (Jacq.) Merr.	Rain tree	Mimosaceae	t
Schoenoplectus articulatus (L.) Palla	-	Cyperaceaceae	h
Scoparia dulcis L.	Bandhuni	Scrophulariaceae	h
Senna tora (L) Roxb.	Chakunda	Caesalpiniaceae	h
Shorea robusta (Roxb.) Gaertn. f.	Sal	Dipterocarpaceae	t
Sida acuta Burm f.	Kureta	Malvaceae	h
Sida cordifolia L.	Berela	Malvaceae	s
Sida rhombifolia L.	Lal-berela	Malvaceae	s
Smilax zeylanica L.	Kumarilata	Smilacaceae	c
Smilax prolifera Roxb.	Kumarilata	Smilacaceae	c
Spatholobus acuminatus Benth.	Bean	Fabaceae	c
Spermacoce articularis L.f.	Antharogia	Rubiaceae	h
Spilanthes acmella (Auct. Non) L.	Marhatitiga	Asteraceae	h
Sporobolus diander (Retz.) P. Beauv.	Bina joni	Poaceae	h
Staurogyne argentea Wall.	-	Acanthaceae	h
Stephania glabra (Roxb.) Miers.	-	Menispermaceae	c
Stephania harnandifolia Walp.	Muichanlata	Menispermaceae	c
Stereiospermum personatum (Hassk.) Chatt.	-	Bignoniacae	t
Streblus asper Lour.	Shaora	Moraceae	s
Suregada multiflora (A. Juss.) Baill.	-	Euphorbiaceae	s
Swietenia mahagoni Jacq.	Mehogoni	Meliaceae	t
Swintonia floribunda Griff.	-	Anacardiaceae	t
Synedrella nudiflora (L.) Gaertn.	-	Asteraceae	h
Syzygium firmum Thw.	Dhakijam	Myrtaceae	t
Syzygium formosum (Wall.) Masamune.	Panijam	Myrtaceae	t
Syzygium fruticosum DC.	Khudijam	Myrtaceae	s
Syzygium cumini (L.) Skeels	Kalojam	Myrtaceae	t
Syzygium oblanatum (Roxb.) A.M Cowan & J.M. Cowan	-	Myrtaceae	s
Syzygium Syzygioides (Miq.) Merr. & L.M. Perry.	-	Myrtaceae	s
Tabernaemontana corymbosa Roxb. *ex* Wall	-	Apocynaceae	s
Tabernaemontana recurvata	Tagor	Apocynaceae	s
Tectona grandis L.	Segun	Verbenaceae	t

Species name	Local name	Family	Habits
Tephrosia purpurea (L.) Pers.	Bon-neel	Fabaceae	h
Terminalia bellirica (Gaertn.) Roxb.	Bahera	Combretaceae	t
Terminalia citrina (Gaertn.) Roxb. *ex* Flaming	Hora	Combretaceae	t
Terminalia arjuna (Roxb. *ex* DC.) Wt. & Arn.	Arjun	Combretaceae	t
Tetracera srmentosa (L.) Vahl	Chaillalata	Dilleniaceae	c
Thespesia lampas (Cav.) Dalz. & Gibs.	Bon korpus	Malvaceae	s
Thunbergia fragrans Roxb.	Nillata	Acanthaceae	c
Thysanolena maxima (Roxb.) O. Kuntze	Phuljharu	Poaceae	h
Tiperia hirsuta Kurz.	-	Sapindeace	s
Trema orientalis (L.) Blume.	-	Ulmaceae	t
Triumfetta rhomboidea Jacq.	Banokra	Tiliaceae	h
Uraria crinita (L) Desv. *ex* DC	Dieng-kha-rin	Fabaceae	h
Uraria lagopoides DC.	-	Fabaceae	h
Urena lobata L.	Banokra	Malvaceae	h
Utricularia bifida L.	Choto jhanjhi	Utriculariaceae	h
Vanda teres (Roxb.) Lindl.	-	Orchidaceae	h
Vernonia cinera (L.) Less.	-	Asteraceae	h
Vitex peduncularis Wall. *ex* Schauer	Awal	Verbenaceae	t
Vitex altissima L.f.	-	Verbenaceae	t
Vitex glabrata R. Br.	-	Verbenaceae	t
Willoughbeia edulis Roxb.	Lata aam	Apocynaceae	c
woodfordia fruticosa (L) Kurz.	Dhalri-phul	Lythraceae	s
Zanthoxyllum rhetsa DC.	Bazna	Rutaceae	t
Zizyphus oenoplia (L.) Miller.	Banboroi	Rhamnaceae	s
Zizyphus oxyphylla Edgell	Bonboroi	Rhamnaceae	s
Zizyphus funiculosa Buch.-Ham. *ex* Lawson	Bonboroi	Rhamnaceae	s
Zizyphus mauritiana Lamk.	Boroi	Rhamnaceae	s

Status of Tourism at Five Protected Areas of Bangladesh

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Abstract

Ecotourism is being initiated to promote at the forest-based Protected Areas of Bangladesh since the last mid-decade. This initiation was started particularly through Nishorgo Support Project (NSP) where co-management approach has been introduced to conserve the biodiversity of the pilot sites (five Protected Areas) of the project. Here, ecotourism has been chosen as one of the Alternative Income Generation (AIG) activities along with its benefits to serve environmental awareness to the both locals and visitors. The present study aims to analyze the status of tourism since recent past at these five Protected Areas (PAs) implemented by NSP . The sites are Lawachara National Park (LNP), Satchari National Park (SNP), Rema-Kalenga Wildlife Sanctuary (RWS), Chunati Wildlife Sanctuary (CWS) and Teknaf Wildlife Sanctuary (TWS). Mixed method (both quantitative and qualitative data) has been followed here to analyze various secondary data on tourism from the study area. The results of the study clearly show that tourism at these PAs is getting popularity day by day among the people of Bangladesh. The trend of visitors at these PAs is positive where it can also contribute to improve the socio-economic condition of the local people and both hosts and guests are becoming environmentally conscious. The average number of visitors/month were 5,114 at these five Pas; the maximum concentration of visitors were 7,855/month at LNP followed by 2,805/month at SNP. Of the total visitors at these five PAs, 99% were domestic visitors and only 1% international visitors. LNP is the most popular destination among the five PAs for both the types of visitors. Two National Parks (LNP and SNP) were mostly (97.27% of the total visitors) visited by different types of visitors and LNP contributed more than three-fourthsof revenue (76.86%) earning. The visitors visit all these PAs all round the year but their concentration is the highest in December to March which may be considered as the peak-season of tourism. Co-management approach is overwhelmingly facilitating ecotourism development at these PAs. SWOT analysis for ecotourism development at the PAs has been conducted in this study.

Keywords: Protected Area, Tourism, Co-management approach

Introduction

Natural areas, especially protected areas, their landscape, wildlife and flora together with any existing cultural elements constitute major attractions for the people. The conservation organizations in the world recognize the relation between the protected areas and tourism. The organizations are also aware of many dangers that badly managed or uncontrolled tourism can cause harm to the world's natural and cultural heritage (Ceballos-Lascurain, 1999). Protected areas such as national parks, wildlife sanctuaries and different forest reserves form the frontline in the campaign to conserve wild flora and fauna (Fox, 2007). The protected area covers more than 12% of the world (Chape *et al.* 2003) and in Bangladesh it covers only 10.7% of the total forest area of the country and only 1.82% of the total land area (FD, 2011). Bangladesh ranks 129 out of 155 countries in terms of the percentage of its national territory under some form of protected area status (World Resources Institute, 2006). At present, Bangladesh has 28 forest-based protected areas (FD, 2011) which attract many visitors (domestic and international).

Scialabba and Williamson (2004) states that focus on ecological aspects of Protected Areas (PAs) and exclusion of rural forest related livelihood, has been one of the most significant difficulties for Protected Area (PA) management. To overcome this difficulty, several people-oriented approaches have been developed and promoted by various international conservation agencies to improve the effectiveness of PAs (Jeanrenaud ,2002).

Bangladesh's forest has disappeared over 50% in the last 30 years and today, the forests of PAs are critically threatened. If the trend of degradation continues then many unique flora and fauna will be lost forever from this country. To address this critical situation, Nishorgo Support Project (NSP) (2003-04 to 2008-09) was started in 2004 in Bangladesh with an aim to develop collaborative management (co-management) approach by the collaboration of different stakeholders to lead measurable improvements in forest and resource conservation in the PAs and their buffer zones .This project completed its tenure in October 2008 and a follow-up project 'Integrated Protected Area Co-management (IPAC)' (2008-2013) is now implementing the activities at all the PAs of Bangladesh. One of the objectives of the NSP was to develop infrastructure for ecotourism and develop local youths as eco-guides which is an alternative livelihood option.

Co-management is a common strategy, with both historical roots and more recent manifestations. Bangladesh has a long history of community involvement in forest management which dates to 1871, when tribal *jhum* (swidden) farmers in the Chittagong Hill Tracts were engaged in planting of trees (Mukul *et al.* ,2007). The existing national forest policy (1994) of Bangladesh has placed a great emphasis on ecotourism and reconises that ecotourism needs to be taken as a forestry activity that should be promoted within the carrying capacity of nature (Ahsan ,2007) However, there was no remarkable development in this sector until the NSP has initiated.

Before the initiation of NSP, there was neither any provision of keeping record of visitors' information nor any specific tourism management option at these five PAs. The local people were not involved in tourism activities to get them benefits and the visitors' facilities were not adequate at all. After launching NSP, the Forest Department tried to develop various infrastructures for the visitors, provided attended and unattended service to the visitors. The visitors had free access into those PAs without any entry fee till October, 2009. The PA authorities started keeping visitors' information under NSP in 2007 in a very informal way, but not in all the PAs under NSP. The visitors were given free entry ticket to make the visitors acquainted with the entry fee system and the data was recorded by the management authority. Though the entry ticket was free of cost, the visitors were not aware of this and most of them didn't collect it. As a result, the complete status of the visitors at that time frame was not available. After the government's Gazette notification on collection of entry fee, the PA authorities started collecting entry fee from the visitors in the designated entry points of these five PAs. Considering the above background, this paper aims to analyze the current status of the tourism (particularly the number of visitors and the revenue earned from them) in these five PAs of Bangladesh.

Materials and Methods

Study Area

All the five pilot sites (Fig. 1) of Nishorgo Support Project (NSP) were selected as the study area. The five protected areas are: i) Lawachara National Park (LNP), ii) Satchari National Park (SNP), iii) Rema-Kalenga Wildlife Sanctuary (RWS), iv) Chunati Wildlife Sanctuary (CWS) and v) the then Teknaf Game Reserve (TGR) which is currently known as Teknaf Wildlife Sanctuary (TWS).

LNP, SNP and RWS are situated in the north-eastern part of Bangladesh having same bio-ecological zone (9b Sylhet Hills) which is characterized by high rainfall and a multi-tier mixed tropical evergreen and semi-evergreen plant species with the assemblage of rich biodiversity (NSP 2006a, 2006b and 2006c). These three PAs are known as Sylhet cluster (north-east cluster). On the other hand, CWS and TWS are hill forests in their type which are situated in the south-eastern part of Bangladesh having same bio-ecological zone (9a Chittagong Hills and Chittagong Hill Tracts) which is also characterized by high rainfall and a multi-tier vegetational assemblage of rich biodiversity. Due to geographical location s these two PAs are known as south-eastern cluster. Currently, these five PAs are potential ecotourism destinations for many domestic and international visitors/tourists due to its location, climatic condition, aesthetic beauty, dense high forests, biodiversity, landscape, historical and cultural values and ethnic diversity (after NSP 2006a, 2006b, 2006c, 2006d and 2006e).

Data Collection and Data Analyses

To fulfill the objective of the study, information were collected from official secondary data provided by the PA authorities. In addition to this, information were also collected on individual interview with the key management personnel such as Divisional Forest Officer and Assistant Conservator of Forests of the associated PAs.

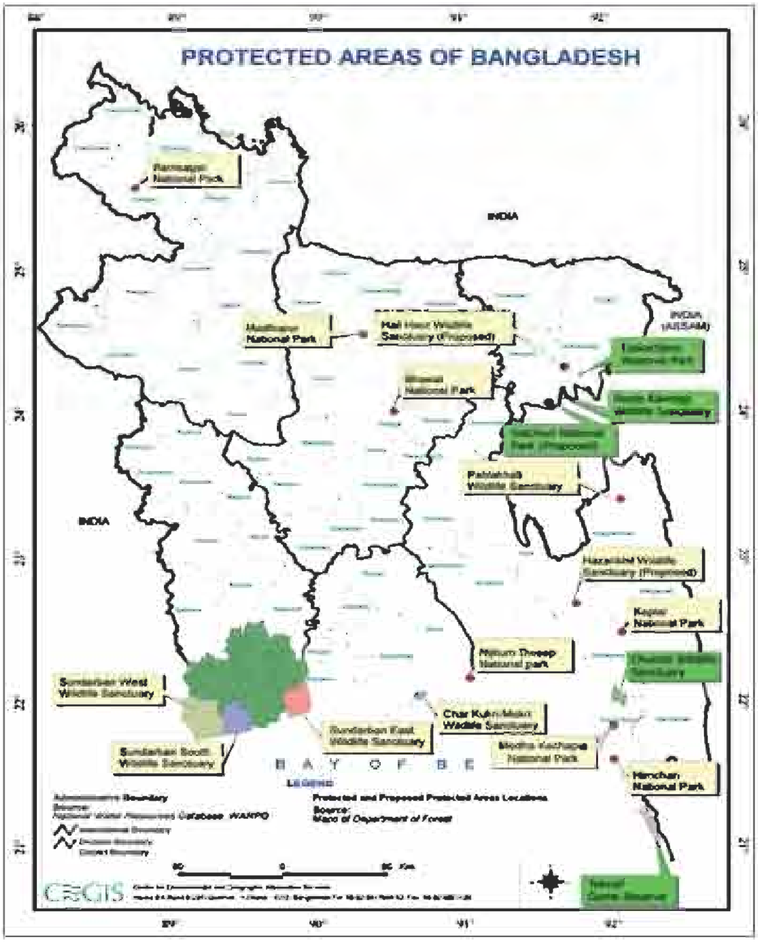


Fig. 1: The map showing (shadow) the five NSP sites, i.e., the study area (Source: FD, 2011)

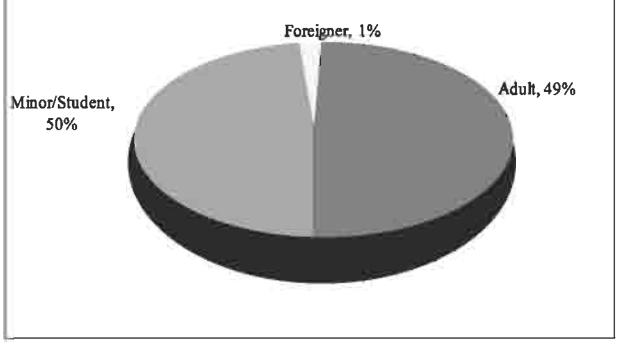
Two different sets of data have been collected for this study. There was no entry and other fees (e.g., parking, shooting) at these five PAs before November, 2009. So, the official data regarding the entry fee and other revenues (parking, picnic spot fee, shooting) have been collected from November 2009 to December, 2010 for the study. The entry fee for the (domestic) adults, (domestic) minors/students and international visitors are Tk. 20/-, 10/- and 350/- respectively (MOEF 2006, 2008). These data of 14 months are considered as one set of collected data. Another set of collected data deals with the number of registered visitors at LNP, SNP and TWS. Here, the actual number of visitors at each PA is much higher than the registered figure. According to some officials this is 3-4 times higher. At that time there was no entry fee and the registration was not compulsory. Only the visitors who visited the information/sales centre and requested for the registration were recorded as registered visitors. Table 1 shows more information on PA-wise visitor and sales/revenue status. Such data of registered visitors (before introducing entry fee) have been collected from January, 2007 to June, 20008 for these three PAs ,but the same data for LNP have been collected from January, 2007 to December, 2008. The official sales data record (different souvenirs such as booklets, maps, view cards, T-shirts, caps, local handicrafts, mineral water sale, toilet using fee, etc.) from the sales centers situated at three PAs (LNP, SNP and TWS) have also been collected for the same time frame. Here, these data (visitor number and sales record) from Jully, 2008 to October, 2009 (Jananuary, 2009 to October, 2009 for LNP) are not available from the concerned office. The sales records in 2009 and 2010 were also officially unavailable for these five PAs. So, these are the gaps in collected data time frame. Here, the term visitor has been used as most of the guests are day-excursionists at these PAs. The collected data was analyzed by representations as different types of figures and table using different analytical tools of MS Excel package.

Results and Discussion

Types of Vsitors and Their Status

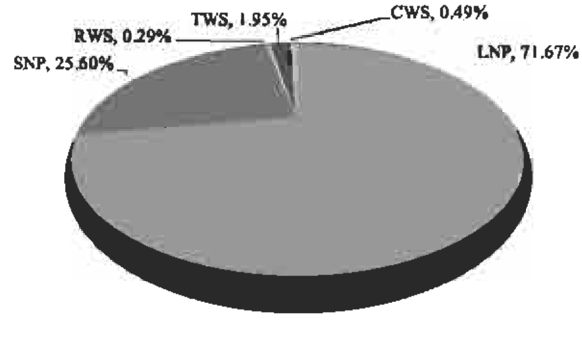
Both the domestic and international visitors visit these five protected areas (LNP, SNP, RWS, CWS and TWS) of Bangladesh throughout the year. According to the official record (Noveber, 2009 to December, 2010. i.e., after introducing the entry fees at these five PAs) there are total 1, 53,429 visitors (average 5,114 visitors/month) at these five PAs. Of them, 99% (151,962 visitors) are domestic visitors (average 5,065 visitors/month) and the rest (only 1%) are international visitors. Among the domestic visitors, only adult and minor/student categories are recorded while they collect entry permission from the respective PA authorities. Of these domestic visitors, 50% are minors/students and 49% are adult category (Fig. 2). From this analysis, it is transparent that a few numbers of international visitors (average 49 visitors/month) visit these PAs. This may be due to lack of promotional activities of these PAs to the international tourists, less safety and security, poor infra-structure and communication system (particularly for RWS), etc. These PAs are mostly visited by the students especially when they come on study tour/excursion/picnic. According to the personal communication with these PA authorities, the adult category of domestic visitors is mixed with different professions (i.e., service holders, businessman, farmers, etc.) who come here to refresh themselves.

Fig. 2: Different types of visitors at the five PAs.



LNP is the most popular destination among the five PAs for both the domestic and international visitors (Fig. 3). According to the official data of the PAs (November, 2009 to December, 2010), about three-fourth (71.67% of total visitors) visitors (both domestic and international visitors) visit LNP mainly for its natural beauty, enriched biodiversity (especially for African Oak or so-called chloroform tree, Hollock Gibbon, birds, etc.) . Indigenous members of Khasia, Manipuri and Tripura groups live inside the core area of the park as well as outside but adjacent to the park (Ahsan, 2007) Better law and order situation of Kamalganj (adjacent upazila of LNP), well-known Shyamoly Guest House owned by the Forest Department also attract tourists .Surrounding the tourist spots these is eye catching scenic beauty (e.g., tea garden, Madhobkundo Water Fall, Baikker Bill, hilly landscape, etc.), activities of Nishorgo Support Project, etc. More than one-fourth (25.60%) of the total visitors visit SNP during these 14 months. The rest i.e., 2.73% of the visitors visit the other three PAs where RWS is visited least (0.29%) by the visitors mainly due to poor communication system. It is noticeable, the two National Parks among the five PAs are clearly far ahead (97.27% of the total visitors) to be visited than the three Wildlife Sanctuaries. The major reasons of being such popularity of these two National Parks (LNP and SNP) are: easy accessibility, close to Dhaka and compose of promotional activities. Visitors from greater Dbaka and adjacent districts can make an easy day-trip at these destinations.

Fig. 3: Comparative visitors' status at the five PAs.



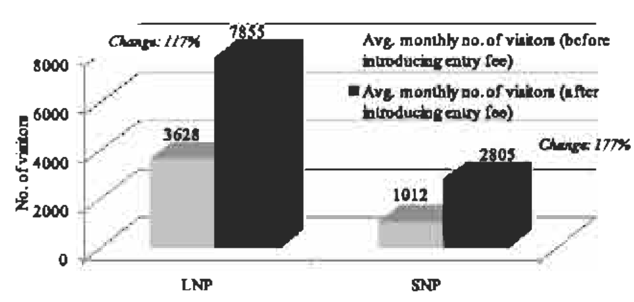
Alike domestic visitors, most of the international visitors visit LNP (94.54% of total international visitors), followed by TWS (2.52%), SNP (2.25%) and very negligible at CWS (0.41%) and RWS (0.27%).

Considering the visitor status of LNP and SNP between before and after introducing the entry fee, the change percentage is 117% and 177% respectively (Fig. 4). This is due to systematic record keeping system by introducing visitor entry ticket, motivation of Co-management Committee, promotional activities of these PAs, activities of local eco-guides, psychological effects of the visitors that imposing entry fee indicates some sorts of attractions, etc. Besides these, there are some other attractions around these two PAs where visitors wish to visit while they make their tour.

Revenue Earned from Five PAs

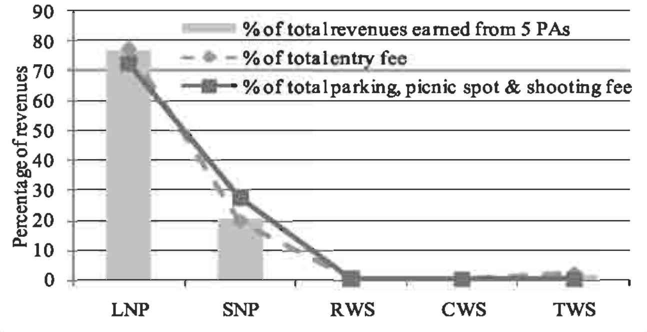
There was no entry and other fees (e.g., parking, shooting) at these five PAs before November, 2009. The entry fee for the (domestic) adults, (domestic) minors/students and international visitors are Tk. 20/-, 10/- and 350/- respectively. From November, 2009 to December, 2010, a total of Tk. 27,74,585/- has been received from these five PAs as entry fee of the visitors. As most of the visitors visit LNP, so most of the revenues as entry fees (77.42% of total entry fees) are earned

Fig. 4: Change status of visitors after and before introducing entry fee.



from the PA followed by SNP (19.89%), TWS (2.11%), RWS (0.32%) and CWS (0.26%) (Fig. 5). Besides the revenues from entry fees, there are some other means (viz. vehicle parking fee: Tk. 25/vehicle, picnic spot fee: Tk. 10/person, and shooting fee: Tk. 6,000/shooting) (MOEF 2006, 2008) to generate revenues from these five PAs. LNP begets 72.22% (Tk. 242,365/-) of the total revenues collected (from five PAs) from these three means, followed by SNP (27.26%). Considering the total revenues (i.e., entry fee, parking, picnic spot and shooting fee) earned from all these PAs in the specified 18 months, LNP contributes more than three-fourth revenue (76.86%, i.e., Tk. 2,390,580/-) earned followed by SNP (20.68%). It is also noted here that 89.21% of the total revenue (Tk. 3,110,185/-) from five PAs come solely from entry fee and the rest (10.79%) from others sources. The sales records in 2009 and 2010 were officially unavailable for the PAs.

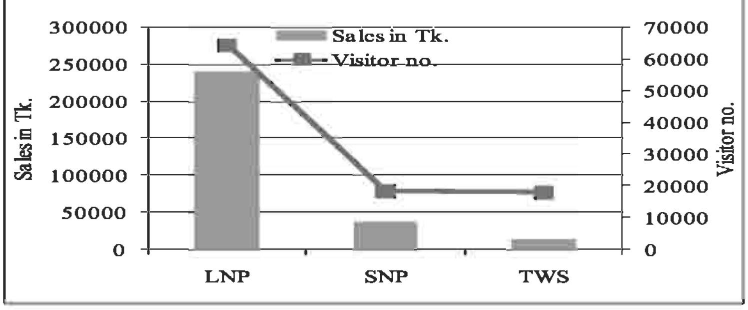
Fig. 5: Revenues earned from five PAs.



Registration of visitor number and record keeping of sales (different souvenirs such as booklets, maps, view cards, T-shirts, caps, local handicrafts, etc.) from the sales centers situated at three PAs (LNP, SNP and TWS) were started from January,2007 . According to the official data (January,20 07-June,20 08), total sales at LNP accounts 81.83% of total sales at these three PAs ,followed by SNP (13.04%) and TWS (5.13%). The sales at LNP increased 105% in 2008 than the sales in 2007. These sales centers play an important roles for the local people as they can sell there local products/handicrafts to the visitors at these points. This type of endeavor encouraged many local community people to produce more local products which facilitated them to improve their socio-economic condition. This also assisted them to practice their own culture and hence to preserve the local art and culture through tourism.

There is a positive relationship between the number of visitors and sales at these PAs (Fig. 6). At this time period, LNP received the highest (64.04%) number of registered visitors followed by SNP (18.09%) and TWS (17.87%). Here, the actual number of visitors at each PA is much higher than the registered figure. According to some officials this is 3-4 times higher. At that time there was no entry fee and the registration was not compulsory. Only the visitors who visited the information/sales centre and requested for the registration were recorded as registered visitors. Table 1 gives more information on PA-wise visitor and sales/revenue status.

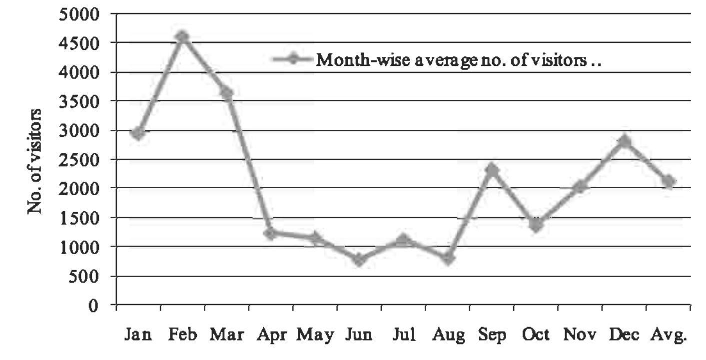
Fig. 6: Comparison between visitor no. and sales among 3 PAs (Jan' 07-Jun' 08).



Month-wise Visitor Status and Tourism Season

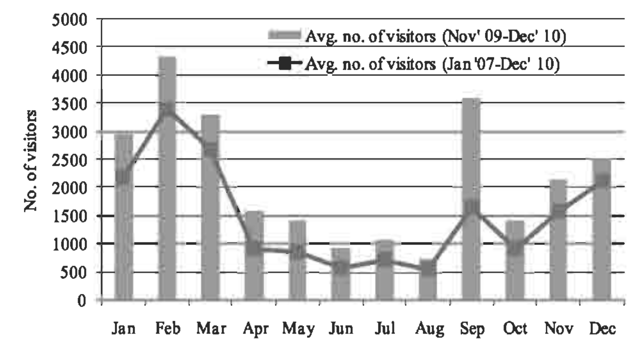
It has been found from the available data that visitors go to all these PAs round the year. But the concentration of the visitors at these PAs is the highest from December to March (Fig. 7). During this peak-season for tourism at these five PAs proper tourism management is required to maximize the satisfaction of the visitors and minimize the negative impacts of their visits at these PAs as well as the surrounding communities. If month-wise visitor status is accounted, then the average number of visits attain maximum in February. On the other hand, the concentration of the visitor is the lowest from April to August that may be considered as the off peak-season for tourism. August is the lowest visitor concentrated month ,followed by June-July-May. Summer, rainy and winter season are visible in Bangladesh. From this point of view, winter is the most preferable season for tourism, whereas summer and rainy seasons are considered as the least preferred season for the visitors.

Fig. 7: Month-wise average no. of visitors at 5 PAs. (2007-2010)



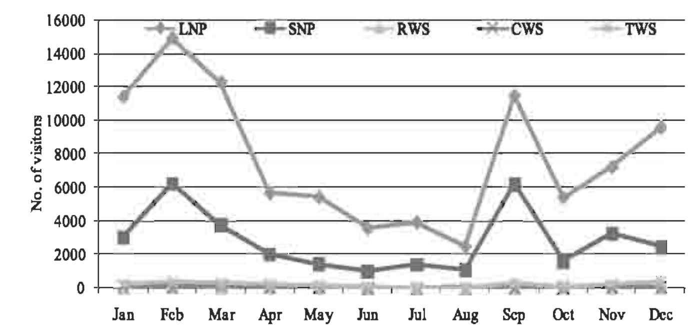
The data of two time frames, i.e., from the time of starting of visitor registration record (January, 2007 - December, 2010) and from the time of introducing visitors' entry fee (November,2009-December,2010) show that month-wise average number of visitors has increased since November,2010 (Fig. 8). But, the trend of month-wise average number of visitors is the same as before introducing entry fee. These two data sets also denote that the visitor status has increased after introducing the entry fee.

Fig. 8: Average no. of visitors per month in two different time frame.



Taking into account of the visitors' record from introducing the entry fee at these PAs, it is remarkable that almost every PA has more or less same peak-season for tourism i.e., Dec to March (Fig. 9 and 10). As mentioned earlier, 97.27% of the total visitors have been recorded at the two National Parks, i.e., LNP and SNP. The result of the visitor status in Fig. 9 is not clearly visible on using the scales of the visitors. So, Fig. 10 has been constructed to get the better idea about the rest of these three PAs (RWS, CWS and TWS).

Fig. 9: Month-wise visitors' concentration at five PAs (after introducing entry fee).



It is noticeable that 14,908 visitors visited LNP in February, 2010 (497 visitors/day). This is the highest among the five PAs followed by 12,284 in March 2010 and 11,399 in January2010 . On the other hand, there were only 381 visitors who visited TWS in Febuary, 2010 .This was the highest visitor concentration per month among these three PAs. There were also some months (June, July and August 2010) when there was not a single visitor at RWS and CWS.

Fig. 10: Month-wise visitors' concentration at three PAs (after introducing entry fee).

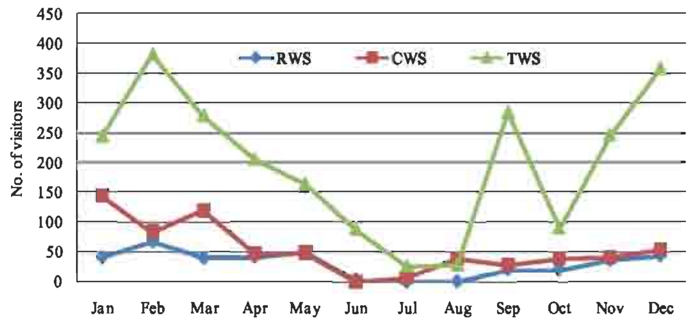


Table 1: Some important facts about the five Protected Areas

Name of PAs	LNP	SNP	RWS	CWS	TWS
Avg. no. of visitors/month	3,628[a] & 7,855[b]	1,012[c] & 2,805[b]	31[c]	53[c]	1,000[c] & 214[b]
Avg. sales or revenue/month	Tk. 11,070[a] & Tk. 1,70,756[b]	Tk. 2,111[c] & Tk. 45,944[b]	Tk. 689[c]	552[c]	Tk. 830[c] & Tk. 4,216[b]

[a] Jan' 07-Dec' 08 (before introducing entry fee), [b] Nov' 09-Dec' 10 (after introducing entry fee), [c] Jan' 07- Jun' 08 (before introducing entry fee).

Co-management and Tourism

Though visitors have been visiting the NSP sites since long back ,no information of visitors were recorded by the concerned FD offices before starting NSP. At that time, visitors usually came to the sites and sought the permission from DFO for visiting. If the visitors were of high profile, the FD provided them untrained forest staff in tourism as escorts. It was also found that the use of signage was also very limited at that period. As mentioned earlier, there was no provision of collecting entry fee until November, 2009. After forming the co-management bodies (co-management council and co-management committee ,i.e., CMC), it took long time to start collecting entry fee form the visitors. There was no tourist guide before the initiation of Nishorgo Support Project. After the formation of co-management bodies, NSP started developing different tourism facilities such as: foot trail establishment, trail brochure, signage placing, eco-tour guide training, leaflet publishing (do's and don'ts), trash bin placement, tourism management plan preparation, toilet facilities, websites development, eco-lodge building, picnic sites development, visitor information center, eco-rickshaw introduction, etc. The local eco-tour guides facilitate significantly contributed to tourism management by educating the visitors especially from environment point of view; providing them various information on the biodiversity and local culture, local affairs as well as the surrounding areas. Besides these, the CMC engages people to collect the entry fee from the visitors and submit accounts in relation to the entry fee/other fee collection (except the sale from the visitors' information center) to the concerned range office. Most of the CMCs, randomly examine/monitor the visitors for their entry ticket which encourages the visitors to collect tickets before entering the PA. CMC also plan and implement Annual Development Plan (ADP) including tourism activities. A guide line has been approved by the government for the smooth operation of visitor entry fee accounts and it's sharing between FD and CMC .Now, tourism is mainly managed

by FD staff and CMC by taking and implementing various decisions. Under the guideline, CMC receives 50% and FD the rest 50% of the total entry fee. The revenue earned by CMC is spent for various community and tourism development activities. When necessary, a work plan is prepared by the CMC and submitted to the concerned DFO (Divisional Forest Officer) for its official approval. The sales revenues from the visitor information centre entirely go to the CMC account. In this way, co-management approach is assisting tourism management at these PAs and by this way tourism is also facilitating the co-management approach to be implemented at these PAs through the active involvement of the local people as well as creating alternative income generation activities along with disseminating conservation awareness and education among the hosts and guests.

Box 1: A success story

Mr. Md. Shamsul Alam is an owner of an eco-cottage in Sreemangal, Moulvibazar. He started his eco-cottage business in 2007 with the help of Nishorgo Support Project (NSP). He was assisted financially by the NSP and got training through the project. He is also an eco-tour guide. He conducts his business very sincerely and successfully. Now he is a well established and proud owner of the eco-cottage. It is remarkablethat his eco-cottage attracts mainly the international tourists. He earns Tk. 150,400/- anually (US$ 2150) on average ,which is considered a significant income for a local community member. This is a good example of community-based tourism at LNP.

Table 2. The eco-cottage: At a glance.

Year	Domestic tourists ((number)	International tourists (number)	Earned income (Tk.)
2008	124	42	81,500
2009	158	269	182,700
2010	71	260	187,000
Average	**118**	**190**	**150,400**

Problem Faced in Tourism Development at the PA

The PAs have to confront many obstacles in developing tourism. Some of these major hindrances faced by the PA authorities are: littering, lack of awareness of the local community and visitors on environment and (eco) tourism, harassment of the young girls by the local youths, lack of empowerment of CMC and delay in decision for implementation, poor communication system and promotional activities (particularly in RWS), poor involvement of the local people in tourism activities, poor maintanence of tourism facilities developed under NSP are, lack of trained manpower in the tourism management, inadequate FD staff for patrolling and tourism management, lack of fund for tourism facility development and maintenance, etc. These problems have been identified through a SWOT analysis (Table 3) .

Table 3. SWOT Analysis of Five Protected Areas to Develop Ecotourism

	STRENGTHS	WEAKNESSES
Internal factors	• Rich biodiversity • Hoolock gibbons as a flagship species (particularly at LNP) • Natural beauty and wilderness • Ethnic/indigenous culture of local community • Surrounding tourists attractions • Overall hospitable local communities and their interest on ecotourism and community-based tourism • Co-management approach which created access of the local people in tourism enterprise • Source of revenue earning from tourism and benefit sharing mechanism through Co-management Committee (CMC) • Trained local eco-guides • Less expectations of the domestic tourists • Good communication system (except RWS) • Promotional activities of the PAs	• Uncontrolled access of people and illegal resource harvestation • Less tourism facilities for the tourists • No tourism carrying capacity determined • No separate tourism management plan • Lack of waste disposal system • Lack of training in tourism for the locals • Lack of proper interaction among CMC, FD and local people • Lack of conscience of the tourists regarding biodiversity conservation and Do's & Don'ts • No single entry point • No definite season for tourism activities • Lack of monitoring in tourism activities • Poor tourism marketing • Limited Public Private Partnership (PPP) initiatives
	OPPORTUNITIES	**THREATS**
External factors	• Increasing tourists interests in nature travelling • Legal recognition of collaborative management organizations (CMC, Co-management Council, Forest User Groups, Community Forest Patrolling, etc.) • Public Private Partnership (PPP) concept approved by the government • Poverty of the local community to find out an income generating opportunity • Co-operation with Bangladesh Parjatan Corporation (BPC) • Tourism controls illegal felling and other criminal activities • Networking among conservation institutions (GOs and NGOs) through Nishorgo Network	• Misunderstanding of ecotourism concept • Uncontrolled tourism practice (Mass tourism) • Picnic parties and littering • The prevailing rate of illicit felling • Shortage of funds for tourism development • Acute shortage of (trained) tourism manpower • Unscientific release of wildlife in some of the PAs which might wipe out the native keystone species of the PAs • Lack of political commitment in controlling the illicit felling

Recommendations

- Trained-up manpower in tourism (particularly in ecotourism and community-based tourism) is badly needed to promote nature-based tourism at the PAs and also to manage tourism. Locals, FD and some NGO personnel should be trained-up in this regard;
- Each of the five PAs should be restricted to the visitors at least for some period every year during the lean period of tourism. This is essential for plants to regenerate, wildlife to breed, make the eco-system healthier and for the maintenance of tourism facilities.The recommended time of restriction for the visitors may be May to August;
- Tourism Carrying Capacity (TCC) is not known for none of these PAs. The TCC for each PA should be determined considering the eco-system, visitors' behavior, the demand of the visitors and host, etc., to manage tourism activities and these Pas;

- More active participation of the local community in the tourism activities is required for their sustainable livelihood and to reduce their pressure on the natural resources of the Pas;
- The function of CMC in the current state is not so satisfied. The CMC should be more strengthened by all means to assist PA management with particular reference to tourism management. The level of participation and accountability of locals in co-management committees should be increased in this regard. The CMC should be encouraged to work in small entrepreneurship, liaison with businessmen to build eco-cottages, food supply, monitoring the tourism activities, etc.;
- Refresher training should be arranged for the eco-tour guides to promote better positive impacts of tourism and to minimize the negative tourism impacts in these PAs and its surroundings. It will facilitate the ecological, social, economic and institutional sustainability of respective PA. These local guides may encourage conservation actions amongst both visitors and the local community people;
- Partnership among FD, CMC, Bangladesh Parjatan Corporation (BPC), tour operators, local tour-guides should be developed to promote tourism at these Pas;
- Transportation facilities to Rema-Kalenga Wildlife Sanctuary should be improved so that the ecotourists can visit the destination. It is not necessary to increase tourism facilities at all these PAs in the same fashion. Some PAs should be kept as less disturbed for the further considerations to develop.

Conclusion

North-east cluster (LNP, SNP and RWS) is clearly ahead in terms of visitor and sales/revenue status in comparision to the south –east cluster. Controlled nature-based tourism (particularly 'ecotourism' and 'community-based tourism') has been suggested according to the respective Co-management Plan of all these five PAs. But the progress of such controlled nature-based tourism is still in its infant stage due to many problems that have been discussed.. Nevertheless, it is appreciable that the number of visitors is increasing every year in these PAs since the initiation of Nishorgo Support Project and its activities related to tourism. Now, it is needed to develop effective tourism management strategies along with tourism marketing plan to improve visitors' and hosts' satisfaction, management and conservation of the biodiversity of the PAs, and to safeguard the local culture and heritage. Co-management approach has great potentialities to develop and promote ecotourism at these PAs.

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Local Residents' Perceptions on Co-management: A case Study at Lawachara National Park

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Abstract

Perceptions of local residents on co-management were examined among three levels of stakes (i.e., major, moderate and minor based on their dependency on the natural resources of the park) at Lawachara National Park (LNP), Bangladesh. Three villages were selected from each level of stake. In this fashion a total 9 (3x3) villages were selected. Snowball sampling method was followed to select 20 local respondents from each level of stake,thus a total 60 (20x3) respondents were chosen as samples. Every respondent was aware of Nishorgo Support Project (NSP) and/or Integrated Protected Area Co-management (IPAC) project but they had a meager knowledge on the co-management approach at LNP. They perceived that their awareness had been increasing towards biodiversity conservation through different awareness raising programs arranged by the project. However, surprisingly, only 40% of the respondents from major level of stake were involved with different co-management activities compared to the moderate level of stake (55%). This was due to the absence of ethnic people in different Forest User Groups (FUGs). Ethnic people were not happy to share their patrolling power with Community Patrolling Group (CPGs) from other villages. Whereas 55% respondents from minor level of stake wanted to get involved with different Alternative Income Generation (AIG) activities to generate their income for livelihood. Respondents (50%) from this minor level of stake knew very little about the co-management committee and they were totally aloof from their roles at LNP. Albeit their lack of knowledge of the current activity going on at LNP, they were very happy to be informed about the institutional platform where they could share power with Forest Department for managing the park. There was an urge among local community for the creation of more AIG opportunities. They also wanted uniform representation of committee members from the surrounding villages of the LNP. This study also finds that more careful investigation is needed on the cultural diversity before implementing any new program. Regular monitoring is required for the sustainability of co-management at LNP. Forest Department should take necessary steps to make the co-management system more transparent and to involve more people in FUGs.

Keywords: Lawachara National Park, Co-management approach, Ethnic people, Alternative income generation activities

Introduction

Human exclusionary strategies like nationalization of forested areas and creating and expanding of Protected Areas (PAs), however, do not offer a promising basis for sustaining forests on a global scale (Wilshusen *et al.,* 2002). If the history of forestry in Bangladeshis an evidence of the similar portrait of continuous depletion of forest resources both in terms of area and quality (FMP 1994). After addressing the problem like other Asian countries, Government of Bangladesh (GoB) has been taking attempts to include local people in forest use and management by introducing different social forestry programs since 1980 (Mustafa, 2002). With these initiatives Forest Department (FD) introduced co-management through Forestry Sector Project (1996-2006), where local communities are taking part in developing, protecting and managing forests/plantations in and around PAs in lieu of usufruct rights granted as per Participatory Benefit Sharing Agreements (PBSAs). But co-management truly came to light in 2004 with the introduction of Nishorgo Support Project (NSP), jointly implemented by FD and United States Agency for International Development (USAID) as corollary to the Tropical Forest Conservation Fund (TFCFA), aimed at improving the management and governance of PAs of Bangladesh (Khan, 2008).

However, Lawachara National Park (LNP) is one of the five pilot sites of NSP,which is now being managed by co-management approach under a five years management plan since 2006 (NSP 2006). The communities living in and around LNP consisting of diversified groups of people with unequal status, interests and power were brought in a single management paradigm comprised of three tier institutions ,viz., Co-management Council, Co-management Committee (CMC) and Forest User Groups (FUGs). The CMC plays the leading role to manage the park which consists of 19 members (This study was conducted in November 2009, now the size of CMC is 29), who are elected by the council in every two years. The third tier is FUGs represents the local poor community and there are now 43 FUGs at LNP (Sharma and DeCosse , 2007). The main purposes behind the creation of FUGs were to reduce forest dependency and improve the financial situation of the poor people living within 5 km of the park boundary. This has been accomplishing by providing training in various AIG (Alternative Income Generation) activities and through awareness raising programs addressing forest protection, future benefits from forests, health, education and other topics of interest to the members.

However, afterward 5 Community Patrolling Groups (CPGs) were formed to assist FD in patrolling and protecting the LNP based on consultation with the FUG members. Members of the CPGs were provided with different AIG opportunities. During the initial stage they were also given some financial incentives (Tk. 2,150/month). People from two *khasia punjis* i.e., Lawachara and Magurchara punji, Dolubari (muslim para), two adjacent villages Bagmara and Baligaon were incorporated into these five CPGs. One of the patrol teams was comprised of female members only. So, now LNP is being managed by a new paradigm ,i.e., co-management approach which is completely different from the colonial FD approach.

Now it is a high time to reveal the perception of the grass-root people about the ongoing management approach as it is a sudden shift from the colonial management approach to participatory management of PAs. For the sustainability of co-management approach, local communities need to accept co-management approach spontaneously and should be contented on the activities undertaken after the introduction of this new approach. So, this study was conducted with a view to reveal the perception of diversified local residents on co-management approach.

Materials and Methods

Study Area

Lawachara National Park is one of the five pilot sites of NSP. This park was selected on getting information through some regular articles published in different newspapers and after coming in contact with the ex-member secretary of the CMC of the park. It is located nearly 160 km north-east of Dhaka and approximately 60 km south of Sylhet city. It lies between 24°32' N and 91°37' – 91°47' E (NSP, 2006). Two Forest Villages, Magurchara Punji (40 households) and Lawachara Punji (23 households) inhabited by *Khasia* ethnic minority are located within the core zone were established by FD in 1950. There are 18 villages surrounding the LNP having varied stakes in the forest, which lie within landscape zone of 5 km from the park boundary. Of these, 6 villages (Bagmara, Magurchara, Lawachara, Baligaon, Dolubari, and Biranpur) were identified having major stake, another 6 villages (Botertol slum, Rashtila, Saraibari, Veerachara and Radhanagar and Chatakchara) with moderate level of stake and the remaining 6 villages (Langurpur, Ballarpur, Noagaon, Tilagaon, Bhasaniganj and Bongaon) with minor level of stake on the forest resources covered under the Park. There are two ethnic communities viz., *Khasia and Tipra* located in and around LNP. The *Tipra* people inhabit at Dolubari. Their main source of income is cultivation of lemon, pineapples, day labor, shifting cultivation outside the LNP and weaving. There are four tea estates bordering the NP namely Fulbari, Khaichara, Jakchara and Gilachara tea estates (Hossain 2007).

Selection of the respondents

For selecting villages from each level of stake and selecting the respondents from villages purposive and snowball or chain referral sampling technique were followed respectively. At first, 3 villages were selected from each level of stake (major, moderate and minor) considering the presence of FUG, CPG and especially cultural diversity. In this way total 9 (3x3) villages from 18 villages in and around the LNP were selected. By using snowball technique maximum 8 and minimum 4 villagers were taken as samples from each of the 9 villages. From each level of stake total 20 samples were taken from 3 villages. Only one respondent, age 18 years or above, was drawn from a family, thus the 60 (20x3) respondents representing the 60 households as well. Table 1 shows the details about the villages and diversity of the respondents.

Table 1. Study villages and diversity of the respondents

Level of stake	Selected villages for this study		
Major	Magurchara (1)	Bagmara (2, 3, 4)	Dolubari (1, 3, 4)
Moderate	Rashtila (2, 4)	Verachara (2, 4)	Botertal (2, 4)
Minor	Bongaon (4)	Langurpar (2, 4)	Tillagaon (2, 4)

*1= Ethnic Minority, 2= FUG, 3= CPG, 4= Bangali.

Indicators

Indicators perform many functions. They can lead to better decisions and more effective actions by simplifying, clarifying and making aggregated information available to policy makers. They can help incorporate physical and social science knowledge into decision-making and they can help measure and calibrate progress toward sustainable development goals. They can provide an early warning to prevent economic, social, institutional and environmental setbacks. They are also useful tools to communicate ideas, thoughts and values (United Nations ,2007).

Some relevant indicators were selected for this research. These indicators were set to know the people's perception about the newly introduced co-management approach at LNP. These were set to know the performance of current co-management activities at LNP. Different publications (Cortell *et al.* ,2005; *Cottrell and Cutumisu,* 2006; ITTO, 1998; Borrini-Feyerabend ,2007) were reviewed for selecting these indicators. The indicators are given in Table 2.

Table 2. Institutional Impact Indicators/Statements

No.	Indicators/statements
1.	Local inhabitants have influence on decision making process
2.	Increase in people awareness related to biodiversity conservation by CMC, Nishorgo or other parties
3.	Adequate awareness program taken by different agencies after introduction of co-management
4.	Conflict resolution mechanism of CMC is good
5.	There is good communication among parties involved in policy and decision making process
6.	Significant number of people getting benefits from locally created AIG opportunities
7.	Wide participation of local community in co-management
8.	Monitoring and feedback towards sustainability
9.	CMC work in more open/transparent manner
10.	Role of FD is clear and supportive to co-management
11.	Structural formation of CMC is acceptable
12.	Coherence among the key stakeholders are good for park management
13.	CMC will independently manage the park without the donation from donors
14.	NGOs are supportive to co-management development
15.	CMC adhering to and complying with their agreed entitlements and responsibilities
16.	The co-management plans, agreements and organizations progressively institutionalized in the society

Six points Likert scale was used to evaluate the perception of the local residents on these sixteen statements both for satisfaction and importance rating. In Likert, scale 1 indicates strongly disagree or strongly unimportant and the highest value 5 means strongly agree or strongly important. When the respondent had no knowledge on any of these statements then his perception was marked as 0 means 'I do not know'.

Data analysis

Qualitative data were analyzed by organizing the data into categories on the basis of themes, concepts, or similar features. The quantitative were been analyzed by using different statistical tools and techniques such as descriptive analysis, Chi-square test, multivariate analysis, importance–performance analysis (Bacon, 2003; Martilla and James, 1977), etc. 'Do not know' category of Likert scale was considered as missing value for statistical analysis. It had been used only for the descriptive analysis.

Results and discussion

Demographic profile of the respondents

As mentioned earlier, nine villages were selected from three levels of stakes purposively. Among the respondents from these 9 villages, 70% of the respondents were males. Most of the respondents were illiterate (38%) and had primary education (30%). Fifteen percent of local people were from ethnic community. All the respondents from the local community were categorized into three groups: CPG (8%), FUG (27%) and local resident (65%). Here, local resident means the people who were not involved in any type of co-management activities. Major portions (67%) of the respondents were between 18-40 years old; while only 18% of the local respondents were above 50 years. Average number of members in a family was found 6, whereas the average no. of earning member was only 1. There was a significant association (χ^2 (2) = 9.23, $p<0.05$; Cramer's V= 0.39) between the level of stake and involvement of local residents in different co-management activities (FUG, CPG, tour guiding, etc.). Most of the respondents from moderate level (55%) of stake were involved with co-management activities followed by major (40%) and minor level of stake (10%). It is remarkable that the involvement of the respondents of the moderate level of stake is greater than the major level of stake. This is due to the tribal people of Magurchara punji and Dobubari (*Tipra Para*) who are from the major level of stake were not involved with FUGs in those days. Though all of the respondents were aware of NSP/IPAC project only 63% respondents were familiar to the concept or idea on co-management.

Residents' perception on co-management

Though these respondents were aware of co-management approach and NSP/IPAC project, they were aloof of the activities run by the Co-management Committee (CMC) members and some of the decisions made by theses members were also not transparent. People were not satisfied with the selection procedure of beneficiaries for buffer zone plantation. Local people perceived that most of the beneficiaries were the relatives of the CMC members. Even the CMC members never visited the villages in and around the LNP to know the demands and opinion of the locals on the park management. People had direct contact only with the NGO officials. Since the introduction of co-management at LNP 4 NGOs name by RDRS, CODEC, CNRS and NACOM have been involved in implementing the new approach so far for different period of time. Residents urged to involve smart and honest representatives in the CMC.

Nevertheless, the respondents were very happy to learn that the local people participation in park management activities. They also opined that now they could share their views with FD and talk to FD officials without any hesitation or being frightened. A good relationship had been built up between FD and the local people. Now, the FD could recover the illicitly cut timbers from different villages which was quiet impossible before the introduction of co-management approach. However, 80% of the respondents perceived that CPG members were associated with illicit felling. This was existing as the CPGs were not provided with any monthly incentives during this study. But they had to patrol the forest regularly with FD. So, local people suspected that CPGs were not fairly doing their duties.

In contrast, CPG members opined that they were suffering from insecurity. The illicit fellers threatened them to leave CPG, as CPG members were associated with the illicit fellers before and were then working with FD against the illicit fellers. Furthermore, the cases against them were not withdrawn as FD promised. They were also enforced to stay in CPGs by CMC members. All of the respondents from CPGs blamed that they were not provided with any medicine or care after being wounded during the patrolling duties. So, without any incentive and lack of security they were dubious about their fate after the termination of the IPAC project.

Most of the respondents (73%) were very interested to be involved with different income generation activities through co-management. But they demonstrated that the provided AIG activities to them were not good enough and effective. *Khasia* people complained that the training ,on pisciculture and poultry rearing provided to them, was not a realistic concept. Because there was no fish pond in *khasia punji,* and they were not acquainted with poultry rearing practice. Some of the FUG members also had to sell their rickshaws ,which were provided to them as one of the AIG options, because in hilly areas like Lawachara rickshaw pulling was a very troublesome job.

Scale-wise responses

The responses of the respondents on 16 institutional impacts of co-management had been collected from the field by taking responses of two categories,i.e., importance rating and satisfaction rating. If the answer of the corresponding statement was known to them then they responded with the help of 5-level Likert scale. On the contrary, if the respondent had no idea about the impact statement, then he had option to choose 'Do not know' (scaled as 0). For two types of rating each respondent responded 32 (16x2) times. By this way, a total 1920 (32x60) responses were recorded for the different impacts of co-management.

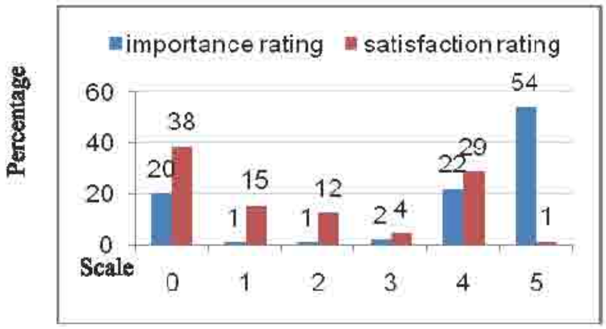

Fig. 1. Scale-wise response of the community people for different

Fig. 1 shows shows that 76% of the total responses of local respondents for different co-management impacts were perceived as important and strongly important. Thus ,it can be viewed that they were aware of the importance of the co-management impacts and its positive contributions to them. On the other hand, only 30% of total responses of the respondents were perceived as agreed and strongly agreed on the performances of co-management. Whereas, 27% of total responses were perceived as strongly disagree and disagree on the performances of the co-management activities and its impacts. More importantly, 38% responses were from 'do not know' category. As local people were not actively involved with co-management and less familiar with the present CMC as well as this new paradigm for PA management, so they perceived impact statements as 'do not know' category.

Importance-Performance Analysis (IPA)

Importance-Performance Analysis (IPA) was introduced by Martilla and James (1977). Sethna (1982) found the IPA technique to be a valid and powerful technique for identifying service quality areas that require remedial strategic actions. The IPA had been also used to formulate and to evaluate tourism policy (Evans and Chon, 1989). Recreation researchers have used the IPA technique as an ideal evaluation tool (Guadagnalo, 1985; Mengak *et al.,* 1986). The underlying assumption of the IPA technique is that peoples' level of satisfaction with the attributes is mainly derived from their expectations and judgment of the policy or serviceperformance. IPA has many advantages for monitoring the socio-economic impacts of parks (Oh, 2001; Tarrant and Smith, 2002; Cottrel, 1991). IPA is relatively easy for managers to interpret data to make decisions, IPA offers insight on potential guidelines for future allocation of resources, and IPA provides important information about sustainability to help prevent problems associated with making decisions based solely on stakeholder group perceptions.

The first step in the analysis the data involved calculating the means of perceived importance and satisfaction of the aforementioned institutional impacts(Table 2). The mean of each satisfaction attribute was then matched with the importance attribute and plotted on the I-P matrix. The next step was to calculate and position the crosshairs for the I-P matrix. Most past studies which have used the Importance-Performance Analysis have positioned the crosshairs at the middle point of the scale used (Mengak *et al.*1986), some arbitrary point (Guadagnalo 1985) or the overall mean for each of the Importance and Performance (Hollenhorst 1992). The co-management approach is a new approach for PA management in Bangladesh and still it is in initial stage, there is a gap between the expectation and performance of co-management activities. The result of the study shows that most attributes tend to fall in the high importance and medium to low satisfaction categories. For this study, the decision was therefore made to set the cross-hairs at the middle point of the scale (3, 3) for each of the importance and satisfaction attributes.

Mean scores for both importance and performance data were plotted as coordinates on the Importance-Performance matrix (Fig. 2). The Figure shows that all the means fall in Quadrant I and Quadrant II. These indicate that both performance and importance of the systems are satisfactory. Therefore, the systems are qualified for further improvement effort and maintenance. The Importance-Performance matrix (Fig. 2) reveals that all sixteen institutional impacts (Table 2 for the details) are performing below the respondents' expectations. Fig. 2 also shows that impact statements number 1, 6, 7, 8, 9, 13 and 15 (respective statements given in Table 2) have higher importance but lower satisfaction perceived by the respondents.

Eight impacts fall in Quadrant 1. These impacts are perceived to be very important to the respondents, but performance levels are fairly low. So, the policy makers should take improvement efforts to enhance the performance of these institutional impacts. According to the respondents, more socially accepted people should represent the co-management council and co-management committee. Priority should be given to involve the ethnic community more actively. Co-management committee members should mobilize community people towards biodiversity conservation, and work in more transparent way. In addition, they opined that they had little opportunity to influence the decision of CMC, as CMC members hardly visited the community and listened to their problems. Local residents also urged for more opportunity to get involved into different income generation activities for the sustainable development of the community.

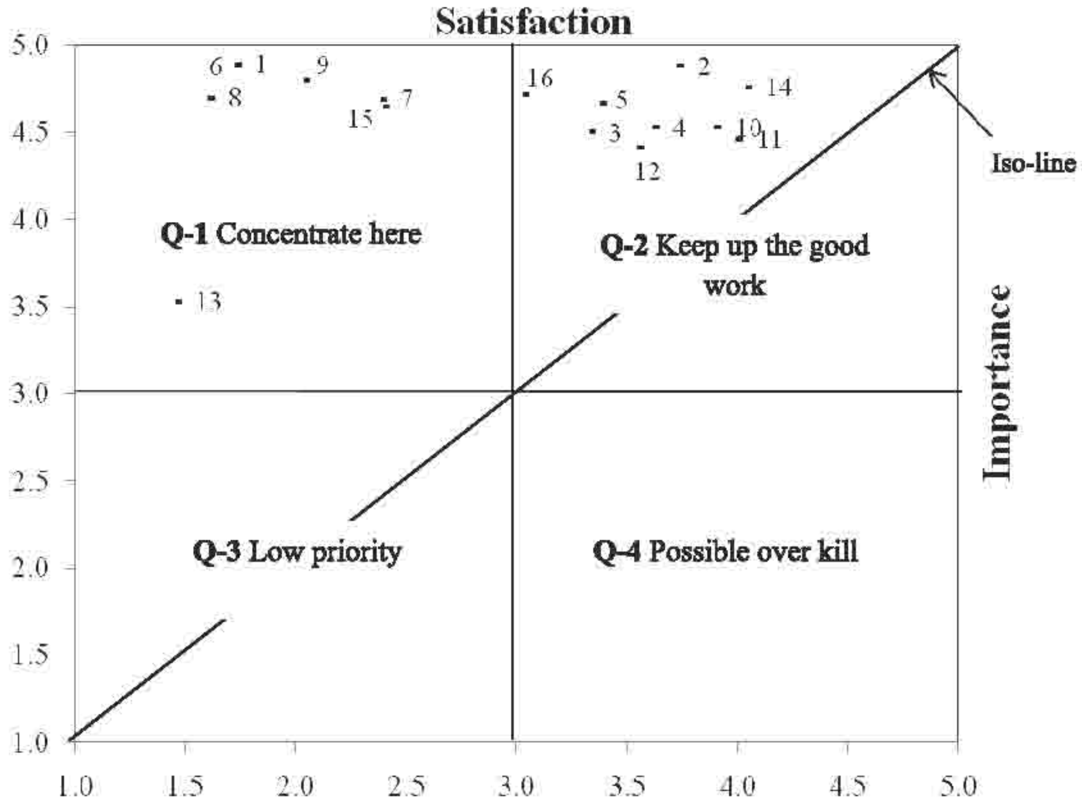

Fig. 2. Importance-Performance Analysis Grid of institutional impacts* with iso-rating line.

* Table 2 for sixteen statements and their corresponding numbers

Besides these, other nine impacts fall in Quadrant 2. It implies attributes are perceived to be very important to respondents and at the same time, these institutional impacts seem to have high levels of performance on these activities. But, all of them are above the iso-rating line (Fig. 2), thus indicating that importance exceeds performance. This implies that there are opportunities for improvement in these impact statements (Ainin and Hisham, 2008). People were satisfied with the activities of awareness raising programs and on the role of NGOs in the implementing different programs of the project. Unfortunately, most of the local residents were aloof about the structural formation and activities of the CMC. So, from the responses of a little portion of the sample, it cannot be concluded that the structural formation of CMC is good and their conflict resolution mechanism as well. Same result can be drawn for the role of FD towards co-management, as 50% of the respondents were aloof about this impact statement.

Conclusion

Local residents were skeptics about the institutionalization of co-management into the society. They were concerned about the transparency of the CMC members. They urged for more socially accepted members should be in the CMC. They also urged for more AIG opportunities to generate income for their livelihood. Higher officials of FD and IPAC should review the monitoring and feedback process of the project. Most importantly, people were very glad to have a platform to share power and influence the decision on park management. However, the dissatisfaction of the community patrol group should be addressed. A holistic approach is necessary to include culturally diversified people in FUGs thus they can play roles in park protection. As people were very happy with this new paradigm co-management and loved to shift from colonial approach to participatory approach, intensified social and need assessment is needed for the sustainability of co-management approach for managing and protecting the LNP.

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Congress Proceedings

Theme-3:
Trans-boundary issue in forest ecosystems and biodiversity conservation including human and wildlife conflicts

Geo-spatial Techniques and Route and Corridor Mapping of Asian Elephants: a Participatory Initiative for Conservation

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Abstract

Asian Elephant (Elephas maximus Linn.) is the critically endangered largest terrestrial animal. Over the past few decades, the number of Asian Elephants has dwindled due to human encroachment and unplanned settlements and cultivation along the movement routes and corridors of this majestic animal. So, proper conservation initiatives require a detailed spatial database on the routes and corridors of Asian Elephant. In this study, geo-spatial techniques were used to delineate routes and corridors of Asian Elephants, ensuring local people's participation in Shinga Baruna and Rani Shimul Unions in Sreebardi Upaziala of Sherpur District. Collected geo-spatial information and high resolution satellite images were analyzed to generate detailed landuse of the selected site, routes, corridors and human-elephant conflict (HEC) sites. Participatory sessions (PRA and RRA) were conducted at the selected sites to verify the collected GIS dataset on routes, corridors and HEC of Asian Elephant. The present study is an initiative to coalesce indigenous knowledge with geo-spatial techniques which can be replicated for conservation of other important species of Bangladesh and the world as a whole.

Keywords: Asian Elephant, Conservation, Routes, Corridor, GIS, Participatory approach

Introduction

Asian Elephants (*Elephas maximus Linn.*) were once distributed in the moist deciduous forest of Mymensingh Forest Division and semi-evergreen forests of Sylhet (SE), evergreen forest of Chittagong and the Chittagong Hill Tracts (CHT). But now they are confined to the forests of Mymensingh and CHT (Islam and Al-Zabed, 1992). In Bangladesh, IUCN has been carrying out conservation initiatives for Asian Elephants since 2001 (IUCN, 2004). Till now a number of noteworthy initiatives have taken from 2001; such as, Elephant census, habitat and HEC assessment, etc. About 50,000 Asian elephants remain in the wild, scattered across fragmented habitats in 13 Asian countries (Sukumar, 2003). Elephants are known to move between Bangladesh and the neighboring forested areas of Arakan Yoma in Myanmar, and Assam, Meghalaya, Mizoram, and Tripura states in India. Elephants from the Tura and Garo Hill Ranges of Meghalaya occasionally enter Bangladesh through the patchy sal forests of Balijuri and Durgapur Ranges of Mymensingh Forest Division. The threats to Asian elephants are habitat loss, construction of unplanned settlements and, inevitably, resulting conflicts with farmers and plantation owners along its routes and corridors (IUCN, 2004).

Conservation initiatives are indispensable ways of dealing with the accelerated natural habitat depletion and degradation, especially for the threatened and endangered species. Geospatial techniques are technical tools that allow us to analyze conservation initiatives and approaches giving the opportunity to detect, monitor, map, and model the changes. Spatial ecology equips us to analyze collected data, to build on ecological theory and to design conservation initiatives for endangered species (Roy *et al.*, 1996). The population of elephants is decreasing rapidly, not only because of habitat loss but also due to HEC. The major causes of HEC are denuded elephant habitats and construction of unplanned human settlements and agricultural activities along elephant movement routes.

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The aim of this study was to identify the routes and corridors of Asian Elephant by using the geo-spatial techniques and participatory approach minimizing the threats and HEC at Sreebardi Thana of Sherpur District in Bangladesh.

Study Approach

GPS data were collected along the routes and corridors and at the HEC sites using GPS device (Garmin E-Trex) in Shinga Baruna and Rani Shimul Unions of Sreebardi Upazila, Sherpur District. High resolution satellite images and a generalized platform, Google Earth, were used to delineate the landuse for the routes and corridor mapping of Asian Elephants in Sreebardi Upazila. Advanced GIS and integrated spatial analysis were executed in a well-known GIS platform (ArcGIS 10) to delineate the routes and corridors of Asian Elephant using conservation extension tool (Hwath's Analysis Tool). In this study, high resolution satellite images, Global Positioning System (GPS), Geographic Information Systems (GIS) were used to delineate routes and corridors of Asian Elephant at the Shinga Baruna and Rani Shimul Union of Sreebardi Upazila of Sherpur District. The detailed landuse database was generated utilizing high resolution satellite images (GeoEye-1). Google Earth platform was used in this study to validate and correlate the collected data. Integration of Google Earth and GIS platform were done to identify the exact location and to validate the data collected from the participatory sessions. High resolution satellite images were shown to the local people and to the professionals of Forest Department to collect and verify information regarding Asian Elephants.

Transect walk (5 km) was done to collect first hand information on the routes and corridors of Asian Elephants. GPS Locations of HEC were collected from sites of causalities and were validated during the participatory sessions. Focus Group Discussions (FGD) and Targeted Group Discussions (TGD) with the affected farmers, local stakeholders, forest dependent people and forest management authority (Forest Department) were conducted to identify and document relevant information.

Results and Discussion

Asian Elephant and Their Movement

The Asian elephant is in peril; in Bangladesh it is considered as 'critically endangered' in IUCN Bangladesh's Red List of Threatened Animals of Bangladesh (IUCN Bangladesh, 2000). There are only 239 wild elephants present in nature in the wild (IUCN, 2004) and their current status is poorer compared to the past decade. Asian elephant was widely distributed in Bangladesh in the past, but now the distribution has become patchy and sporadic. The resident elephants are mainly distributed in Chittagong Hill Tracts and Cox's Bazar region whereas, in Sherpur, Netrokona and Moulavibazar migratory elephant from India are commonly sighted.

Elephants move seasonally in the upper north-central regions of Bangladesh. According to the participatory sessions, elephants start visiting from the months of October-November and this continue up to January-February. Sometimes, they also move during the period of April-August, especially when the paddy is reaped. Elephants come from forested areas of Assam in India, neighboring the Sherpur district of Bangladesh. Elephants travel along the entire belt of Netrokona, Sherpur and some parts of Jamalpur District in Bangladesh. These large mammals usually trek 100-150 kilometers per day for foraging. They take the same routes followed by their ancestors, but now due to anthropogenic interventions, the paths are encroached and this leads to HEC in Sreebardi Upazila. According to the findings of the participatory sessions, the movement towards Lalmonirhat has completely seized, attributed once again to unplanned human settlements and infrastructures.

Overview of Human-Elephant Conflicts (HEC)

Habitat fragmentation, deforestation, indiscriminant logging, encroachment, unplanned settlements near elephant habitat are the major issues of human elephant conflict in Bangladesh. In all frequently sighted elephant spots of Bangladesh, HEC is now a key concern. Due to unplanned settlements and agricultural practices, a number of forested areas have been converted and fragmented. Conversion of forests to agricultural lands has given rise to frequent and dangerous HEC. For logging, a number of people go inside the forest and it was revealed that the number of human casualties has increased near or at the elephant habitats. Encroachment of forest areas and scarcity of fodder leaves the elephants with little choice, they venture out to the agricultural lands in search of food.

Need for Asian Elephant Conservation in Bangladesh

Elephant is a 'flagship species' and a majestic animal, culturally significant in Bangladesh. Elephants are one of the most important animals of all terrestrial mammals and their presence normally indicates sound health of an ecosystem. Illegal logging can be reduced if there is sufficient number of elephants present in the natural forest.

Elephants can also serve as source of income for the people who live in the forest fringe areas, to promote eco-tourism. During the participatory sessions, it was revealed that there is an animosity amongst the people regarding elephants, since these animals destroy their crops and houses. There is a humungous potential for reaching a win-win solution where human beings and elephants can co-exist in harmony; these avenues need to be explored properly.

Geo-spatial Techniques in Conservation of Asian Elephant

Analysis of satellite images and GIS facilitate wildlife conservation through better understanding of the changes in natural habitats of critical and protected areas around the world. Remote Sensing and GIS are often used in combination for habitat and corridor mapping, monitoring, assessment and analysis of the progression of conservation activities, ecological patterns, encroachment of protected wildlife parks, monitoring of wildlife and building management support systems using spatio-temporal satellite images and GIS analysis.

Delineation of Routes, Corridors and HEC Sites at Sreebardi Upazila

The collected GPS data of 'Asian Elephants' biological corridor was cross-matched with the routes and corridor data and it showed the congruency with the other collected data (Figure 1). The GPS locations of the HEC were collected and processed in GIS platform which was then set into the detailed dataset to generate the base map. The sites were visited during field survey and the ancillary data of the casualties were collected in a separate dataset.

The collected ancillary data was then linked with other GIS layer (shapefile) to calculate the exact number of casualties (death and injuries) caused by Asian Elephants. High resolution satellite images were used for landuse generation of the study area. About 0.5m resolution satellite images were analyzed to define the landuse of Sreebardi Upazila. Coarse resolution satellite data (Landsat ETM+) were also analyzed to identify the forest patches, human settlement and other features.

Figure 1. *Collection of GPS location at the routes and corridors of Asian Elephant*

The routes and corridors were generated with the collected GPS data during transect field survey using sophisticated GPS device (Garmin e-Trex) in the selected unions of Sreebardi Upazila. The collected GPS data was then applied into GIS platform to delineate exact routes and corridors of Asian Elephant in Sreebardi Upazila.

The generated routes and corridors were validated during the participatory sessions ensuring local people's participation (Figure 2). Google Earth platform was used to show the collected data in a real world scenario for summarizing the results, incorporating indigenous knowledge, active and abandoned corridors were also identified and validated with the local people during field visits.

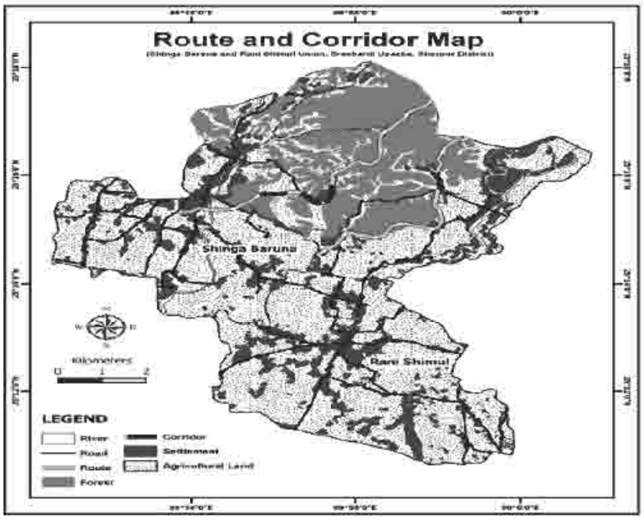

Figure 2. Map showing routes, corridors at Sreebardi Upazila

People and elephants have coexisted in Asia for thousands of years (Sukumar, 2003). The recent rise in HEC is due to the dramatic changes in how people interact with land and elephants (**Figure 3**). HECs of Sreebardi Upazila have transpired in a number of casualties and crop damage in the Balijuri Range (Sreebardi Upazila).

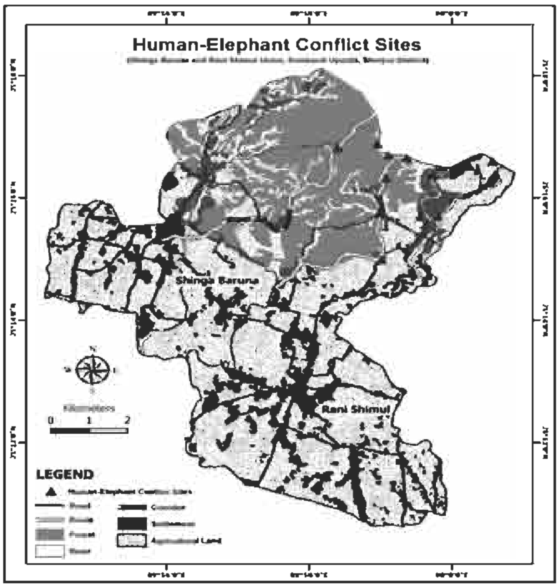

Figure 3. Map showing HECs at Sreebardi Upazila

According to the Forest Department, in Balijuri bit area 5 people died and 8 were injured from the year 2002 to 2010, and 110 families were affected either through crop damage or destruction of houses. Total crop loss had been calculated to be more than 0.22 million BDT at Balijuri Sadar Bit area, whereas at Malakocha bit area, 51 families and 1 household was affected and the crop loss was more than 0.13 million BDT during 2002-2010.

Table 1.HEC (Human died and Injured) and Crop Loss in Sreebardi Upazila from 2002-2010

BALIJURI RANGE							
BIT AREA	HUMAN DEAD	HUMAN INJURED	ELEPHANT DEAD	AFFECTE D FAMILY	AFFEC TED HOME	AFFECTE D CULTIVA TED AREA/ AMOUNT (TON)	CROP LOSS (BDT)
Balijuri Sadar Bit	5	8	-	110	5	109.09	2220000
Malakocha Bit	1	1	-	51	1	60.65	1380000
Karnojora Bit	-	-	-	40	5	13.45	296000

[Source: Forest Department, 2011]

At the same time, no human casualties have been reported at Karnojora bit, but 5 homes and 40 families have been affected at the same time and crop loss is also low compared to other two bits (Table 1). This has been estimated by Forest Department within that time frame. Using the participatory approach and collected primary and secondary data, it was found that Balijuri Sadar bit area has the highest incidents of conflicts, followed by Malakocha and Karnojora bit, as these two bits are to be found far away from the routes and corridors of Asian Elephants.

Participatory Mapping of Routes, Corridors and HEC sites

People's views and opinions were taken into consideration while delineating routes and corridors of Asian Elephant in Sreebardi Upazila of Sherpur district. During the participatory sessions, local people's suggestions about Asian Elephant conservation and reduction of crop damage, bio-fencing and alternative crop cultivation were taken into account, and these approaches were found helpful in reducing HEC in elephant movement areas.

The landuse maps using Google Earth platform were shown and summarized in participatory sessions with local people and Forest Department (FD) professionals to identify, verify and validate the exact routes and corridors of Asian Elephants. With the high resolution images, local people understood the complex mapping environment quite easily. After a brief orientation, they were able to identify their homestead locations and even their ponds and agricultural lands. Local people showed the tracks, active corridors and HEC sites including the locations of casualties in Sreebardi Upazila. The overall outcome regarding participatory mapping was very user-friendly and applicable.

After giving a brief on their homestead and important social locations, they shared what they knew about the routes, corridors and HEC sites of Asian Elephants. Geo-spatial techniques were well-mixed with indigenous knowledge to identify route, corridors, transboundary locations (entry point) and HEC sites of Asian Elephants. The approach was found very effective, as they could identify and avoid routes and corridors of Asian Elephants to reduce the HEC stop construction of infrastructures along those paths.

Figure 4. Local people sharing their knowledge during participatory mapping

Any conservation practice involving local people is usually successful, so an initiative was taken to ensure people's participation and geo-spatial techniques in conservation of Asian Elephants. During this study, participatory sessions were conducted at about five different locations. Different indigenous practices have been shared by the local people during the sessions and well documented. According to the local people, community based awareness programs, bio-fencing, protection of habitats, sustainable logging, halting deforestation, encroachment of forest area and construction along the routes and corridors of Asian Elephant can all be instrumental in reducing HEC and restoration of natural habitats.

Conclusion

Routes, corridors and HEC mapping are regionally based and not absolute at a property scale. An approach had been taken to incorporate geo-spatial techniques with indigenous knowledge and practices to conserve Asian Elephants in some areas of Bangladesh. The routes, corridors and HEC were generated using geo-spatial techniques and were verified and validated during participatory sessions. Local people suggested many integrated approaches to conserve Asian Elephants and shared their experiences. They recommended the formation of a corridor map, for better planning and conservation of elephants. This type of integrated participatory approach in generating routes and corridors with geo-spatial techniques can be replicated in conservation initiatives for other threatened and endangered species of Bangladesh and for other developing countries as well.

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Transboundary Issues in Forest and Biodiversity-Focusing on Sundarbans Forests and mitigating measures

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Abstract

The present international boundaries are marked politically. Ecosystem does not match with such political barrier because it existed much earlier before the political boundaries were fixed. Many countries in the Asian region share common biological and natural resources across their boundaries, and hence there are ample chances of illegal harvest and trade in wild plants and animals involving organized crime, criminal networks and pervasive corporation driven sheer greed which tends to risk to human health, bio-security and livelihoods.

Bangladesh has long felt the need for conservation of trans-border biological resources. The Sundarbans, the largest mangrove forest in the world is lying in Bangladesh (60%) and India (40%). The area has a wide range of rare flora and fauna, including the Royal Bengal Tiger, estuarine Crocodile, Indian Python and many reptiles and birds. The transboundary issues on Sundarbans Forests of Bangladesh and India can be identified as chances of poaching and in trade of endangered species, drawbacks in wildlife protection legislation, and lacking healthy transboundary cooperation and public awareness on wild species trade especially tiger trade ban. The aspects which come front to establish the basis of the issues might be biological resources of both flora and fauna, cultural heritage, local human population, visitors and visitor's facilities, scientific research and facilities, conservation values, conservation management and management constrains. Transbaundary issues present risk to human life and health, biodiversity and livelihood. It exploits local communities. There might be some challenges for transboundary cooperation such as political commitment for biodiversity conservation, formal legal agreement, institutional set up, communication and low government priority on management of transboundary region. Many organizations both national and international are working for resolving these issues. Based on the literature review this paper suggests mitigating measures to resolve the transboundary issues in this region.

Key words: Biodiversity conservation, Sunderbans, Transboundary Issues

Introduction

The plants, animals, micro organism, water, weather systems and other elements including human being that constitute the environment, do not remain within jurisdictional boundaries. Not only that, more often they cross the political boundaries between nations. When this occurs, the environmental issues of mutual concern that arise from the shared natural area, resource, system or migratory species are called transboundary.

The key ecological system and components occurring in two or more nations are often subject to a range of opposing management and land use practices. To manage such resources, cooperation is needed between different groups, institutions and the communities living there. In south Asia as well as in India and Bangladesh the most common way of approaching biodiversity conservation to-date has been through in-situ conservation in protected area systems. Ecosystems crossing national boundaries here face variety of threats, including illicit harvest and trade in wildlife and species losses. For this reason, there is a growing realization that creative networks of protected area can serve the well being of both human and wildlife. An inter-connected network of natural conservation areas supports species, maintains natural ecological resources, and protects landscapes where people work has been suggested. (Oli, 2002). This paper briefly highlights the biological resources of the Sundarbans reserved forests as a potential site for transboundary, the issues facing the region and discusses the efforts on the conservation of bidiversity. It also brings forth the historical linkage of the area as well as the challenges pertaining to the development of the Transboundary protected area.

Study Area

The paper is presented with the focus on to the study area in Sundarbans Reserve forest, Bangladesh and the Sundarbans national park, India based on the literature review. The Sundarbans lies across the outer deltas of the Ganges, Brahmaputra and Meghna rivers with an area of about 10,000 sq km (Fig.1). It forms the largest mangrove forest in the world, 40% in India and 60% in Bangladesh. The adjacent world heritage sites in Bangladesh and India cover nearly 1/4th of its area. The forest is composed of small-forested islands and mudflats intersected by a complex network of tidal waterways and exemplifies the ecological processes of monsoon rain flooding, delta formation, tidal influence and plant colonization. The area has a wide range of rare fauna and flora.

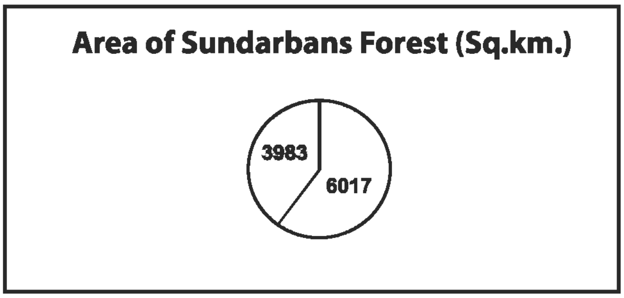

Fig. 1. Area of the Sunderbans

The Sundarbans in Bangladesh is inscribed on the world Heritage list under natural criteria IX and X in 1997 and Sundarbans National Park inscribed on the world heritage list under natural criteria IX and X in 1987. The Sundarbans Reserved forest in Bangladesh designated as wet land of international importance under the Ramsar Convention (601,700 ha) in 1992 and in 2001 the Indian Sundarbans site (India) is designated as Biosphere Reserve under the UNESCO Man and Biosphere Program . Again under IUCN management category ,Bangladesh treats it as IV managed national reserve when India treats it in a strict nature reserve. According to the geographical location the Sundarbans mangrove forest lies among the creeks and distributaries of the Ganges and Meghna (Brahmaputra) river deltas. The Bangladesh site of Sundarbans is situated 200-300 km south-southeast of Dhaka, between the Raimongal and Balswar rivers and between 21^{0}30' N and 89^{0}12' to 90^{0}18'E. On the other hand the Indian site lies about 130 km southeast of Kolkata , between the Matia and Raimongal rivers and between 20^{0}21' to 22^{0}53'N and 88^{0}37' to 89^{0}09'E.

Objectives

- To discuss and identify the transboundary issues, challenges and effects
- To review the history and present situation of Sundarbans forests
- To suggest the mitigating measures

Methodology

This paper stems from review of the literature.

Transboundary Issues – a Burning Question

Many countries of south Asia have reported seizures of parts and derivatives from endangered wildlife such as tiger, leopard, elephant, rhino, marine species, birds and rare medicinal plants. These seizures point to the fact that the rare and endangered fauna and flora of the region are in great demand locally as well as globally, leading to unsustainable harvest and illegal trade. Investigations have revealed that illegal hunting and trade is accomplished through a deep-rooted and well established clandestine chain of operators who have developed a strong nexus with international wildlife crime networks. Any country cannot solve these problems individually and so transboundary issues have been highlighted. The rationale for trans-boundary protected area has become very important and consists of maintaining ecology and improving its management, economic opportunity, bringing isolated people together and provides the basis for peace and collaboration reducing hostilities among people and nations.

History of the Sundarbans Forests

In 1875 the entire forests in the twenty-four Parganas, Khulna and Bakerganj districts were made protected forest reserve under the Indian Forest Act of 1865. Much of the area was later leased out by the government for cultivation. In 1926, the Boundaries of the remaining protected forests were fixed by notification 4457-for. The forest in the Bashirhat Division were declared reserved forests in 1928 under notification 15340 and those in Namkhana division in 1943 under notification 7737-for. In 1973, 1976 and 1984 the Indian Sundarbans were declared as Tiger Reserve designated (258,000 ha), Sajnakhali wildlife sanctuary established (36,234 ha) and the tiger reserve established a national park respectively. For Bangladesh site in 1977 the separate Sundarbans South wildlife sanctuary (17,878 ha), Sundarbans West wildlife sanctuary (9,069 ha) and Sundarbans East wildlife sanctuary (5,439 ha) were established under the Bangladesh Wildlife (Preservation) (Amendment) Act of 1974, respectively. In 1996 each sanctuary was extended to 36,970 ha, 71,502 ha and 31,227 ha respectively which are their present area. (United Nations Environment Program, World Conservation Monitoring Center, World Heritage Site). The eco-regions of the Sunderbans is shown in Fig.2.

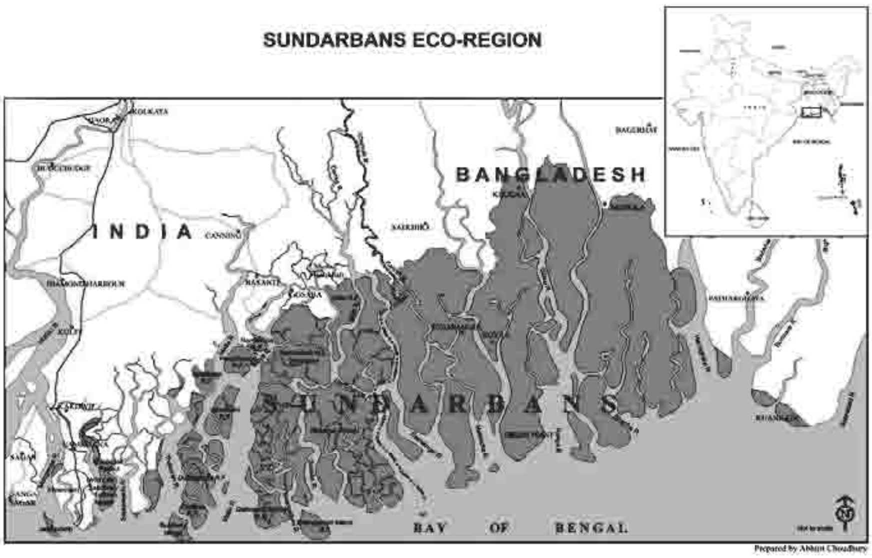

Fig.2. The eco-regions of the Sundarbans

The Transboundary Issues

In the Sundarbans forest, Bangladesh shares borders with India. Many of its ecosystem and natural resources are transboundary. It has considerably high floral diversity with atotal about 334 plant species. Among which sundri (*Heritiera fomes*), keora (*Sonneratia apetala*), kankra (*Bruguiera gymnorhiza*), etc., are most important. There are more than 375 wildlife species, which includes 35 reptiles, 315 birds and 42 mammals. There are 291 aquatic species (210 white fish, 24 shrimps, 14 crabs and 43 mollusks). The number of recorded of major wildlife in the Sundarbans is listed in Table 1.

Table 1.The number of major wildlife in the Sundarbans

Wildlife	Number
The Royal Bengal Tiger	440
Deer	100,000-150,000
Monkey	40,000-50,000
Wild boar	20,000-25,000
Saline Water Crocodile	150-200
Others	20,000-25,000

Source: Sundarbans, The World Heritage Site.

The major transboundary issues of the Sundarbans might be stated as:

- *Poaching and trade in endangered species*

For years after year people living in the border areas are reported to be involvedt in illegal trade of wild species and animal parts though there was no authenticated report regarding this issue. It is assumed that incentives for such illegal acts generally come from outside the area. Culturally, local people generally respect the wild fauna and flora of their surroundings but they have neither the capacity nor the authority to control the illegal harvest and trade being done by people intruding from elsewhere. Law enforcement agencies are based far way, and so the intruders always have the upper hand. Thus ,it is very difficult to control the illegal hunting and trade of species especially spotted deer ,monitor lizard, etc., that were traditionally protected by the local communities.

Fig.3. Natural scenic beauty of movement famous Royal Bengal Tiger

- *Drawbacks in wildlife protection legislation*

Each country in the region has its own protected area legislation and sometimes it is more progressive than others are. However when it comes to the implementation or enforcement the challenge o inaccessibility is the same. At the same time, where important natural resources such as water are concerned, these legislations become potential source of conflict between countries.

- *The lacking in transboundary cooperation*

Though there is transboundary cooperation, the political commitments for transboundary biodiversity conservation are not satisfactory. It is often confronted by several problems. First and foremost is countries have different political system and different level of political commitment to establishing Transboundary cooperation.

- *Lack of public awareness on wild species trade specially tiger trade ban*:

South Asia covers an area of approximately 42,916,000 km^2. Encompassing Afganistan, Bangladesh, Bhutan, India, Maldeves, Nepal, Pakistan and Srilanka, the region contains over 15% of the world's flora and fauna. It encompasses 16 of the 234 globally important eco-regions and the Sundarbans mangrove forest of Bangladesh and India is one of those. This eco-region supports exceptionally rich biodiversity and a huge array of unique, threatened and endangered species specially the Bengal Tiger. The natural scenic beauty of movement famous Royal Bangal Tiger in the Sunderbans is seen in Fig.3.

Like South East Asia, this area might be targeted by criminal networks. Unscrupulous traders may take advantage of the traditional forest skills of impoverished communities, using them to commit wildlife crimes for the benefit of wealthy traffickers and rich international consumers. During the past two decades there has been a sudden increase in the demand for wild animals and plants from this region. Many countries of the region have reported seizures of parts and derivatives from endangered wildlife such as tiger and other animals including marine species, birds and rare medicinal plants.

Aspects of Transboundary Issues

Transboundary issues arise on the basis of following aspects

- *Biological resources*

a) Flora: Only low mangrove forest and saltwater Heritiera forests occur within the Indian part of the Sundarbans (Champion, 1936). The main species include Rhizophora, Bruguiera, Sundri, etc., and the forest is scattered over the areas of higher elevation along with other species. The northwest margin of the mangroves and some forest tract on low lying islands were cleared for agriculture about two hundred years ago and various exotic species were introduced (Mukharji,1975, Jain and Sastry, 1983). Some varieties have been lost for the higher salinity and partly due to large scale irrigation schemes on the Ganges upstream.

In Bangladesh, all the four types of tidal forests are found. Sundarbans west is in the saline water zone.

b) Fauna: The Sundarbans is the only remaining habitat in the lower Bengal Basin with a great variety of fauna. Some species are now locally extinct due to agricultural reclamation and the increase in soil salinity during 20th century. These include Javan rhinoceros (*Rhinoceros sondaicus*), Indian rhinoceros (*Rhinoceros unicornis*), Water buffalo (*Bubalus bubalis*), Swamp deer (*Cervus duvuali*), etc. The documented mammals species are 45% of the Bangladeshi total. The Sundarbans support one of the largest populations of tiger, the Royal Bengal Tiger (*Panthera tigris tigris*). According to the WWF, Tiger program, the area may now shelter about 450 tigers in the Bangladesh part and an estimated 250 on the Indian Side, though an IUCN species survival commission study suggests that Indian's one may be fewer than 100 (UNESCO, 2002).

The varied and colorful bird-life of the Sundarbans waterways is a great attraction. A total of 375 species have been recorded of which 84 are migratory (Hussain and Acharya, 1994).
Some 53 reptile species and 8 amphibians are recorded (Hussain and Acharya, 1994). 18 species of snake including King cobra were recorded. Estuarine crocodile (*C. porosus*) 100 individuals still survives

Hunting and trappings for skins might deplete its numbers. Over 120 species of fish are said to be commonly caught by commercial fishermen and 400 species are said to exist with 20 shrimps, 8 lobster and 7 crab species.

- *Cultural heritage:* In Bangladesh art, there is archaeological evidence of early human occupation on the deltaic islands in the Sundarbans, which indicates the former presence of abundant fresh water, both from the Ganges and from non-saline ground water. Human occupation ceased in the 17th century, reportedly due to pirate attacks (Christensen, 1984). A ruined Hindu temple at Shekher Tek draws an annual festival for the community (Ramsar, 2004).

In India, Baghmara forest block near the coast contains the ruins of a city by the Chand Sandagar merchant community approximately 200-300 AD. During the Moghul Empire, Raja Basand Rai took refuge in the Sundarbans from the armies of Emperor Akbar.

- *Local human population*: In Bangladesh part approximately 5 million people are directly dependent on Sundarbans for their livelihood and approximately 205 million people live in small villages surrounding Sundarbans in Indian portion. These people are poor in livelihood.

- *Visitors and visitor's facilities:* In Bangladesh a report says that in recent years more than 10,000 local and about 1,500 foreign tourists per year visit Sundarbans (BFD, 2008). The potentials for mass tourism and eco-tourism from October to April or May are increasing (Figure). In India visitors are not allowed to visit the national park without a permit. But the buffer zone, on average 34390 tourists visit in a year between 1992-1997 (Project tiger, 2001).

Table 2. Number of visitors in Sundarbans West Forest Division

Year	No. of local visitors	No. of foreign visitors	Revenue earned (Tk)
2007-2008	11521	132	561520
2008-2009	17033	70	1175180
2009-2010	19194	283	1781780
2010-2011(up to Feb'11)	23604	142	2608200

- *Scientific Research and facilities:* Bangladesh Forest Department needs to do a lot in this sector. There is always the potential for tigers to die from disease, but there has been no research in this area. Likewise, for other wildlife and also plants the same deficiency prevails.

- *Conservation value:* The Sundarbans forest is the world's largest mangrove forests, covering six percent of Bangladesh and forming over half of its remaining natural forests. It is one of the most biological productive of all natural ecosystems, containing a rich biota, including the Bengal Tiger and many threatened reptiles. These are of great economic importance as a source of natural resources, for protection of the land from frequent storm and are the most important source of fish and shrimps. These are an excellent example of the ecological process of monsoon, rain flooding, delta formation, tidal influence and plant colonization. It is inscribed on world heritage site and also Ramsar Wetland also.

- *Conservation management:* The Sundarbans had a history of scientific management since 1879. Gradual update of management systems is taking place till today.

- *Management constrains:* In Bangladesh long term ecological change is taking place in the Sundarbans, due to the eastward migration of the Ganges. Sometimes illegal hunting and trapping is practiced by fishermen and even reported by others. A total of 118 offences were recorded and over 3300 meter of deer nets were removed between 1981-82 and 1986-87 (Habib, 1989) but this poaching is now rare.

Oil spill could cause immense damage to aquatic fauna and seabirds and probably to the forest itself (Blower, 1985). There have been several spillages from tanker passing nearby. The reduction in freshwater flow due to upstream water diversion, the construction of dykes combined with the pollution from the industries and the ports of Khulna and Mongla have greatly affected the plant and fish population of Sundarbans (Ramsar, 2004). The international sea lane in Sundarbans for cargo ships may cause illicit activities inside Sundarbans.

Cyclone and tidal waves normally cause some damage to the forest along the sea-face and result in considerably occasional mortality among spotted deer. For India the picture is more or less same as in Bangladesh.

The Effect of Transboundary Issues

The existing transboundary issues present risk to human health, biodiversity and livelihoods. It exploits local communities. It offends religious beliefs and moral values. It results in significant loss of revenue to governments. It generates massive products for criminals and insurgent groups have exploited the trade.

The Challenges for Transboundary Cooperation

- Political commitment for transboundary biodiversity conservation:

The fundamental obstacles for transboundary cooperation are effective political will of the participating countries and their governments. Transboundary conservation can be promoted both through legal and institutional mechanisms and by community led conflict resolution. Because biodiversity and other natural resources of Sundarbans are a common heritage, they demand regional cooperation for protection, management and sustainable use. To achieve this, strong political commitment and understanding between the participating countries, Bangladesh and India are the starting point.

- Formal legal arrangement:

Bangladesh and India is the region, which have their own protected area legislation. When comes the question of implementation or enforcement, the challenges of inaccessibility is the same. At the same time, where important natural resources such as water are conserved, these become a potential source of conflict between countries. Therefore for formal collaboration it is important to establish legal provisions between countries. Again who should lead this effort is still a major challenge in the region.

- Institutional set up:

For effective trans-boundary protected area management, appropriate national and local institutional mechanisms are important. Because of variation in tradition, political and legal systems, one single mechanism will not work. Rather this demands that government authorities work in cooperation with their partners in local communities to implement activities such as for joint planning, research, meeting, training and information exchange.

- Communication:

Communication is a major component for management of transboundary issues, both to prevent illegal harvest and trade and for tourism promotion. Further, local people often do not have the capacity to communicate in another language and hence it becomes a barrier. Information sharing can be resulted from poachers being arrested and information needs to be spread across the border areas so that cross border prosecution can be promoted. Awareness in general needs to face the challenges of transboundary issues.

- Low government priority on management of transboundary:

It is often seen that respective country's concerned ministry is not putting priority on the issues.

The Role of Different Organizations for Transboundary Issues

- World wildlife fund (WWF) is working with the following objectives:

a) To stop tiger poaching ,the longer-term strategic activities include:

i) Closing markets for tiger parts and products both in and outside tiger range countries, focusing on trade routes, processors and consumers
ii) Preventing any legal commercialization of dead tiger body parts
iii) Ensuring all tiger range countries to have fully CITES compliant national legislation
iv) Establishing transboundary customs post to foster international cooperation and liaisons

b) To conserve tiger habitats:

i) Recovering tiger and prey population
ii) Managing tiger habitat
iii) Establishing sustainable funding mechanisms to support tiger conservation
iv) They are working with a number of influential groups in tiger range status including government regional coalitions and international and multinational institutions to get endorsement of transboundary agreements

- Global tiger forum (GTF):

Considering that the tiger throughout its range in India, Nepal, China, Bhutan, Bangladesh, Myanmar, Thailand, Malaysia, Laos, Cambodia, Vietnam and Russia is threatened and in some places is becoming critically endangered. Hence, the forum is sorting out the problems facing the tiger in the world and working out effective strategies and solution for future implementation for the survival of the species.

Suggested Mitigating Measures

- Strengthened political relation between Bangladesh and India will help settling disputes. Moreover strong political commitment will improve co-ordination in conservation and sustainable use of resources and help developing appropriate policy and legal instruments

- Formal legal arrangements should be made to lead the effort to resolve the disputes and control the crime

- Institutional set up must be built up to provide inter and intra governmental co-ordination for the implementation of treaty and international obligations

- Through proper communication between two countries cross border prosecution might be promoted. Awareness needs to be raised on transboundary issues.

- Government should give priority in pointing out the problems and solve those instantly
- To protect natural resources from theft and destruction, intelligence led enforcement, effective patrolling and anti poaching activities need to be visible

- Government law enforcing agency needs to control effectively the illegal domestic wildlife use and reducing demand for illegal wildlife products.

- International NGOs and donor agencies need to establish sustainable funding mechanism to support nature and biodiversity conservation.
- A long-term strategy should be taken for regional cooperation in regulating transboundary wildlife trade and for managing the legal trade effectively and efficiently.

Conclusion

Transboundary issues are not the problems that countries can tackle individually. Neither will enforcement alone resolve them. Indiscriminate demand for plants and wild animal products is a driving force of crime. To mitigate those, effective demand reduction strategies must be developed and implemented.

For conservation of biodiversity of Sundarbans forest, efforts have been instituted in the region both in Bangladesh and India. In Bangladesh many institutions are already aware of the benefits. The legal and political environment, better communication and information sharing between two governments are important to face the challenges of transboundary issues. All this needs to be consolidated activities to be further promoted for the conservation and sustainable use of the unique biodiversity of the area.

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Tigers and the Economy

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Abstract

Tigers are a symbol of all that is splendid, mystical and powerful about nature. The loss of tiger would eventually mean the loss of cultural and spiritual values that connect humans to nature. There is a wealth of legend and lore connected with the tiger in Asian countries. Analysis of investment record revealed that plenty of money is being spent for tiger conservation probably because of no dearth of interest in saving tigers from extinction. A considerable number of conferences were held and money was spent for its conservation. But tiger monitoring result invokes to call for new strategy not limited by its control only. In neighboring areas of tiger habitat in Bangladesh and elsewhere, agricultural productivity is abysmal, poverty is endemic, and non-farm economic opportunities are scare. This put pressure on neighboring inhabitants to share the tiger conservation landscape (TCL) and to involve with wildlife crime. Hence, there should have realization that economic (human) development may provide a more effective way to improve the environment than monitoring and counting every tiger in its habitat.

Key words: Tiger, Tiger conservation landscape (TCL), Tiger range country (TRC), Economic development.

Introduction

The wildlife protection and conservation is an integral part of the forest ecosystem management. Among different wildlife, tiger (*Panthera tigris*) plays the most vital role to keep the forest ecosystem healthy for a range of other wildlife and also human community who share it. Tigers are a symbol of all that is splendid, mystical and powerful about nature and it is the largest cat with majestic symbol in many ancient and modern cultures. The loss of tiger would eventually mean the loss of cultural and spiritual values that connect human being to nature. Over the last century, tigers have disappeared in many forest ecosystems because their habitat has been degraded, fragmented or lost. Besides, poaching, illegal trade, conflict with humans and the loss of prey base have caused local extinction of tiger from its wild habitat. But historically tiger was found over a large tract of forest ecosystems across Asia and Central Asia. But now it has reduced considerably. Tigers have already disappeared from Central Asia. Tiger now occupies only 7 percent of its historic range in Indonesia. The Sundarbans mangrove forest is the last habitat that exists for tiger in Bangladesh. Tiger is considered as the Asia's most iconic animal and here is a wealth of legend and lore connected with the tiger in Asian countries. At present only 13 countries from Asia (Bangladesh, Bhutan, Cambodia, China, India, Indonesia, Laos, Malaysia, Myanmar, Nepal, Russia, Thailand and Vietnam) are treated as tiger range country (TRC) because of the presence of wild tiger in forest ecosystems. Their habitats have shrunk by 93 percent and world population of tiger reduced to 95 percent in just over a century from an estimated 100,000 in 1900 to approximately 3,700 today (Dey, 2010). The World Conservation Union (IUCN) has listed tiger (*Panthera tigris*) as Endangered to Critically Endangered species of the wild. Tigers are divided into six living sub-species: the Royal Bengal tiger (*Panthera tigris*), Indochinese (*Panthera tigris corbetti*), Malayan (*Panthera tigris Jacksoni*), Sumatran (*Panthera tigris sumatrae*), Siberian or Amur (*Panthera tigris altaica*), and South China tiger (*Panthera tigris amoyensis*). The three extinct sub-species were the Bali tiger (*Panthera tigris balica*), the Javan tiger (*Panthera tigris sondaica*) and the Caspian tiger (*Panthera tigris virgata*) (Dey,2010).

Tiger protection and conservation has received especial attention since long and plentiful of money is being spent for tiger conservation probably because of no dearth of interest in saving tigers from extinction. A number of global initiatives were undertaken and are also undergoing for tiger protection and conservation. A considerable number of conferences and symposium were held and some are scheduled to be held in near future. It is now realized that further development of our wildlife conservation capabilities is needed to deal with the threats faced by the tiger and other wildlife in the forest ecosystem. We need to improve our understanding of its root causes and how that impacts wildlife and especially the tigers, so that we can focus to maximize conservation efforts in forest ecosystem management. Tiger monitoring result invokes to call for new strategy not limited by its control only. Until now, in neighboring areas of tiger habitat in Bangladesh and elsewhere agricultural productivity is abysmal, poverty is endemic, and non-farm economic opportunities are scare. This put pressure on neighboring inhabitants to share the tiger conservation landscape (TCL) and to involve with wildlife crime. Hence there should have realization that economic (human) development may provide a more effective way to improve the environment than monitoring and counting every tiger in its habitat.

Tiger Conservation Needs

Tigers are iconic mega wildlife in nature and it is a flagship species (Khan, 2008). The loss of tigers would inevitably mean the loss of cultural and spiritual values that connect human being to the wild world. There is a wealth of legend and lore connected with the tiger in Asian cultures and elsewhere. In Bangladesh, tiger is the national animal and it is the emblem of the East Bengal Regiment which fought for the liberation war, the logo of the National Cricket Team (Ahmad *et a.,l* 2009) and also a brand name of a soft drink.

Ecologically, loss of large cats such as tigers from their natural habitat has been seen to result in irreversible changes in natural ecosystems. Being at the top of the food-chain, the decline of large predators inevitably leads to over-abundance of herbivores such as deer, which in turn has repercussion on tree regeneration and seed dispersal. Such effects reverberate through the food-web, causing long-term changes in natural flora and fauna, eventually leading to species losses. For instance, the absence of carnivores has led to over-population of white-tailed deer in Eastern United States, of blue bull in the Gangetic plains of northern India and agoutis in Barro Colorado Island, Panama.

Habitats where wild tigers live are high-value ecosystems that provide vital services to human being, such as carbon sequestration, hydrological balance, pollination services, protection from natural disasters and soil erosion, medicinal plant genetic diversity, and bio-prospecting (Dey, 2010). For instance, tourism values from tiger habitats run into billions of dollars today and contribute to the livelihoods of millions of people worldwide. Further, wildlife tourism is still highly under-valued, but people are willing to pay many times more than they currently do. It is exhibiting as the revenue-generating potential of natural habitats. It has also been demonstrated that lasting benefits from nature depend upon the maintenance of essential ecological structure and processes and upon the diversity of life forms. By allowing tigers to go extinct, therefore, we would essentially be depriving future generations of the benefits from natural diversity that has been the bedrock of human progress.

Many of the tiger conservation landscapes (TCLs) exist in regions of high biodiversity. Thus actions to protect tigers in their natural habitats will automatically lead to global benefits for biological diversity. Seventy one percent of the TCLs lie in one of the designated 25 biodiversity hotspots of the world.

Finally, the tiger is an indicator of how human society is doing on the larger question of sustaining environmental quality in the face of ever-increasing demands on finite resources. Tiger presence will be a barometer of the critical question: are we making the right choices to sustain the planet?

Global and National Tiger Conservation Initiative

A number of global and national tiger conservation initiatives are undertaken in all the tiger range countries (TRCs). Among others, main initiatives are discussed below:

Global Tiger Initiative

The World Bank convened Global Tiger Initiative (GTI) to work with TRCs and coalition of international organizations such as the World Wildlife Fund, Wildlife Conservation Society, and Smithsonian Institution for tiger conservation across the globe. The goals of the GTI are as follows:

- To support capacity-building in governments for responding effectively to the transnational challenge of illegal trade in wildlife and for scientifically managing tiger landscapes in the face of mounting and varied threats;
- To curtail international demand for tiger parts and other wildlife that has been responsible for drastic declines in tiger populations;
- To develop mechanisms for safeguarding habitats from development through planning 'smart, green' infrastructure and sensitive industrial development;
- To create innovative and sustainable financing mechanisms for tiger landscapes including protected areas;
- To build strong local constituencies for tiger conservation through development of economic incentives and alternative livelihoods for local people;
- To spread the recognition among governments, international aid agencies and the public that tiger habitats are high-value diverse ecosystems with the potential to provide immense benefits- both tangible and intangible.

Global Tiger Forum

Global Tiger Forum (GTF) is the only inter-governmental and international body of the TRCs for tiger conservation. The forum started conservation activities after the Dhaka declaration on tiger conservation at the first General Assembly held on 18-20 January 2000. The forum is addressing the following issues:

- The loss and degradation of habitat;
- The reduction of prey base;
- Poaching and illegal trade; and
- Reconciling human development needs and tiger conservation.

This forum has provided capacity building support to the officers of the concerned departments of TRCs.

National Tiger Recovery Program (NTRP)

National Tiger Recovery program (NTRP) aims to present the incremental effort that Bangladesh needs to make in order to accelerate the implementation of its Tiger Action Plan with a focus on actions of highest priority. These efforts are over and above major ongoing or planned projects, many supported by donors, which form a vital base for the scaling up envisaged in the NTRP. The national goal is to stabilize or marginally increase the current tiger population by reducing some key threats to tigers, prey and habitat. However, the priority actions to achieve long term strategic goals are: (1) building Institutional capacity, (2) engaging local communities, (3) protecting the habitat, and (4) trans-boundary collaboration with India on illegal trade.

By cooperating with each other world leaders (specially the Tiger Range Countries) and the resource group could save tigers in the wild. But this will require a huge change in thinking. Only when governments realize that human development provides a more effective way to improve the environment than monitoring and counting every tiger, probably tiger conservation would be successful.

The available information suggests that the major threats to tigers in the Bangladesh Sundarbans are: a) poaching; b) tiger-human conflict when tigers stray into villages or villagers venture into forests to collect forest produce; c) depletion of prey due to poaching; and c) habitat-related threats stemming from unsustainable wood and aquatic resource harvesting, upstream water extraction/divergence and pollution, and the various effects of climate change.

National Tiger Recovery Priorities

This process of national reflection was undertaken by TRCs through a National Consultation in which many, but not all, TRCs decided to invite teams of GTI experts to work with their own experts. The outcome of these consultations is the 13 National Tiger Recovery Priorities (NTRPs) is presented here. For some TRCs starting from a low base, the NTRP represents a large part of the total future effort, while for others with a long track record of tiger conservation, the NTRP represents the modest additional effort needed to accelerate or fast track the chosen priorities.

The NTRPs collectively rely upon three pillars to create a new dynamic not just to reverse the current decline but to restore tiger landscape and populations. The three pillars are:

- Policy support priorities.
- Institutional development priorities
- Expenditure priorities

Conference, Symposium, Meeting on Tiger Conservation

A number of conference, symposium and meeting have been organized to find solution to the tiger conservation. A list of main conference, symposium and meeting is given in Table 1.

Table 1. Main conference, symposium and meeting on tiger conservation

Date and Venue	**Conference, Symposium and Meeting**	**Objective/Outcome**	**Organizers**
April, 1986, Minneapolis, USA	Symposium	Development of a Global Tiger Survival Plan	Minnesota Zoological Garden and the IUCN/SSC Captive Breeding and Cat Specialist Groups.
January 2000, Dhaka, Bangladesh	First General Assembly	10 point agenda and action plan for TRCs	Global Tiger Forum (GTF)
April 2009, Pattay, Thailand	Meeting of the Head of the Governments of the TRCs	The manifesto on combating wildlife crime in Asia	Thailand Government
October 2009, Kathmandu, Nepal	Meeting for TRCs	A number of recommendations on tiger conservation	Nepal Government
January 2010, Hua Hin, Thailand	First Asian Ministerial Conference on Tiger Conservation (1st AMC)	Hua Hin Declaration on tiger conservation	Thailand Government
July 2010, Bali, Indonesia	Meeting on Pre Tiger Summit	Preparatory meeting	Indonesia Government
August 2010, Hunchun, China	Meeting	Strategy for tiger conservation	Tiger Forum
12 October 2010, World Bank Head Quarter, Washington	Meeting	on to align strategy to find support for the goals of the GTI	GTI
October 2010, Sariska	15th Executive	National Tiger Action Plans of	GTF

Date and Venue	Conference, Symposium and Meeting	Objective/Outcome	Organizers
Tiger Reserve, India	Committee Meeting	TRCs	
November 2010 St. Petersburg, Russia	Summit on tiger conservation	To bring game changing strategies and to secure highest-level political support for influencing tiger conservation.	GTI
Time to time	CITIS meeting	on wildlife trade and illegal trafficking of tiger parts across the globe	CITIS

Source: Modified from Tilson & Seal 1987; Dey 2010.

So it is clear that top politician, policy makers, scientists, academia and government officials of TRCs and development partners are participating in meeting and conferences and contributing to the effort of tiger conservation from its policy development to its implementation. But there is long way to go to the final solution of tiger conservation in the TRCs.

Investment in Tiger Conservation

Plenty of money was spent for the tiger conservation over the last two to three decades. During the last decade, the Indian Central Government alone has increased its allocation for Project Tiger to US$128.0 million in the current 12th Five Year Plan (2007-2012), from US$32.0 million in the tenth Five Year Plan (1997-2002) and US$16.0 million in the ninth Five Year Plan (1992-1997). It reveals that allocation for each tiger conservation initiative is about US$25,000/- only. Again for compensation for life lost of tiger victim is US$2,200/- only. But in India, according to the World Bank database, per capita GDP increased three times to US$1,046 from US$374. With this GDP growth, the agricultural growth declined slowly to 18 percent from 29 percent but forest cover stayed the same, from 22 percent to 23 percent. Although there is trend for GDP growth in India, present rural economy may be characterized as abysmal agricultural productivity, endemic poverty, and scarce non-formal economic opportunities. With this economic dynamics, therefore, Indian Government could not withdraw pressure of its local people from tiger habitat and thus failed to overcome tiger-human conflict of tiger conservation intervention (Mitra 2010).

In case of China, according to the World Bank data base, China's per capita GDP increased eight fold to US$2,566 from US $314, during 1990-2007. During the same period, China's agricultural share of GDP shrank to 11 percent from 27 percent, and forest cover, as a share of total land area, rose to 22 percent from 17 percent. This has shifted rural people to the non-farm activities which were able to build new forest cover and wildlife habitat where reintroduction of wildlife was possible (Mitra, 2010).

Over the past decade, the Government of Bangladesh along with the aid from development partners allocated Taka 1,671.94 million (US$23.49 million) for conservation of tiger through Forest Department (FD). Government's initiative for poverty reduction through other sectors is also prudential. But, according to the Bangladesh Bureau of Statistics (BBS), around 48 per cent people of Upazilas (Local administrative unit) adjacent to the Sundarbans live below poverty line. The livelihood of approximately 1.2 million of people depends on extraction of the resources of Sundarbans. Available data suggests that inhabitants of the Sundarbans Impact Zone (SIZ) are far from achieving the Millennium Development Goals (MDGs) as poverty is widespread in the regions surrounding the forest. In Satkhira district, the population below the poverty line is at least 60 per cent. The low income levels in the region together with poor transport systems and challenges in providing access to income, livelihood, education and health have contributed to the difficulties of daily life of the people in the SIZ. Low income levels mean that in order to survive many SIZ inhabitants are required to unsustainably exploit the Sundarbans Reserved Forest (SRF) for timber, fish, shrimp eggs, and other forest produce. Sea level rise and extreme weather events compound the development challenges of the Sundarbans area. This indicates that in Bangladesh there is much higher pressure on the forests from people who are not able to move beyond rural livelihood, and explains the continuing conflict between man and animal especially the tiger of Sundarbans.

The current GDP growth performance of agricultural sub-sector of Bangladesh is shown in Table 2.

Table 2.GDP growth performance of agriculture sub-Sectors

	2001/02-2008/09	1996/97-2000/01	1991/92-2000/01	1981/82-1990/91	1975/76-1999/00	1975/76-1990/91	% Share of GDP 1975/76	% Share of GDP 2008/09
Agriculture	**3.8**	**4.8**	**3.4**	**1.9**	**2.2**	**2**	**49.8**	**20.6**
Crops	3.4	4.7	2.3	1.8	1.8	2	**40.7**	**11.5**
Forestry	4.9	4.8	3.9	3.8	3.3	3.6	**1.8**	**1.8**
Livestock	5	2.7	2.8	2.8	3.4	1.6	**2.8**	**2.7**
Fisheries	3.6	6.2	7.1	1.8	3	0	**4.5**	**4.6**
Non-Agriculture	**6.4**	**5.4**	**5.4**	**4.7**	**5.4**	**4.8**	**50.2**	**79.4**
GDP	6	5.2	4.9	3.9	4.1	3.6	**100**	**100**

Source: GED, Planning Commission, 2011

The table indicates that non-agricultural activities have increased ,and this should be enhanced to reduce dependency on subsistence agriculture in the country. There should have strategy to increase agricultural productivity to fell down demand for agricultural land in the country. At present shrinkage of agricultural land is 1 percent per year. Experience of China revealed that natural environment could improve and tiger habitat could rebuild by rapid economic development in the country.

Tiger Conservation Status in Bangladesh

Tigers were present in a number of greater districts of Bangladesh in early 1930s. It has occupied all the forest ecosystems of the country; but now it has reduced to the minimum state by occupying only the mangrove forest ecosystem. Currently tiger is present in the Sundarbans mangrove forest (also known as SRF) which covers only 6,017 km² (Barlow and Ahmad, 2007). At present there are 440 (approximately) tigers in the Sundarbans mangrove forest. According to the record, there are 121 males, 298 females and 21 calves (Barlow and Ahmad, 2007; Government of Bangladesh, 2004). The Sundarbans has been classified as Class III (low priority) tiger conservation landscape (TCL) because of presumed high threat levels and low tiger population levels relative to other areas (Barlow, 2009). Due to sea level rise caused by climate change, tiger habitat will be lost during coming century (Loucks *et al.* 2010). There are three Wildlife Sanctuaries in the Sundarbans. A Wildlife Management and Nature Conservation Division is established in the Sundarbans. Besides, Government of Bangladesh has prepared the conservation management plan of the wildlife sanctuaries in the SRF (prepared by Rosario 1997). This plan is the main basis for tiger conservation in the Sundarbans.

A mean female home range size was estimated to 14.2 km² which indicates a density for the south-east Sundarbans of seven adult females/100 km², or a total of 23.5 tigers/100 km² based on similar population structure as Nepal. Using mean home ranges of 14.2 km² (naïve), 28.4 km² (reasonable), and 42.6 km² (conservative), the 4,267 km² landmass of the Bangladesh Sundarbans may contain 300, 150, or 100 adult female tigers or approximately 1,000, 500, or 335 total tigers under the respective scenarios. These may be slight underestimates because the recorded home ranges included some waterways, whereas the total landmass area used to calculate population size did not.

While tiger monitoring result of Sundarban is satisfactory to many of us including wildlife managers, record of the increasing trend of tiger-human conflicts demoralized the effort for tiger conservation in the Sundarbans. Year wise incidence of tiger-human conflicts for the last one decade in the Sundarbans is shown in Table 3.

Table 3 Year wise incidence of tiger-human conflicts in Sundarbans

Year	**Name of Forest Division**	**Human Killed by Tiger**	**Tiger Killed**	**Tiger Incidence Occurred**
2001	Sundarban (West and East)	19	**3**	Record not available
2002	Do	28	**3**	Record not available
2003	Do	21	4	Record not available
2004	Do	15	3	Record not available
2005	Do	13	1	Record not available
2006	Do	6	1	Record not available
2007	Do	10	4	Record not available
2008	Do	21	2	65 incidences
2009	Do	30	3	58 incidences
2010 (Up to September)	Do	26	2	41 incidences

Source : Dey, 2010

The problem in Bangladesh, as well as other tiger range countries is underdevelopment. Typically, in such areas agricultural productivity is abysmal, poverty is endemic, and non-farm economic opportunities scarce. This puts pressure to encroach on the habitat of tigers. Without resolving this human problem, efforts at tiger conservation will not save the species.

Conclusion

The tiger (*Panthera tigris*) is not only considered as large cat and a beacon of biodiversity conservation in forest ecosystem management but also considered as a majestic symbol in many ancient and modern cultures of various civil societies and governments in Asia and elsewhere. The loss of tiger would eventually mean the loss of cultural and spiritual values that connect humans to nature. Degradation of their habitat and ecosystems would inevitably result in a historic, cultural, spiritual and environmental catastrophe for the TRC. Despite the fact, in many places tiger has been disappearing even in the area with considerable effort of ecosystem management for tiger conservation, e.g.,the recent tragedy of the Sariska Tiger Reserve and the Ranthambhore Tiger Reserve in India.

It is now evident that conferences and money cannot save tiger alone. There is wide a gap between the reality and prescriptions as outcomes of dialogues held in seminars and conferences. Poaching, illegal trade, habitat loss and tiger-human conflicts are still major threats to tiger conservation in TRC. Scarcity of non-farm economic opportunity, poverty, abysmal agricultural productivity leads people to continue subsistence economy within the tiger habitat and involve with crime through illegal trade. In order to solve problem of tiger-human conflicts, there is in practice to give compensation for the tiger victims in India. Similar prescriptions are made in the proposed amendment of the wildlife law of Bangladesh. But experiences from India show that such an arrangement could not completely solve the problem on the ground because of the economic plight of the people surrounding the TCL. Recent tiger monitoring result invokes to call for new strategy not limited by its control only. There should have realization that promoting economic development would be the key to wildlife conservation. Hence, there should have wider approach of ecosystem management for tiger conservation not just by including monitoring and counting tiger but also undertaking concerted and collaborative effort of local economic development surrounding tiger habitat.

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Long-tailed Macaque (*Macaca fascicularis*) in Bangladesh

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Abstract

An investigation was carried out to determine the present status of the long-tailed macaque (*Macaca fasiculularis*) in the mangrove coastal belt along the Naf River of Teknaf, Bangladesh. Seven visits were made from July 2007 to February 2010 and one group of macaques (3) was found between Boroitoli Ansar Camp and Keruntoli Bandor living within 7.91 hectares area. The cause of dwindling population has been assessed. An urgent action is needed to save the critically endangered species in Bangladesh.

Key Words: Bangladesh, Long-tailed macaque, *Macaca fascicularis*, Habitat destruction

Introduction

Bangladesh is a home 10 species of primates (Ahsan, 1984) and all are threatened of different categories except slow loris (data deficient) and Rhesus macaque (least concern) (Molur *et al.*, 2003). Long-tailed macaque, locally called Parailla banor, (*Macaca fasiculularis*) is a critically endangered species in Bangladesh but least concern species globally (IUCN 2011). Body is grey-brown with paler under-parts. Long langur like tail is a distinguishable feature that indicates its name and the presence of white eyelids (both upper and lower).

The wildlife biologists of Bangladesh confirmed the occurrence of the species in 1981 at Whykheong coastal belt along the Naf River (Khan and Ahsan, 1981). At that time the total population of the species in the areas was estimated to be 253 (Ahsan, 1984; Khan *et al.*, 1984). The fate of this species became in danger with extinction during late 1980s due to the clearing of the habitat of the species range in Bangladesh for shrimp culture, saltpan along the Naf River coastal belt. After that few people have seen the macaques and recently we have located one group at the Naf River belt. So, an attempt was taken to search this species along the Naf River belt, estimate population size and recommend conservation measures.

Study Area

Teknaf is an Upazila of Cox's Bazar District under Chittagong Division (Figure 1). It is the most south-eastern coastal Upazila of Bangladesh. A small Naf River connects it to Myanmar. It consists of 6 Unions, 13 Mauzas, and 133 villages with an area of 388.68 km². Mangrove vegetation grows along the Naf River coastal belt. Important mangrove plant species are keora (*Sonneratia apetala*), baen (*Avicennia officinalis*), baro baen (*Avicennia alba*), etc. Whykheong, Jimonkhali, Keruntoli support good mangrove vegetations.

Methods

Seven visits were made to the sites where long-tailed macaques were previously recorded along the Naf River belt at Teknaf, Jimonkhali, Whykheong, Keruntoli (Figures 1 and 2) between 2007 (June and July 2007; December, February and August 2008; February 2009) and 2010 (February). Local people, Whykheong forest officials, coastal forest officials and Bangladesh Rifle persons of Teknaf were interviewed about the occurrence of this species in the area. Boat trips were done from Teknaf to Whykheong along the coast belt of the River Naf in search of the species. Old description (before clearing the mangrove forests for shrimp culture) of the study area can be found elsewhere (e.g., Khan and Wahab, 1983); but a new description is essential.

Figure 1: Map of Teknaf Peninsula

Results and Discussion

Only a small group of long-tailed macaque was found in the coastal forest belt along the Naf river between Boroitoli Ansar Camp and Keruntoli Bandor (Port) (Figure 1). The group composed of 5 individuals in 2007 and only 3 individuals (2-male and 1-female) in 2010 (February) from the same location. Local people said that one macaque died due to pariah dog bite and the death of another one was unknown. Ahsan (1984) recorded a mean group size of 12 (n=4) individuals in the Whykheong area, which is now devoid of any macaques due to the clearing of the coastal vegetations for shrimp culture projects. The group size of long-tailed macaques varies from 5-100 individuals throughout its world range (Table 1). The approximate home range of the group is 7.91 hectare, while Ahsan (1984) reported that the macaques live within 10 km^2 along the Naf river belt of Bangladesh.

Figure 2: Present habitat of the long-tailed macaque in Bangladesh (Source: Google Earth).

The long-tailed macaque is a critically endangered mammal in Bangladesh, but least concerned globally (it is under CITES Appendix II) and guessed to be less than 100 individuals present in Bangladesh (Molur *et al.*, 2003). Probably this macaque will be exterminated from Bangladesh within few years if proper measures are not taken for its conservation.

Table 1. Group size of crab-eating macaque

Group size	Mean	n	Sources(s)
3	3	1	This study
9-17	12.0	4	Ahsan, 1984
up to 100	-	-	Roonwal & Mohnot, 1977
10-30	18.0	-	Kurland, 1973
7-44	24.0	9	Southwick & Cadigan 1972
7-100	-	-	Fooden, 1971
8-40	-	-	Medway, 1969, 1970
14-70	29.8	4	Bernstein, 1967
38-72	-	-	Furuya, 1962
5-15	10.0	-	Blanford, 1888-91

Most of the present habitat has been taken lease by the Bangladesh Coast Guard to make a new Jetty. Already a Jetty has divided the present habitat into two fragments. If a new jetty is built in the area, some medium large trees and undergrowths like hargoza (*Acanthus ilicifolius*), tora (*Rotudifolia* sp.) and chuilla gola (*Dalbergia spinosa*) will be destroyed. Villagers of Keruntoli are regularly collecting firewood and cutting leafy tree branches for cattle feeding and destructively clearing the undergrowth vegetation for fire wood especially tora (*Rotudifolia* sp.). Children also collect fruits of keora and chuila gola for consumption. Some people also sell some fruits (e.g., keora @ taka 15-20 [about 0.20 US$) per kg) to the nearest markets.

Crab-hunters regularly hunt crabs from the study area. About 100 crab hunters are engaged to crab hunting from Teknaf to Damdamia (about 10 km long area). Hunted crabs are sold to the markets costing Taka 120-130 [about 2 US$] per kg (information from interviewed people). Crab hunting has decreased the crab population in turns decreasing macaques' food in the area as they consumed crabs and hence often called them crab-eating macaques.

Whkheong area supported 22 plant species (Khan and Wahab, 1983; Khan *et al.*, 1984), but the present cited area supports less plant diversity (only 8 species). This is due to the clearing mangrove forests for shrimp culture and agriculture practices. About 15-20 cattle are being grazed from Keruntoli and Boroitoli villages regularly in the area.

Recommendations

- Lease of habitat of long-tailed macaque to Bangladesh Coast Guard should be banned and the area be declared as protected one for macaques.
- Construction of any building or jetty inside the macaque's habitat should not be allowed.
- Some parts of study area have become degraded/empty due to firewood and leafy tree branches collection, so mangrove species should be planted which would be ecologically beneficial for the long-tailed macaques.
- The collection of any resources should be strictly maintained by the Forest Department through regular patrolling.

- Long-tailed macaques (about 20 individuals consisting 4-5 males and 15-16 females) may be introduced (brought from Myanmar) in the areas, because long-tailed macaques of Myanmar and Bangladesh are the same population.

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Congress Proceedings

Theme-4:
Mangrove and coastal land/forest management for long term resource sustainability

Coastal Afforestation Potential Using Quantifying Inundation Vulnerabilities with Tidal Trends along the Central Coast of Bangladesh

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Abstract

Tidal level trend along the central coast of Bangladesh and quantifying the rate of inundation using previous 30-year (1977-2007) tidal data of three central stations- Char Ramdashpur (Bhola), Chital Khali (Lakshmipur) and Char Changa (Noakhali) were examined. Data sets of BIWTA (Bangladesh Inland Water Transport Authority) were used to assess coastal vulnerability to future inundation. The results revealed that larger and alarming rising trend (13 mm yr^{-1}) of mean tidal level in the lower Meghna river, is likely to reflect a high vulnerability of the central coastline to the sea level rise and local factors like land subsidence. This higher tide level trend may cause 1 m of inundation in this zone by 2085, which may lead to a large area of land to be lost under water. By the year 2100, Char Ramdashpur may be inundated up to 1.21 m, Chital Khali 1.11 m and Char Changa 0.74 m. Tide level rise is likely to exacerbate land subsidence there. These possibilities of disaster need to be verified with actual geological observations. However, this study provides adequate information for initial assessment regarding the extent and timing of coastal flooding and associated hazards due to tidal level rise thereby promote taking adaptation and mitigation mechanisms including afforestation .

Key words : Coastal inundation, Vulnerability, Tidal level, Climate change

Introduction

Since the beginning of the 20th century, the seas have continued to rise at an average rate of 1.7 ± 0.5 mm per year (Bindoff et al., 2007). This increase, however, has not happened at a constant rate. Sea level rise has various impacts on Bangladesh, a coastal country facing 710 km long coast to the Bay of Bengal. Bangladesh because of its geographic locations: flat and low-lying topography is frequently cited as one of the most vulnerable countries to sea level rise (SLR) (CDMP, 2006). Moreover, as it is one of the most densely populated countries on the planet (more than 1100 people per square km) (UN Population Division, 2006) with around half of its total 150 million people below the poverty line, any climate related change such as the inundation of coastal areas will inevitably affect millions of people (Pender, 2008) and impede the country's development. It already has affected Bangladesh by land erosion, salinity intrusion and loss in biodiversity. The impacts of increasing tidal level trend could be extremely detrimental to the economy, the environment, national development and the people in terms of loss of income and shelter of the central coastal zone of Bangladesh. The increasing tidal level is ultimately contributing to the sea level rise. Therefore a need may exist to determine the rate of tidal level changes using tidal data of central coastal region and probable inundation vulnerability.

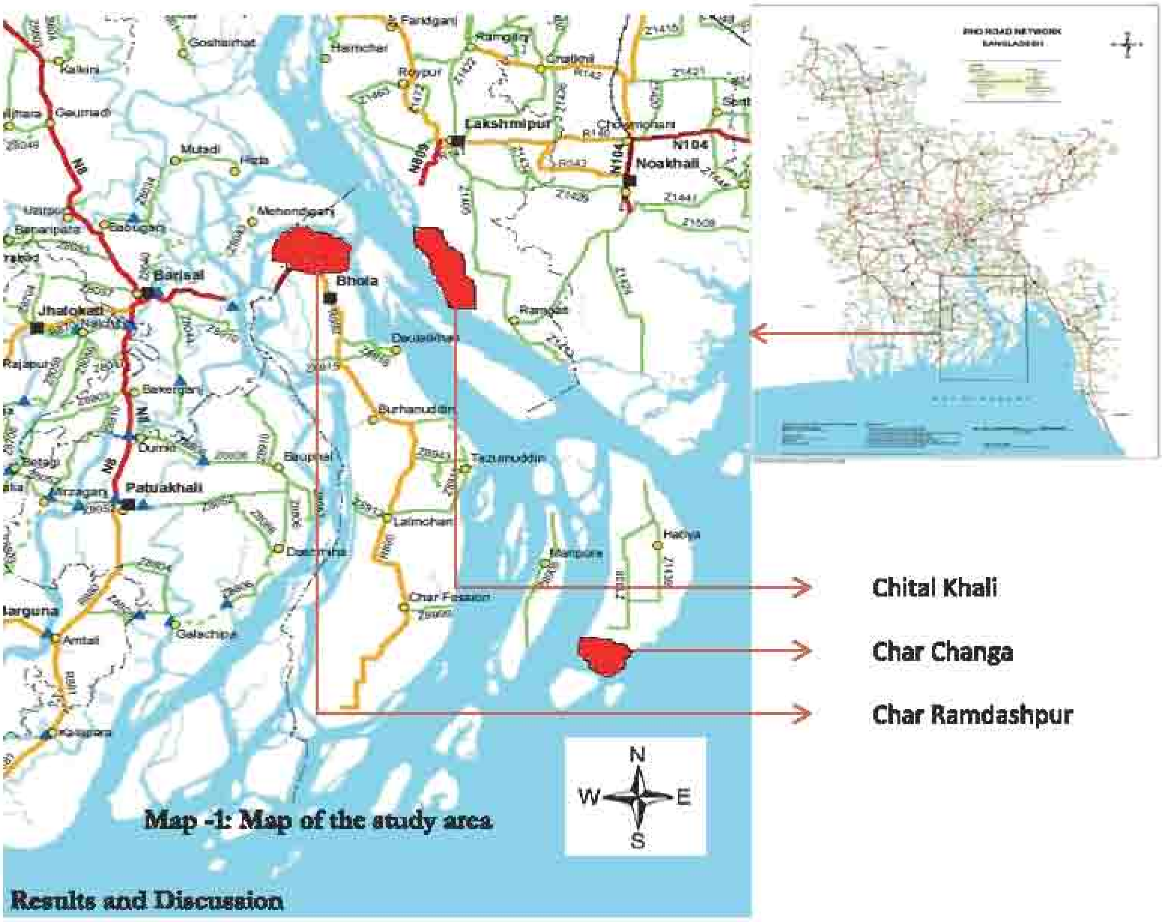
Materials and Methods

BIWTA Tidal Data

A 30-year monthly extreme tidal level data for the period 1977-2007 recorded at three stations (Table 1 and Map 1) namely Char Changa (Noakhali), Char Ramdashpur (Bhola) and Chital khali (Lakshmipur) in the central coastal region of Bangladesh coast were obtained from the Bangladesh Inland Water Transport Authority (BIWTA). Seasonal and annual linear trend co-efficient for different types of tidal levels, viz.,, mean, highest and lowest, were calculated using the method of least squares. Categorization of season is as follows; winter- December, January and February; pre-monsoon- March, April and May; monsoon- June, July and August; Post-monsoon- September, October and November. MS Excel 2003 and Minitab 2002 version 13.2 were used to process and statistically analyze the data.

Table 1. Tide gauge station details for central coastal zone

Tidal station	River	Latitude (N)	Longitude (E)	Datum
Char Changa	Shahbajpur	22°08'	91°06'	4.996
Char Ramdashpur	Lower Meghna	22°48'	90°39'	5.137
Chital Khali	Lower Meghna	22°45'	90°48'	4.996



Map -1: Map of the study area

Results and Discussion

Variation of annual mean tidal level (MTL)

Amongst all of the three tidal gauge stations, Char Ramdashpur shows the maximum and alarming rising trend (13 mm yr^{-1}) (Figure 1) for the period of 1977-2007. The differential trends, in annual MTL revealed the sea level rise along the central coast and contribution of other factors into it, that the fluctuated and somewhere increasing trends of MTL of the central coast is due to a geological local factor like land subsidence. The highest MTL trend and higher trend value of highest tidal level are in Char Ramdashpur. The data indicate the comparative raising of the sea level at the central coastal zone. The other two stations Chital Khali and Char Changa show 12 mm yr^{-1} and 8 mm yr^{-1} increase respectively in tide level.

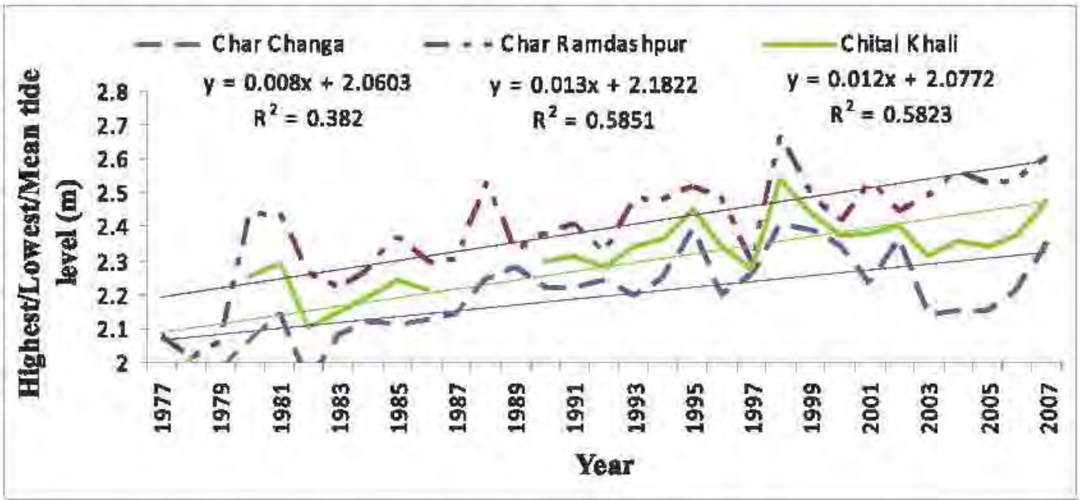


Figure 1. Variation of MTL of all three stations.

Variability of tidal levels at different stations

30- year time-series of mean, highest and lowest tidal levels at Char Ramdashpur throughout the year is presented in Figure 2(a).

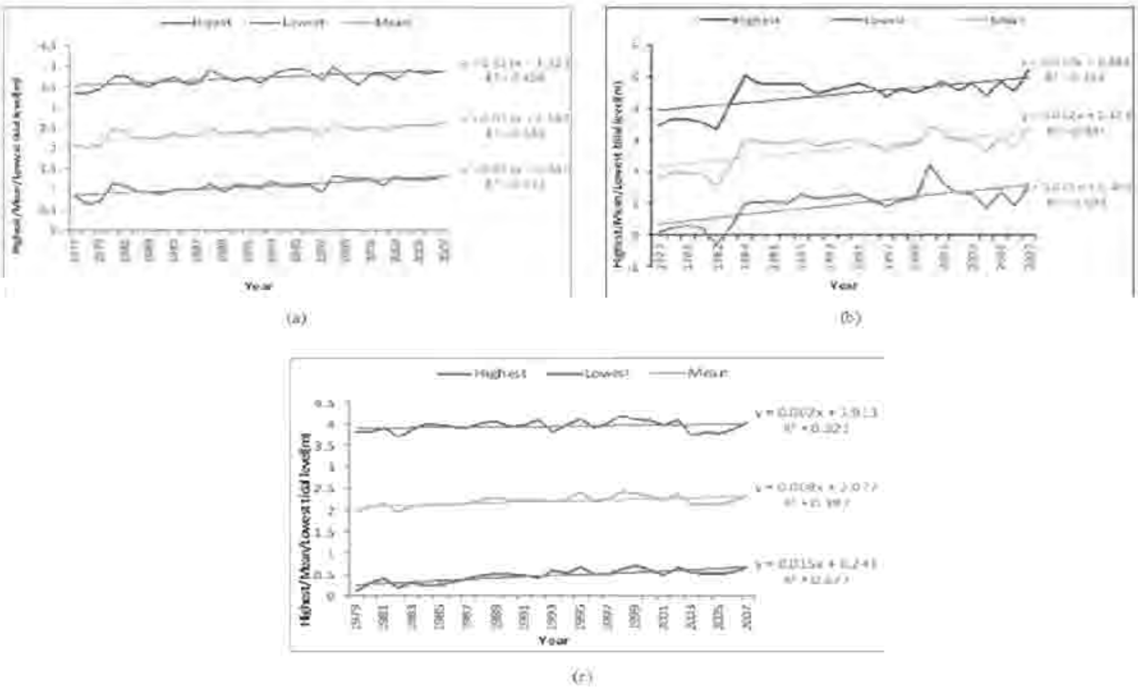


Figure 2. Variability of highest, lowest and mean tidal levels at (a) Char Ramdashpur (b) Chital Khali and (c) Char Changa through the year of 1977 – 2007

The results in Figure 2 (a) depict the significant differences between the high tide level and the low tide level of Char Ramdashpur. The highest MTL trend and higher trend value of highest tidal level of Char Ramdashpur are shown in this figure 2 (a). The data show the comparative raising of the sea level at the central coastal zone. In case of Char Changa, the tidal level is lowest compare to other stations. Here, in Char Changa (Figure- 2 (c)) the increase of low tide level is higher than the high tide level. This indicates that the amount of sediments coming with the water flow are depositing on the river bed. The depositions of sediments are increasing the water level in the area surrounding the Lower Meghna River. This may be a reason for the continuous growth of low tide level. Moreover, the total volume of water flow of these rivers may be decreasing which is responsible for the lower increasing rate of high tide level. Singh (2002) in his recent study on 22-year time-series (1977 - 1998) of mean, highest and lowest tidal level of Cox's Bazar found a striking feature of sea level variability - the consistent increasing trends in lowest tidal level and consistent decreasing trend in the highest tidal level.

Probable inundation vulnerability

The increasing trend of highest tidal level is the result of increasing trend of SST during that period (Khan *et al.*, 2000), which exacerbates with land subsidence in the central coast. So, the tidal level trend is observed to increase. Char Changa is an island and Char Ramdashpur and Chital Khali are attached to the main land. The increasing rate of tidal level is higher in the river than the sea. The highest increasing rate is figured out in Char Ramdashpur, and the lowest in Char Changa. This may be because of the sediment load coming with the water flow of the river. Total sediments in the river flow may get a narrow space compared to the sea, which may increase the height of the river bed and the water level, thus increasing the tide level. On the contrary, when it come to the sea, the sediments get dispersed on the sea bed and show a lower increase, which may affect the tide level of the island areas like Char Changa. However, global changing climate with changing level of sea with geological data may assist to provide answers of the changes stated.

As the present tidal level of Lower Meghna River shows an alarming increasing trend value of 13 mm yr^{-1}. With this drift,it can be predicted that by 2085, the coast area of Char Ramdashpur of Bhola will be flooded by 1 m high water mark, affecting the main land. Chital Khali station shows the increasing trend value of 12 mm yr^{-1}. This reveals that this area will inundate with 1 m sea level rise by the year 2090. Again, with the trend value of 8 mm yr^{-1}, Char Changa will be flooded by 2133 by 1 m sea level. The increasing trend of tide level (Table 2) at Char Changa is close to the result given by IPCC (28 cm in 2050 and 59 cm in 2100) and NAPA (32 cm in 2050 and 88 cm in 2100). There is also similarity of increasing trend of Char Ramdashpur and Chital Khali with the resultreported by Warrick and Oerlemans, 1990; Cited in Warrick *et al.*, 1993 (29 cm in 2030, 48 cm in 2050 and 110 cm in 2100) (model assumption-high).

Table- 2: Local tide level rise scenario for Bangladesh

Stations	Tide level (m)		
	2030	**2050**	**2100**
Char Ramdashpur	0.3	0.56	1.21
Chital Khali	0.3	0.51	1.11
Char Changa	0.18	0.34	0.74

Conclusion

The results revealed that central coastal region is alarmingly vulnerable to consequences due to SLR as it is one of the most important areas for fisheries and agriculture. Venerated for its immense contributions to the country□ s economy and for its readily available natural resources, the central coastal zone of Bangladesh is an area whose destruction via climate change would be more than devastating. This paper has analyzed the tide levels to exemplify the sea level rise phenomenon in the central region of Bangladesh coast and quantified the extent of vulnerability using tidal trend. Analyzing the 30-year tidal level data at three stations in the central coastal region, it is found that the tidal level in Char Ramdashpur (Bhola) is likely to increase over time at a higher rate than that of the other two stations, despite other factors such as river bank erosion, land subsidence and sea surface warming to maximize such effects. The prominent impact of this SLR will also exert on the landmass and settlement of the people. Most of the landmasses of this area, under the direct or indirect threat of future inundation, are mainly agricultural lands and homesteads. A large number of people will be landless, displaced and finally refugee as consequences of this SLR and related hazards. Saline water intrusion in the coastal areas has already become a serious issue which will be exacerbated and thus will disrupt the crop production very badly. The projected sea level rise will affect the coastal plantation and protected areas of this zone very badly. Thus, it is recommended that coastal plantation should be increased in central coastal zone to create a green belt along the coast This will in future, help to reduce the adverse affect of climate change induced natural hazards in this region.

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A New Forest Management Planning Paradigm for the Sundarban Reserve Forest in Bangladesh

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Abstract

The Sundarban Reserve Forest (SRF) is an important ecological as well economic asset for Bangladesh. Current forest management planning process based on an area-control method employing a singular harvest regime is unsuitable for addressing sustainability of both timber and a growing array of non-timber values. This paper suggests a new paradigm in forest management planning process for the SRF that aims to utilize a spatial database linked with an updated forest inventory, a stand dynamics simulator, and a decision framework for designing a forest management plan cognizant of long-term resource sustainability.

Key words: Sundarban Reserve Forest, Stand dynamics projection, Harvest model, Selection cut, Sequential simulation

Background

The Sundarban Reserve Forest (SRF) is an important ecological asset for Bangladesh. The forest is rich in biodiversity and harbors some 334 species of plants and 269 species of wild animals including the famous Royal Bengal Tiger (*Panthera tigris*). According to the 1997 Forest Resource inventory, total forest area is 601,700 ha including rivers, creeks and tributaries of which about 411,300 ha are under forest cover of various mangrove species. Of the forested tracts, 139,700 ha have been set aside primarily as wildlife sanctuaries thus leaving an estimated 271,600 ha available for timber management purposes. Economically, the SRF is quite significant as it constitutes nearly 40% of total forest area of Bangladesh and earns half of the total forest revenue in addition to providing livelihood support for nearly 2.0 million people (Bangladesh Forest Department— BFD web site).

Despite its ecological and economic significance, forest management planning for the SRF has not been updated periodically due to logistic and technical limitations within the BFD (pers. comm.). The current forest management plan, in particular, the timber harvest plan, is essentially a continuation of the 'Forestal plan' designed by a Canadian consulting company in the 1960. The Forestal plan delineated the forest into a set of hierarchical geographic units such compartments, sub-compartments, coups and cutting series- the ultimate harvest unit. Under this plan, the annual allowable cut (AAC) was determined by the equal amount of acres allocated annually on a 20-year cutting cycle. The silvicultural system suggested is a form of 'selection cut' known as '*selection-cum-improvement*' felling that prescribes cutting all trees having a minimum 15 cm and above diameter at breast height (dbh) including the dead and dying ones from a designated cutting series every 20 years allowing the remaining trees to grow before the same harvest unit can be cut again (Rahman, L.M. 1999)
Although the Forestal plan is credited for creating the first-ever statistically designed forest inventory of the SRF, its management plan has a number of limitations, however. First, the diameter-limit based cutting strategy in setting up the annual allowable cut (AAC) relied on a relatively small number of sub-sample plots to determine relative growth estimates of forest cover types. In absence of any subsequent follow-up measurements on those sample plots, it is difficult to ascertain whether the Forestal growth estimates remained true over time as result of the prescribed harvest implementations. Second, the plan also did not leave any mechanism by which decision makers could make necessary adjustments to the AAC to account for possible variations in stand growth from their pre-set estimates. As a result, it is believed that harvest continued since the 1960's have possibly exceeded actual forest growth and thus deteriorated the overall growing stock. In fact, the 1985 ODA inventory (Overseas Development Agencies, UK, now known as DFID) indicated that an overall decline in growing stock took place,

particularly in two major timber species —Sundari (*Heritiera fomes*) and Gewa (*Excoecaria agallocha*)—by 40% and 45% respectively between 1959 and 1983 (Wikipedia).

Between 1985 and 1995, it is not known whether any operational changes were brought in to the Forestal prescription or not. But the 1995-1998 FAO/UNDP sponsored study — 'Integrated Resource Development for the Sundarbans (IRDS)' — indicated that salvage harvesting (necessitated by a relatively recent wide-spread top-dying mortality of Sundari) as well as the regular removal of other species continued as per legacy practice. The final project report also indicated the need for use of simulation model to approximate future stand structure under an array of harvest regimes to adjust AAC level that can be ratified from the following statement:

"...that the FD set the AAC from the Sundarbans by means of volume control methodology, rather than area control. It is further recommended that simulation models be devised to determine not only the effect that different levels of cut might have on growing stock estimates, thus enabling computer-sensitivity analyses to be carried out for determination of the most appropriate AAC for sustainable harvesting, but also the proper management of all other resources."

The IRDS study, however, did not conduct any new forest inventory but strongly suggested for an updated one using the spatial database created under the project that contained forest cover type mapping within the original Forestal management unit boundaries.

While the spatial database of the SRF constitutes an important component for designing an integrated forest management plan, its ability, however, cannot be fully leveraged without being able to project forest structure over time as a result of natural process and harvest considerations. Also needed is a decision framework that allows decision makers arrive at an optimum management plan subject to various logistic, resource and policy constraints.

The objective of this paper is to provide a conceptual framework for: i) dynamic projection of stand conditions over time, ii) design of alternative management strategies and finally, iii) a decision modeling tool to develop an optimum annual allowable cut (AAC) level under various objectives.

In the following sections of this paper, an outline of the necessary modeling framework is presented in three sections. First section presents the underlying concepts for a stand structure and dynamics model, second section presents a conceptual outline for generating alternative harvest strategies, and the third section outlines a simulation algorithm for designing forest management plans.

Stand Structure & Dynamics Model

Stand structure

In a natural uneven-aged, unmanaged stand, typically a higher stem count is observed in the lower diameter classes compared to the upper diameter classes; the distribution of stem count frequency across the diameter classes tend to follow an inverse-J shape curve (Vanclay, 1994).

Nonetheless, in a managed uneven-aged stand, such a distribution may not always exist. It will depend on how stems are removed from the stand. For instance, if an uneven-aged stand is managed following a certain *q-ratio*[1] where the target stem counts in the largest size class is multiplied by the *q-ratio* in order to calculate stem counts in its preceding size class until completing stem counts in the smallest size class. Therefore, if stems above the specified stem counts in each size class are removed through harvest, the stand will still maintain its pre-harvest inverse-j shape distribution. In case of SRF, all stems above

[1] Originally described by French forester Leo Decourt(1889) to explain distribution of trees in an uneven-aged stand, the Q-ratio suggests that the ratio between the tree count in a given diameter class (n1) and the tree count in the next higher diameter class (n2) is a constant, i.e. $n1/n2 = n2/n3 = Q$, where $n1 > n2 > n3 > 0$

specified diameter limits are removed every 20-year. As such, whether the stand just harvested would have the same characteristics before it is marked for harvesting again after a specified time elapsed i.e., cutting cycle, is a matter of speculation only until validated by field data.

In an effort to quantify the dynamics of both unmanaged (outside timber harvest plan) and managed uneven-aged stand in the SRF, I assume that a J-shape distribution exist in terms of stem counts per-hectare basis. The following section illustrates a theoretical model suggested by Buongiorno and Gilless (2003) that could be used to illustrate the stand dynamics in the SRF with or without management intervention or natural disturbances.

Unmanaged Natural Uneven-aged Stand

In modeling an uneven-age stand's structure and its growth dynamics over time, there are essentially four elements: i) the number of stems entering into the smallest diameter class (in-growth), ii) the proportion of stems that stay in the same size class between two consecutive measurements, iii) the proportion of stems that would grow to the next higher class, and iv) the mortality in any given size class. These four elements can be expressed as a system of equations:

$$Y_{1,\,t+1} = a_1 y_{1t} + R_t \quad \text{..........1a}$$
$$Y_{2,\,t+1} = b_1 y_{1t} + a_2 y_{2t} \quad \text{..........1b}$$
$$Y_{3,\,t+1} = b_2 y_{2t} + a_3 y_{3t} \quad \text{..........1c}$$

In these equations, y_1, y_2 and y_3 respectively represent the stem counts in diameter class i ($i = 1, 2, 3$) in any given time step t. An in-growth (R_t) represents new stems recruited in diameter class y_1 between time t and $t+1$, where the interval between these two time steps is assumed fixed and sufficiently small such that $y_1 > y_2 > y_3$. The coefficients a_1, a_2, a_3 respectively represent the proportion of stems remained in their respective diameter classes and b_1, b_2, and b_3 respectively represent the proportion of stems that grew into the next higher diameter class.

In the above equations, Yi_t can be treated as vector and the various proportions of stem movement across diameter classes can be expressed as a transition matrix, G. Thus, one can obtain the next state in each diameter class by simply multiplying the respective diameter-class row in the transition matrix i.e. $Yi_{t+1} = Yi \times G$.

However, in the absence of a stem recruitment model, one can simply assume a certain percent of y_{1t} constitutes recruitment. Mortality can be accommodated in the above set of equations by simply assuming that it occurs equally across diameter classes. Thus, mortality adjusted $Yi_{t+1} = Yi_{t+1} \times C$, where C is mortality ratio ($0.0 < C < 1.0$).

Harvest and Disturbance Considerations

Both harvest and natural disturbance in an essence are similar because the net effect is reflected in terms of stem reductions from stand structure. However, natural disturbance does not occur as predictably as a planned harvest. Thus, with harvest, one can define the post-harvest stand structure as below:
$Y_{i,\,t+1} = (Y_{i,\,t} - H_{i,\,t}) * G$ where $H_{i,\,t}$ represents the proportion of harvest in any given diameter class before the transition is applied.

Stand Projection Model Application

Suppose S_1, S_2, S_3, S_4 respectively represent a successive series of forest development stages, i.e., strata, expressed in terms of hectares harvested 0-4, 5-9, 10-14, 15-19 years ago in a given area of the SRF. Thus, S_4 represents the state where forest is ready for harvest as per existing 20-year cutting cycle.

Assume S_1 represents the beginning average forest condition and contains 450, 220, 80, 0 stems/acre respectively in 10-14, 15-19, 20-24, and 25+ cm diameter classes. Now consider 30% of the stems in any diameter class grow to the next higher class, and 70% of the stems remain in its current class every 5 years. Thus, the initial state of the stand in terms of stem count in each of these diameter classes is a vector(v_0), and movement of stems from one size class to the next higher size class can be expressed as transition matrix (G), where:

V_0 = [450, 220, 80, 0], and G = [[0.7, 0, 0, 0], [0.3, 0.7, 0, 0], [0, 0.3, 0.7, 0], [0, 0, 0.3, 1.0]].

Now, by simply multiplying the initial state vector V_0 with the transition matrix, G, we can obtain the probable stem count in S_2 where $S_{2(pred.)}$ = [[450 * 0.7 + 220 * 0 + 80 * 0 + 0 * 0], [450 * 0.3 + 220 * 0.7 + 80 * 0 + 0 * 0], [450 * 0 + 220 * 0.3 + 80 * 0.7 + 0 * 0], [450 * 0 + 220 * 0 + 80 * 0.3 + 0 * 1.0]] = [315, 289, 122, 24]. If we apply 4% mortality across diameter class, we obtain v_1 = [297, 280, 118, 24].

However, sample measurements for strata S_2.., S_4 exist which may not agree with the predicted values. One way to resolve this would be to iteratively minimize the sum of squared deviations between observed and predicted stem count in each diameter class for a given transition matrix. Once a suitable transition matrix is established, and an initial state is known, one can then predict the future stand development stages by recursively moving from its preceding states.

Design of Harvest Strategies

The current harvest practice in the SRF constitutes removing all trees above 15 cm dbh. There might be several strategies one might apply in an effort to design a series of alternative strategies. However, it is also important that each such strategy is quantifiable in terms of products as well as stand structure that are likely to be created over time.

Table 1. A format for developing alternative timber harvest strategies using a hypothetical stand

	Before harvest							After harvest						
Strategy	Years since Last cut	Trees/hectare (TPH) by diameter class, cm. *Values in parenthesis represents avg. stem height, m				Total BA[2] (m^2)	Total Vol. (m^3)	Trees/hectare (TPH) by diameter class, cm				Res. Basal Area (m^2)	Cut Vol. (m^3)	NPV[3] (Taka ,000)
		10-14 *(5.5)	*15-19* (7.5)	*20-24* (9.5)	*25+* (11. 5)			*10-14* (5.5)	*15-19* (7.5)	*20-24* (9.5)	*25+* (11.5)			
Default	**20**	507	190	61	47	34.01	84.48	480	0	0	0	5.45	67.12	335.6
1st pass 50% cut	**15**	541	225	55	20	28.72	66.85	247	101	25	9	20.33	26.55	132.7
2nd pass 50% cut	**25**	524	135	75	60	32.67	106.02	236	61	34	27	22.11	48.55	179.9
Q[1]-ratio cut1 (q = 1.8)	**15**	541	225	55	20	28.72	66.85	275	49	27	15	20.17	46.10	230.5
Q[1]-ratio cut2 (q = 1.8)	**25**	510	182	60	42	30.33	84.11	255	68	38	21	21.68	33.85	125.4

1. *Q-ratio* assumes a certain retention of TPH in the largest diameter class (in this case, TPH = 5). By multiplying the assumed q-ratio, the target TPH in smaller size classes can be calculated, e.g., 10 * 2.5, 25 * 2.5 and so on. However, one must choose a *Q-ratio* in a way that the target retention does not exceed the available TPA in a given size class.
2. Total basal area = sum ($BA_{10-14} + BA_{15-19} + BA_{20-24} + BA_{25+}$); BA_i = * (d_i * d_i)/ 4 * 10^4, where d_i = diameter class mid-point (cm). Assume 5% logging damage across diameter class and a graduated form-factor set starting with 0, 0.6, 0.7, and 0.8 for all but 2nd pass cut strategy where each form factors should be increased by 0.05 to differentiate better stem grade.
3. For NPV, 8% discount rate was used; time span, t equals years between consecutive harvests. NPV = current market value of products removed / ((1 + 0.08) exp (t)). Assumed timber price = Tk. 5,000 /m^3 for 1st cut and Tk. 8,000/m3 for 2nd cut timber.

One such strategy might be removal of stems across diameter classes at a certain proportion (e.g. remove 50-70% stems from each diameter class between 15-25 years since last harvest. The second strategy would be to apply a certain q-ratio[1] to determine the number of stems that need to be retained at harvest across diameter classes. There are opportunities to bring variations in any of the two methods proposed, however. Table 1 illustrates four types of harvest strategies that could be considered for timber harvest planning purposes in the SRF.

Stand structure, as depicted in Table 1, before and after harvest is not supported by any field data rather they are at best an educated guess based on a few observations of the current stand structure in the SRF. The purpose here is to show the likely conditions under which an alternate harvest strategy might be comparable with the current practice. For instance, in a 50% cut strategy, the combined NPV is quite comparable to the existing harvest strategy in addition to achieving structural diversity.

Decision Model

A systematic structured decision making process is essential for making consistent management decisions under various logistic and policy constraints. Currently, no such decision making tools or techniques are known to exist for the management planning purpose of the SRF. This section deals with general outline of a sequential simulation technique forest management planners have used widely (for details, see Baskent and Jordan 1995, Baskent et al.2000).

Of the various planning techniques, sequential simulation is relatively the easiest of all, to implement and interpret. However, on the flip side, it requires an in-depth knowledge of the problem domain to be able to generate reasonably good results. Besides, it cannot guarantee an optimum solution under a heavily constrained situation. There are various forms of simulation technique, however. This paper deals with what is known as 'sequential simulation technique'.
Essentially, a sequential simulation begins with an initial state of the forest, typically stored in a spatial database i.e. GIS linked to the current forest inventory. A set of equations and/or an explicit table (known as yield table) generally hold values for all sorts of yields such as, timber volume (m^3/ha), basal area (m^2), no of large trees, habitat values for one or more wildlife species, product types- saw-log versus pole. Users define harvest rule(s) exogenously for which yield consequences are also defined before the simulation begins. Simulation progresses sequentially one time step at a time, where the width of time step, i.e. period length is equal to the time interval used in the yield table. So, if volume yields are reported in the yield table every 5 years apart, the planning time step will also be 5 years apart.

At the beginning of simulation, the user might just choose to grow the forest over a certain number of periods before assigning a harvest target. This is known as *'inventory projection'*. In order to achieve a particular harvest target from a given forest, the user needs to queue all harvest-eligible tracts (spatial units) or just acres identified in terms of forest type, site class, density class, time elapsed since last harvest, known as strata subject to a given *'queuing rule'*. Once a particular harvest regime is applied on the current forest, the potential outcomes are calculated and if the initial target is met, simulation then moves to the next time step and apply the same rules all over again to achieve the target for the period under consideration. When all time steps are covered and the desired product and/or structure objectives are met, simulation ends. The flow-diagram (Fig.1) depicts the various steps in a forest management simulation process.

Given the above algorithm, one can easily program a relatively simple simulation model for timber harvest decision in any relational database environment such Microsoft Access, Foxpro as well as in other high-level computer languages such as java and python. The simulation data can also be linked to the GIS to enable visualization of management decisions over time and space.

Discussion and Conclusion

This paper has presented three main ideas towards developing an integrated forest management plan for the SRF based on a series of assumptions. First, it has provided a theoretical framework by which forest stand structure can be predicted over time by use of a simple transition matrix. In the proposed model, the transition matrix is purely hypothetical and is used only to demonstrate the concept. Developing a practically usable transition matrix is not that difficult, however. Sometimes, opinion of experts can provide a reasonably accurate estimate since stems in any given size class of any given stand can stay only in three finite states—the proportion of stems recruited in the smallest size class, the proportion of stems that stay in the same size class, and the proportion of stems that move to the next higher class. One can also adjust transition matrix based on field sampling of various managed and unmanaged forest cover types. Compared to complex equation based whole-stand model projection, a transition matrix based stand table projection provides simplicity while maintaining sufficient accuracy.

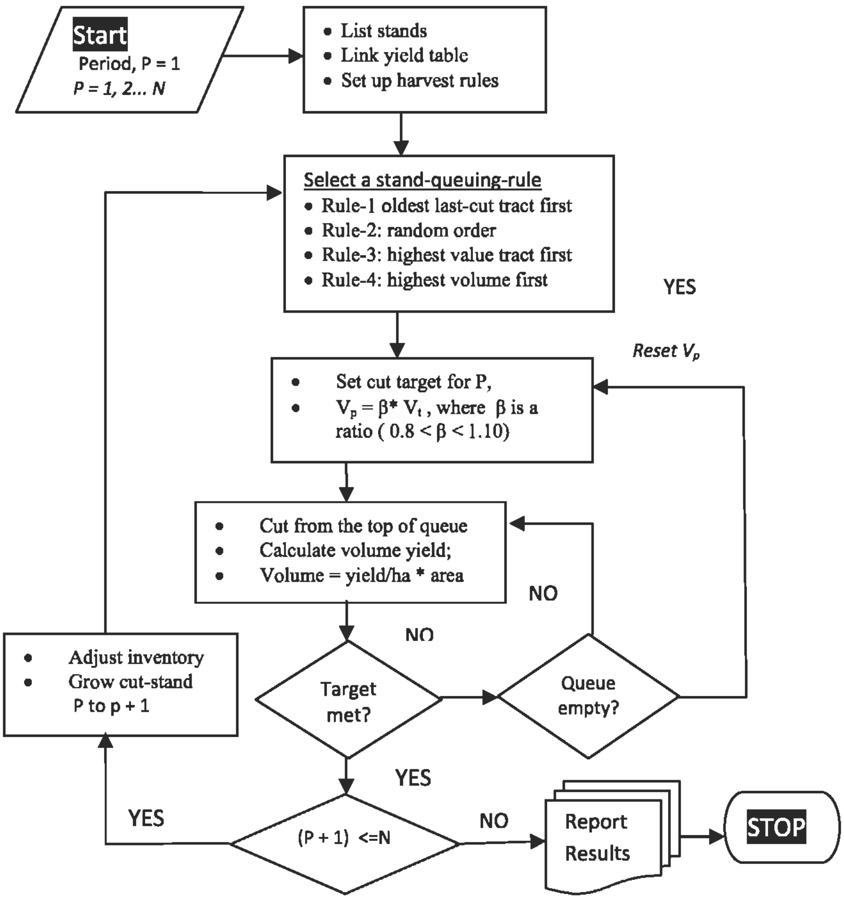

Fig. 1. Algorithm for a sequential simulation model in timber harvest planning (Nurullah, 2011)

The second idea presented in this paper is about generating alternative harvest regimes. Currently, there is only one harvest practice that prescribes removing all trees at 15 cm and above dbh including dead and dying ones. The downside of this practice is that it can degenerate genetic diversity of the forest by systematically exploiting all larger diameter trees. Also, it does not leave sufficient structural diversity,i.e., presence of residual stems from across diameter classes in the post-harvest stand. This paper suggests several alternative harvest strategies. For instance, by varying the q-ratio, one can generate harvest strategies that may result in stand structure resembling from an inverse-J shape distribution to multi-cohort stand comprised of two or three major vegetation layers. Some alternative harvest strategy, e.g., 50% removal across diameter class in two successive harvests may be even provide better financial returns than the current practice besides providing structural diversity that have other potential ecological values. However, one has to be cautious in applying the transition rule a stand might follow under any of the alternative harvest strategies proposed. One has to adjust the transition matrix through professional acumen and the knowledge of silvics of the forest types under consideration.

The third idea is a decision model by which decision makers can generate a harvest plan far longer than the current cycle of 20 years. The ability to forecast forest structure after executing harvest actions gives tremendous flexibility not only to control potential harvest flow from one time period to the next, but also the flow of non-timber values that can be associated with different forest structures. Since decision model can generate harvest plan over time and space, it makes the whole planning process transparent, easy to implement and arrange necessary logistics in advance, thereby helps improve administrative efficiency. In order to account for a wide array of resource values, not only just timber, one has to define such values in quantifiable terms as a function of forest structure in a decision model to generate their best possible mix in a management plan. Having a model like this removes the impediment of an area-control harvest method currently being used that cannot ensure a predictable harvest flow between time periods, nor can it predict the evolving forest structure as a result of harvest and/or natural succession. Using a decision model in close collaboration of a growth model will help detect any potential undesirable changes in forest stand structure or a significant shift in forest cover composition so that decision makers can take appropriate intervention strategies. Although, simulation based forest management planning process has not occurred in the past within the BFD, all three ideas presented in this paper can be implemented with moderate training of the technical staff.

In conclusion, a spatial database of the forest when used in conjugation with a stand-growth simulator and a decision simulator provides the necessary wherewithal to resource planners to arrive an optimum forest management plan under an array of management objectives.

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Population Ecology of Deer and Other Tiger Prey Animals in the Sundarbans

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Abstract

The main prey animal of tiger is Spotted Deer, Wild Boar, Barking Deer and Reshus monkey. The natural population of Spotted Deer is confined in the Sundarbans Reserved Forests of Bangladesh. The critical issue of tiger conservation is related with the abundance of deer with other prey population in the Sundarbans. But no systematic scientific study has been done on the population status and distribution of tiger prey animals in the Bangladesh Sundarbans. The study on population dynamics, population density and fluctuation, radio telemetric home range (RTHR), activity pattern, movement, dispersal, social interaction herd structure, habitat preference of the Spotted Deer and Barking Deer was made between January, 2000 and December, 2002 in the Sundarban reserved Forests (SRF).

There are 9 (nine) different types of vegetation , and the density of the deer also varies according to the vegetation types. The mean density of deer (number /sq km) varied from 3-4 in sundri (*Heritiera fomes*), 10-13 in sundri-gewa (*Exocecaria agallocha*) forest, 15-16 in gewa-goran-passur (*Exocecaria agallocha-Ceriops decandra-Xylocarpus mekongensis*), 14-18 in passur-kankra-baen (*Xylocarpus mekongensis-Bruguiera gymnorrhiza-officinalis*), 43-55 in goran gewa-keora (*Ceriops decandra- Exocecaria agallocha-Sonneratia apetala*) and 112-195 in keora-gewa (*Sonneratia apetala- Exocecaria agallocha*) open grassland associations. The least preferable habitat was the pure sundri (*Heritiera fomes*) forest and the most preferable habitat was the keora - gewa open grassland association. The Spotted Deer population density decreased with the increase of canopy closure.

The Barking Deer exists only in five different vegetation types out of nine in the Sundarbans Reserved Forests,and population size was 2150 approximately. The mean population density (number/sq. km) varied from 1-2 in sundri forest, 2-3 in sundri-gewa and passur-kankra-baen forest, 4-5 in gewa sundri forest and 3-5 in sundri-passur-kankra forest. The Barking Deer was found only in the north and northeast regions. Spotted Deer population decrease was recorded in October-January (non-breeding season) and an increase in April-September which was considered as peak breeding season . However, they were found to breed also throughout the year. The population remained more of less stable during March to July, and average ratio of male: female: fawn was 15:60:25. During peak breeding season (August September) average ratio of male: female: fawn was 15:50:35.

The radio-tracking home range (RTHR) of Spotted Deer of both the sexes varied from 140-200 ha during the non-breeding season (October-January). The home range of the male increased to 295 to 410 ha during the peak-breeding season (August-September),which was about double than that in the non-breeding season. The home range (RTHR) of Barking Deer also varied from 45-90ha during the non-breeding season (November-February). The home range of the male increased to 80 to 170 ha during the rutting period.

Radio-telemetric study on the habitat preference of the Spotted Deer in the Sundarbans Reserved Forests showed that keora-gewa open grassland association was the most suitable habitat for both the sexes during the winter and summer.

Food plants of Spotted and Barking Deer were recorded.. Both the species of deer used 85 plants out of which 20 are trees, 12 shrubs, 9 creepers/climbers and 44 herbs/sedges as their food. The Spotted Deer prefers to live in herds and the average herd size was 8. On the other hands, the Barking Deer preferred to live in both solitary form or in pair, herd structure and social organization were absent. The study shows that population size of Spotted Deer varie from 83,000-95,000 (approx.), Barking Deer 2,000-2,200, Wild Boar 26,000-30000 and Rhesus Monkey 48,000-52,000.

Key words: Deer, Prey animal, Tiger, Sundarbans

Introduction

Deer are for the most part inhabitants of forest and grassland. With the abundance of firearms, everywhere deer have become more vulnerable to prey. So their population has undergone tremendous reduction from over-exploitation. Conversion of lowland forest areas into agricultural field is a major threat for deer conservation (Dey, 2004)

There are deer of 17 existing genera under family Cervidae. Asia has 9 including both primitive and derived forms. The status and distribution of cervus deer in the South Asia region is given in Table 1(Grubb and Gardner 1999).

Table 1 . Status and distribution of cervus deer of South Asia Region

Species	Sub-species	Common name	IUCN and CITES Status	Countries with range
1. *Cervus axis*	*C. a. axis* (Erxleben, 1777)	Spotted Deer	NO	Bangladesh, Nepal , India and Sri Lanka.
2. *Axis porcinus*	A.p.porcinus (Zimmermann 1780)	Hog Deer	LR, nt	India, Nepal, Sri Lanka; Pakistan and Bangladesh (rare and only recorded in Khagrachari area of Chittagong Hill tracts)
3. *Cervus duvauceli*	*C.d. duvauceli* (Cuvier, 1823)	Swamp Deer or Barasingha	VU	India and Nepal
4. *Cervus unicolor*	*C. u. unicolor* (Kerr, 1792)	Sambar	CR	India, Bangladesh (Chittagong Hill Tracts and Sylhet) and Nepal.
5. *Muntiacus muntjak*	*M.mmuntjak* (Zimmermann 1780)	Barking Deer	EN	Bangladesh, Bhutan, India, Nepal and Myanmar.

Deer Habitat in Bangladesh

There were five species of deer in Bangladesh,viz., Spotted Deer (Cervus axis axis Erxleben, 1777), Barking Deer *(Muntiacus muntjak muntjak* Zimmermann, 1780), Hog Deer (*Axis porcinus porcinus* Zimmermann, 1780), the Sambar *(Cervus unicolor unicolor* Kerr, 1792) and Swamp Deer or Barasingha (*Cervus duvaucili ranjitsinhi* Groves, 1982) (Sarker and Sarker, 1988)

The Spotted Deer (*Cervus axis*) is not threatened or endangered (IUCN Bangladesh, 2000). In Bangladesh they are normally confined in the Sundarbans Reserved Forests (SRF), but are abundant in the south, where stretches of extensive grassland and scattered forests of keora trees occur. Grasslands provide excellent grazing grounds, and keora leaves and fruits are preferred food for the deer. Such combinations of vegetations are found in the Sundarbans East, Sundarbans South and Sundarbans West Wildlife Sanctuary areas. In all these areas Spotted deer are plentiful.

The Barking Deer (*Muntiacus muntjak*) is endangered in Bangladesh (IUCN Bangladesh,2000). They are found in the Chittagong Hill Tracts, Sylhet, Cox's Bazar, Chittagong, Madhupur sal forest, Garohills and in the Sundarbans Reserved Forest. The population of Barking Deer was much higher in the past than it is now. The population is decreasing very rapidly due to illegal hunting, destruction of their habitats, lack of food, lack of public awareness and commercial exploitation. In the SRF they are confined in the north and north-east area where there is more fresh water flow. Form management aspect of view it is very important to know the population size and habitat requirement of the Barking Deer in the SRF.

Study Area and Floristic Composition

The Sundarbans Reserved Forest (SRF) in Bangladesh is the single largest mangrove forest in the world. The SRF is a unique bio-climatic zone in a typical geographical situation in the coastal region of the Bay of Bengal. This is the only habitat where natural population of the Spotted Deer is confined. The SRF is situated in the extreme southwest of Bangladesh between the river Baleswar in the East and the Harinbanga in the west adjoining to the Bay of Bengal. The forest is lying between latitude 21°27′30″ and 22°30′00″ North and longitude 89°02′00″ and 90°00′00″ East at the southern part of Khulna, Bagerhat and Satkhira administrative districts. The forest has an area of some 6,017 sq. km (7,620 sq. km including the marine zone) determined from the visual interpretation of multi spectral SPOT satellite data (Table 2).

Table- 2 : Major physiographic areas of the SRF

Description	Area (km^2)
Land area (including sandbars)	4142.6
Marine zone	1603.2
River, channels, streams & canals	1874.1
Total area including marine zone	7620.0
Total area excluding marine zone	6016.7

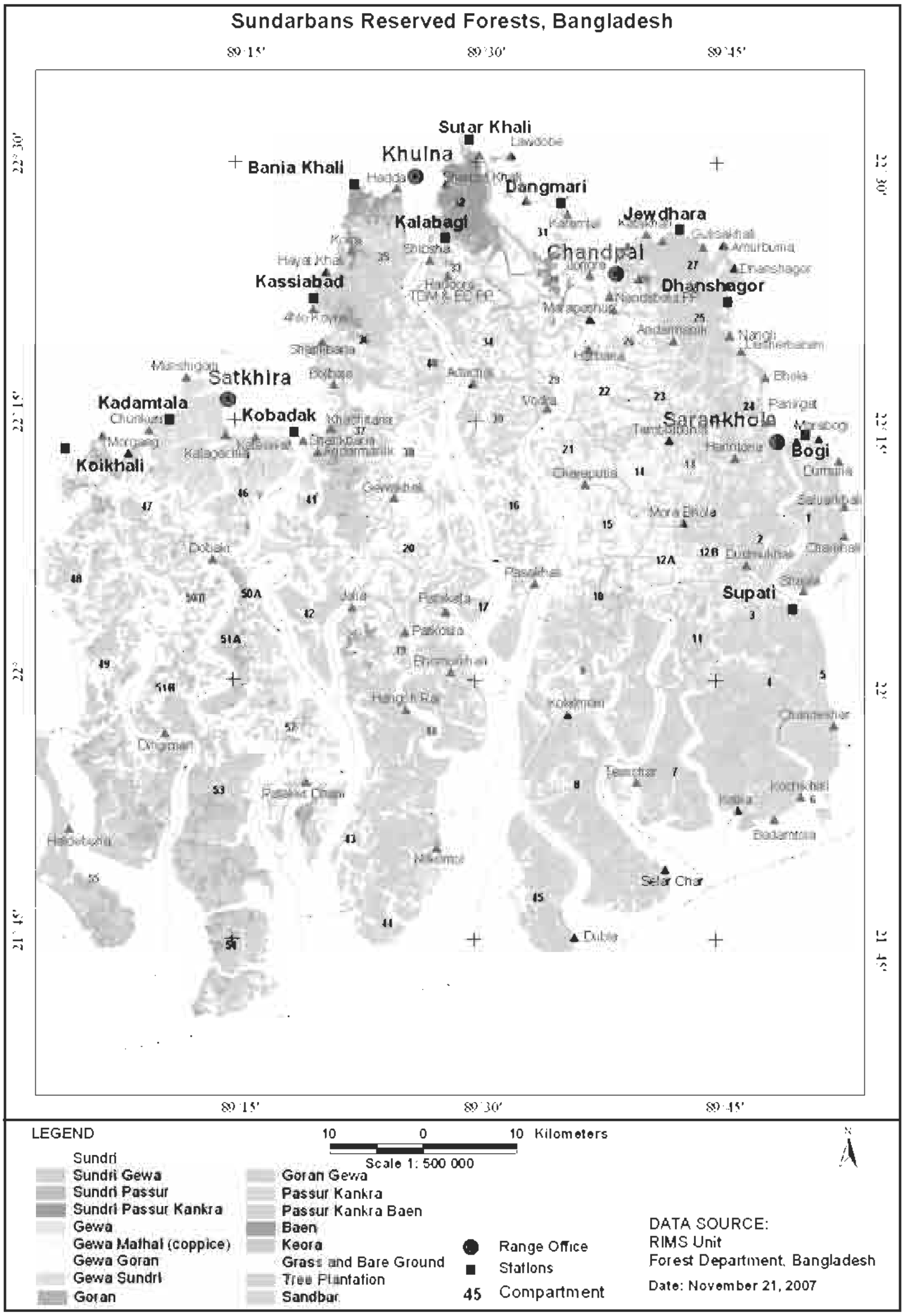
Floristic Composition

The main tree spp. of Sundarbans are sundri, gewa, goran, keora, passur, olpata, kankra, garjan, hental, bola and singra, etc. Innumerable roots of the mangroves , help to keep the stems erect against the turbulent current of streams and *nalas* (narrow canal) and also help the plants in respiration. Most of the mangrove spp. are also charecterized by vivparous germination as in case of germination of kankra, goran, gajan, khalsi, tora, etc. providing anchorage with pencil-like roots developed before detachment of the seed from the parent.

The floristic composition of the SRF is rich compared to many other mangroves of the world. Prain (1903) recorded 334 species of plants belonging to 245 genera and 75 families in the Sundarbans and adjoining areas.

Chaffey and Sandom (1985) presented a list of 91 species in the Bangladesh Sundarbans. *Heritiera fomes* and *Exoecaria agallocha* are the principal species. Sundri (*Heritiera formes*) covers about 73% and gewa 16% of total landmass. Canonizado and Hossain (1998) have identified nine different vegetation types with percentage of vegetation cover such as sundri (18.77%), sundori-gewa (26.52%), sundri-passur-kankra (2.39%), gewa (5.38%), qewa-sundri (18.95%), gewa-goran-passur (8.66%), gora-gewa-keora (16.22%), passur-kankra-baen (10.08) and keora-gewa open area (2.07%). (Table-3). The distribution of the species is also shown in the map of the Sundarbans (Map1).Table-3 : Major Vegetation types of the SRF including area (Canonizado and Hossain,1998)

Vegetation types according to pre-dominant species	Area (ha)	Area (sq.km)	% of the total area
Sundri	74,992.0	749.92	18.77
Sundri-Gewa	105973.0	1059.73	26.52
Sundri-Passur-Kakra	9556.0	95.56	2.39
Gewa	21520.02	15.20	5.38
Gewa-Sundri	75703.0	757.03	18.95
Gewa-Goran-Passur	34604.0	3460.4	8.66
Goran-Gewa-Keora	64807.0	648.07	16.22
Passur-Kakra-Baen	4030.0	40.30	10.08
Keora-Gewa-Open gressland	8286.0	82.86	2.07
Total	399471.02	6909.07	109.04


Sundarbans Reserved Forests, Bangladesh
Sutar Khali
Khulna
Bania Khali
Dangmari
Kalabagi
Jewdhara
Chandpal
Kassiabad
Dhanshagor
Satkhira
Kadamtala
Kobadak
Sarankhola
Bogi
Koikhali
Supati
Selar Char
Dubla
LEGEND
10 0 10 Kilometers
Scale 1: 500 000
Sundri
Sundri Gewa
Sundri Passur
Sundri Passur Kankra
Gewa
Gewa Mathal (coppice)
Gewa Goran
Gewa Sundri
Goran
Goran Gewa
Passur Kankra
Passur Kankra Baen
Baen
Keora
Grass and Bare Ground
Tree Plantation
Sandbar
Range Office
Stations
45 Compartment
DATA SOURCE:
RIMS Unit
Forest Department, Bangladesh
Date: November 21, 2007

Pellet Group Count Plots, Transects and Grids

Four Grids were selected for radio-telemetric study in Karamga, Katka, Kachikhali and Nikamal area (Table 6). A total of 27 Pellet Group Count (PGC) Plot (Table-4) and 24 transects were laid out in 9 (nine) different vegetation units in the SRF (Table-5) - 3 in sundri, 15 in sundri-gewa, 5 in sundri-passur-kankra, 1 in gewa, 6 in ewa-sundri, 3 in ggewa-goran-passur, 5 in goran-gewa-keora, 1 in passur- kankra-baen and 3 in keora-ewa open grassland.

Table 4. Summary of locations and vegetations of the pellet group counting (PGC)

PGCPlot No.	Name of Range	Name of nearest Patrol Istational Centre	Compart·mentNo.	GPS location Northing	Easting	Vegetation Vegetation type	Conopy Averag		ODA
PGC·I	Sarankhola	Kata WS.C (Jamtola)	C-6	21° 51' 4.3"	89°47' 08.4"	Keora-Gewa open		0-5	3b,a
PGC·2	Sarankhola	Kaehikhali W S. C	C-6	210051'59.1"	8900 50' 18.7"	Gewa- Sundri	50-60	6-8	3a
PGC .3	Chandpai	Karamial Wildlife Breeding	C-31	22° 25' 38.8"	9° 35' 29.5"	Sundri - Passur·	70 - 80	17	la
PGC·4	Khulna	NilkamalWS.C(Hiron	C-M	21 ° 48' 11.2"	89° 27' 02.3"	Gewa	40-50	7	3b
PGC-5	Satkhira	Dubeki P.P.	C-50A	22° 05' 40.4"	89° 19' 46.1"	Gewa-Goran·Passur	50-60	8	3b
PGC-6	Satkhira	Mandarbaria WS.C	C-55	21° 45' 01.7"	89° 17'35.1"	Goran-Gewa- Keora	50-60	6	3b
PGC-7	Chandpai	Harbaria P.P	C-26	21° 17' 58.7"	89° 38' 10.8"	Sundri	70 - 80	16	la
PGC·8	Chandpai	Marapassur PP	C-27	22° 19' 41.2"	89° 37' 14.2"	Sundri-Gewa	70 - 80	12	2a
PGC.9	Chandpai	LaodubP.P	C-31	22° 29' 09.3"	89° 32' 12.7"	Passur -Kankra-Baen	70 - 80	15	la
PGC-lO	Chandpai	Tambulbonia P.P	C-l3	22° 12'1.6"	89°41' 11.7"	Sundri	70 - 80	17	la
PGC -11	Sorankhola	Bogi F. S.	C-l	22° 12' 28.1"	89° 47' 51.0"	Sundri	70- 80	18	la
PGC·12	Sarankhola	Sarankhola F. S	C-l	22° 12' 27.5"	89° 48' 38.2"	Sundri	70 - 80	19	la
PGC-l3	Sarankhola	Dasherbharani P.P	C-24	22° 17' 12.7"	89° 47' 12.8"	Sundri-Gewa	70 - 80	12	2a
PGC-14	Sarankhola	ewdhara P.P.	C-27	22°14' 13.8"	89° 43' 12.5"	Sundri-Gewa	40 - 60	12	2b
PGC-15	Chandpai	Jongra P.P.	C·3l	22° 22' 19.5"	89° 37' 08.6"	Sundri-Passur-Kankra	70 - 80	16	la
PGC-16	Chandpai	Sibsa PP.	C-30	22° 23' 12.8"	89° 27' 12.7"	Sundri-Passur-	70- 80	15	2a
PGC·17	Khulna	Hodda PP	C-35	22° 27' 19.8"	89° 25' 11.7"	Sundri-Passur-	70- 80	15	2a
PGC-18	Khulna	Pateosta PP	C-19	22° I' 22.4"	89° 25' 14.4"	Gewa	50-60	10	3b
PGC-19	Chandpai	Dhansagar P.P.	C-25	22° 20' 14.2"	89° 46' 18,2"	Gewa·Sundri	70 - 80	13	2a
PGC -20	Chandpai	Baddamari P.P.	C-28	22° 23' 54.8"	89° 39' 14.2"	Gewa-Sundri	50-60	12	2b
PGC-21	Satkhira	Kalagaehia P.P	C-46	22° 12' 50.7"	89° 14' 21.8"	Gewa-Goran-Passur	30-50 .	8	3b
PGC-22	Khulna	Khasitana P.P	C-37	22° 13' 08.9"	89°21' 11.6"	Gewa-Goran-Passur	40-60	8	3b
PGC-23	Khulna	Hansaraj PP	C-18	21 ° 49' 56.9"	89° 25' 13.5"·	Gewa-Goran-Passur	40-60	8	3b
PGC-24	Sarankhola	Kokilmoni P.P	C-8	21° 56' 42.8"	89° 35' 48.7"	Gewa-Goran-Passur	50 -6 0	8	3b
PGC -25	Khulna	Sutarkhali F.S.	C-32	22° 28' 23.8"	89° 29' 28.5"	Passur - Kankra- B	70 - 80	16	la
PGC -26	Chandpai	Laodub PP	C-31	22° 29' 46.9"	89° 32' 28.5"	Passur -Kankra-Baen	70 - 80	15	a
PGC -27	Khulna	Nilkamal WS.C	C-M	21° 49' 26.9"	8900 27' 28.5"	Keora-Gewa open	50- 60	8	3b

Table 5. Summary of location and vegetation of the transect units in the Sundarbans Reserved Forest (T -1 to T -24).

.Transect No.	.Name of Range	.Name of nearest Patrol Post/Staton Centre	Compart ment no	GPS location		.Vegetation			
				Northing	Easting	Vegetation type	Canopy closure (%)	Average heigh (m)	ODA c1assifi cation
T·I	Chandpai	Karamjal Wildlife Breeding	C·31	22"25'35.2"	89"35' 30.6"	Sundri·Passur ·Kankra	70· 80%	17m	la
T·2	Sarankhola	Kalka Wildlife Sanctuary Centre	C·7	21 °51'11.5"	89° 46' 32.4"	Keora·Gewa	50· 60	5·14	2b,3b
T·3	Chandpai	Laodub Patrol Post (P.P.)	C·31	22"24'07.3"	89° 32' 10.4"	Sundri	70·80	18	la
T-4	Khulna	Nilkamal W.S.C	C·44	21°49'25.1 "	89° 27' 31.5"	Keora·Gewa open grassland	50·60	8	3b
T·5	Chandpai	Harbaria P.P.	C·26	22°17'&5.7"	89° 37' 09.6"	Sundri	70· 80	17	la
T·6	Sarankhola	Sarankhola Range H/Q	C·I	22° 12'26.0"	89" 48' 51.0"	Sundri·Gewa	70·80	16	la
T·7	Sarankhola	Dasherbharani P.P.	C·24	22° 17' 18.0"	89° 47' 22.0"	Gewa·Sundri	50·70	12	2b
T·8	Chandpai	Marapassur PP.	C·29	22°19'39.0"	89°37'07.1"	Sundri·Gewa	70·80	16	la
T·9	Chandpai	Mrigamari P.P.	C·28	22"21'57.1"	89° 40' 10.8"	Sundri·Gewa	70· 80	17	la
T·IO	Chandpai	Tambulbonia P.P.	C·13	22°12'307"	89° 42' 08.3"	Sundri·Gewa	70· 80	16	la
T·ll	Satkhira	Kalagachia P.P.	C·46	22°12'53.8"	89° 14' 30.5"	Gewa·Goran·Passur	30·50	8	3b
T·12	Satkhira	Munshigonj P.P.	C-46	22°16'12.3"	89° 12' 00.2"	Gewa·Sundri	50·60	12	2b
T·13	Satkhira	Kaikhali Forest Station (F.S)	C·48	22°11 '32.8"	89° 04' 48.1 "	Gewa·Goran· Keora	40· 60	7	3b
T·14	Satkhira	Chunkuri P.P.	C·47	22°13'04.4"	89° 09' 45.6"	Gewa·Sundri	50· 60	II	2b
T·15	Satkhira	Kadamtola FS	C·47	22°13'40.0"	89° 10' 54.9"	Gewa·Sundri	50·60	12	2b
T·16	Satkhira	Dingimari P.P.	C·51	22°30'31.1 "	89" 13' 14.9"	Goran·Gewa·Keora	70·80	6	3a
T-17	Khulna	Khasitana P.P.	C·37	22°13'13.5"	89° 21' 04.8"	Gewa·Goran·Passur	40·60	8	3b
T·18	Khulna	Sakbaria P.P.	C·36	22°18'09.9"	89"20' 11.3"	Sundri·Gewa	70· 80	12	2a
T·19	Khulna	Patcosta P.P.	C·19	2200 I '32.9"	89° 25' 43.8"	Sundri·Gewa	70· 80	12	2a
T·20	Khulna	Gewakhali P.P.	C·19	22°04'60.4 "	89" 23' 20.2"	Gewa	50·60	8	3b
T·21	Khulna	HoddaP.P.	C·35	22"27'10.4"	89° 25' 00.3"	Sundri·Passur·Kankra	70·80	15	2a
T·22	Khulna	Adachai P.P.	C·34	22°16'14.7"	89" 29' 47.8"	Sundri·Gewa	70· 80	12	2a
T·23	Khulna	Kalabogi FS.	C·33	22"24'40.0"	89" 28' 11.2"	Sundri·Passur· Kankra	70· 80	16	la
T·24	Khulna	Sutarkhali FS.	C·32	22"28'13.]"	89" 29' 59.2"	Passur ·Kankra·Baen	70·85	16	la

Table 6 . Summary of the location and vegetation of the grid units.

Grid No.	Name of Range	Name of the neare t Patrol Po t1Staton Centre	Compart ment no	GPS location		Vegetation			
				Northing	Easting	Vegetation type	Canopy clo ure (%)	Averag heigh (m)	ODA c1as ifi cation
G-I	Chandpai	Karamjal Wildlife Breeding Centre	C-31	22° 26' 24.8"'	890037' 10.6"	Sundri-Passur-Kankra	70-80	17	la
G-2	Sarankhola	Katka Wildlife Sanctuary (Jamtola) Centre	C-7	21°51' 12.5"	8900 46' 21.6'	Keora-Gewa	50- 60	5-14	2b,3b
G-3	Sarankhola	Kachikhali Wildlife Centre Sanctuary (Chankhala Math)	C-6	21 ° 51' 49.9"	89° 50' 14.1"	Gewa - Sundri	50 - 60	6-8	3b
G-4	Khulna	Nilkamal Wildlife Sanctuary Centre	C-44	21°48' 58.8"	89° 27' 48.4"	Goran-Gewa-Keora	50 - 60 g		3b

Methods and Materials

Deer Population Estimation Methods

An extensive and , in some cases, elaborate body of mathematical theory has been developed regarding population dynamics and animal abundance. However, in a number of cases such theory has been characterized by a relative lack of interaction with relevant population data (White *et al.,* 1982). Population density of small mammals has been estimated using three methods such as non-trapping, removal trapping and non-removal trapping.

Karanth *et al.* (2000) estimated prey species of tiger (Spotted Deer, Barking Deer, Samber, etc.) in the tropical dry deciduous forest of Nagarhole Reserve of Kamataka, India by the line transect survey, and the population density of the Spotted Deer *(Cervus axis)* and Barking Deer *(Muntiacus muntjak)* were 38.1 sq.km and 6.0/sq.km respectively. But no population study has been conducted in the mangrove forest.

The following methods are suitable to estimate the population size of deer in the forestland :

- Pellet group count (PGC) method.
- Line transects count (LTC) method
- Complete count (CC) method
- Track count method.
- Night spotlight count method.
- Water hole Count method

During the study Dey (2004) used pellet group count method, line transect count method and complete count method for population estimation of the Spotted Deer and Barking Deer.

Pellet Group Count Survey

During field data collection, the following materials and methods Dey (2004) were used by . The data are presented in the Table 9 in summary form. Field work related to the assessment of deer population was carried out from dry season October ,2000 to December 2001. The Sundarbans Reserved Forest is sub-divided into 55 compartment each varying in size from 4000-16,000 ha. Visit to the SRF is possible only by launch, speedboat, cabin cruiser or houseboat. Forest Department launch was used for movement. Visiting all the compartments made general reconnaissance. Intensive data collection was carried out in 35 compartments including Sundarbans East, Sundarbans South and Sundarbans West Wildlife Sanctuaries. A total of 27 plots were laidout in nine different types of vegetation in the SRF, and the data were collected from the 15th October to 30th December, 2001 on weekly basis for 5 to 6 weeks continuously.

The plot size was 10m x 10m covering on area of 100 sq.m. The Spotted Deer and the Barking Deer were observed and classified by sex, age and herd size according to the type of vegetation occupied. Adult, sub-adult, juvenile and young were estimated on the basis of comparative sizes. Visibility was poor in all forest types at all time except in some coastal grass areas and keora forests. visibility was poor combined with impossibility to census animals on foot. So indirect method census of the Spotted and Barking Deer was applied like pellet group counts. During 24-hours period of continuous observation, total defections of free-ranging tamed Barking and Spotted deer were recorded with reference to the habitat subunits where the feces were deposited and the animal activity at the time of deposition. Once in each 2-week 1 pair, 2 individuals or pair of mature deer were released and allowed to roam freely for a 24 hours period. Four different deer were used on each site, but only 4 (2 Spotted Deer and 2 Barking Deer) deer were observed on a given date in captivity at the Karamjal Wildlife Breeding Centre. Only 2 particular deer would remain together for the period of observation, thus necessitating 2 separate observers on days when different deer were used. The observer stayed with the deer for 24-hours. From the size of pellet male, female and fawn were identified. The fawn pellet size was comparatively smaller than the mature male and female. In addition to recording defecations, percent of total activity time was determined. Activities like razing, ruminating, resting, sleeping, traveling, standing, playing and drinking were noted.

Method of Analysis of PGC Data

Application of the method is as follows: A number of plots are selected in such a manner that the study area is adequately represented and of the sampling designs can be employed.
Then the number of pellet group was counted in each plot. Then ,

N=t/r

where , N=No. of deer per sample plot area, t=Pellet groups per sample area, r = Defecation rate

So number of deer per hectare will be N x 1,000.If it is multiplied by 10,000, then we get population density per sq. km.

Line Transect Count Survey

Line transect counting theory and techniques

Most deer species are not individually identifiable, and are therefore not amenable to the capture-recapture sampling type of approach. Because the vision and hearing of ungulate prey are relatively poor, they cannot be seen and counted. However, because of the screening effect of the vegetation in forested habitats, it is not appropriate to count tigers prey using block counts or total counts, or other methods which assume that all animals in the sampled area are seen (Lance *et. al.,* 1994; Thompson *et al., 1998).*

The method involves observers moving along straight trails called transect counting animals seen on either side. Additionally, using range finders and compasses, the observer measure the distance and angle from the transect to animals that are seen. During analysis, these counts and associated distance data are used to generate sighting probabilities. Transect data can be analyzed using computer programs that estimate detection probabilities to estimate the animal abundance (N) in the sample area from the estimation process, density can be estimated directly.

Field techniques

Unlike sampling methods based on fixed width transects, the line transect method does not assume that all objects within a specified width are detected. Rather the assumption is that objects on the line are seen with probability that the number of objects sighted away from the line decreases in some fashion. These transect lines are comprising generally 2.5-4 km long, but considering the topography and geographical condition of the SRF, 1.0 km long straight trails (chilla) were cut and marked clearly using painted tags.

Two trained observer walked along the line counting prey animals observed on the line. The sample counts were done between 0600-0900 and 1600-1900 hours when prey animals species were most active.Then the included angle (sighting angle) between the transect line and the center of the animal cluster were recorded. The sighting distance was measured with optical range finders (ISm-180m range) and the angles were calculated from the azimuths (bearings) recorded using a liquate levels of sampling effort. Trained volunteers were engaged to collect field data from line transect surveys. At each site about 10-20 such volunteers carried out the surveys under the supervision of the investigator. In the case of Spotted deer surveys in the SRF, considering the physical barriers like khals, small and big rivers 1,000 m long transects were found to be satisfactory. In areas where deer density is low, transects longer than 1000 m may be more appropriate. A minimum of approximately 5-10 separate transect lines were selected within each area of vegetation type. During the present study 1,000 m long transects were established in the SRF.
Care was taken when choosing the timing of surveys. Seasonal environmental fea such as vegetation growth, or high tide or low tide may lead to difficulties in finding dung, resulting in increasing the level of effort required to obtain the desired precision, or result in an underestimated number of animals in the region. Dry season (October- March) is the best time for pellet group count or line transect survey can be done throughout the year in the SRF.

Data collection

Once the survey design has been completed, the starting position can be determined based on topographic features extracted from a map or by using a global positioning system (GPS). A compass can then be used to determine the direction in which observers should walk in woodland areas, however following a compass bearing along a straight line can be difficult. The size of a rope or cable of known length, with additional length marks along it, provides an effective means of marking the line. The cable can be placed along the desired bearing and observers can then walk alongside it. This has the additional advantage that the transect line is dearly marked, facilitating the recording of perpendicular distances of detected objects from the line. The cable can also be used as a tool for measuring the distance should be skipped between transect lines.

During the present study LTC data were collected from May/ 2001 to February/2002, in 42 (Forty two) different types of vegetation the SRF. To study the distribution of animals in the SRF along transect in the absence of source of disturbance 1 km long walking trail (locally called chilla) were selected adjacent to the nearest forest offices. A total of 42 permanent transect lines of 1 km long were laid out / selected in the SRF. Each transect was covered once in the morning (0530 to 0630 h) and once in the evening (1600 to 1830 h) each week. The transects were covered from starting and ending alternatively in order to minimize any basis arising from variation in animal activity with . time. For each sighting the central location of the animal group was noted, and the perpendicular distance from this location to the transect line (or Chilla) was recorded on each side (20 m to 30 m range) using a range finder (20m to 60m range) at 10m class intervals, in addition details of group composition. Sometimes a range finder was used wherever possible.

Data analysis

Line-of-sight measurement are used in the King Census Method; in the Webb method measurements are taken perpendicular from the transect to the fleshing location (Webb, 1942). The formula of the King census

$$P = \frac{AZ}{ZYZ}$$

where, P = population ,A= total area of study, Z= number flushed , Y = average flushing distance X = length of line

Ten morning and ten afternoon counts of deer were made between 10th to 30th of each month from July to December /2000-2001. Twenty additional counts were made in early of late November 2001 to December . Regular wildlife observation data sheets recorded by the Forest Department staff at the Kachikhali Chankhola Math area were also consulted . Each deer seen was scrutinized closely with binocular and recorded as a buck, doe or fawn. Accuracy tests revealed that less than 5% of individual marked yearling (sub-adult) bucks were being misclassified as does. Most fawn were born between March-August and reached near adult size in December .

Results and Discussion

Observation and Results of Pallet Group Count Survey

Population size and density of the Spotted Deer

Twenty seven pellet group plots were established in nine different types of vegetation in the SRF during October to December 2001 and the results of the population census is presented in the Table7. The standard defecation rate of the Spotted Deer was 13 PG/day and the number of pellet was 70-80 per pellet group. The Spotted Deer was found in all plots. The mean density (number/sq km) of the Spotted Deer in different types of vegetation were: 4 in sundri, 12 in sundri-gewa, 14 in sundri-passur-kankra, 14 in gewa, 7 in gewa-sundri, 16 in gewa-oran-passur, 55 in gewa-goran-keora, 18 in passur-kankra-baen and 175 in keora-gewa open grassland . Population density was lowest in the pure sundri forest and highest in the keora-gewa open grassland areas. A total of 8,324 Spotted Deer were estimated by the PGC method. The study also has indicated that the most suitable habitat of the Spotted Deer is the keoragewa open grassland association and the poor habitats was sundri and sundri-gewa forests.

Population size and density of the Barking Deer

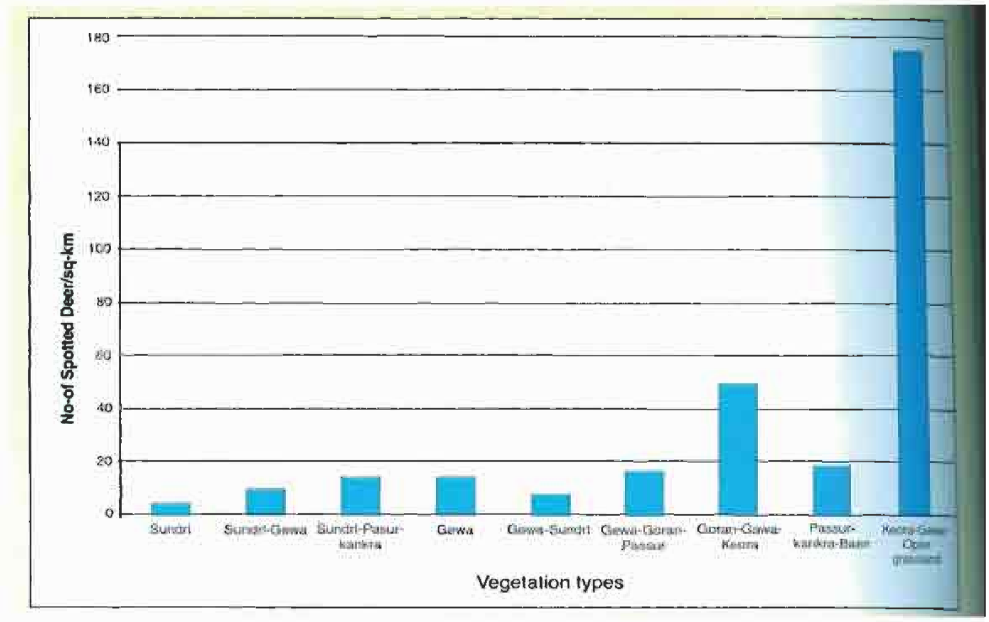
PGC method also was applied similarly in the nine different types of vegetation of the SRF in 27 PGC plots from October to December 2001 and results are presented in the Table 8. The study reveals that the Barking Deer exists in the five different types of vegetation, vig., sundri, sundri-gewa, sundri-passur-kankra, gewa-sundri and passurkankra-baen association. The mean population density (number /sq km) of Barking Deer were: 2 in sundri, 3 in sundri-gewa, 3 in passur-kankra-Baen, 4 in gewa-sundri and 5 in sundri-passur-kankra forests. The Barking Deer was found only in the North and Northeast regions within 16 compartments (C-1,2,3,4,5,6, 13,22,23,24,25,26,27,28,29,30, 31, 32, 33 and 34) out of the 55 compartments of the SRF, especially in the fresh water and moderately fresh water zones. They were not found in the high saline zone. A total of 2,265 Barking Deer were estimated in the SRF. The habitat zonation of the Barking Deer is presented in the Map 2.

Table 7. Population density and size of the Barking Deer in relation to the vegetation types in the SRF as estimated by the PGC survey during October to December 2001

SI. No.	Vegetation types according to predominant species	Total area (sq.km kkm	Data collection period	Duration in days	Number PGC plots	Total no. of pellet group	Mean no. of PG per plot	Dfecation rate / day	Density of Spotted Deer (No/Sq. km)	Total no. of Spotted Deer in each
1	Sundri	749.92	15 Oct-26Nov	42	4	1	0.0059	13	4	2,999
2	Sundri-Gewa	1059.73	15 Oct-26 Nov	42	3	2	0.1580	13	12	1277
3	Sundri - Passur - Kankra	95.56	20 Oct-1 Dec	42	4	3	0.0178	13	14	1,338
4	Gewa	215.20	15x10-12 Dee	28	2	1	0.0178	13	14	3,012
5	Gewa-Sundri	757.03	20 Oct-1Dec	35	3	1	0.0095	13	7	5,299
6	Gewa-Goran-Passur	346.04	26 Nov- 30Dec	35	4	3	0.0214	13	16	5,536
7	Goran-Gewa-Keora	648.07	15 Nov-12Dec	28	2	4	0.0714	13	59	38236
8	Passer-Kankra-Baen	40.30	20 Oet- Dec	42	3	.3	0.0238	13	18	725
9	Keora-Gewa-open grassland	82.86	15 Nov.-20 Dec	35	2	16	0.2285	13	175	14500
	Total	**3994.71**				**27**	**28**			**83024**

Table 8. Population density and size of the Barking Deer in relation to the vegetation types in the SRF as estimated by the PGC survey during October to December 2001

SI. No.	Vegetation types according to predominant species	Total area (sq. kIn)	Data collection period	Duration in days	Number of PGC plots	Total no. of pellet group observed	Mean no. of PG per plot	Defecation rate/day	Density of Spotted Dear (No. Per Sq. km n)	Total no. of SpOiled Deer in each vegetation type
1	Sundri	280.63	15 0ct-26Nov	42	4	0.50	0.125	12	2	561
2	Sundri-Gewa	256.04	15 Oct-26 Nov	42	3	0.5.	0.166	12	3	768
3	Sundri-Passur-K k	49.73	20 Oct-1 Dec	42	4	1.0	0.25	12	5	248
4	Gewa-Sundri	157.73	20 Oet-1 Dec	35	3	0.50	0.166	12	4	630
5	Passer -Kankra - B	19.31	20 Oct-1 Dec	42	3	0.50	0.166	12	3	58
	Total	**3994.71**				17				**2,265**



Line Transect Count Survey

Species composition in the transect vegetation units

During the entire LTC period a total of 10, 544 individuals 13 (Thirteen) different species of major mammals, reptiles and birds were recorded in the transect vegetation in the SRF.

Combined Species percentage of the Spotted Deer *(Cervuss axis)* was 59.33% of the total observed animals, the highest of all observed species. The combined species percentage of Barking Deer was 1.52%. The combined species percentage of the other species were Wild Boar *(Sus scrofa)* 6.81 %, Bengal tiger *(Panthera tigris)* 0.17%, Rhesus Monkey *(Macaca mulatta)* 22.03%, Monitor Lizard *(Varanus spp)* 6.92%, Jangla Cat (Felis chaus) 0.33%, Fishing Cat *(Prionailurus viverrina)*, 0.09%, Clawless Otter *(Aonyx cinerea)* 0.43%, Estuarine Crocodile *(Crocodylus porosus)* 0.14% , Python *(Python morolus)* 0.18%, and Indian Porcupine *(Hytrix indica)* 0.18% .

A total of 6,256 Spotted Deer were observed in 42 transect in 998 observation days. This species was observed in the all the transects in the SRF (Table 12a and 12b). Similarly a total of 160 Barking Deer were found in 19 transects out of 42 transects in compartment numbers -1, 2, 3,4,5,6,13,22,23,24,25,26,27,28,29,30,31,32,33 and 34 of the SRF. There was no observation record of the Barking Deer in the remaining 35 compartments in the SRF.

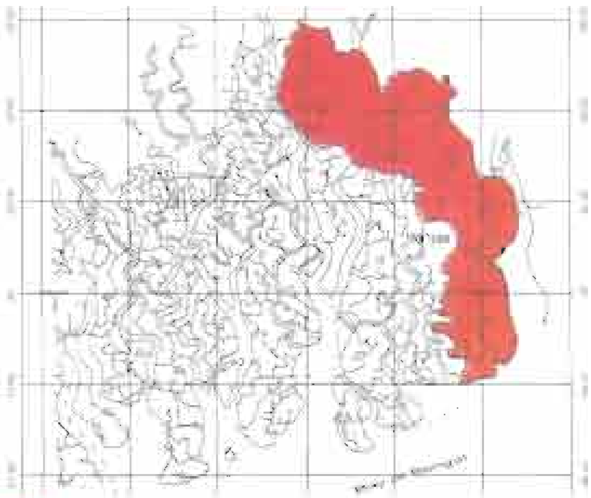
Population density and population size of the Spotted Deer

The population density of the Spotted Deer is given in the Table 9 . In sundri forest the density is 3 per sq.km which was the lowest, 10 in sundri-gewa, 12 in sundri-passur-kankra, 12 in gewa,6 in gewa-sundri, 3 in gewa-goran-passur, 43 in goran-gewa-keora, 14 in passur-kankra-baen and 174 in keora-gewa open grassland.

The population density was the highest in the keora-gewa open grassland. The estimated population size of the Spotted Deer in the SRF was 79,531 (Table-9).

Table-9 . Population density and size of-the Spotted Deer as estimated by the line transect count (LTC) survey

Sl No	Vegetation types according to predominant species.	Area (sq. km)	Transect units	Total no. of transect	Mean density of Spotted deer	Total no. of Sgotted deer
1	Sundri	749.92	T-3, 5, 35	3	3	2,250
2	Sundri-Gewa	1059.73	T-6, 8, 9,10,18,19,22, 25,29,30,34, 36,38,39,40	15	10	10597
3	Sundri-Passur-Kankra	95.56	T-I, 21, 23, 26, 42	5	12	1,146
4	Gewa	215.20	T-20	1	12	2,582
5	Gewa-Sundri	757.03	T-7, 12, 14, 15,28,33	6	6	4,542
6	Gewa-Goran- Passur	346.04	T-I1,13,17	3	15	5,190
7	Goran-Gewa- Keora	648.07	T-16,27,30,31,37	5	43	27,867
8	Passur- Kankra- Baen	40.30	T-24	1	14	5,642
9	Keora-Gewa open grass land	82.86	T-2,4,41	3	174	14417
	Total	3,994.71		42		79531



Map.2.Habitat zonation map of the Barking Deer in the SRF

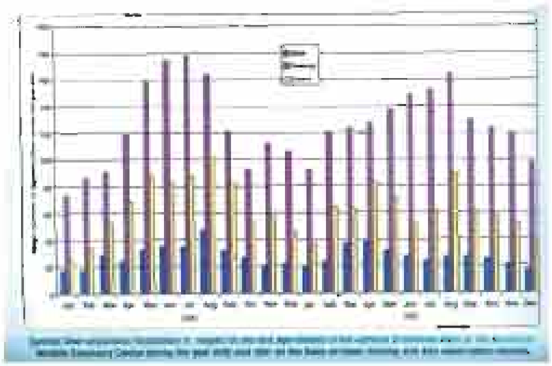


Table-10: Population density and size of the Barking Deer estimated by the line transect count (LTC) survey

SI No	Vegetation types according to ~redominant specIes.	Area (sq. kIn)	Transect units	Total no. of transect Unit	Mean density of Barking Deer (no.lsq.km)	Total no. of Barking Deer in
I	Sundri	280.63	T-3, T-5, T- 35	3	1.66	466
2	Sundri-Gewa	256.04	T-6, T-8, T-9 T-IO, T- 22, T-30 T-34, T-36	8	2.25	576
3	Sundri-Passur Kankra	49.73	T-I, T-23, T-26, T-42	4	2.25	112
4	Gewa-SlJ1ldri	157.73	T-7, T-32, T-33	3	5.66	893
5	Passur-Kanlcra baen	19.31	T-24	I	2.0	39
	Total	763.44	19	2086		

Population density and size of the Barking Deer

The population density of the Barking Deer is given in the Table10. The observed Barking Deer density was 1.66/ sq krn in sundri, 2.25 in sundri-gewa, 2.25 in sundri-passur-kankra, 5.66 in gewa-sundri and 2 in passur-kankra-baen. The population density was the lowest in sundri forest and the highest in gewa-sundri forest. The estimated population size of was 2086

Home Range and Habitat Preference Estimation By Radio-Telemetry

The Spotted Deer is commonly associated with a mixture of forest and more open grass and shrub association (Graf and Nichols, 1966; Ables *et at.* ,1977; Dinerstein ,1979b; Mishra, 1982). Although Spotted Deer congregate in large herds, the social structure of the species is loose, with individuals readily joining and splitting from groups (Mishra,1982).

This study focused on Spotted Deer and Barking Deer movement and activity patterns, and habitat selection in the SRF in Bangladesh. The following hypotheses tested were (1) home range in breeding and non-breeding season, (2) seasonal difference in forage availability in different habitats after the seasonal habitat preferences of deer, (3) habitat preferences between the sexes in deer (4) a fine-grained habitat structure (many small patches evenly distributed) reduces home range size in deer and (5) ranges of males and females increase during the rut. The present study also attempted to identify the best method of calculating RTHR during breeding and non-breeding season and to determine the minimum number of radiolocations required for home range asymptotes of the Barking and Spotted Deer.

Capture of Deer

Drop nets are most useful in semi natural conditions where animal regularly congregate in feeding areas. Ramsey (1968) reported the successful capture of several hundred White-tailed and Axis deer with drop nets. Pienaar (1969) also used drop nets to capture many medium sized species in African game. All netting techniques require rapid handling of captives so that damage is minimized. This method was successfully used for capturing Spotted Deer and Barking Deer in the SRF.

Data collection

Tracking sessions began in January, 2000 and continued until November, 2001 at 23 weeks intervals. This period covers both the non-breeding and breeding season of potted and Barking Deer. Radio-tracking operations were conducted in all six grids. Sometimes if the radio-tagged animals went outside the grids, then immediately reference points were established around the new bedding place (outside the grid) with reference to the main grid and radio-tracking operation were continued. In such case GPS locations also were taken into account. A total of 5 male and 6 female Barking Deer, and 5 male and 5 female Spotted deer were tagged with radio-collars during the study period .

Method of analysis

Activity and movement pattern of the radio-tagged animal were determined by plotting the radio-locations on graph paper and a grid co-ordinate map using the compass bearing as the reference point. Location of fixes for each animal was transferred to a scaled diagram of the grid by plotting the compass bearings. When the animals moved outside the grid or where the grid reference pegs were not visible at night, locations were recorded by putting new peg with red flag and with the help of Garrnin GPS with the date and time. The following morning, the distance of these fixes was measured with measuring tape along with a compass bearing from the nearest grid reference peg. In some cases, Garmin GPS was used to know exact location of the animal. A specific x, y co-ordinate value on the basis of the scale was determined. Location fixes for some resident animals were plotted month-wise separately.
After plotting all fixes of a particular animal, the x, y value put into the Text file of I
Microsoft excel and the radio-tracking home range (RTHR) was estimated using the ANTELOPE program (Bradbury and Vehrencamp,1993). The summary is given in the Table- 11 and 12.

Table 11 . Summary of radio-tracking home range (RTHR) estimates of the Spotted Deer in the Sundarbans Reserved Forest during the entire study period using the Program ANTELOPE

Species !.D.No.	Sex	Tracking period	No. of fixes	RTHR by MCP method {at 95% confidence) in hectares	RTHR by Elliptical method I at 950/c map value) in hectares	RTHR by Andmen Fourier method (at 95% confidence) in hectares	RTHRbyHMM method lat 95lk isopleth's) in hectares
168	M	13 Jul- 0 I Jun-2001	322	312.44	279.12	291.51	377.28
204	F	13 Jan - 02 May-2001	221	189.5 1	141.77	161.79	215.19
230	F	09Mar-12Jul-2001	175	165.41	133.51	147.91	191.52
235	M	09 Mar-1O Oct-2001	144	291.55	242.17	259.22	315.21
238	M	28 Apr-13 Sep-2001	130	371.03	282.72	318.57	419.22
254	F	28 Apr -10 Dec-2001	119	141.5 I	127.54	139.50	172.41
260	M	14 Jan -18 Dee-2001	122	299.42	237.68	261.91	365.19
Male average home range size (ha)				x = 318.61	x = 260.42	x =282.80	x = 369.22
Female average home range size (ha)				x = 165.47	x = 134.27	x = 149.73	x = 193.04

Table 12.Summary of radio-tracking home range (RTHR) estimates of the Barking Deer in the Sundarbans Reserved Forest during the entire study period using the Program ANTELOPE

Species I.D.No.	Sex	Tracking period	No. of fixes	RTHR by MCPmethod {at 95% confidence) in hectares	RTHR by Elliptical method map value) in hectares	RTHRby Andersen latmethod confidence) in hectares	RTHRby HMM (atmethod (at 95% isopleth's) in hectares
697	M	20 Jan - 22 May, 01	222	112.32	77.87	86.15	151.39
698	F	20 Jan - 29 Mar, 01	198	92.71	62.13	79.12	118.73
699	F	22 Feb-14 Jun, 01	162	87.41	53.71	67.39	112.31
Male average RTHR (ha)				x = 112.32	x = 77.87	x = 86.55	x = 151.39
Female average RTHR (ha)				x = 90.31	x = 57.92	x = 73.25	x=115.52

Frequency of occurrence of radiolocation was used to determine habitat preference. The data were split in to daytime (06:00-17:59) and nighttime locations (18:00-05:59) because of the tendency of animals to move into more open area during the evening and night.

Observations and Results

Radio-tracking home range (RTHR) of the Spotted Deer

The RTHR of 8 (eight) Spotted Deer in Grid-1, 2, 3 and 4 in the SRF were estimated on the basis of radio- tracking data by four different methods using the program ANTELOPE. The RTHR estimates for the Spotted Deer varied considerably in different methods. The home range of the Spotted Deer varied with sex, season and population density. The radio-tracking home range (RTHR) of both the sexes remained more or less the same in 140-200 ha during the non-breeding season (December-January). The home range of the male increased to 295 to 410 ha during the peak-breeding season (August-September), which was about two times larger than that of the non-breeding season. The home range of the female during the breeding season varied from 150 to 200 ha which was 1.5 times larger than that of the non-breeding season.

The RTHR by HMM (Harmonic Mean Measure) method at 95% isopleths and RTHR by MCP (Minimum Convex Polygon) gave more or less the same home range estimates and the differences were less than 12%. The home range overlaps between the sexes were limited during the non-breeding period but increased during the breeding period.

A male shared a home range with 4 to 5 females during the rutting period. The female home range overlap was considerably less during the breeding and non breeding period as they were non-territorial in nature.

RTHR of the Barking Deer

A total of 3 (Three) Barking Deer radio-tagged in the SRF. The mean RTHR estimates of these animals were compiled during the breeding and non-breeding season (Table-23).

In the SRF home range of Barking Deer varied with sex, season and population density. The radio-tracking home range (RTHR) of both sexes remained more or less the same (60-90 ha) during the non-breeding season (November-February). The home range of the male increased to 140-170 ha during the rutting period, which is about two-fold larger than in the non-breeding season. The home range of the female during the breeding season varied from 90-120 ha which was 1.25 times larger than that of the non~breeding season. The RTHR by the HMM (Harmonic Mean Measure) method at 95% isopleths and RTHR by the MCP (Minimum Convex Polygon) gave more or less the same home range estimates, and the differences were less than 18%. The home range overlaps between sexes were limited during the non-breeding period but increased during the breeding period. A male shared a home range with 2 to 3 females during the rutting period. The female-female home range overlap was considerably less during both the breeding and non-breeding seasons as they were non-territorial in nature. The area traveled during the day (early morning to late evening) was about 22% of the total night traveling distance.

Food Plants and Habits Analysis

Grasslands in the Southern part (Kachikhali, Katka, Nilkamal and Mandarbaria) of the SRF provide important foraging habitats for many native ungulates. Spotted Deer (Cervus axis Erxleben), congregate on that grassland after cutting and burning. Spotted Deer, the most abundant herbivore with estimated densities exceeding 100-150/ sq. km can be is classified as an intermediate feeding on a mixture of browse and grass. Throughout the year the Spotted Deer and Barking Deer are mostly associated with forest habitats, but they do utilize grassland opportunistically when high quality forage is available there (Mishra, 1982; Moe and Wegge, 1994).
Johnsingh and Sankar (1991) recorded the food plants of Spotted Deer and Sambar on Mundanthurai wildlife sanctuary in Tamil Nadu and found the Spotted Deer in total used 162 plant species: 51 trees, 23 shrubs and 29 creepers/climbers, and 59 species of herbs.

Food and food plants of the Spotted Deer and the Barking Deer were recorded between the January,2001 and December,2002. A flora list has been made on the basis of palatability of the plant part like leaves, flower, fruits, bark, shoot, seedling and pnuematophores, etc.,

Recommendation for Prey Species Conservation

The shooting and killing of deer continued until the end of 1972, even though they have been declared as endangered and threatened animals. The Bangladesh Wildlife Preservation Ordinance was promulgated in 1973 and amended in 1974 to become the Bangladesh Wildlife (preservation) (amended) Act 1974. But there are hundreds of forest cases regarding illegal hunting, poaching and shooting of the Spotted Deer and Barking Deer throughout the country. The problem on the protection and preservation of the deer resources in the SRF is execrated by a number of factors that include rampant poaching, uncontrolled gathering of forest products and fishing, and natural disaster like severe storms or cyclones which destroy wildlife habitats and kill a considerable number of wildlife including deer. This problem is very serious in the SRF and coastal areas.

Cervid deer populations generally appear to have considerable resilience. In spite of human pressures with poaching and illegal hunting of the Spotted Deer population in the SRF, the status of the species still not threatened. Fishing and fishermen villages in the southern part of the SRF are also a conservation threat. The past offence records showed that illegal hunters and poachers are mixed with the fishermen, and they used drop net for hunting. The present
study will be the benchmark for future conservation aspects and scientific study. Poaching is a regular practice in the SRF except few places for longtime. Forest Department is trying hard to stop poaching. Especially Ganpara is a well known village near the Patharghata Upazilla under the Barguna district at the southeast corner of the SRF. This village community possesses lethal weapons, illegal fire arms and drop nets for hunting deer. Most of the poaching occur in the monsoon period and they frequently used drop nets. The main mode of the transport was engine boats and trawlers.

The following mitigation measures should be taken for the conservation of the Spotted Deer and the Barking Deer in the SRF:

i) establishment of strict protection management zone to be developed in the potential deer
habitats in which all forms of extractive activities shall be totally banned/prohibited;

ii) strict enforcement of law, rule and regulation with all logistic supports, staffing, fast moving vessels and field equipment with well equipped guards;

iii) construction of killas and sweet water hole at strategic potential deer habitats;

iv) construction of sweet water ponds for deer 011 strategic places;

v) grass cutting should be allowed on permit basis in the all wildlife sanctuary areas;

vi) at the end of grass cutting operation the refuges of the dry plant material should be burnt for rapid regeneration of new shoot and sprouting;

vii) illigal hunting and poaching in the fishermen villages in the southern part of the SRF should be stopped immediately;

viii) frequent entry of the unauthorized water vessels (trawlers, engine boats, speed boats and boats) inside the SRF is to be stopped;

xi) local law and enforcing agencies like police, coastguard and naval forces to be included in the anti-poaching program;

xii) alternative job opportunities for the local poachers communities and fishermen to be created engaging as game guard on master roll basis before the permanent guard are engaged;
xiii) staffing to be increased;

xiv) communication system and equipments supply to be improved;

xv) community based wildlife conservation education program to be developed;

xvi) strengthening anti-poaching program.

xvii) all categories of fire arms in and around the SRF are to withdrawn immediately;

xxi) appropriate training opportunities for the field staffs and administrators to be developed;

xxii) contracting a mobile game guard to patrol the whole hinterland with close contract with local people;

xxvi) development of community participation in conservation activities through community education program.

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Revamping and Conservation of Marsh Crocodile (*Crocodylus palustris* L)-A Critical Ecological Significance and Revolutionary Aspect of Bangladesh

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Abstract

The marsh crocodile is one of the extinct species in natural habitat once found abundant in most of the fresh water rivers of Bangladesh. Considering the regional and global importance of the species, Bangladesh Forest Research Institute (BFRI) emphasized the importance of conservation aspect of this species and recommended to collect the crocodiles from India for captive breeding and subsequent release in the natural habitats.

With a view to study the breeding behavior, forty adult marsh crocodiles (32:8) were collected for Bangabandhu Safari Park (BSP), Dulahazra, Cox's Bazar from Madras Crocodile Bank, India in 2005 by Forest Department in association with BFRI. However the breeding habitat of BSP for crocodiles as observed in subsequent years was found unproductive. Further distribution of this species was made to Dhaka and Chittagong Zoo as well as in the pond of Khan Jahan Ali, Bagherhat in order to find out suitable habitat for its captive breeding. Since then, the performance of breeding was closely observed by BFRI and found 80 newly born crocodiles resulting the total stock up to 120 in Bangladesh. Hatching rate of the species has been recorded more than 80% in the ecological conditions of Bangladesh.

Key words: Bangabandhu safari park , Captive breeding, Crocodile,

Introduction

Bangladesh has a network of numerous rivers and a large coastal area. Historically she has been considered as the home of a large population of crocodiles. Three major species have been reported to exist in the country: saltwater crocodile (*Crocodylous prosus*) of the Sundarbans mangroves, marsh crocodile (*Crocodylous palustris* L) and gharial (Gavialis gangeticus) of the big rivers. There is a good evidence in the history that the marsh crocodile (*Crocodylus palustris* Lesson) was once common and widely distributed in most of the rivers (the Padma, Meghna, Dhaleshori , Karnafully and their affluents) of Bangladesh (Khan, 1987). It has already been extinct in the natural habitat (Whitaker and Daniel, 978). It is an extinct reptilian species of Bangladesh (IUCN,2000). It disappeared from the nature due to over exploitation and habitat loss. Population size of the marsh crocodile in Bangladesh was only 16 (sixteen) in 1992 (Rahman, 1992).The species was only in captivity in the pond of Khan Jahan Ali, Bagerhat and some zoos of Bangladesh (Rahman, 1999). Since then, its population in the captivity was declining very fast and called for artificial breeding to prevent the species extinction.

So, Bangladesh Forest Research Institute (BFRI) developed a crocodile breeding centre (CBC) in 1994 at Chittagong Zoo for breeding marsh crocodile in captivity and observed its breeding success (80%) and the optimistic survival rate from 1995 to 1999. Afterwards, in 2005 another 40 (forty) marsh crocodiles was brought from Madrash crocodile Bank and stocked in Bangabodhu Safari Park, Dhaka Zoo and in the pond of Khan Jahan Ali, Bagerhat. Among the stock locations of the country spontaneous breeding has been seen in Dhaka and Chittagong Zoo that brightened the future of marsh crocodile in Bangladesh. So, constant observation is necessary to adopt further initiatives like subsequent release in the natural habitat, survival capacity and post impacts of release.

Ecological Significance of Crocodile

Crocodiles help the distribution of nutrition from bottom of the river to the surface water.
Thus, they increase producer and fish population, and maintain the aquatic ecosystem. Crocodiles are carnivorous reptiles and often play the role of top-predators in an ecosystem. They often feed on the

large carnivorous fish allowing other fish to grow. They also feed on weak and sick fish and so keep the fish population and water clean by scavenging on dead animal matter they keep the aquatic environment uncontaminated. That's why crocodiles are also termed as 'indicators' of a clean aquatic environment (Rashid, 2003). In many part of India crocodile decline has been concomitant with fish yield decline and /or drastic changes in catch composition (Whitaker, 1978).

Study Areas

Bangabodhu Safari Park at Chokoria in Cox's Bazar, where a large pond is excavated to ensure the species breeding ground and 29 marsh crocodile brought from Madras crocodile Bank stocked there to observe its breeding success. Pond and sand beds waere made at Dhaka Zoo, Mirpur, Dhaka where a total of 6 imported marsh crocodile were kept in captivity.

The pond of Khan Jahan Ali, Bagerhat , Khulna , the ancient captive habitat of the species where were released the rest five of the collected individuals with one previous indigenous male.

BFRI established Crocodile Breeding Centre at Chittagong Zoo, Chittagong where thre were a total of 5 marsh crocodile of previous stock in 2005. Population structure of marsh crocodile stock on the above Park and Zoos in 2005 is shown in Table 1.

Table 1. Population structure (in number) of marsh crocodile in parks and zoos in Bangladesh

Name of the zoo	Year	Male	female	Total
Dhaka Zoo	2005	01	05	6
Dulhazara Safari Parh	2005	06	23	29
Khan Jahan Ali Shrine	2005	02	04	06
Chittagong Zoo	2005	01	02	03
Grand Total		10	34	44

Source: Forest Department; Chittagong Zoo

Material and Methods

Data of spontaneous mating, nesting, breeding and survival rate were collected through observation, questioning the staff who look after the captive marsh crocodile on the above study areas. Special observation was done in late November and December in mating period, March to April in nesting period and late June and July in hatchling period from 2005 -2010. Previous record, literature and relevant information both published
and unpublished were reviewed and assessed.

Results and Discussion

The study reveals that captive breeding and rearing programs in Bangladesh have met with success since stocking in 2005 including the four stock places aimed at captive breeding . It is observed that the marsh crocodile released in the Bangabondhu Safari Park has been making nest and laying eggs from 2006-2010, but hatched no baby crocodile so far as the stock is unproductive. At Chittagong Zoo, it bred spontaneously twice in 2009 and 2010. The hatching rate was 80%. Twenty three among 33 hatchlings that hatched in 2009 survived, where survival rate is 70% and 28 among 36 hatchlings survived that hatched in 2010 amounting to survival rate of about 77%. A total of 53 crocodiles are living in a small space (95'×33'×5') of hatchery made earlier. So they are at the risk of high mortality if not rehabilitated or released in the natural habitat. In Dhaka Zoo, it bred spontaneously in 2008, hatching rate was 100% and 29 hatchlings survived among 31 that hatched in 2008 (survival rate is about 94%). A total of 32 crocodiles are living in small ponds of the Zoo. So they are also at the risk of high mortality due to high stock density and intra conflict causes if it is not rehabilitated or released in the natural habitat. The marsh crocodile released at the pond of saint Khan Jahan Ali, Bagerhat, Khulna has been making nest and laying eggs between 2007-2010, but hatched no baby crocodile, so far as the stock is also unproductive.

Population structure of marsh crocodile in *ex situ* condition in Bangladesh in 2010 is shown in Table 2.

Table 2. Population structure of marsh crocodile in *ex situ* condition in Bangladesh

Name of the zoo	Number of Crocodile	Male	Female	Young 2009	Young 2010
Dhaka Zoo	35	01	05	29	00
Dulhazara Safari Park	26	05	21	00	00
Chittagong Zoo	54	01	02	23	28
Khan Jahan Ali Shrine	05	01	04	00	00
Total	120	08	32	52	28

Conclusion

It is observed that marsh crocodile captive breeding success has been achieved between 2005-2010. This will lead to increase of marsh crocodile population in Bangladesh. This is a significance development in naturally extinct species conservation approaches. Excess numbers of captive-bred marsh crocodile at high stock density now reside in captivity, due to lack of suitable release initiatives in the natural habitat. Hence, it is high time to take necessary steps for subsequent release of marsh crocodile in the selected natural habitats.

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Congress Proceedings

Theme-5:

Research and education focusing on resource assesment, carbon inventory, collaborative and co-management

Eucalypts in Bangladesh – Does Research Findings Support the Environmental Issues of Eucalypts Planting?

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Abstract

Eucalyptus citriodora was introduced for the first time in Bangladesh probably in the 1930's in the eastern part by the tea planters as ornamental trees. The first trial of *Eucalyptus* was initiated by Bangladesh Forest Research Institute (BFRI) in 1965, and seedlings were raised and planted in Rasulpur (Mymensingh) and Hathazari (Chittagong). But the trial was closed down with inadequate information. In eighties, *E. camaldulensis, E. tereticornis,* and *E. brassiana* were found suitable in the climatic and edaphic conditions of Bangladesh from the trials of 84 seedlots of 12 species of *Eucalyptus* imported through CSIRO from different parts of Australia. Following some other trials, *E. camaldulensis* -Petford provenance was found suitable and promising for large scale plantation programs in the country. But, the issues of environmental degradation due to *Eucalyptus* planting that arose from different sources remain an unanswered question. The Government has a ban on further planting of Eucalypts in Forest Department's land. However, people are still planting eucalypts in their homesteads, marginal and fallow lands for immediate return from plantations. The present paper briefly discusses the research findings of different trials of *Eucalyptus* and analyses the prospects and problems for future eucalypt plantations in Bangladesh.

Key word: Allelopathic effect Coppice, Elimination trial, *Eucalyptus*, Homesteads, Provenance trial

Eucalypts in Forest Plantations of Bangladesh

Selection of Eucalypts through elimination and provenance trials by BFRI

In Bangladesh, like many other developing countries, Eucalypts were introduced in the 19th century as ornamental plants to decorate parks, road sides, or for collection in botanical gardens. Probably in the 1930's, *Eucalyptus citriodora* was introduced in the eastern part of Bangladesh by the tea planters as ornamental trees (Davidson and Das, 1985). Later on, it spread throughout the country in haphazard manner by botanists, foresters, gardeners and tree planters (Hassan, 1994). The first trial of *Eucalyptus* was initiated by Bangladesh Forest Research Institute (BFRI) in 1965, and seedlings were raised and planted in Rasulpur (Mymensingh) and Hathazari (Chittagong). But of the trial was closed down with incomplete results and inadequate information (Rashid, 1969).

Bangladesh Forest Research Institute imported 84 seedlots (provenances) of 12 species of *Eucalyptus* from different parts of Australia through CSIRO in 1977-78. Among those, only three species of *Eucalyptus,* viz. *E. camaldulensis, E. tereticornis,* and *E. brassiana* were found suitable in the climatic and edaphic conditions of Bangladesh (Davidson and Das, 1985; Hossain *et al.*, 1989) through elimination trials. From the view point of coppicing ability of different provenances, *E. camaldulences, E. tereticornis* and *E. brassiana* showed high coppicing ability and *E. camaldulensis* produced the highest coppice yield (Hossain *et al.*, 1994). Some other provenance trials of *E. brassiana* (12 provenances) and E. *urophylla* (12 provenances) were laid out during 1983 to select the superior provenances for Bangladesh (Islam *et al.*, 1997). However, the seeds of a total of 218 provenances of 37 species of *Eucalyptus* were introduced in Bangladesh (Table 1) from which finally *E. camaldulensis*-Petford-1 was found suitable, promising and recommended for large scale plantation programs (Davidson and Das, 1985).

Table 1. Eucalyptus species/ provenances introduced in Bangladesh for experimental plantations

Species	Provenances No.	Species	Provenances No.
Eucalyptus acmenioides	8	*Eucalyptus moluccana*	4
Eucalyptus botryoides	5	*Eucalyptus obliqua*	1
Eucalyptus brassiana	18	*Eucalyptus occidentalis*	1
Eucalyptus camaldulensis	25	*Eucalyptus pellita*	3
Eucalyptus citriodora	10	*Eucalyptus pilularis*	5
Eucalyptus cloeziana	16	*Eucalyptus polybractea*	1
Eucalyptus crebra	3	*Eucalyptus propinqua*	1
Eucalyptus deglupta	1	*Eucalyptus radiata*	1
Eucalyptus delegatensis	1	*Eucalyptus resinifera*	7
Eucalyptus dives	1	*Eucalyptus robusta*	15
Eucalyptus drepanophylla	1	*Eucalyptus saligna*	18
Eucalyptus exserta	5	*Eucalyptus smithii*	1
Eucalyptus fibrosa	1	*Eucalyptus tereticornis*	12
Eucalyptus globulus	9	*Eucalyptus tesselaris*	1
Eucalyptus grandis	11	*Eucalyptus tetrodonta*	1
Eucalyptus macrorhyncha	1	*Eucalyptus torelliana*	2
Eucalyptus maculata	9	*Eucalyptus urophylla*	12
Eucalyptus microcorys	3	*Eucalyptus youmanii*	1
Eucalyptus microtheca	3	*Total- 37 species*	218 prov.

Eucalypt planting by Forest Department and Individuals

The suitability of *Eucalyptus* was described by Banik and Alam (1995) at Sitakunda hilly regions of Chittagong Forest Division. Bhuiyan (1995) reported the potential of *Eucalyptus* grown in hilly regions of Chittagong as well as North Bengal agroforestry plantation and the degraded sal forest areas of central zone. The expected yield from eucalypt plantations in Bangladesh was 19.00 m^3 $ha^{-1}yr^{-1}$, though the performance at the silvicultural research station was comparatively higher (Davidson and Das, 1985). Recent study showed that the actual yield per ha per year was only half of the expectations (Hassan, 1994). However, Davidson *et al.* (1985a, b, c and d) determined the volume table, biomass production for young Eucalypts in Bangladesh. Some plants, particularly in the hill forest areas of Chittagong and Cox's Bazar looked poor and erratic even within the same plantations throughout the rotation cycle. Origin of quality seed sources was probably the reason of this poor performance, is considered essential for the optimum growth of the species.

In Bangladesh, *Eucalyptus camaldulensis* were planted by the Forest Department and are being planted by private sectors owing to its proven capacity to supply fast grown timber for a wide variety of end uses. By 1995, some 12,000 ha eucalypt plantations were raised in the forest land besides scattered plantings of unknown hectare in the farm lands, homegardens, strip plantations and ornamental plantings throughout the country (Bhuiyan, 1995).

Growth of Eucalypts in Plantation Forests of Bangladesh

Three species of *Eucalyptus*, e.g., *E. camaldulensis, E. tereticornis* and *E. brassiana* proved superior to over 36 other Eucalypt species tried in Bangladesh (Davidson and Das, 1985). With these species, Petford, Mt. Garnet and Coen provenances respectively are the best ones. After 5 years of growth, mean annual increment per ha ranged from 11.7 to 95.6 m^3 for Petford, 4.9 to 66.6 m^3 for Mt. Garnet and 7.3 to 34.2 m^3 for Coen. Latif (1988), Latif and Islam (2004), Latif *et al.* (1983, 1985a, 1985b, 1999) determined the biomass, volume and height diameter relations of Eucalypts in Bangladesh. MAI in m^3 h^{-1} yr^{-1} of three superior *Eucalyptus* species at different research stations at the age of 5-6 years are shown in Table 2, which was exceptionally promising in early growth and development.

Table 2. Growth performance of 3 major *Eucalyptus* species (5 - 6 year old) in different experiment stations of Bangladesh Forest Research Institute, Bangladesh (Davidson and Das, 1985)

Locality	Species	Survival %	ht (m)	dbh (cm)	MAI ($m^3 h^{-1} y^{-1}$)
Lawachara	*E.camaldulensis*	56	8.8	4.8	17.1
Charaljani	*E.camaldulensis*	66	13.2	11.9	95.6
Charkai	*E.camaldulensis*	84	7.9	5.6	23.4
Hathazari	*E.camaldulensis*	89	9.5	5.9	28.9
Keochia	*E.camaldulensis*	60	7.5	5.7	13.9
Lawachara	*E. tereticornis*	59	5.7	4.0	9.1
Charaljani	*E. tereticornis*	60	13.0	10.1	67.3
Charkai	*E. tereticornis*	57	8.0	5.7	18.4
Hathazari	*E. tereticornis*	59	9.8	6.9	24.7
Lawachara	*E. brassiana*	61	8.7	4.9	15.3
Charaljani	*E. brassiana*	56	10.6	7.6	34.2
Charkai	*E. brassiana*	76	8.1	6.0	16.3
Hathazari	*E. brassiana*	76	9.7	5.9	23.9
Keochia	*E. brassiana*	81	6.2	4.5	11.7

Similarly trial plantation in Madhupur in Tangail showed the superiority (Table 3) of eucalypts in comparison to some other species (Hossain et al., 1995).

Table 3. Survival percentage, mean height (m) and mean dbh (cm) in a species trial at the age of 5.5 years

Name of the species	Survival %	Mean ht. (m)	Mean dbh (cm)
Acacia auriculiformis	82a	9.41a	9.1b
A. mangium	52bc	10.40a	11.5a
Albizia procera	-	-	-
Eucalyptus camaldulensis	83a	9.58a	7.0c
Prosopis juliflora	-	-	-
Artocarpus chaplasha	-	-	-
Chukrasia tabularis	06b	6.74b	6.8c
Dipterocarpus turbinatus	37c	3.72c	4.1b
Xylia kerrii	57b	7.09b	7.2c
Syzygium grande	59b	3.96c	4.1b

Another trial of 12 provenances of 4 *Eucalyptus* species at Chittagong University campus showed the initial growth of 4 Eucalyptus species (Hossain et al., 1996) where *Eucalyptus camaldulensis*, *E. tereticornis* and *E. urophylla* appeared as promising species (Table 4).

Table 4. *Eucalyptus* species-provenances seed lot number, origin, survival %, height and collar diameter at 1.5 years after out planting at Chittagong University campus (Hossain *et al.,* 1996).

Species, Seed lot No. and Origin	Survival %	Height (cm)	Collar diameter (cm)
E. camaldulensis- 12355, Western Australia	81ab*	194.8 c	2.66 ab
E.camaldulensis- 15026, Victoria	56 c	197.0 bc	1.86 d
E. camaldulensis- 18604, Queensland	87 a	218.1 ab	2.73 ab
E. tereticornis- 14846, Queensland	65 c	175.0 e	2.17 c
E. tereticornis- 17864, Queensland	84 a	219.6 a	2.69 ab
E. tereticornis- 18760, Queensland	37 d	175.4d	2.15 c
E. Pellita- 18149, Queensland	81 ab	195.1 c	2.40 bc
E. pellita- 18749, Queensland	69 bc	146.6 f	2.16 c
E. pellita- 18759, Northern territory	75 ab	187.5 c	2.47 bc
E. urophylla- 13828, Indonesia	76 ab	175.2 de	2.91 a
E.urophylla- 17836, Indonesia	69 bc	182.4 cd	2.64 ab
E. urophylla- 18095, Indonesia	75 ab	156.1 ef	2.61 ab

* Means denoted by the same letter(s) are not significantly different, Duncans Multiple Range Test (DMRT)

Similarly, another trial plantation was established with 15 multipurpose tree species of both exotic and indigenous (*Acacia auriculiformis, Alstonia scholaris, Anthocephalus chinensis, Cassia nodusa, Casuarina equisetifolia, Chickrasia tabularis, Dalbergia sissoo, Eucalyptus camaldulensis, Gmelina arborea, Melaleuca leucadendron, Melia azedarach, Mesua ferrea, Pinus caribaea, Polyalthea longifolia* and *Terminalia arjuna*) in 1994 with a view to find out suitable species for degraded hill areas of this region.These plantation species were assessed for survival and growth (Table 5) at the age of 7 years (Hossain and Khan, 2005).

Analysis of data showed that the survival percentage was highest (100%) for Melaleuca leucadendron, followed by Eucalyptus camaldulensis (98%), Acacia auriculiformis (97%) and Gmelina arborea (96%). Similarly, considering the growth parameters (dbh, merchantable height, total height), A. auriculiformis, E. camaldulensis and M. leucadendron were superior in comparison to other species (Table 5). The height and diameter growth of A. auriculiformis (13.2 m and 16.6 cm respectively) and E. camaldulensis (14.1 m and 14.6cm respectively) of this study closely support the findings of Ahmed (1990) and Ara et al. (1989). It was found that some exotic species grow better than the tested indigenous species. A. auriculiformis and E. camaldulensis were also found promising in the same area (Osman et al., 1992) and in Tangail (Hossain et al., 1995). These MPTS may be exploited to rejuvenate the degraded sites in the south-eastern hilly areas of Bangladesh.

Table 5. Comparative growth performance of 15 multipurpose tree species in the degraded hill areas of Chittagong University campus

Species	Growth parameters			
	Dbh (cm)	Merchantable ht. (m)	Total height (m)	Survival (%)
Acacia auriculiformis	16.6 a*	9.5 ab	13.2 ab	97 ± 2
Alstonia scholaris	9.5 c	5.4 bcd	6.5 cd	78 ± 13

Anthocephalus chinensis	14.2 ab	4.6 cd	7.5 bcd	73 ± 14
Cassia nodusa	12.1 abc	6.3 abcd	9.8 abcd	91 ± 7
Casuarina equisetifolia	15.3 ab	9.6 ab	13.6 ab	92 ± 6
Chickrasia tabularis	12.5 abc	7.2 abc	11.3 abc	86 ± 9
Dalbergia sissoo	11.8 bc	7.8 abc	11.2 abc	64 ± 18
Eucalyptus camaldulensis	**14.6 ab**	**10.2 a**	**14.1 a**	**98 ± 2**
Gmelina arborea	15.4 ab	8.5 ab	12.2 abc	96 ± 3
Melaleuca leucadendron	15.6 a	10.4 a	14.7 a	100 ± 0
Melia azedarach	12.7 abc	5.6 bcd	9.4 abcd	84 ± 12
Mesua ferrea	8.8 c	3.5 d	5.5	80 ± 14
Pinus caribaea	11.7 bc	5.4 bcd	7.2 bcd	82 ± 12
Polyalthea longifolia	13.5 abc	3.2 d	5.8 d	74 ± 17
Terminalia arjuna	11.2 bc	6.7 abcd	9.2 bcd	87 ± 10

* Means followed by the same letter (s) are not significantly different at $P<0.05$, Duncan's Multiple Range Test (DMRT)

Coppicing ability of Eucalypts

Eucalypts possesses excellent coppicing ability, and first few generations are more productive than the seedling crops (Latif *et al.,* 1985c). A comparative study of the coppicing ability of different provenances of *E. camaldulensis, E. tereticornis* and *E. brassiana* in Charaljani Silvicultural Research Station at Madhpur in Tangail showed that their coppicing ability was very high (Table 6) and *E. camaldulensis* produces highest coppice yield (Hossain *et al.,* 1994).

Table 6. *Eucalyptus* coppice crops at Charaljani Silvicultural Research Station at Madhupur in Tangail at the age of four year (Hossain *et al.,* 1994)

Species	Stumps Coppicing (%)	Coppice stocks (stems ha^{-1})	Height (m)	DBH (cm)	Stem volume over bark (m^3 ha^{-1} yr^{-1}
E.camaldulensis	95	6733	11.5	11	86.0
E. tereticornis	95	5371	10.9	10.2	59.5
E. brassiana	*95*	5432	8.7	7.5	30.8

Controversy and Criticisms of *Eucalypts* Grown as Plantation Species

Though eucalypts have become an important industrial species in many countries, debate still remains about their effect on the environment (Shiva and Bandyopadhyay, 1983; Karanth and Singh, 1983). However, the current expansion rate of eucalypt around the world shows not all countries embarking in large scale plantations are convinced by concerns raised in India.

This controversy has resulted in confusion about the suitability of eucalypt plantations in Bangladesh. Research results suggest that some provenances of several species of the genus are suitable for the country in terms of growth and site adaptability. As a result, the country has undertaken large scale eucalypt planting program and to date about 12,500 ha have been brought under plantations to supply domestic fuelwood. Research projects have under-taken to verify objections under Bangladesh conditions revealed that the effects in Bangladesh are the same as those in India. However, confusion and negative attitude towards eucalypt planting has developed among policy makers, politicians and elites. The news media and environmentalists publish articles on the possible bad effect of these species in Bangladesh and neighboring countries. There is a directive from the government not to plant these species further. Some established plantations were also felled or cleared off.

Eucalyptus is blamed for more water absorption than other species, to reduce soil fertility, leading to soil erosion, harmful for wildlife and reduces native understorey vegetation diversity. But, the criticisms and blames are not supported by sufficient scientific research findings. Contrary, the leading forestry, agroforestry experts and scientists concluded that eucalypts may be a suitable species for afforestation and reforestation in denuded areas, marginal lands, roadside plantations and agroforestry programs (Amin *et al.*, 1995; Hossain *et al.,* 1997).

However, the mass of rural people, who plant eucalypt on their homesteads have not shown any negative reaction to these environmental whims. These people participate in tree planting in small rural woodlots, agroforests and marginal land in rural areas (Ahmed *et al.*, 2007b). An early return of a handsome volume of wood is very important to them. They are in crucial need of fuelwood, poles and posts for domestic uses (Ahmed and Akhter, 1995). So, a sharp divergence of opinion exists between different groups of people in society. Therefore there are some findings both in favor and against of *Eucalyptus* plantings in Bangladesh. Some of the controversies are discussed below:

Excessive water consumption

It is claimed that Eucalypts consume more water in comparison with other species, which results into drying of site and converting the site as unsuitable for the growth of other crops. Eucalypts are known to be highly water demanding mainly because of their rapid growth (Davidson, 1995). Though the water consumption efficiency of eucalypts is much higher in comparison to many native species, t Eucalypts consume less water based on unit weight of dry matter produced (Chaturvedi, 1983; Tiwari and Mathur 1983). On the contrary, Eucalypts actually economise soil water storage because of having minimum evapo-transpiration surface, waxy leaves, stems and fewer lenticels (Karschon and Heth, 1967; Banerjee, 1972). Dabral (1970) conducted a study on potted seedlings of several forest species (*Eucalyptus citriodora, Dalbergia* sp., *Pinus* sp., and *Populus* sp.) and concluded that Eucalypt was producing more biomass per unit weight of water consumed, though its total water consumption was greater than other genera. A nursery experiment in Chittagong University also supports the same findings.

Depletion of Soil Nutrients

Eucalyptus is frequently blamed for its adverse ecological effects in contribution to depletion of soil nutrients. However, the fact is that it is impossible to provide a full introduction of Eucalypt's contribution to soils and the nutrient cycle before getting experimental results on the effects of *Eucalyptus* to the soils. A substantial enrichment of nutrients in the *Eucalyptus* litters is reported (George 1978, 1979, 1982; Sharma *et al.,* 1984). Davidson (1973) reported that *Eucalyptus* can accumulate nutrients in top soil from the deeper horizons through nutrient pumping mechanism.

Aryal *et al.,* (1999) studied the effect of mixed planting of *Eucalyptus camaldulensis* and *Albizia procera* on the soil fertility compared to their mono-plantation in Bangladesh. It wasfound that both the species performed well in mixed condition compared to the mono-plantations. Soil in mixed plantation showed better nutrient contents compared to that in single plantations. The authors suggested mixed plantation for improving soil properties. However, based on propaganda excluding a high yielding species from plantation program would not be a wise decision for any government while doing large scale mono-plantation with Eucalypt will also be a symbol of unwise vision.

Depletion of Ground Gegetation

Study on the undergrowth of *Eucalyptus* plantations in comparison with some non-eucalypts (*Acacia*, chapalish, mahgony, mixed plantation) did not reflect any allelopathic effects of eucalypts in Chittagong University Campus and Madhupur sal forest area (Hossain *et al.*, 1998). Undergrowth vegetation however, depends on the previous vegetation and cultural practices of the plantation management. Increase or decrease of biodiversity in Eucalypt plantation is a controversial issue, and this is also applicable for any other plantation species, as the plantations starts with slash and burning of sites that accelerates the erosion of genetic resources. However, occasionally nesting and honey comb are seen in Eucalypt plantations. The number and oven-dry weight of ground vegetation in some eucalypt and non-eucalypt plantations in Bangladesh showed that eucalypt plantations support luxurious ground vegetation in comparison to other species (Table 7).

Table 7. The number of undergrowth species and oven dry weight (kg/ha) in different *E. camaldulensis* plantations at Madhupur sal forest area

Plantation species	Plantation year	Age (year)	No of species represents	Oven-dry weight (kg ha^{-1})
Eucalyptus camaldulensis	1978	16	18	398
E. camaldulensis	1982	12	16	305
Acacia auriculiformis	1985	9	18	439
E. camaldulensis	1988	6	19	617
E. camaldulensis	1989	5	9	189
Cassia siamea	1989	5	15	275
Xylia dolabriformis	1989	5	18	395

Allelopathic Effects of Eucalypts

All species of *Eucalyptus* have foliar oil glands that are rich in essential oils, principally terpeneoids; typically 1 to 5 percent of the fresh weight is essential oils (Baker and Smith, 1920; Guenther, 1950). The leaves contain diverse phenolic compounds (Hillis, 1967; Hillis and Brown, 1984). Several researchers (Ahmed *et al.*, 1984; Igoanugo 1986, 1987; Bowman and Kirkaptric, 1986 and Lovett *et al.*, 1989) have contributed to studies of allelopathy in *Eucalyptus* species. From an experiment in plantation mixed stands of *Eucalyptus citridora*, *E. camaldulensis*, and *E. grandifolia* in Nigeria, Igoanugo (1988) found that beans can be incompatible with *Eucalyptus*, while maize and sorghum may be compatible with eucalypts for agro-silvicultural practices. May and Ash (1990) noted that various *Eucalyptus* species could yield allelopathic chemicals that may be effective in suppressing under-story vegetation.

Allelopathic implications of *Eucalyptus* on other crops

Considering the issues and debate of allelopathic effects of Eucalypts on associate crops, a series of experiments were carried out in the laboratory and nursery of the Institute of Forestry and Environmental Sciences, Chittagong University to assess and confirm the allelopathic effects of *Eucalyptus camaldulensis* on agricultural crops and forest crops (Ahmed *et al.*, 2004). The series of experiments along with their outcomes was compared with control treatments (Ahmed *et al.*, 2007a; 2008).

In all the experiments, allelopathic effects of eucalypts were seen but the effects were diminished in field conditions rather than in controlled laboratory and nursery trials. Receptor crops also respond variably which may conclude that the effect in field conditions depends on many environmental factors.

Social Implications of Planting Eucalypts in Bangladesh

The future of eucalypts in Bangladesh depends on the acceptability of the species in society among different groups of people. To indicate the degree of acceptability, it is relevant to understand how people react with participatory forestry practices especially in woodlot and agroforestry plantations, where eucalypts are a major component of the systems. Peoples' participation is so far, encouraging in such plantation activity. In a social study, it was found that the average participants in woodlot and agroforestry plantations are about one hectare per family and peoples' participation is increasing day by day. In

Northern Bangladesh, agroforestry practice has got momentum with mass people's active participation (Bhuiyan, 1995; Ahmed, 2001).

Social surveys can be an indicator of social acceptance of eucalypts. Chowdhury (1993) interviewed people living in and near the forest and plantation areas to understand their preference in choosing species. Among the interviewee, 80% favoured short rotation species, 15% favoured combination of short and medium rotation species, whereas less than 2% respondents favoured long rotation species; the rest did not have any choice or they did not understand about the choice. However, none mentioned fuelwood as the first priority but the majority advocated for cash returns. It was found that the majority prefer *E. camaldulensis* and *A. auriculiformis* for immediate returns from plantations. These species are significantly contributing to the forest products in the society.

In Bangladesh trees are planted around homesteads as a part of whole farm systems to produce food, fodder, fuel, timber and organic matter and supports other functions like wind break and shade. Agroforestry practices in both encroached forestland and homestead areas have, therefore, emerged as a pressing national land use, demanding for tree production along with crop and other areas (Bhuiya *et al.,* 2001). In the present context of Bangladesh, agroforestry practices are appropriate for long-term benefits. A unique combination of different species of fruits, timber and biomass yielding trees can generate high amount of earnings for the farmers of Bangladesh (Abedin *et al.,* 1990; Chowdhury and Sattar, 1993). In both tropical and sub-tropical countries, *Eucalyptus* as an agroforestry component tree has been used for a long time. Not only in Bangladesh, are Eucalypts popularly grown in India and in China.

People's Attitude about Eucalypts in Sitakund Upazila

It was observed that *Eucalyptus* species have been extensively planted in the homesteads, roadsides, fallow lands and agricultural fields of Sitakunda upazilla, Chittagong (Ahmed *et al.*, 2007b), and a survey with the growers support the planting of eucalypts because of the need of less care and management of the crops and early return in comparison to other crops.

Mono-plantation of Eucalyptus

Mono-plantation of *Eucalyptus* species were raised on the homestead fallow lands. 100 % of the respondents informed that it is the abandoned part of the homestead where water logged exists for long time. But, the site is not harmful for *Eucalyptus* trees as the species are growing well.

Mixed Homestead Plantations including Eucalypts

Eucalyptus was seen randomly growing with other species in home gardens in the study area of Sitakunda upazilla, Chittagong. The result showed that 67% of the respondents planted it in the border of the homestead, while 18% planted it with other species in the bunds of the ponds and remaining 12 % of the respondents planted it in a mixed plantation with other species.

Effect of Eucalyptus on Associated Crops

Eucalyptus was raised as an agroforestry component in agricultural field and other fallow lands with an aim of getting more economic return. The main agricultural crops grown were bean and rice. Most farmers reported the depressing effect of *Eucalyptus* on rice yield. However, there was variation of its effect with ages as they observed (Table 8). Production of paddy progressively declined with the increasing age of *Eucalyptus* plantations. Plants of above 10-year old had the most adverse effect on the yield as it caused almost 15% reductions on an average under its canopy. The farmers also opined that this is also applicable for other tree species; even the situation is severe with *Albizia saman* (rain tree) because of its wide spreading canopy.

Table 8. Reduction of paddy yield by *Eucalyptus* in agroforestry system as stated by the respondents in the study area

Species with age	Reduction of yield in comparison to control
Eucalyptus (>10 yrs old)	15%
Eucalyptus (7-10 yrs old)	12%
Eucalyptus (5-7 yrs old)	8%
Eucalyptus (<5 yrs old)	negligible

In contrast, plants below 5 years old showed insignificant or very little effect on the crop yield. However, this is a rough estimate made by the farmers and they did not bother for the adverse effect, as they believed that the profit from the plant (Eucalypts) was more than the loss. In regard of bean and eucalyptus association, no negative effect was reported; rather the farmers viewed it as positive as the crops need support. In this case, they need not care for extra maintenance.

Farmers view on Allelopathic Effect of Eucalyptus

Regarding the investigation on allelopathic effect of *Eucalyptus,* most of the farmers (92%) said that they did not know any allelopathic effect of it on other crops. However, they opined that it had suppressive effect caused by shade and root system. The remaining 8% said that it might have poisonous effect, which is insignificant both in the field and homestead.

Reasons of Planting Eucalyptus

The farmers in the study area of Sitakunda upazilla, Chittagong of Sitakunda upazilla, Chittagong favor the planting of eucalyptus for the adaptability of the species as it grows well both in dry and wet sites, followed by its fast growing characteristics. The other reasons were that the species is not palatable, excellent fuelwood productivity, ornamental and less shade casting characteristics of the plant.

Conclusions

Eucalypts are the only species that were introduced in Bangladesh after elimination, provenance and growth trials. Though *Eucalyptus* is conspicuously successful in many countries, some governments, organizations and individuals have raised concerns about alleged adverse impacts of these species. The concerns about the impacts of *Eucalyptus* are depletion of water resources, deterioration of soil and wildlife, allelopathic effects, etc. However, some of the criticisms in Bangladesh have been caused by disappointed expectations rather than by ecological effects. *Eucalyptus* has often been heralded as wonder fast grown tree species which will bring immediate solutions to local wood fuel crisis and reduce erosion problems. When these ambitious expectations are followed by poor plantings, because of wrong species or seed sources or on the wrong species-site matching, than the local peoples or the Forest Department are disappointed with the poor field performances and returns.

Bangladesh has an immense scope and opportunity in extending plantation forests in barren, marginal and degraded forest areas. Whereas, Bangladesh is importing timber from more than 23 countries and the trend is increasing day by day with the hard earning foreign currencies. Huge population in Bangladesh is unemployed and if they are involved in plantation programs in available lands, the environment of the country will improve and the gap between demand and supply of forest produces shall be minimized. The controversies of environmental degradation by planting eucalypts are not strongly supported by scientific findings and professional experiences. Allelopathic effects pronounced in controlled laboratory conditions must not be projected in the fields, since field conditions are regulated by many environmental factors, that dilutes the inhibitory effects of phenolic compounds.

Social survey also supports the planting programs for immediate return from the plantations. However, native species must be given priority for plantation programs, but if there is no suitable alternative to meet the immediate requirements, exotics like eucalypts may be planted in limited areas. Instead of mono-plantation, mix plantations must be given priority, so that multiproduct may be available from the plantations. Mix plantations are able to solve many controversies of environmental issues of mono-plantations.

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State of Forest Genetic Resources Conservation and Management in Bangladesh

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Abstract

Genetic resources including forest genetic resources are among the most valuable assets that a country possesses. Assessment of forest genetic resources provides a basis for planning the conservation, sustainable use and development of forest genetic resources at the national level and contributes to regional and global actions. Preparation of the state of forest genetic resources provides an opportunity to engage and stimulate the interests of wide range of stakeholders to reflect on these immensely valuable resources of the country, on what has been accomplished and what remains to be done and to identify the needs required to achieve their conservation and sustainable use. It is apparent that about 50% of the forest area is covered by trees and only 22.9% of the forest area has more than 70% of tree cover. Large areas of forest have been deforested and degraded owing mainly to such reasons as illegal logging by organized gangsters, organised encroachments and conversion of forest lands for agriculture, industry, construction of roads and homestead purposes. High population pressure of the country and involvement of influential people of the society are liable to impose tremendous threats to government efforts to conserve public forests.

In this paper different forest types in Bangladesh are described . These are tropical wet evergreen forest, tropical semi-evergreen forest, tropical moist deciduous forest, tidal swamp forest, tropical fresh water swamp forest and littoral forest. The main plant species occurring in these forests are noted. Bangladesh possesses a good species diversity of both flora and fauna. Although rich in diversity the population size of most of the species has remarkably declined. High population pressure, clearing of forests, draining and filling up of wetlands, introduction of exotic species, and introduction of improved genotypes, pests and diseases , improper silvicultural techniques and management, and lack of public awareness are some of the major threats to Forest Genetic Resources (FGR). Poverty and the attitude of the people towards exploitation of natural resources as free goods also contribute to the loss of germplasm in the country. It was observed that 2% of labour force of the country is engaged in forestry activities. The paper has identified priority species in the Forest Department plantation program. In conclusion, the study emphasised on the critical need to develop coordinated efforts to conserve and manage FGR.

Key words: Bio-diversity, Conservation, Forest genetic resources, Management

Introduction

Bangladesh is situated in the north – eastern part of South Asia between 20°34′ and 26°38′ north latitude and 88°01′ and 92°41′ east longitude. Having border with India on the west, the north and the north-east and Myanmar on the south-east and the Bay of Bengal on the South, Bangladesh is one of the most populous countries in the globe. About 146.6 million people live within an area of 147.57 thousand km^2 in this country, the density of population per km^2 being 993 (BBS, 2009). Bangladesh has a subtropical monsoon climate with three prominent seasons in the year; summer monsoon and winter. In winter minimum temperature ranges from 7-13^{0}C to a maximum of 24-31^{0}C, while summer temperature various from 36^{0}C to 41^{0}C. The mean annual rainfall ranges from 1400 mm. to 4340 mm. (BBS, 2008) and the monsoon (June to October) accounts for 80% of the total rainfall. Except the hill ranges in the north-east and south - east, majority area of the country is low-lying floodplain.

Forest Genetic Resources can be defined as the economic, scientific of social values of the heritable materials contained within and between species. They are associated with different levels of natural diversity from ecosystem to species, populations, individuals and genes. Conservation of forest genetic resources means managing forest genetic resources for human use to yield the greatest sustainable benefits for present generations, while maintaining their potential to meet the needs and aspirations of future generations (FAO 1993).

Genetic resources including forest genetic resources are among the most valuable assets that a country possesses. Assessment of forest genetic resources provides a basis for planning the conservation, sustainable use and development of forest genetic resources at the national level and contributes to regional and global actions. Preparation of the state of forest genetic resources provides an opportunity to engage and stimulate the interests of wide range of stakeholders to reflect on these immensely valuable resources of the country, on what has been accomplished and what remains to be done and to identify the needs required to achieve their conservation and sustainable use. Hence it is necessary to carefully and comprehensively assess

- the state of forest genetic resources in the country and their role in production systems, including associated bio-diversity and the factors driving changes;
- the current contribution of genetic resources in forest development and food and agriculture;
- how the contribution of forest genetic resources to sustainable forest development and food and agriculture can be enhanced, identifying opportunities and obstacles, as well as strategies to realize the opportunities and overcome those obstacles;
- needs and priorities for capacity building to enable the conservation, sustainable use and development of forest genetic resources.

Forest Resources

Area and Distribution

The total area of Bangladesh is 14.757 million hectares of which 2.25 million hectares are forests which makes up 15.24% of the total land of the country. The forest area includes 1.52 million hectares of government forest managed by the Forest Department and 0.73 million hectares of Unclassified State Forest (USF). The Unclassified State Forests are controlled by the Deputy Commissioners and mainly situated in Chittagong Hill Tracts.

The Forest Department managed forests may be classified into Hill Forest, Natural Mangrove Forest, Mangrove Plantation Forest and Plain Land Sal Forest (Table 1; Fig.1.).

Table 1. Distribution of Forest Department Managed Forest

Category of Forest	Area (m.ha.)	% with respect ot country's area
Hill Forest	0.67	4.540
Natural Mangrove Forest	0.60	4.066
Mangrove Plantation Forest	0.13	0.881
Plain Land Sal Forest	0.12	0.813
Total	1.52	10.30

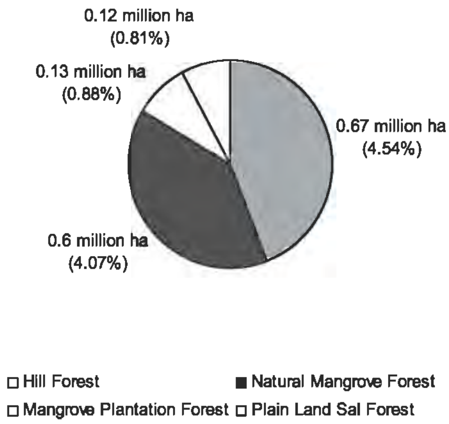

Fig. 1. Distribution of Forest Department Managed Forest

Hill Forests are mainly distributed in the north-eastern districts of Sylhet, Sunamgonj, Moulvi Bazar and Hobigonj and in the south-eastern districts of Chittagong, Cox's Bazar, Rangamati, Khagrachari and Bandarban. The major hill reserve forests are Kassalong (including Mainee Head Water Reserve), Rainkheong, Sitapahar, Sangu, Matamuhuri, Chittagong, Cox'Bazar and Sylhet reserve forests. Sitapahar was the first forest reserve in the hills and was declared as such in 1875. Hill forests make up 44% of the forest department managed forests of the country. The Unclassified State Forests (USF) are under the control of the Deputy Commissioners and are mainly situated in the hill districts of Rangamati, Khagrachari and Bandarban. A small portion of USF is also found in Sylhet. Tea garden is another category which needs mention where a substantial area is covered with forest. Approximately, 2800 hectares of land is covered with forest trees in the tea gardens and these are distributed in the districts of Moulvi Bazar, Sylhet, Hobigonj, Chittagong and Rangamati.

Sundarbans the world's largest contiguous tract of mangrove forest in the delta of the river Ganges and the Bramhaputra lies in the south-western corner of Bangladesh. Two-third portion of Sundarbans falls in Bangladesh and one-third in India. The area of Sundarbans that falls in Bangladesh measures 601,700 hectares situated in the districts of Khulna, Bagerhat and Satkhira. The Sundarbans represents nearly half (40%) of the remaining forests of Bangladesh and is dominated by halophytic tree species.

Forest Department started a coastal afforestation program in early nineteen-sixties and by far about 175,000 hectares of mangrove plantation has been raised which is strected from Cox'Bazar in the SE through Barguna in the SW in the coastline. Coastal Plantation Forests have been established in the districts of Cox's Bazar, Chittagong, Feni, Noakhali, Laximipur, Bhola, Barisal, Patuakhali, Perojpur and Borguna.

The Inland Sal Forests are mainly distributed in the districts of Gazipur, Mymensingh, and Tangail. Small patches of sal forest are also available in the districts of Sherpur, Netrakona, Dinajpur, Rangpur, Naogaon and Comilla. The total area of sal forest is 0.12 million hectares and accounts for 0.81% of total area of the country.

According to a most recent report (Altrell *et al.*, 2007) on National Forest and Tree Resources Assessment (NFA) conducted jointly by Food and Agriculture Organization (FAO), Bangladesh Space Research and Remote Sensing Organization (SPARRSO) and Bangladesh Forest Department during the period from 2005 to 2007 an area of 1.442 million hectares of the country is covered by forest which is 9.77 percent of the total area of the country and distributed (Table 2)

Table 2. Different Land Use Classes (LUC) designated as 'Forest' by NFA (2007) report

Land use classes			Area (000')ha
Level-1	Level-2	Level-3	
Forest 1,442	Natural Forest 1,204	Hill forest	551
		Sal forest	34
		Mangrove Forest	436
		Bamboo or Mixed Bamboo/ broad level forest	184
	Forest plantations 237	Long rotation forest plantation	131
		Short and Medium rotation forest plantation	54
		Mangrove plantation	45
		Rubber plantation	8

National Forest and Tree Resources Assessment 2005-07 report (Altrell *et al.,* 2007) provided some important indicators regarding Tree Cover in the land use class which is traditionally recognized as forest as well as other non-forest land use classes of the country. It shows almost 50% of the area of Bangladesh has some kind of tree cover. But only 2.3% of the area has a very high tree cover (> 70%) and roughly 20% has low tree cover (<5%). From the report it is evident that about 50% of the forest area is covered by trees and only 22.9% of the forest area has more than 70% of tree cover. Large areas of forest have been deforested and degraded owing mainly to such reasons as illegal logging by organized gangsters, organised encroachments and conversion of forest lands for agriculture, industry, construction of roads and homestead purposes. High population pressure of the country and involvement of influential people of the society are liable to impose tremendous threats to government efforts to conserve public forests.

NFA (2007) report also shows that a significant amount of tree resources are also available in villages and in cultivable lands apart from forest. According to this report, almost all the villages have got some tree cover. However, only a very small fraction of the village area has a very high tree cover. It may be predicted on the basis of the report that some 3.35 percent of the country's area is under village tree cover indicating a remarkable improvement than that of the Forestry Master Plan document where only 1.9% of the area of the country was reported to be under village forest. 1.75 percent area of the country were reported to be under the tree cover which is planted in cultivable lands by NFA which was not reflected by any authenticate previous report. Improvement of tree cover in the villages and cultivable lands is the testimony of brilliant success of tree planting movement in the country led by the government with enthusiastic participation of citizen. The area of tree cover by different land uses classes is given in Table 3 and tree cover under different land uses classes in Table 4a and Fig. 2.

Table 3. The area of Bangladesh under Tree Cover by different Land Use Classes (LUC)

Land Use Class	Area under Tree Cover (1000 ha)						
	No Tree Cover	<5%	5-10%	10-30%	30-70%	>70%	Total
Forest	0	68	30	440	574	330	1,442
Cultivated Area	5,552	1,866	460	197	227	25	8,327
Village	40	752	873	675	491	31	2,862
Built-up Area	13	72	19	0	0	0	104
Inland Water	1,910	100	12	0	0	0	2,022
Total	7,515	2,858	1,394	1,312	1,292	386	14,757

Table 4. Tree Cover shown as % of different Land Use Classes (LUC)

Land Use Class	Percentage of Area under Tree Cover						
	No Tree Cover	<5%	5-10%	10-30%	30-70%	>70%	**Total**
Forest	0.0	4.7	2.1	30.5	39.8	22.9	**100**
Cultivated Area	66.7	22.4	5.5	2.4	2.7	0.3	**100**
Village	1.4	26.3	30.5	23.6	17.1	1.1	**100**
Built-up Area	11.6	69.7	18.7	0.0	0.0	0.0	**100**
Inland Water	94.5	4.9	0.6	0.0	0.0	0.0	**100**
Total	51.5	19.5	9.7	8.6	8.3	2.3	**100**

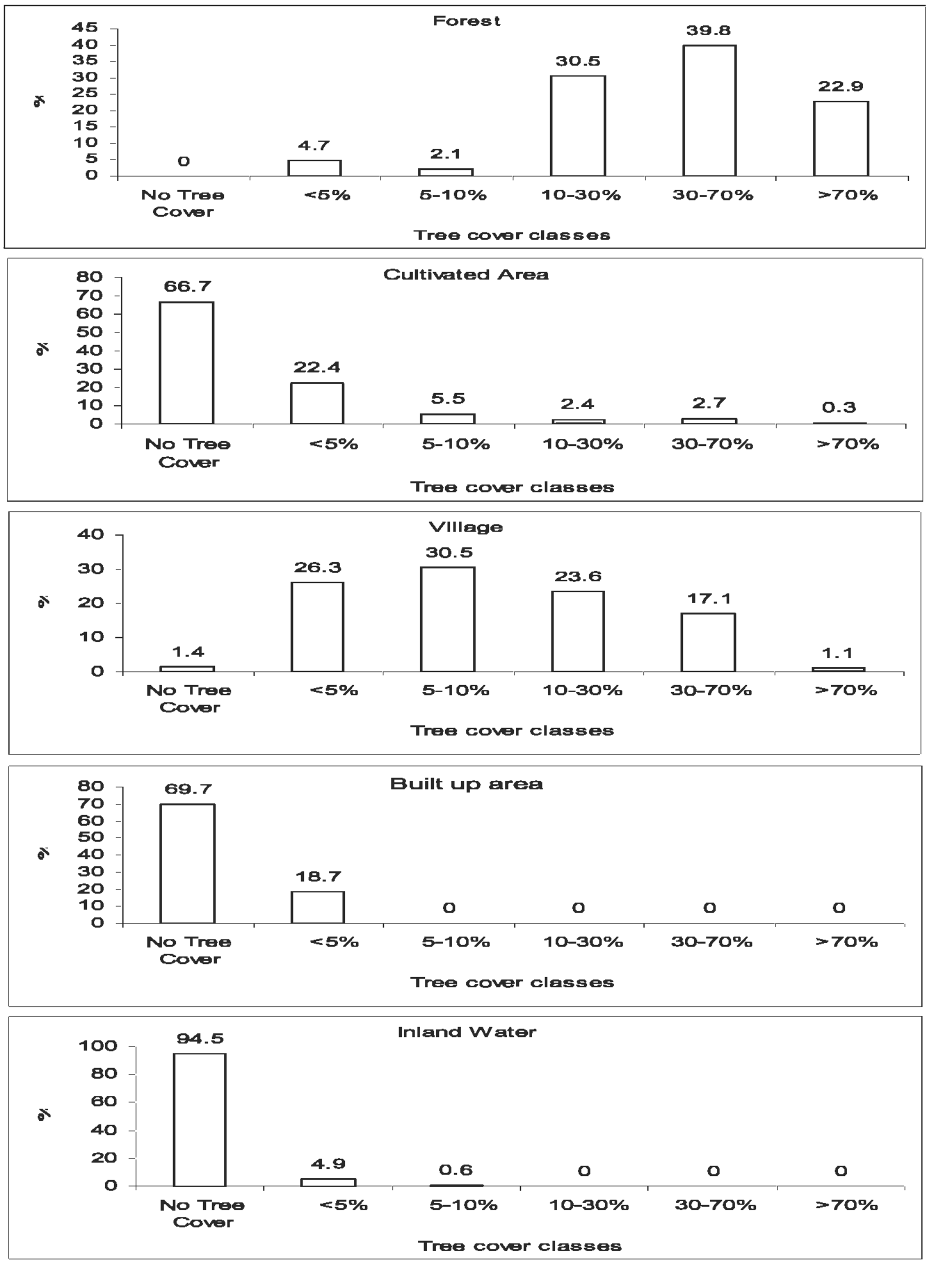

Fig. 2. Percentage of area under tree cover

Forest Types

The world is divided into 5 ecological domains and 20 global ecological zones. Bangladesh falls in two of these zones, namely Tropical Rain Forest (TAr) and Tropical Moist Deciduous Forest (TAwa). Maximum areas of South-eastern Chittagong Division and almost entire of north-eastern Sylhet Division falls in Tropical Rain Forest zone and rest of the country falls in Tropical Moist Deciduous Forest Zone (FAO, 2001). Not necessarily these ecological zones are forests. However, in early twentieth century, based on ecological characters the forests of Bangladesh divided into Tropical Wet Evergreen Forest, Tropical Semi- Evergreen Forest, Tropical Moist Deciduous Forest, Tidal Swamp Forest, Tropical Freshwater Swamp Forest and Littoral Forest. (Champion, 1935)

Tropical Wet-evergreen Forest: This type of forest is characterized by dominance of evergreen plants with rich bio-diversity; although a few semi-evergreen and deciduous species also occur but do not change or alter the evergreen nature of the forest. They occur in the hilly areas of Chittagong, Chittagong Hill Tracts, Cox's Bazar in the SE, and Moulvi Bazar, and Hobigonj in the NE. This type occurs commonly in the deep valley where the water is plentiful. It favours the slopes with a northern aspect where shade is prevalent. (Chawdhuri M. U., 1973) This is a magnificent dense evergreen forest with an irregular top storey of outstanding large and tall trees, characterized by rich flora. About 700 hundred species of flowering plants have been reported to grow in this type of forest (Banglapedia 2011). The canopy is irregular apart from the giant emergent trees projecting well above the main canopy, differentiation into definite canopy layers probably does not exist (Richards, 1952). Dipterocarps are characteristic of the emergent stratum and the *Anacardious Swintonia* (civit) often predominate. *Sterculiace, Anacardiaceae, Artocarpus* and *Syzygium* generally form an important part of the upper canopy, whilst *Lauraceae* and *Cupuliferae* more typical of the temperate forest are often present. *Mesua ferrea* and *Hopea* are generally found though not abundant. Some bamboos occur if the upper canopy is broken, but they are typically absent or inconspicuous in the undisturbed forests where canes and palms are the chief woody monocotyledons. Tree ferns occur but not commonly though epiphytes and ground ferns are abundant. *Rubiaceae* and *Acanthaceae* are frequent among the shrubby undergrowth.

Tropical Semi-evergreen Forest: Generally similar to wet-evergreen forest, the chief feature being the appreciable proportion of the upper canopy formed by the trees of deciduous species that also occur in the moist deciduous forest. Not only are more trees deciduous but the leafless period is longer and the canopy is correspondingly lighter during the period of minimum rainfall (November to March). This in turn is reflected by the somewhat greater prevalence of epiphytes and climbers, as well as bamboos which to some extent replace the canes and palms of the climax evergreen. They have more undergrowth than wet evergreen forests.

These forests occur in the hilly regions of Chittagong, Chittagong Hill Tracts, Cox's Bazar, Sylhet, Sunamgonj, Moulvi Bazar and Hobigonj and also in some parts of Dinajpur district in the NW. This type occupies the greater part of hill forests both on the hilly undulating ground and on the alluvial flats. Over 800 species of flowering plants have been recorded in these forests (Banglapedia, 2011). The emergent trees are mainly deciduous species and attain heights from 45 meters to 60 meters.

In the upper canopy *Dipterocarpus* spp. usually but not always a ssociated with evergreens such as *Mangifera, Lophopetalum, Amoora, Cinnamomum and Syzygium,* but also a fair proportion of deciduous forms such as but also a fair proportion of deciduous forms such as *Tetrameles, Artocarpus, Salmalia, Duabhanga, Garuga, Albizzia, Cedrella* and *Chikrassia.* The lower canopy is largely evergreen with various *Meliacea, Lauraceae, Myrtaceae* and *Cupuliferae.* The stratification of the tree canopy is more prominent in this type in comparison to wet evergreen forest. Bamboos of many species are typical and with them a few dwarf palms such as *Licula.* Monocotyledons such as *Phrynium, Alpina* and *Clinogyne* are locally abundant especially in wet places. *Rubiaceae* and *Acanthaceae* are also usually common in the shrub layer.

Tropical Moist Deciduous Forest : Closed Forest of 25 to 30 meters height, practically all the dominant species being deciduous though usually only briefly so in the drier months or only for a short period at the beginning of the hot weather. There is typically a mixture of several species in the top canopy but *Shorea robusta* (sal) grows markedly gregarious – a feature which has been intensified by biotic influences, hence this forest is commonly known as 'Sal Forest'. There may be a small proportion of evergreens even in the top canopy and their proportion increases in the middle canopy which is developed where the shade is not too dense. Bamboos often occur in this middle canopy whilst canes are rare and restricted to wet sites. Epiphytes are infrequent, but climbers numerous especially in the open. Shrubby undergrowth is present but is greatly influenced in density and composition by burning which is very prevalent in this type and grasses especially *Imperata* may replace the shrubs with repeated burning.

Shorea robusta is the principal species. *Terminalia* (*T. belerica* chiefly) and *Albizzia* are the commonest associates in the top canopy. *Dillenia pentagyna, Laegerstroemia* and *Salmalia, Lannea, Garuga* and *Sterculia* are also commonly present.

Tidal Swamp Forest: Sundarbans Mangrove Forest is the ideal example of this type of forest. Besides Sundarbans of Khulna, there was a small chunk of tidal swamp forest namely Chakoria Sunder bans in Cox's Bazar also. This was leased out and mostly deforested for shrimp culture and salt bed preparation. This type of forest is found on ground which is flooded at every high tide, and is evergreen closed high forest. The height of this forest is moderate, ranges from 5m to 25m. Usually a two storied forest, mainly *Heritiera* and less commonly *Bruguiera* occupying the top canopy. Younger trees of the same species or of other species such as *Ceriops,* with maximum height of only 10m occupy the under wood storey. At higher levels which flooded only at spring tides, there is more varied undergrowth of *Pandanus,* canes, ferns , etc. and if definitely saline, much *Phoenix peludosa.* Nearer the sea with definitely salt water, the *Heritiera* is replaced by the *Rhizophoraceae.* Species are relatively few there and most occur gregariously; all evergreen with simple coriaceous leaves. Grasses are rare. Climbers are usually few but epiphytes fairly numerous (notably the tuberous *Hydnophytum*).

Rhizophoraceae are most typical in the newly deposited mud banks submerged by the tides everyday. A few genera, each usually with several species, belonging to a considerable number of families such as *Sterculiceae (Heritiera), Meliaceae (Carapa), Lythraceae (Sonneratia), Verbenaceae (Avicennia), Euphorbiaceae (Excoecaria), Apocunaceae (Cerbera), Liguminosae (Cynometra)* are specially adapted to this type of unusual conditions. Shrubs are few, *Acanthus* being the commonest, whilst the fern *Achrostichum aureum* is very typical. Palms are limited to a few species notably *Phoenix peludosa* and *Nipa fruticans. Oryza coarctata* a grass species is an early colonizer where the water is fairly fresh. Sundarbans harbours 334 species of trees, shrubs, herbs, and epiphytes.

Tropical Fresh Water Swamp Forest: The determining factor for this type is a permanently moist soil, almost always subject to flooding during the rainy season. Swamp forest is adapted to monsoon flooding for three to four months, to depths 0.5 to 2.5 metres. The soil is typically deep and rich in humus and is usually fine textured. A fully developed canopy with mature trees standing 10 to12 meters tall *Barringtonia acutangula* and *Pongamia piñata* occur in varying proportions to form this vegetation type. *Crataeva nurvala, Trewia nudiflora* are frequently present, while *Salix tetrasperma* is rarely visible. These trees mostly produce their seeds in monsoon, and are dispersed through water, seedlings grow in great quantities. In addition, woody shrubs such as *Phyllanthus reticulate, Ficus heterophylla, Rosa involucrate* and *Sclepias* climbers are found. In stagnant shallow water, more or less pure consociations of *Typha* occur.

These forests are found mostly in Sylhet, Sunamgonj and Kishoregonj districts. Much of the area which currently remains under monsoon paddy would once have been occupied by swamp forest as well as reed lands and other aquatic vegetation. Remnant of swamp forest are now restricted to sloping away from village highlands down towards the haors helping to homesteads from wave erosion, and some recently replanted areas. These patches vary from a few plants to several hectares of more than a thousand trees. Depending on local conditions particularly the extent of human disturbance, the luxuriance of the vegetation varies, from sparse low trees with undergrowth grasses, as at Ranguchi and Rupnagar at *Tanguar Haor*, to dense close canopy with poor undergrowth, as was at *Pashua Beel* in *Gurmar Haor*, Tahirpur, Sunamgonj district.

Littoral Forest: This type of forest is best represented along the eastern shore of Bay of Bengal south of Chittagong and Cox's Bazar districts. Restricted development may be observed on sandy beaches on the seaward edge of Sundarbans and Patuakhali district. The determining factors are a loose sandy soil and full exposure to sea breezes, often with salt spray, depositing more soil whilst blowing some away. The soil is continuously wet below the surface; its lime content is quite high with shell fragments.
The vegetation is very sparse currently. *Casuarina equisetiolia* is the main species and occpies the top canopy having maximum height of 30 metres. *Pongamia pinata, Callophyllum inophyllum, Trewia nudiflora Terminalia catappa, Tamarix dioica, Erythrina variegata and Barringtonia* are the tree associates of *Casuarina. Pendanus foetidus, Vitex negundo, Hibiscus tiliaceaceus, Thespesia populina, Dolichandrone spathecea, Ixora arborea, Acanthus ilicifolius* are the important shrubs. *Ipomea pescaprae, Crinum spp* occur as trailing herbs. Grasses like *Cynodon dactylon, Saccharum spontaneum,* and *Oryza coarctata* also found in this type of forest.

Role of Forest in the Economy

Forest sub-sector contributed 81,660 million Taka (Equivalent to1,166.57 million US dollars) to the GDP in the year 2008- 09 which was1.75% of the GDP of Bangladesh. The growth of GDP in forest sub-sector exceeded 5% every year in previous five years (BBS, 2009). Labour force to the extent of 2% of the country is employed in forestry activities.

Forest Genetic Resources

Genetic Diversity

It is concerned with the variation in genes within a particular species and/ or between species. Genetic diversity occurs due to variability of genetic constitution within the species or between the species. Cross breeding also helps in occurring genetic diversity. Genes determines the ability of an organism to survive in a particular habitat under special conditions. They also increase the ability of species to with changing environment.
Comprehensive information on forest genetic resources (FGR) is not available in the country. Information on population diversity of species in terms of (i) chromosome numbers, (ii) morphological variation, (iii) flowering and seed production habit, (iv) flowering time and nature, and (v) seed morphology and viability etc. are available for a few agricultural species only. Forest species are neglected in this respect.

Species Diversity of Flora in Bangladesh

Bangladesh possesses a good species diversity of both flora and fauna. The tropical semi-evergreen forest is the richest in terms of species diversity. Although rich in diversity the population size of most of the species has remarkably declined. David Prain (1887-1944) was the pioneer to make a comprehensive study of flora of the then Bengal, Assam and Orissa and published his famous compilation 'Bengal Plants' in 1903. In this book he described about 2,700 species of angiosperm. Later it has been estimated by scientists that the total number of angiosperm species in Bangladesh would be nearly 5,000. Recently (2007) Encyclopaedia of Flora and Fauna of Bangladesh has been published. In this compilation it has been reported that there are a total of 3,611 species of angiosperms species available in Bangladesh. Out of which 2,623 species are dicotyledons belong to 158 families and 988 are monocotyledons under 41 families. These include indigenous as well as exotic species, either naturalized or commonly planted for economic or aesthetic purpose. D. K. Das and M. K. Alam (2001) documented 337 tree species of flowering plants, whether indigenous or introduced and naturalized in Bangladesh in their book *Trees of Bangladesh.* There are only 7 species of Gymnosperms reported to grow in the country but only five of them are found in the wild, and these are *Cycus pectinata*, *Podocarpus nerifolia, Gnetum latifolium* var. *funiculare, G. montanum,* and *G. oblongum.* Plant species in various groups are presented in Table 4.

Table 4. Number of Species in Various Groups of Plants

Plant group	Number of Species		
	World	Sub-continent	Bangladesh
Virus/Bacteria	8,050	850	470
Algae	40,000	7,175	1988+
Fungi	72,000	14,500	275
Lichen	13,500	2,223	*
Bryophytes	14,500	2,500	248
Pteridophytes	10,000	1,200	195
Gymnosperms	650	67	7
Angiosperms	250,000	17,527	3,611

Source: Encyclopaedia of Flora and Fauna of Bangladesh (2007) and Biodiversity National Assessment and Programme of Action (2010). * Published record not available

At least 1,000 species of forest plants are economically important; of these about 400 are considered tree species and about 450 as medicinally important. About 50 tree species and about 100 shrubs and herbs are viewed as commercially important (Banglapedia, 2011). The major forest tree species of the country are shown in appendix 1.

Siddiqui *et al.* (2007) reported that a total of 195 species of Pteridophytes have been identified and described in Bangladesh. However, according to M. K. Pasha (Banglapedia, 2007) there are about 250 species of Pteridophytes are there in Bangladesh, found mostly in the north-eastern hilly forests. *Selaginella,* and *Lycopodium* grows in moist and shady undisturbed places of hill forests. The most common ferns are *Pteris, Dryopteris etc.* grows commonly throughout the country. Tree fern species of *Cyathea gygantea, C. glauca, c. spinosa and Angiopteris evecta* grows in the eastern hilly region of Bangladesh. The tiger fern *Achrosticum aureum* is an integral part of vegetation of the Sundarbans forest.

Diversity of Species in Forest Ecosystems

Hill Forests: The Hill forests are the forests where the tropical wet evergreen forest ecosystem and the tropical semi evergreen forest ecosystem exist. This forests harbour tall canopy of wood trees and undergrowth of rattan, bamboo, medicinal herbs etc. Hossain and Khan (2010) reported that 2,260 species of angiosperm are available in the Chittagong Hill Tracts region. Heining (1925) discussed the annonated checklist of all the plant species known for the Chittagong Collectorate and Hill Tracts. Khan and Afza (1968) furnished the preliminary floristic report on Teknaf forest. Khan *et al.* (1994) reported the keystone species of plants of ecological and socio-economic value in the Teknaf Game Reserve, which comprises of 290 species belonging to 212 genera fewer than 65 families. Hossain *et al.* reported 85 tree species in the reserve forest of Bamu under Cox's Bazar forest division. Similarly, Hossain and Nath (1995) reported 85 tree species from a sample area of 2 ha in Sitapahar reserve block of Chittagong Hill Tracts (South) Forest Division representing 68 genera and 36 families.

Annonated Check List of Woody Flora of Sylhet Forests was prepared by Alam in 1988. In this list 795 species of 96 dicotyledonous families and 22 species of 2 monocotyledonous families has been included. 15 species of bamboos and 7 species of canes comprise monocotyledonous flora.

Moist Deciduous (Sal) Forest Ecosystem: In moist deciduous (sal) forest area, a record of woody taxa includes 260 species under 160 genera comprising of 56 families (Alam, 1995)
Mangrove Forest Ecosystems: The floristic composition of the mangrove forest ecosystem of Bangladesh is very rich in comparison many other mangrove forest of the world. Prain (1903) recorded 334 species of plants belonging to 245 genera under 75 families for the Sunder bans and adjoining areas. Heining (1892) reported 70 species from 34 families for the entire Sunder bans (Bangladesh and India). Chaffey and Sandom (1985) represented a list of 66 species in the Bangladesh Sundarbans from 37 families. *Heritiera fomes* and *Excoecaria agallocha* are the principal species of the forest. *H. fomes* constitutes about 65% of the total merchantable timber.

Diversity of Tree Species in the villages

Villages in Bangladesh are considered as the rich and diverse source of flora and fauna. Alam *et al.* (1996) reported 183 tree species comprising of 136 genera fewer than 48 families in the villages of Bangladesh. NFA 2005-06 report recorded 198 tree species in villages out of a total of 258 tree species in the country. 15 species represents over 80% of the total tree volume in the villages. The 4 most common species (*Cocos nucifera, Samanea saman, Mangifera indica* and *Areca catechu*) represent 50% of the gross volume in villages (Altrell *et al.,* 2007)

Forest Growing Stock

In Bangladesh the average gross volume of forest growing stock is 14 m^3 per ha. And the average commercial volume is 10 m^3 per ha. Forest is the Land Use Class (LUC) with the highest gross volume per ha. Of 48.3 m^3 and commercial volume of 29.7 m^3 followed by villages 36.1m^3 and 28.2 m^3 respectively.

Table 5. Total Gross and Commercial Volume of Growing Stock by LUC's (million m^3)

	Forest	**Cultivated Land**	**Villages**	**Built-up Area**	**Inland Water**	**Total**
Gross Volume	70	36	103	2.4	1.0	212
Commercial Volume	43	24	81	1.8	0.6	150

The total gross volume of forest growing stock in Bangladesh is 212 million m^3 and the total commercial is 150 million m^3 (Table5) .Almost 50% of the total gross volume can be found in the villages. Almost one third of the gross volume and less than 30% of the commercial volume is found in the forest. Out of the total gross volume 1/3rd can be found in the hill forests, 1/3rd in the bamboo forest and almost 1/3rd in the mangrove forest. Out of the total commercial volume 30% can be found in the in hill forests, almost 30% in bamboo forest and almost 40% in the mangrove forest. Plantations constitute only 3% commercial volume of the forest (NFA 2007).

Table 6. Total Gross and Commercial Volume of Growing Stock by Forest LUC's (million m^3)

	Hill Forest	**Mangrove Forest**	**Bamboo Forest**	**Long Rot. Plantation**	**Short Rot. Plantation**
Gross Volume	23	21	23	1.4	0.5
Commercial Volume	12	16	13	0.8	0.3

Bamboo forest has the highest gross and commercial volume per ha (Table 6, Table 7). Mangrove forest and Hill forest have significantly lower gross and commercial volume per hectare. The plantations in general have low tree volumes

Table 7. Average Gross and Commercial Volume per ha. of Growing Stock by Forest LUC's (million m^3)

	Hill Forest	Mangrove Forest	Bamboo Forest	Long Rot. Plantation	Short Rot. Plantation
Gross Volume per ha.	42.2	48.0	127.6	11.1	9.7
Commercial Volume per ha.	21.8	37.7	72.2	6.4	6.3

Management of Forest

Hill Forests used to be managed under clear felling of naturally growing trees followed by artificial regeneration with commercially important species with a rotation of 60 years (long rotation) and 30 years (short rotation). Although initially this system appeared successful in creation of plantation in large areas of forest, deleterious effects of the system has been gradually visible and manifested in several ways such as, heavy erosion of soil, loss of productivity of the site, inadequate growth of trees in the plantation, serious and irrevocable loss of biodiversity and forest genetic resources, etc. This management system had been continued until a moratorium was imposed on the felling of trees in the natural forest by the government in1989. The bamboo growing in the hill forest either as pure stand or as under storey are managed under the culm selection system with a felling cycle of 3 to 4 years. The tidal forests had been managed under selection system followed by natural regeneration with a felling cycle of 20 years. This management system has al so been suspended. However, harvesting of non timber forest product gol pata (*Nypa fruticans)* is continuing. The inland moist deciduous (sal) forest had been managed under coppice system with a rotation of 25 years. Areas where *Shorea robusta* trees was comparatively less had been managed under clear felling followed by artificial regeneration system mostly with sal and other suitable species. All forests mentioned above had been managed as per prescription of the management plans. Apart from social forestry sites (mostly outside the forest) felling of trees from the forest are not the usual official practice now a days. Plantations in most of the occasions are currently being created in the forest in participatory method by involving local people. A considerable portion (261,891.50 ha.) of government managed forest has been declared and managed as protected areas in order to conserve flora and fauna.

NFA (2007) report shows that 46% of the country's total forests are under "Formal management plan" and 50% are under "Traditional management plan" (Table 8). Of the different forest types only Mangrove forest is totally covered by a "Formal management plan". Most of the areas in Hill forest and bamboo forest or mixed bamboo/ broad-leaved forest are under "Traditional management plan".

Table 8. Forest area by type of management and by forest LUCs (1,000 ha)

Forest type	Formal	Traditional	Not Known	Total
Hill Forest	63	453	35	551
Mangrove Forest	436	0	0	436
Bamboo Forest	7	162	14	184
Long Rotation Pltn	104	27	0	131
Short Rotation Pltn.	37	14	3	54
Mangrove Pltn.	0	45	0	45
Forest	648	700	52	1,400
Forest (%)	46%	50%	4%	100%

Identification of Threats

Forests in Bangladesh are declining at an alarming rate. Some species are disappearing fast and are considered threatened. A total of 19 tree species and 9 rattan species need immediate conservation measures (Khan, 1996). The ongoing loss of germplasm is a threat to FGR. High population pressure, clearing of forests, draining and filling up of wetlands, introduction of exotic species, introduction of improved genotypes, pests and diseases, improper silvicultural techniques and management, and lack of public awareness are some of the major threats to FGR. Poverty and the attitude of the people towards exploitation of natural resources as free goods also contribute to the loss of germplasm in the country.

The destruction of forest by shifting cultivation is another problem in Bangladesh. The forests are cut and cultivated for a short tome only, and when the residual nutrieants in the soil are leached as a result of erosion removing the top soil, the shifting cultivators move to some other places.

The country has four wild gymnosperms, viz., *Cycas pectinata, Gnetum scandens, G. funiculare* and *Podocarpus nerifolia. C. pectinata* is regionally threatened and the two *Gnetum* species have become very rare while the population of *P. nerifolia* are much depleted. Immediate appropriate conservation measures are needed to protect these species in the country. Khan (1996) reported that the number of plant species threatened in the country is 45. Among mammals, birds, reptiles and amphibians 15 species have become extinct and 33 species are endangered. According to the Government of Bangladesh (GOB,1992), there are 27 threatened and 39 endangered species of wildlife in Bangladesh at present.

Past and Present Activities in Conservation, Utilization and Management of FGR

Establishment of forest plantations in Bangladesh started in 1871 with teak (*Tectona grandis)* using seeds brought from Myanmar. Since then plantation forestry became a part of the overall clear felling silvicultural system. Teak was the main species planted because of its high value. Other species such as *Gmelina arborea, Artocarpus integrifolias, Dipterocarpus turbinatus, Swetenia mehagini, Lagerstroemia speciosa, Toona ciliate, Artocarpus chaplasha, Xylia kerri,* and *Syzygium grande* were introduced later. Most of the plantations were monocultures established with the assistance of shifting cultivators through taungia system. Since the plantations were established through clear felling followed by artificial regeneration, there was a severe loss of native vegetation. Moreover, with the development of mechanized logging for commercial purposes, the shifting cultivators could not cope with the extensive area cleared, which resulted in a rapid loss of FGR. The above mentioned species used for plantation establishment were slow growing and long rotation species. Plantations with these species were unable to meet the growing needs of the rapidly increasing population.

In 1974, the Forest Department (FD) began to establish plantations with fast growing species such as *Gmelina arborea, Albizia falcataria, Anthocephalus chinensis.* During this period, plantations of industrial species such as rubber, oil palm mulberry and cashew were established, but the overall results were not encouraging but rubber. Later, exotic species like *Eucalyptus camaldulensis, Acacia auriculiformis, Dalbergia sisoo* were planted with success. Now a days most of the plantations are developed by *Acacia auriculiformis* both within and outside the forest.

Forest plantations cannot be substitute to natural forests. The most important reason is that plantations are severely degraded in genetic resources compared to natural forests. In fact the forests of Bangladesh, particularly the plain land (sal) forest and the hill forests are severely degraded due to indiscriminate exploitation. Therefore, GOB has taken initiatives for the conservation of ecosystems and forest genetic resources in the remaining natural forests.

Conservation Strategies

Major international efforts to conserve FGR began in 1960s with the guidance and support of FAO. Conservation efforts of FGR have been implemented with the following strategies:

In situ conservation

Protected Areas : Protected Area is a common term used to designate the nature conservation areas established for different purposes in different names, such as national park, eco park, safari park, game sanctuary, wildlife sanctuary etc. Growth of population, demand for forest products and conversion of forest land for agriculture, housing, industries and for lot many other uses natural forests have been shrinking and degrading. In this context the environmental function and ecosystem services of natural forests have been increasingly recognized, both internationally and nationally. For the conservation of flora and fauna of natural forests human activities in certain tracts of forests are controlled, these tracts are protected areas. The first protected area of the country was Sundarbans Game Sanctuary established in 1960 at Kotka with an area of 121 square miles. 28 protected areas have so far been organized in the country with a total area of 261,891.5 hectares which covers more than 18% of the government forest and 1.77% of the area of the country. An up to date list of protected areas are given in appendix

Protected Area Management Strategies: With the advent of new millennium pressure on the protected areas have become greater through unauthorised felling of trees, collection of fuel wood and encroachments. It is in this context that in 2003 the Forest Department developed a new vision for Protected Area Management and launched a programme called Nishorgo Programme in 2003 to develop a model for collaboration with local stakeholders in protected areas. With the experience of the programme a new USAID supported project named Integrated Protected Area Co-management (IPAC) project has been taken where a system of co-management with the participation of local people has been undertaken for the conservation and management of protected areas.

World Heritage Site: The Sundarbans has been declared a world heritage site by UNESCO in 1998 for its vast expansion, diverse flora and fauna especially the famous Royal Bengal Tiger and unique array of natural mangrove forest, creeks, meandering streams, rivers and estuaries.

Nature Reserves: The objective of nature reserve is to protect communities and species and to maintain natural processes in order to have ecologically representative examples of the natural environment. In Chittagong Hill tracts tribal people maintain small and discrete chunks of natural forests which they call 'mouza reserves'

Ex situ Conservation

In contrast to *in situ* conservation, *ex situ* conservation includes practices that conserve genetic materials outside the natural habitat of the parent population. *Ex situ* conservation methods and materials include gene banks for seed or pollen as well as clone banks, arboreta, preservation plots, sample plots etc.

- Preservation Plots: BFRI has established five preservation plots at different hill forest areas and 27 at the Sundarbans mangrove forest.
- Clone Banks: BFRI has established two clone banks, one at Hyako, Chittagong (4 ha.) and another at Ukhia, Cox's Bazar (4 ha.). Seven tree species *(Tectona grandis, Gmelina arborea, Bombax ceiba, Dipterocarpus turbinatus, Syzygium grande, Swetenia mahagoni, Albizzia falcateria)* have been preserved in these two locations.
- BFRI Bamboo Arboretum: The BFRI Bambusetum (1.5ha.) has been established at the BFRI campus. This arboretum contains 27 bamboo species *(Bambusa balcooa, B. bambos var. spinosa, B. burmanica, B. cacharensis, B. comillensis, B. jaintiana, B. multiplex, B. nutans, B. polymorpha, B. salarkhanii, B. tulda, B. vulgaris, B ventricosa, Dendrocalamus giganteus, D. hamiltonii, D. longispathus, D. strictus, D. brandisii, Gigantochloa andamanica, G. atroviolacea, G. apus, Melocalamus compactiflorus, Melocanna baccifera, Schizostachyum dullua, Thyrsostachys oliveri, T. regis,* and *T. siamensis)* including six exotic species. One arboretum of medicinal plants,(1 ha.) has been established at the BFRI campus with a collection of 40 species. One cane arboretum (0.5 ha.) of seven species has also been established (Banik,1997). Three arboreta of tree species have been established at the BFRI HQ with 56 species, Keochia Forest Research Station with 56 species and Charaljani Silviculture Research Station with 52 species.

- Seed Storage: There is a National Forest Seed Centre {NFSC) at BFRI; however, the centre does not have any facility for long time storage of seeds.
- Tissue Culture: Tissue culture on forest tree species has been done only at the BFRI tissue culture laboratory. The BFRI has so far developed tissue culture techniques for six tree species and seven bamboo species.
- Botanical Gardens :
    - Mirpur Botanical Garden: area 85 ha, with 255 tree species (28,200 plants), 310 shrub species (8400 plants) and 385 herb species (10,400 plants). The total no. of families of trees, herbs, and shrubs is 114 (Ranjit, 1997).
    - Baldha Garden : area 1.15 ha, 18,000 trees, shrubs and herbs of 820 species and 92 families (Ranjit,1997)

Conservation of provenances

BFRI has established provenance trials of *Acacia mangium, Eucalyptus camaldulensis, E. brassiana, E. tereticornis, E. europhylla, Tectona grandis, Gmelina arborea, Pinus caribaea, P. oocarpa, Albizzia falcataria, Leucaena leucocephala, Melaleuca leucadendra, Gliricidia sepium* and *Populus deltoides* from 68 provenances.

Tree Planting Campaign

After independence , in 1970s government initiated tree planting drive throughout the country which has been gradually earned momentum. This drive has turned into tree planting movement as it is termed now a days with enthusiastic community participation. Started with a weeklong program, tree planting campaign are currently observed for three months every year. This campaign has a huge positive impact on FGR conservation and management.

Tree Fair

Tree fair, a very unique of its kind, has been observed in the country mainly in govt. initiative since 1994. The main event is arranged in the capital. Tree fairs are also arranged at all divisions and districts every year. At sub district level (upazila)also tree fairs are arranged. Tree fairs are arranged in private initiative, as well. In conservation and management of FGR role of tree fairs cannot be ignored.

Appendices 2-4 provide information on the conservation of important forest species in Bangladesh, their use and threats.

Institutional Framework

Role of different institutions are important for successful achievement of aims and objectives of any program. The Forestry Master Plan considered five interrelated institutions, i.e., policy, legislation, organizational structure, human resource development, research and extension.

Today, the forestry and forest institutions in Bangladesh are judged in much wider context than before. The interrelated and multiple roles of forests are vital for human welfare and sustained socio-economic development.

Since, Bangladesh is a signatory of the Convention on Biological Diversity held in Rio in 1992 and subsequently ratified it on 20 March 1994 the country has certain obligations under the convention.

Forest Department, Bangladesh Forest Research Institute, Bangladesh National Herbarium, Institute of Forestry and Environmental Science under Chittagong University, Department of Forestry and Wood Technology of Khulna University, Department of Forestry in Shahjalal University of Science and Technology, Botany Departments of Universities, Bangladesh Agriculture Research Council, etc., are the institutions involved in conservation, management and research on FGR. Recently Asiatic Society published a comprehensive compilation "Encyclopaedia of Flora and Fauna of Bangladesh" which may serve as baseline document on FGR.

National Forest Policy

In accordance with the National Forest Policy promulgated in October 1994, the following policy objectives are set in order to eliminate any uncertainty regarding the aims of the Government. These objectives have equal priority, since the successful fulfilment of one objective cannot compensate for the failure of another. The policy objectives are:

- To meet the basic needs of the present and future generations and also to ensure greater contribution of the forestry sector in the economic development, about 20% of the total area of the country will be afforested. Fallow lands, lands not useful for the purposes of the agriculture, hinterlands and in other possible areas, Government sponsored afforestation programs will be implemented.
- By creating employment opportunities, strengthening the rural and national economy, the scope for poverty alleviation and trees and forest based rural development sectors will be extended and consolidated.
- Biodiversity of the existing degraded forests will be enriched by conserving the remaining natural habitats of birds and other animals.
- Agriculture sector will be strengthened by extending assistance to the sectors related with forest development, especially by conserving the land and the water resources.
- National responsibilities and commitments will be fulfilled by implementing various international efforts and agreements ratified by the government relating to global warming, desertification and control of trade and commerce of wild birds and animals.
- Through the participation of the local people, illegal occupation of the forestlands, illegal tree felling and hunting of wild animals will be prevented.
- Effective use and utilization of the forest goods at various stages of processing will be encouraged; and
- Implementation of the afforestation programs – on both public and private lands will be provided with encouragement and assistance.

List of national priority species

The following species are the priority species in the Forest Department plantation program:

Long rotation plantation species

Tectona grandis, Dipterocarpus turbinatus, Syzygium grande, Swietenia macrophylla, Chukrasia tabularis, Michelia champaca, Hopea odorata, Xylia kerrii, Lagerstroemia flos-reginae, Shorea robusta and *Toona ciliata*

Medium rotation species

In addition to the long rotation plantation species *Pinus caribaea, Albizia falcataria, Bombax ceiba, Gmelina arborea, Anthocephalus chinensis and Eucalyptus camaldulensis, E. tereticornis, Dalbergia sissoo, Azadirachta indica, Samanea saman, Bombax ceiba, Acacia nilotica* and *A. catechu*

Short rotation species

Acacia auriculiformis, Acacia mangium, Eucalyptus camaldulensis, Melia azadirachta, Albizia chinensis, Leucaena leucocephala, Trewia nudiflora and Casuarina equisetifolia

Village groves

Artocarpus heterophyllus, Mangifera indica, Aegle mermelos, Litchi chinensis, Psidium guajava, Ziziphus spp., Syzygium, Albizia, Barringtonia, Eucalyptus, Erythea, Ficus, Albizia fuman, Anthocephalus, Tamarindus indica, Bombax ceiba, Swietenia macrophylla, Alstonia scholaris, Cocos nucifera, palmyra palm and bamboo.

On marginal lands such as roadsides

Tectona grandis, Mangifera indices, Artocarpus heterophyllus, Dalbergia sissoo, Butea frondosa, Polyanthina longifolia, Eucalyptus camaldulensis, Acacia auriculiformis, Swietenia, Albizia, Samanea, Syzygium and *Casuarina equisetifolia*

Multipurpose tree species for different zones

Hill zone

Albizia lebbeck, A. procera, Phyllanthus emblica, Eucalyptus camaldulensis, Elaeocarpus robusta, Artocarpus heterophyllus, Acacia auriculiformis and rattans.
Coastal zone
Casuarina equisetifolia, Albizia lebbeck, Acacia procera, S. grandiflora, Cocos nucifera, Phonek sylvestria and *Erythrina indica.*

Mangrove

Heritiera fomes, Avicennia sp., Bruguiera gymnorhiza, Ceriops decandra, Rhizophora mucronata and Sonneratia apetala

Research on FGR

The BFRI conducts research under 12 programme areas in forest management aspects, apart from 6 program areas on utilization of forest resources. Each year the institute undertakes a number of priority research studies following the suggestions of the Bangladesh Forest Department, Bangladesh Forest Industries Development Corporation, Bangladesh Chemical Industries Corporation, Bangladesh TEA Board, Rural Electrification Board, other wood based industries, private owners and non-government organizations. The selected studies are approved by an Advisory Committee.

The BFRI conducts a number of studies on FGR conservation and management under the following programme areas: (i) Biodiversity and its conservation, (ii) Production of quality planting materials, (iii) Plantation techniques and forest management, (iv) Breeding and improvement, (v) Social and non-timber forest products, (vi) Social and farming system research and (vi) Pest and diseases. Seed Orchard Division, Silviculture Research Division, Silviculture Genetics Division, Mangrove Silviculture Division, Plantation Trial Unit Division, Minor Forest Product Division, Soil Science Division, Forest Protection Division and Farming System Research Component are involved in conducting these studies.

A total of 44 technologies have been developed and out of these 28 technologies have been transferred to end users. A total of 16 technologies on conservation and management of FGR have been developed and transferred to different end-users. Training programme based on these new technologies is arranged as and when required.

Other organizations are also involved and have been significantly contributing in the field of FGR conservation and management research. Institute of Forestry and Environmental Sciences of Chittagong University are conducting research on biodiversity conservation and management, clonal propagation of important forest tree species, agro forestry, medicinal plants etc.

Conclusion and Recommendations

The natural forests of Bangladesh have been seriously degraded, resulting in serious genetic erosion of FGR. There is a critical need to develop coordinated efforts to conserve and manage FGR. Effective and hopeful efforts have been undertaken into conservation activities, but national and international financial and technical assistance are needed to bring about success. The following recommendations have been put forward for the conservation and sustainable utilization of FGR in Bangladesh:

- Development of a database on the present status of flora and fauna in different ecosystems of Bangladesh. National Forest and Tree Resources Assessment 2005-2007 was a milestone job, could be successfully conducted and completed with financial and technical assistance of FAO as well as sincere and arduous effort of the Forest Department Officials. In that survey assessment of FGR was not adequately addressed. So, in order to have high quality up to date information on FGR a comprehensive survey is required. Technical and financial assistance from FAO or any other organization is necessary to undertake such survey;

- *In situ* and *ex situ* conservation programme of FGR should be significantly expanded;
- Community based resource conservation needs to be emphasized;
- Improved silvicultural methods should be applied in the management of natural and plantation forest;
- The method of clear-felling followed by burning and plantation establishment must be stopped;
- Silvicultural measures for aided natural regeneration should be followed;
- Enrichment planting should be conducted in low density forest stands with diversified genetic resources collected from natural regeneration in the forest floor;
- Establishment of preservation plots and permanent sample plots in the reserve forest;
- Establishment of gene bank for conservation of FGR;
- Logging in the remaining natural forest must be stopped;
- Creation of diversified job opportunities for hill people through conducive farming system approach which will not be detrimental to FGR conservation;
- Motivation work should be conducted to discourage shifting cultivation as well unscrupulous hill farming;
- Introduction of forest certification system for sustainable forest resource management;
- Education and training to professionals and technicians should be given to equip them with the latest knowledge of forest genetic resource survey, management and conservation;
- Strengthening the international cooperation for FGR conservation;
- Since conservation of FGR is a land based management system, laws regarding transfer and leasing out of forest land should be stringent so that encroachment of forest can be prevented.

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Appendix 1. Value and use of main forest species in Bangladesh

Species name	Value code	Present, future or potential use											
		ti	po	wo	nw	pu	fo	fd	sh	ag	so	am	xx**
1.*Acacia auriculiformis*	1	+		+		+		+	+	+			
2. *A. catechu*	1	+	+	+	+			+					
3. *A. farnesiana*	3			+	+			+					
4. *A. mangium*	1	+		+		+		+		+			pb,v
5. *A. nilotica*	1	+		+	+			+					cw,agi
6.*Acrocarpus fraxinifolius*	3	+											pw
7.*Aegiceras corniculatum*	3			+	+		+						
8. *Albizia chinensis*	1	+				+		+	+				pw
9. *A. lebbeck*	1	+		+			+	+					v
10. *A. lucidor*	3	+		+				+					
11. *A. odoratissima*	2	+		+				+				+	
12. *A. richardiana*	2	+			+		+					+	bb
13. *A. procera*	1	+		+				+					
14. *Alstonia scholaris*	1	+			+	+						+	pc,n
15. *Amoora cucullata*	3		+	+									
16.*Anacardium occidentale*	1	+			+		+						
17.*Anogeissus acuminata*	3	+		+	+							+	agi
18.*Anthocephalus chinensis*	1					+	+					+	
19.*Antidesma ghaesembilla*	3	+					+	+					
20.*Aphanamixis polystachya*	2	+			+								
21. *Aporusa dioica*	3		+		+		+						
22.*Aquilaria agallocha*	2												ab
23. *Artocarpus chama*	1	+				+	+						
24. *A. heterophyllus*	1	+			+		+	+		+		+	
25.*Artocarpus lacucha*	2	+			+		+	+					agi
26. *Avicennia alba*	2			+									pw
27. *Azadirachta indica*	1				+					+		+	
28. *Bambusa sp.*	1			+		+	+	+					pb
29.*Barringtonia acutangula*	2	+		+	+								
30. *Bauhinia purpurea*	3				+		+	+					agi
31. *Bauhinia variegata*	3				+		+	+					
32.*Beilschmiedia pseudomicrocarpa*	3	+											
33. *Berrya cordifolia*	3	+										+	agi,cw
34. *Bischofia javanica*	2	+	+		+			+					agi
35. *Bombax ceiba*	1	+				+	+	+					k
36. *Bridelia retusa*	3		+		+		+	+					

Species name	Value code	Present, future or potential use											
		ti	po	wo	nw	pu	fo	fd	sh	ag	so	am	xx**
37.*Bouea oppositifolia*	3	+					+						agi
38.*Bruguiera gymnorhiza*	2	+	+		+								
39. *B. sexangula*	3	+	+		+								
40. *Buchanania lanzan*	3				+		+						
41. *Butea monosperma*	2	+			+			+					
42.*Callicarpa tomentosa*	3		+	+				+					
43.*Calophyllum inophyllum*	2				+								m,bb, rs
44.*Canarium resiniferum*	3				+								v,pw
45. *Cassia fistula*	2	+			+			+				+	c
46. *C. nodosa*	2	+										+	
47. *C. siamea*	1	+		+				+				+	c
48.*Castanopsis tribuloides*	3	+					+						agi
49.*Casuarina cunninghamiana*	3								+			+	
50. *C. equisetifolia*	1	+		+	+					+		+	bb,m
51. *Ceiba pentandra*	1	+			+			+					k
52. *Ceriops decandra*	3	+	+		+								
53. *Chukrasia velutina*	1	+								+			
54.*Cinnamomum iners*	3												p
55. *Cordia dichotoma*	3	+		+	+		+	+					
56. *Crateva magna*	3	+			+		+						t,n
57.*Croton oblongifolius*	3	+		+	+								
58.*Crypteronia paniculata*	3												cw,c,rs
59. *Dalbergia sissoo*	1	+			+			+					a,v
60. *Delonix regia*	2	+		+					+			+	
61. *Dillenia indica*	3		+	+	+		+						bb
62. *D. scabrella*	3	+					+						
63.*Diospyros montana*	3	+			+								
64. *D. nigricans*	3		+										
65. *D. peregrina*	3	+			+		+						ts
66. *D. toposia*	3	+					+						
67.*Dipterocarpus alatus*	2												bb,rs
68. *D. turbinatus*	1									+			bb,c
69.*Dolichandrone spathacea*	3											+	
70.*Duabanga grandiflora*	3	+				+							pw,d
71.*Dysoxylum binectariferum*	3	+			+								
72. *D. hamiltonii*	3	+			+		+						
73. *Ehretia serrata*	3	+					+	+					agi

Species name	Value code	Present, future or potential use											
		ti	po	wo	nw	pu	fo	fd	sh	ag	so	am	xx**
74.*Elaeocarpus floribundus*	1	+					+						
75. *E. sphaericus*	3											+	
76. *E. varunna*	3									+			tc
77.*Engelhardtia spicata*	3	+			+								
78.*Erioglossum rubiginosum*	3	+					+						c
79. *Erythrina fusca*	3			+				+	+				
80. *E. variegata*	2			+				+	+				d,v,t
81. *E. fusea*	3												
82. *Eucalyptus alba*	3				+							+	
83. *E. camaldulensis*	1			+			+						c,v,rs,pw
84. *E. brassina*	2			+			+						
85. *E. tereticornis*	2			+			+						
86. *E. urophylla*	2			+			+						
87. *E. citriodora*	2	+			+								c, agi
88.*Excoecaria agallocha*	1					+							
89. *Ficus benghalensis*	1	+		+	+			+					
90. *F. hispida*	2			+			+	+					
91. *F. racemosa*	2	+		+	+		+	+					
92. *F. religiosa*	1			+				+				+	pc
93.*Flacourtia jangomas*	3	+			+		+						
94. *Garcinia cowa*	2	+			+		+						va
95. *Garuga pinnata*	2	+			+	+	+	+	+				
96. *Gliricidia sepium*	2			+				+	+				
97. *Gmelina arborea*	1	+			+	+		+		+			
98. *Grevillea robusta*	3	+											v,d
99. *Grewia tiliaefolia*	3						+						agi,m
99. *Heritiera fomes*	1		+										bb,c
100.*Hevea brasiliensis*	1	+				+							v,r
101.*Holarrhena pubescence*	3	+			+								n
102. *Hopea odorata*	1	+	+		+					+			
103.*Hydnocarpus kurzii*	2				+								
104.*Hymenodictyon orixensis*	2	+			+			+					tc,m
105.*Jacaranda mimosifolia*	3				+							+	
107. *Kandelia candel*	3				+								
108.*Lagerstroemia macrocarpa*	2		+										c,bb
109. *L. speciosa*	1	+	+									+	bb,c
110.*Lannea coromandelica*	3	+			+	+		+					
111.*Leucaena leucocephala*	3			+				+		+			

Species name	Value code	Present, future or potential use											
		ti	po	wo	nw	pu	fo	fd	sh	ag	so	am	xx**
112.*Lithocarpus elegans*	2		+	+									
113. *L. pachyphylla*	3			+									c
114. *Litsea glutinosa*	3	+		+	+								
115. *L. monopetala*	3	+			+			+				+	
116. *Madhuca indica*	3	+			+		+						
117.*Mallotus philippensis*	3				+								
118. *Mangifera indica*	1	+			+		+	+		+			
119.*Melaleuca leucadendra*	3		+	+	+	+	+						rs,bb
120.*Michelia champaca*	1	+			+		+			+		+	
121. *Olea dioica*	3			+									
122.*Oroxylum indicum*	3			+	+		+	+					
123.*Paraserianthes falcataria*	2					+							pw,m
124.*Phyllanthus emblica*	1				+		+			+			
125. *Pinus caribaea*	2					+						+	
126.*Pithecellobium dulce*	2	+		+	+		+	+					
127.*Pongamia pinnata*	2				+		+						
128. *Prosopis juliflora*	3	+		+				+					
129. *Protium serratum*	3						+						c,rs
130.*Pterospermum acerifolium*	2	+			+			+				+	agi
131. *Pterygota alata*	2	+				+	+						
132.*Rhizophora mucronata*	1		+	+	+		+						
133. *Samanea saman*	1	+		+				+				+	
134. *Saraca asoca*	2				+							+	
135. *Schima wallichii*	2			+									c
136.*Schleichera oleosa*	2				+		+						
137.*Sesbania grandiflora*	1			+		+	+	+		+			
138.*Semecarpus anacardium*	3				+		+						
139. *Shorea robusta*	1	+			+								c
140.*Sonneratia apetala*	1			+			+	+					
141. *Sterculia villosa*	2	+			+		+						
142.*Stereospermum suaveolens*	3	+		+									
143.*Swietenia mahagoni*	1	+										+	
144. *Syzygium grandis*	2		+							+			
145.*Tamarindus indica*	1	+		+	+		+	+					
146. *Tamarix dioica*	3			+							+		
147. *Tectona grandis*	1	+			+								c,bb
148.*Terminalia bellirica*	1	+			+		+	+					

Species name	Value code	Present, future or potential use											
		ti	po	wo	nw	pu	fo	fd	sh	ag	so	am	xx**
149. *T. catappa*	2				+		+						
150. *T. chebula*	1				+		+						
151. *Toona ciliata*	1	+											bb
152. *Trema orientalis*	3	+		+				+					
153.*Vatica lanceaefolia*	3				+								rs
154.*Xanthophyllum flavescens*	3	+					+						
155. *Xylia kerrii*	2		+										c
156.*Xylocarpus granatum*	2				+								
157.*Zanthoxylum rhetsa*	3	+			+		+					+	
158.*Ziziphus mauritiana*	1	+		+			+	+					agi

VALUE: 1 = Species of current socioeconomic importance; 2= Species with clear potential of future value; 3 = Species of unknown value given present knowledge and technology
UTILIZATION: ti = timber production; po = posts, poles, roundwood; wo = fuelwood, charcoal; nw = non-wood products (gums, resins, oils, tannins, medicines, dyes, etc.); pu = pulp and paper; fo = food; fd = fodder; sh = shade, shelter; ag = agroforestry systems; so = soil and water conservators; am = amenity, antithetic, ethical values; **xx** other:** v = veneer; pw = plywood; cw = cartwheel; pb = particle board; c = construction work; k = Kapok; irs = railway sleepers; mb = mast of boat; p = planking; t = toys; n = novelties; d = decorative; tc = tea chest; va = varnish; agi = agricultural implements; bb = boat building; pc = packing cages; ab = agar batti; m = match splints and boxes; r = rubber

Appendix 2. Conservation and management of important FGR by eco-geographic zone in Bangladesh

Speciesin ecogeographic (or genecological) zones	Nature reserves, protected areas	*Insitu* conservation stands	Managed forests	Unmanaged forests	Plantations	*Exsitu* conservation stands	Villages, fields, homesteads	Experiment, fields, trials
Hill Forest (Chittagong, Chittagong Hill Tracts, Sylhet):								
Artocarpus chaplasha	+	+	+		+			+
Swintonia floribunda	+	+	+					+
Dipterocarpus turbinatus	+	+	+		+			+
D. pilosus	+							
D. costatus	+							
D. gracilis	+							
Mesua ferrea							+	
Hopea odorata	+	+	+		+		+	+
Syzygium spp.		+	+		+			+
Calophyllum spp.	+							
Palaquium spp.	+							
Chukrasia tabularis	+	+	+		+			+
Ficus spp.	+							
Michelia champaca	+	+			+		+	+
Pterygota alata	+							
Lophopetalum fimbriatum	+							
Amoora spp.	+							
Dysoxylum spp.	+							
Albizia procera	+	+			+		+	+
A. lebbeck	+	+			+		+	+
A. chinensis	+	+			+		+	+
Gmelina arborea	+	+			+		+	+
Alstonia scholaris	+	+						
Toona ciliata	+	+					+	+
Quercus semiserrata	+							
Q. gomeziana	+							
Podocarpus neriloforcis	+							

Cassia fistula	+							
Phyllanthus emblica	+						+	+
Tetrameles nudiflora	+							
Bombax insigne	+							
B. ceiba	+						+	
Duabanga grandiflora	+							
Lithocarpus elegans	+							
Castanopsis tribuloides	+							
Calophyllum polyanthum	+							
Macaranga spp.	+							

Species in ecogeographic (or genecological) zones	Nature reserves, protected areas	*In situ* conservation stands	Managed forests	Unmanaged forests	Plantations	*Ex situ* conservation stands	Villages, fields, homesteads	Experiment, fields, trials
Terminalia bellirica	+							
Pterospermum acerifolium	+							
Diospyros embryopteris	+							
Sterculia villosa	+							
Garuga pinnata	+							
Meliosma pinnata	+							
Callicarpa macrophylla	+							
Vitex glabrata	+							
Saraca indica	+							
Elaeocarpus robustus	+							
Lagerstroemia spp.	+				+			+
Mitragyna parvifolia	+							
Calamus guruba	+				+			+
C. viminalis	+				+			+
C. latifolius	+				+			+
Daemonorops jenkinsanus	+				+			+
Melocanna baccifera	+				+			+
Dendrocalamus longispathus	+							+

Species in ecogeographic (or genecological) zones	Nature reserves, protected areas	*In situ* conservation stands	Managed forests	Unmanaged forests	Plantations	*Ex situ* conservation stands	Villages, fields, homesteads	Experiment, fields, trials
D. hamiltonii	+							+
Neobouzeaua dullooa	+							+
Bambusa tulda	+							+
B. polymorpha	+							+
Melocalamus compactiforus	+							+
Oxytenanthera nigrocialata	+							+
B. vulgaris				+			+	+
Plainland Sal Forest (Comilla, Dhaka, Dinajpur):								
Shorea robusta	+							+
Terminalia bellirica	+							
T. chebula	+							
Miliusa velutina	+							
Albizia procera	+				+			+
Dillenia pentagyna	+				+			+
Lagerstroemia spp.	+							
Garuga spp.	+							
Cassia fistula	+							

Species in ecogeographic (or genecological) zones	Nature reserves, protected areas	*In situ* conservation stands	Managed forests	Unmanaged forests	Plantations	*Ex situ* conservation stands	Villages, fields, homesteads	Experiment, fields, trials
Phyllanthus emblica	+				+			+
Adina cordifolia	+							
Butea monosperma	+							
Careya arborea	+							
Schleichera oleosa	+							
Sterculia spp.	+							
Semecarpus anacardium	+							
Litsea polyantha	+							
Aphanamixis polystachya	+							
Microcos paniculata	+							
Littoral and Swamp Forest								
Casuarina equisetifolia					+			+
Calophyllum inophyllum	+							
Terminalia catappa	+						+	
Erythrina variegata	+							
Barringtonia spp.	+							
Hibiscus tiliaceus	+							
Thespesia populnea	+							
Vitex negundo	+							
Trewia nudiflora	+							
Dolichandrone spathacea	+							

Species in ecogeographic (or genecological) zones	Nature reserves, protected areas	*In situ* conservation stands	Managed forests	Unmanaged forests	Plantations	*Ex situ* conservation stands	Villages, fields, homesteads	Experiment, fields, trials
Mangrove Forest (Sundarban and Coastal Forest):								
Heritiera fomes	+				+			+
Excoecaria agallocha	+				+			+
Sonneratia apetala	+				+			+
Avicennia officinalis	+				+			+
Xylocarpus granatum	+				+			+
Nipa fruticans	+				+			+

+ = Available

Appendix 3. Level and nature of threats to the integrity of species/populations of important tree species (Huq and Banik ,1992; Khan, 1991)

Species in ecogeographic (or genecological) zones	Nature reserves, prot. areas	*In situ* conservation stands	Managed forests	Unmanaged forests	Plantations	*Ex situ* conservation stands	Villages, fields, homesteads	Experiment fields, trials	Degree of threat index
1.*Aglaonema clarkei*	+								
2.*Aldrovanda vesiculosa*	+								
3.*Aquilaria agallocha*	+								
4.*Cirrhopetalum roxburghii*	+								
5.*Cymbopogon osmastonil*	+								
6. *Debregeasia dentata*	+								
7. *Elaeocarpus lucidus*	+								
8. *Hippocratea marcantha*	+								
9. *Homalium schlichil*	+								
10.*Justicia orephylla*	+								
11.*Knema benghalensis*	+								
12. *Limnophila cana (endemic)*	+								
13. *Mantisia spathutala (endemic)*	+								
14. *Marsdenia thyrsiflora*	+								

Species in ecogeographic (or genecological) zones	Nature reserves, prot. areas	*Insitu* conservation stands	Managed forests	Unmanaged forests	Plantations	*Exsitu* conservation stands	Villages, fields, homesteads	Experiment fields, trials	Degree of threat index
15. *Ophiorrhiza villosa*	+								
16. *Phrynium imbricum*	+								
17. *Quercus acuminata*	+								
18. *Rotala simpliciuscula (endemic)*	+								
19. *Semecarpus sulepanduriformis (endemic)*	+								
20. *Sonneratia griffithi*	+								
21. *Spatholobus listeri (endemic)*	+								
22. *Tournefortia roxburghii*	+								
23. *Typhonium listeu (endemic)*	+								
24. *Vatica scaphula (endemic)*	+								
25. *Vernonia thomsonii*	+								
26. *Adina cordifolia*	+								
27. *Aphanamixis polystachya*	+								
28. *Bassia latifolia*	+								
29. *Bauhinia malabarica*	+								

Species in ecogeographic (or genecological) zones	Nature reserves, prot. areas	*Insitu* conservation stands	Managed forests	Unmanaged forests	Plantations	*Exsitu* conservation stands	Villages, fields, homesteads	Experiment fields, trials	Degree of threat index
30. *Castanopsis tribuloides*	+								
31. *Derris*	+								

robusta									
32. *Diospyros cordifolia*	+								
33. *Hydnocarpus kurzii*	+								
34. *Lophopetalum fimbriatum*	+								
35. *Mesua ferrea*	+								
36. *Mitragyna parvifolia*	+								
37. *Podocarpus neriifolius*	+								
38. *Pterospermum acerifolium*	+								
39. *Pterygota alata*	+								
40. *Schleichera oleosa*	+								
41. *Sterculia foetida*	+								
42. *Swintonia floribunda*	+								
43. *Tamarindus indica*	+								

+ = Available

Appendix 4. List of priority species for conservation, improvement or seed procurement, their uses and conservation activities needed

Species	End use				Operations / activities needed								Remarks
	W	NW	FW	O	Exploration & collection		Evaluation		Conservation		Germplasm use		
	1	2	3	4	5	6	7	8	9	10	11	12	
1. *Acacia auriculiformis*	+		+					+		+		PVT	Narrow Genetic Base (NGB)
2. *A. catechu*		+		+					+	+			
3. *A. mangium*	+		+					+		+		PVT	NGB
4. *A. nilotica*	+	+	+	+					+	+			
5. *Albizia chinensis*	+		+										

6. *A. lebbeck*	+												
7. *A. procera*	+												
8. *Alstonia scholaris*				+									
9. *Anacardium occidentale*				+									
10. *Anthocephalus chinensis*	+			+									
11. *Artocarpus heterophyllus*	+		+	+					+				MPTS
12. *Azadirachta indica*	+	+	+	+					+				MPTS
13. *Bombax ceiba*				+									

Species	End use				Operations / activities needed								Remarks
	W	NW	FW	O	Exploration & collection		Evaluation		Conservation		Germplasm use		
	1	2	3	4	5	6	7	8	9	10	11	12	
14. *Cassia siamea*			+										
15. *Casuarina equisetifolia*			+										
16. *Ceiba pentandra*				+									
17. *Chukrasia velutina*	+		+										
18. *Dalbergia sissoo*	+		+	+									NGB
19. *Dipterocarpus turbinatus*	+	+											
20. *Elaeocarpus floribundus*				+									
21. *Eucalyptus alba*	+		+										
22. *E. camaldulensis*	+		+										
23. *E. brassina*	+		+									PVT	NGB
24. *E. tereticornis*	+		+									PVT	NGB
25. *E. urophylla*	+		+									PVT	NGB
26. *E. citriodora*	+		+									PVT	NGB
27. *Excoecaria agallocha*	+		+		+								

Species	End use				Operations / activities needed								Remarks
	W	NW	FW	O	Exploration & collection		Evaluation		Conservation		Germplasm use		
	1	2	3	4	5	6	7	8	9	10	11	12	
28.*Ficus benghalensis*			+	+									
29. *F. religiosa*			+	+									
30.*Gliricidia sepium*			+	+									
31.*Gmelina arborea*	+		+	+									
32.*Heritiera fomes*	+		+										
33.*Hevea brasiliensis*	+	+	+										
34.*Hopea odorata*	+		+										
35. *Hydnocarpus kurzii*			+	+									
36.*Lagerstroemia speciosa*	+		+										
37.*Leucaena leucocephala*			+	+									
38.*Madhuca indica*	+	+	+	+									
39.*Mangifera indica*	+		+	+									
40.*Michelia champaca*	+		+										
41.*Paraserianthes falcataria*	+		+										
42.*Phyllanthus emblica*			+	+									
43. *Pinus caribaea*	+	+	+										
44.*Rhizophora mucronata*	+		+										

Species	End use				Operations / activities needed								Remarks
	W	NW	FW	O	Exploration & collection		Evaluation		Conservation		Germplasm use		
	1	2	3	4	5	6	7	8	9	10	11	12	
45.*Samanea saman*	+		+	+									
46.*Saraca asoca*			+	+									

47. *Sesbania grandiflora*			+	+									
48. *Shorea robusta*	+		+										
49. *Sonneratia apetala*	+		+										
50. *Swietenia mahagoni*	+		+										
51. *Syzygium grande*	+		+										
52. *Tamarindus indica*			+	+									
53. *Tectona grandis*	+												
54. *Terminalia bellirica*	+		+	+									
55. *T. chebula*	+		+	+									
56. *Toona ciliata*	+		+										
57. *Xylia kerrii*	+												
58. *Xylocarpus granatum*	+		+										
59. *Ziziphus mauritiana*			+	+									

End uses: 1 = Industrial wood products (logs, sawtimber, construction wood, plywood, chip and particle board, wood pulp etc.); 2 = Industrial non-wood products (gums, resin, oils, tannins); 3 = Fuelwood, posts, poles (firewood, charcoal, roundwood used on-farm, wood for carving); 4 = Other uses, goods and services (food, medicinal use, fodder, land stabilization/amelioration, shade, shelter, environmental values).

Exploration & collection: 5 = Biological information (natural distribution, taxonomy, genecology, phenology etc.); **6** = Collection of germplasm for evaluation

Evaluation: 7 = *In situ* (population studies); 8 = *Ex situ* (provenance and progeny tests)

Conservation: 9 = *In situ*; 10 = *Ex situ*

Reproductive use/germplasm use: 11 = Semi-bulk/bulk seedlots, reproductive materials;

12 = Selection and improvement

Remarks (13): PVT = provenance trials; E = endangered at species or provenance level; PGT = progeny trials; MPTS = multi-purpose tree species; CLT = clonal trials; SO = seed orchard; NGB = narrow genetic base

Forest Cover Degradation at Khadimnagar National Park, Sylhet

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Abstract

Forest cover changes over time. Monitoring cover change is essential to provide forest managers with information they need to assess forest health and productivity, formulate policy decision, and generate management plans. This study maps the forest cover of Khadimnagar National Park (KNP) belonging to Sylhet Forest Division and estimates forest change over a period of 22 years (1988 to 2010) by using Landsat TM imageries and other GIS data. Supervised classification of imageries and Normalized Difference Vegetation Index (NDVI) approaches were applied to classify the imageries to produce three cover classes; namely dense forest, medium dense forest and bare land. The change map was produced by differencing classified imageries of 1988 and 2010 before image and after image respectively in ERDAS IMAGINE. Error matrix and kappa statistics were used to assess the accuracy of the produced maps. Results show that, overall map accuracies resulted from supervised classification of 1988 and 2010 imageries were 84.6% (Kappa 0.75) and 87.5% (Kappa 0.80) respectively. Forest cover statistics resulted from supervised classification shows that dense forest and bare land have decreased from 525.96 ha (66.93%) to 416.52 ha (58.73%) and 104.94 ha (13.35%) to 7.65 ha (0.97%) respectively. Medium dense forest has increased from 154.98 ha (19.72%) to 316.53 ha (40.27%). Forest cover change statistics resulted from NDVI classification shows that dense forest has decreased from 524.88 ha (66.79%) to 420.93 ha (53.57%) while medium dense forest has increased from 252.81 ha (32.17%) to 356.23 ha (45.33%). Amount of bare land remains unchanged. Forest change statistics resulted from both supervised and NDVI classification show similar trend for dense and medium dense forests, i.e., decrease of dense forest and increase of medium dense forest, indicates dense forest has been converted to medium dense forest. Illicit felling, encroachment, settlement close to forest caused the dense forest to decline while short and long rotation plantation raised in different periods caused the medium dense forest to increase. Protective measures should be undertaken to check further degradation of forest at KNP.

Keywords: Forest cover, Landsat TM, supervised classification, NDVI, GIS, change statistics, error matrix

Introduction

Change detection and monitoring of forest cover is essential for forest management (Singh, 1989). Accurate information on forest cover in the form of maps and statistical data is very crucial for spatial planning, management and utilization of forests, investigating forest degradation, growth analysis, forest inventory, preparing management plans, and formulating policy decisions (Karia *et al.*, 2001). Management plan of a forest should be prescribed after evaluating the past and current condition of the area. Forest change detection using satellite

imagery is the most powerful monitoring tool for conservation agency, local administration and the non government organizations (Panigrahy, 2010).

Forest cover dynamics are changed by excess human exploitation, mismanagement, illicit felling, social or political force or by natural course (Zhiming et al., 2008). Tropical deforestation contributes approximately to 20% of the world's anthropogenic greenhouse gas emission. Nevertheless, Matthews (2001) reported that the deforestation rate have been increased in tropical Africa, remained constant in Central America and declined slightly in tropical Asia and South America. It is indeed difficult to have trustworthy data on the actual rate of deforestation in tropical forest because of different methods used to estimate the forest resources, deforestation rate and forest cover change.

Conventional ground methods of forest cover monitoring are labor intensive, time consuming, and are done relatively infrequently. Those maps soon become archaic with the passage of time, particularly in a rapid changing environment. More recently, remote sensing data, because of their temporal resolution, synoptic view and digital format, have become the foremost data source for different change detection applications during the last decades. Remote sensing data are widely used in terms of land use and land cover classification. Field base observation for monitoring the forest status is time consuming and critical. However, Satellite data analysis is more sufficient for accurate assessment (Franklin *et al.*, 2000). Digital nature of remote sensing permits for the advanced computer automated analysis, classification and compatibility with geographic information system (Li *et al*, 2007). Due to increasing rate of deforestation, operational forest monitoring systems at the national level are now a feasible goal in most developing countries in the tropics.

In recent year, fine and high resolution imageries (Quick bird, IRS, IKONOS, ALOS, CASI) deliberate an appreciable forest cover change detection and mapping with a considerable accuracy (80-90)%; but these imageries are very costly. A growing number of studies have dealt with monitoring forest change dynamics, land use patterns, landscape ecology using medium and coarse resolution satellite data (Landsat TM, ETM+, SPOT etc) with quite acceptable level of accuracy (Browder *et al.*, 2005; Vina *et al.*, 2004; Roy and Giriraj, 2008). Imageries from these sensors are low cost or free to obtain, therefore providing the ample opportunity for forest managers and scientists of developing countries like Bangladesh to study forest change incurring no cost of RS data acquisition.

Bangladesh is one of the poorest countries with low natural resource pool and a huge population. Country's forests are very important natural resources which are under constant pressure and have already been drastically degraded and fragmented. 11% of the total landmass (or 2.52 million ha) of the country is designated as forest (Mukul *et al.*, 2008) but the actual tree cover is estimated at around 8-9%. The main cause of degradation are encroachment, illegal felling, increased demand of fuel wood, land conversion into settlement, agricultural land, farm land and also for unplanned industrialization(ADB, 2002; Iftekhar *et al.*, 2003). FAO (2001) evaluated the annual rate of negative change of forests by 2000 ha per year or 0.3% in 2000-2005 in Bangladesh at an annual population growth rate of 1.7%. Such deforestation is likely to continue and forests are likely to disappear by next 35–40 years or earlier (Nishorgo, 2008).

Several studies are found in Bangladesh, which analyzed land cover change using satellite imagery in recent decade (Dewan and Yamaguchi, 2008; Uddin and Gurung, 2005). But not

many studies except a few updated the forest cover change of various forest sites of Bangladesh (e.g., Halim *et al.*, 2008; USAID, 2006; Islam and Quadir, 1988; Islam *et al.*, 2006; Quadir *et al*, 1998). The management approach throughout sustainable development appears to be theoretical with the absence of no or very few information on forest structure and cover change in our country. Even though most of the developing countries are well equipped and updated with detailed forest cover information, Bangladesh as a developing country, suffers for lack of spatial information of forest resource. Present study is aimed to estimate the extent of forest cover change of Khadimnagar National Park (KNP), located in Sylhet forest division from 1988-2010 using Landsat Thematic Mapper (TM) imagery. No study was conducted at KNP to reveal the actual pictures of forest cover and the pace of forest degradation though the park is an important forest chunk of the region with great ecological value.

Description of the Study Site

Khadimnagar national park (KNP) is located in the Khadimnagar Union of Sylhet sadar Upazila and geographically lies between 24°56'-24°58' N and 91°55'-91°59'E. The park is under the authority of Khadimnagar forest beat of North Sylhet Range-1 under Sylhet forest division (Figure 1). The site is situated approximately 15km northeastern of the center of Sylhet city. The KNP was declared as national park in 2006 under the Wildlife Preservation Amendment Act 1974 with the area of 678.80 ha for the purpose of preservation of remaining natural hill forest in Khadimnagar Reserve Forest. The forest is semi-deciduous tropical forest where the tall trees are deciduous and the understory is evergreen (IPAC 2009). KNP undulates with slopes and hillock, locally named as tilla with a height range of 10-50m. It is is submerged with several watersheds locally named as "chore". Total area is surrounded by eight tea gardens (Anon, 2010). The natural forest was covered with inferior quality natural bamboo and gradually felled and converted by tree plantation during early 1960s for being a tropical forest look (IPAC, 2009). Plantation of Khadimnagar Reserve Forest started from 1951 up to 2004. Initially long rotation species including garjan (*Dipterocarpus turbinatus*), champa (*Michelia champaca*), dhaki jam (*Syzygium grande*), teak (*Tectona grandis*), chapalish (*Artocarpus chaplasha*) were planted .From the early 1990s , the forest was introduced with short rotational monoculture plantation mainly with exotic and rapid growing species such as akashmoni (*Acasia auriculiformis*), chickrashi (*Chickrassia tabularis*), champa (*Michelia champaca*), mangium (*Acacia mangium*) and other short rotation species. Bamboo and cane was also planted by the forest department. Faunal composition of the national park is 20 species of amphibians, 9 species of reptiles, 28 species of birds and 26 species of mammals. Soil ranges from clay loams to pale brown (acidic) clay loams. Climatic condition is warm and humid. The tropical monsoon climate prevails in the area with average maximum temperature of 30.7°C and average minimum temperature of 18.9°C. The average annual rainfall is 3931mm, most of which falls between June-September (BBS, 2005).

Methodology

The overall methodical approach followed in this research has been presented as a schematic diagram in Figure 2.

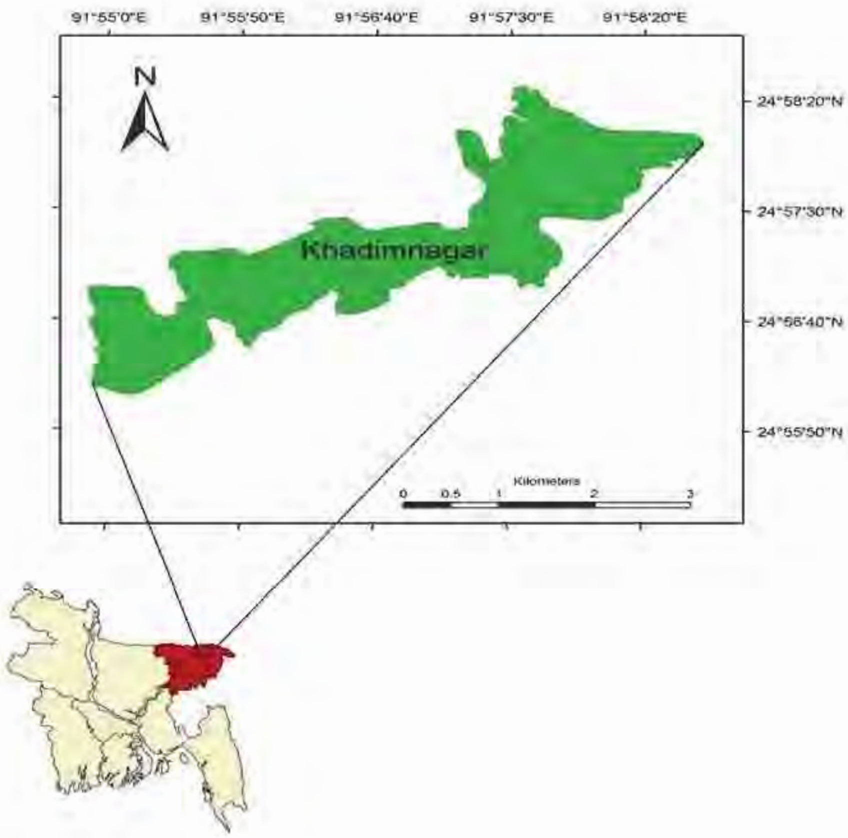

Figure 1. Location of Khadimnagar National Park, Sylhet, Bangladesh

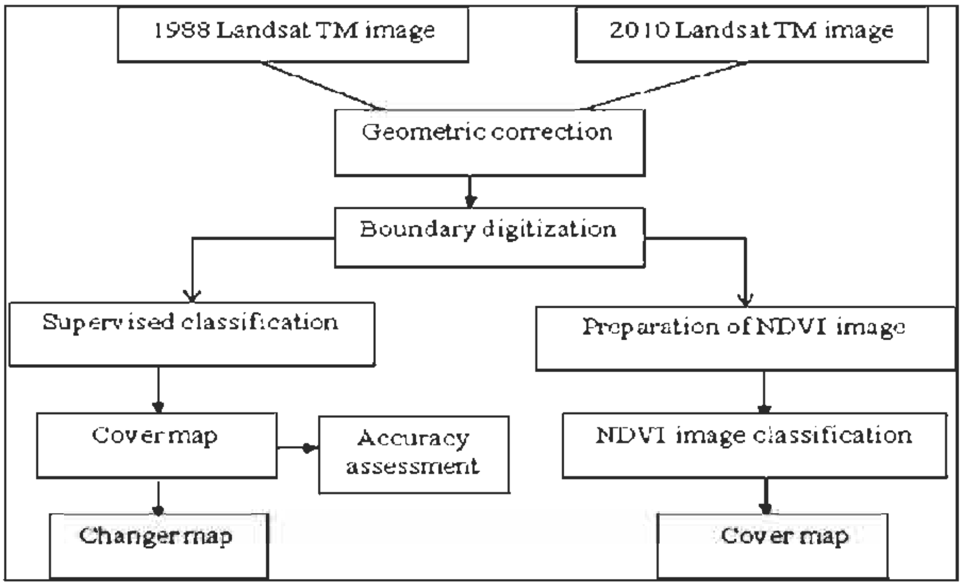

Figure 2. Schematic diagram of the research approach

Acquisition of Satellite Imageries and Preprocessing

Two scenes of Landsat TM sensor of the study site dating 10 November 1988 and 8 February 2010 were acquired. Scenes of KNP were subset from the full scenes (185 km x 185 km) using boundary shape file in ERDAS. Subset images were cloud and defect free. Characteristics of of the imagery used in this study are given in Table 1.

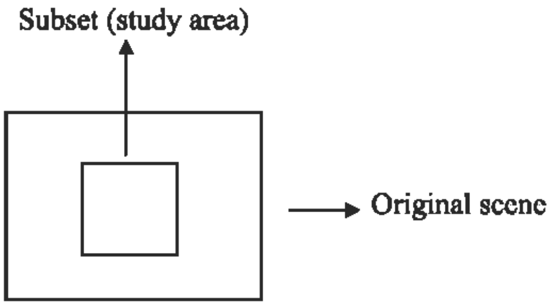

Figure 3. Subsetting process

Table 1. Characteristics of the imagery used in this study

Date	Sensor	Path	Row	Number of bands used	Resolution(m)
10.11.1988	Landsat TM	715	489	6	30 × 30
08.02.2010	Landsat TM	715	489	6	30 × 30

Landsat TM acquires image in seven spectral bands; three in the visible spectrum (band 1, 2 and 3), one in the near infrared (band 4) and two in middle infrared spectrum (band 5 and 7) and one in the thermal infrared (band 6) (Table 2). Bands (1-5) and 7 of have 30mx30m spatial resolution and were used in this analysis. Band no 6 was not used as it thermal band and has coarse spatial resolution of 120mx120m (some similar studies excluded e.g. Fraser *et al.*, 2005; Hossain, 2005; Karia *et al.*, 2001) as it is thermal waveband and not generally used in vegetation remote sensing.

Table 2. Properties of Landsat TM image

Bands Number	Spectral range (μm)
Bands 1 (Visual blue)	0.45-0.52
Bands 2 (Green)	0.52-0.60
Bands 3 (Red)	0.63-0.69
Bands 4 (near IR)	0.76-0.90
Bands 5 (mid IR)	1.55-1.75
Bands 6 (thermal IR)	10.40-12.5
Bands 7 (mid IR)	2.08-2.35

Pre-processing of satellite image prior to image classification and change detection is an essential task. Remote sensing digital image preprocessing includes atmospheric correction and geometric correction (Singh, 1989). Atmospheric correction was not performed as the imageries were defect and cloud free. Landsat TM image of 2010, which is ready geometrically corrected to the coordinate system to Universal Transverse Mercator (UTM) zone 46N with datum WGS84, was used as a master image for georeferencing and image to image co-registration of 1988 image (Townsend et al., 1992; Lillesand and Kiefer, 2000). 13 Ground Control Points (GCP) taken at crossroads, road carvings, trail crossings, canal bands and crosses were used (RMSE 0.4732). 1st order polynomial equation with maximum likelihood resampling approach was used for image transformation in the geometric correction process. All these operations were performed by using ERDAS IMAGINE 9.2, ENVI 4.3 and Arc GIS 9.3 software.

Field Sampling

Field work was carried out in the month of January 2011 for collecting ground training and validating data and for defining the characteristics of each land cover class. Stratified adaptive sampling with strata based on available forest types (plantation and natural) and cover classes resulted from the supervised classification of 2010 images were applied (Phong, 2004). For classification and validation of 2010 image, total 50 points were sampled. For 1988 image 40 points were sampled taking the help of the existing analog historical forest map of KNP and by visual interpretation of image based on some developed interpretation keys. In the selected field points, the following data was recorded: latitude and longitude, forest cover classes, dominant life form, disturbance factor (clear felling, encroachment, conversion of land use, fire.

Image Classification and Accuracy Assessment

After preprocessing the imageries, supervised classification of both the imageries with maximum likelihood classification algorithm was performed in ERDAS IMAGINE 9.2 using the field data to produce three cover classes namely dense forest, medium dense forest and bare land. Two third of the samples were used for training while one-third of them were used for accuracy assessment. 34 samples were training and 16 samples for accuracy assessment of 2010 image while 27 samples were used for training and 13 samples for accuracy assessment of 1988 image. Training and validation points were separated randomly using Hawth's tool in ArcGIS. After classification in ERDAS, the classified imageries were exported to ArcGIS for map production and generating forest cover statistics (Table 3).
Characteristics of each forest cover classes are presented in the following table.

Table 3. Characteristics of forest cover classes

Cover classes	Dominant species
Dense forest	*Tectona grandis, Dipterocarpus turbinatus* *Michelia champaca, Acacia mangium* *Acasia auricoliformis etc* Tree height: (16-25) m Stem/plot: 45-55
Medium dense forest	*Tectona grandis, Dipterocarpus turbinatus* *Michelia champaca, Acacia mangium* *Acasia auricoliformis, Syzygium grande* *Bambusa tulda, Melocanna beccifera* *Calamus guruba,* Herbs, shurbs Tree height: (5-18) m Maximum stem/plot: 20-30
Bare land	Grass land, Agriculture, fallow land, Cane, herbs

Accuracy assessment is very important for recognizing the classification results. Classified maps are hardly used without assessment of their accuracy as quality of the classified maps depends on their classification accuracy. In this we used error matrix (confusion matrix) and kappa statistics to assess the accuracy of the forest cover maps. In error matrix rows contain the result of the classification and columns contain the reference dataset. Diagonal elements of the matrix represent the accurately classified pixel of each class. And the off diagonal elements represent misclassified pixels or the classification error. Kappa statistics is a measurement of agreement between image data and reference data (Jansen, 1996). Kappa is widely used as an unbiased evaluation of classification accuracy. Kappa coefficient is computed as follows:

$$\hat{k} = \frac{N\sum_{i=1}^{r} X_{ii} - \sum_{i=1}^{r} X_{i+}X_{+i}}{N^2 - \sum_{i=1}^{r} X_{i+}X_{+i}}$$

Where: "*r*" is the number of rows in the error matrix, x_{ij} is the number of observations in row i and column j, and x_{+i} and x_{i+} are the marginal totals for row i and column i, respectively, and N is the total number of observations.

Preparation of Normalized Difference Vegetation Index (NDVI) Image and Classification

The NDVI is the normalized ratio of reflectance value at red and near infrared part of the electromagnetic spectrum. NDVI is used widely for monitoring vegetation health. A value of NDVI ranges from -1 to +1. Minus (-) value of NDVI corresponds to non-vegetated surfaces like water body, road surface, settlement etc. Zero (0) NDVI values correspond to no vegetation while 1corresponds to lush-green dense vegetation. NDVI is the most widely used of all vegetation indices because it only requires data from the red and near infrared portion of the electromagnetic spectrum and it can be applied to virtually all multispectral data types. For Landsat TM imageries, NDVI is calculated using the following formula:

NDVI = (band 4- band 3)/ (band 4+ band 3)

NDVI for 1988 and 2010 imageries were calculated separately using the above mentioned formula in ENVI 4.3. NDVI images pixels were then classified into 3 cover classes; dense forest, medium dense forest and bare land; with highest NDVI values corresponding to dense forest, mid values corresponding to medium dense forest and lowest values corresponding to bare land.

Forest Change Map

Image differencing is probably the most widely applied change detection algorithm (Singh, 1989) and used in this study. Image differencing involves subtracting one date imagery from a second date one that has been precisely registered to the first. Image differencing appears to perform generally better than other methods of change detection (Fraser *et al*, 2004; Deng *et al*., 2008). The change map was produced by differencing classified imageries of 1988 and 2010 as before image and after image respectively in ERDAS IMAGINE.

Instrument and Accessories

The following instrument and accessories were used:

- Forest cover map: map of KNP (scale 8 inch to 1 mile) was collected from forest Beat office and was used for field navigation and sample plot selection.
- GPS: Megallan GPS used for recording coordinates of field points
- Computer and software: ArcGIS 9.3, ERDAS IMAGINE 9.2, ENVI 4.3, SPSS and MS-Word and MS Excel were used for satellite and field data analysis and report write up.

Results

Forest Cover Maps

Forest cover maps of 1988 and 2010 resulted from supervised classification of Landsat TM imageries of respective years are presented in Figure 4 and those from NDVI image classification are presented in Figure 5. Three forest cover classes include dense forest, medium dense forest and bare land.

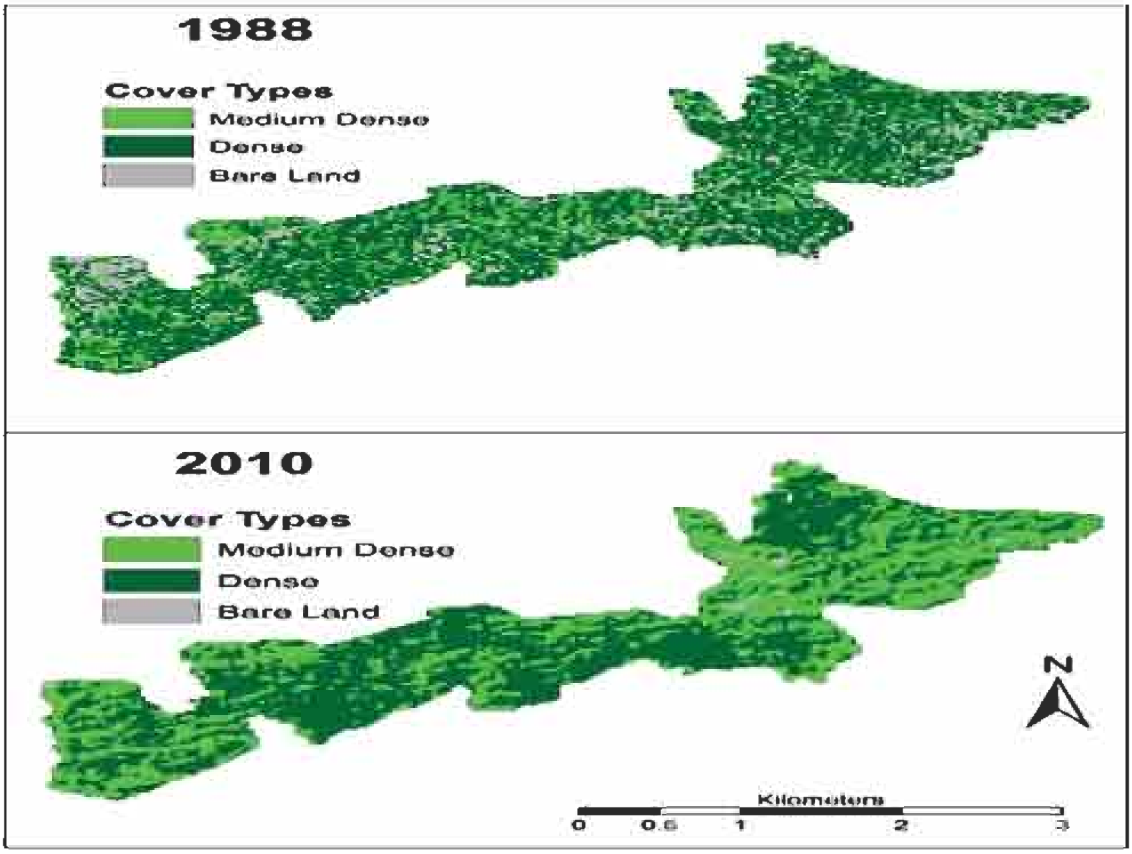

Figure 4. Forest cover maps of 1988 and 2010 resulted from supervised classification

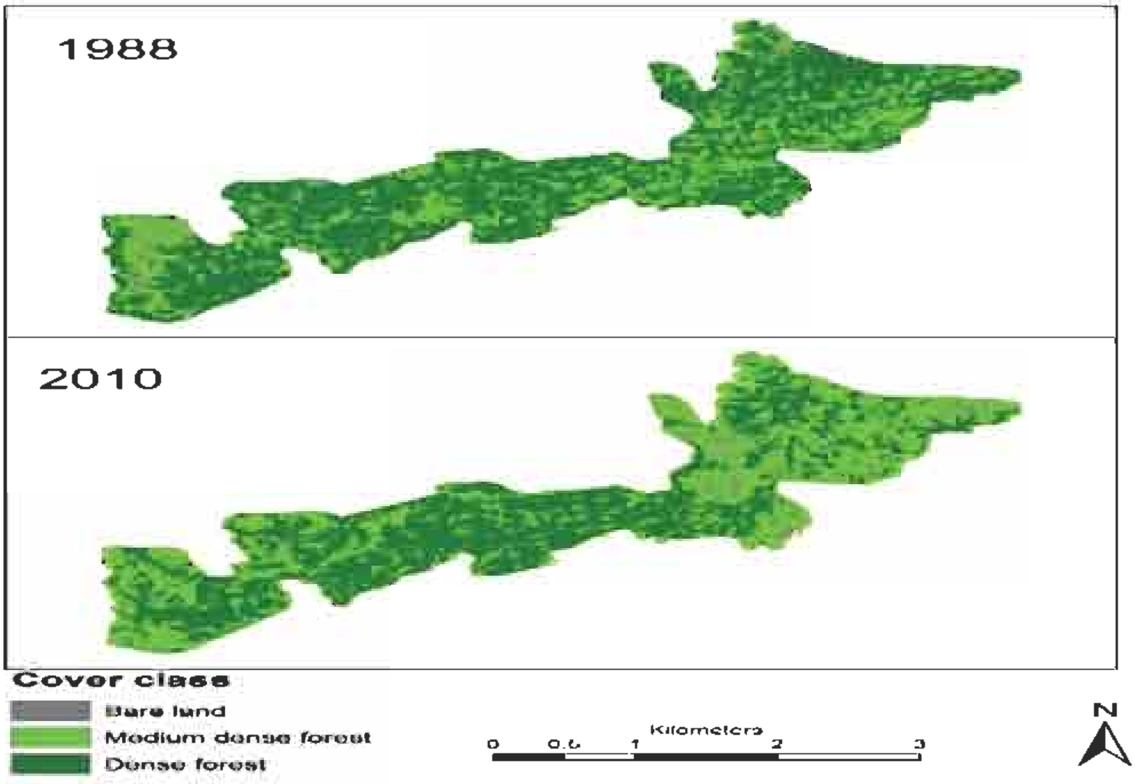

Figure 5. Forest cover maps of 1988 and 2010 resulted from NDVI image classification.

Forest Change Statistics

Summary statistics of forest cover classes of KNP obtained from the supervised classification has been presented in Table 4 (and a diagrammatic representation of the same has been presented in Figure 6). Dense forest has decreased from 525.96 ha (66.93%) to 416.52 ha (58.73%) in 1988 to 2010 respectively whereas medium dense forest increased from 154.98 ha (19.72%) to 316.53 ha (40.27%). Bare land has significantly decrease from 104 ha (13.35%) to 7.65 ha (0.97%).

Table 4. Area (in hectare) of forest cover classes resulted from supervised classification

Year	Dense	Medium dense	Bare land	Total area
1988	525.96 (66.93%)	154.98 (19.72%)	104.94 (13.35%)	785.88
2010	461.52(58.73%)	316.53(40.27%)	7.65(0.97%)	785.70
Change	8.2% (-)	20.55% (+)	12.38% (-)	

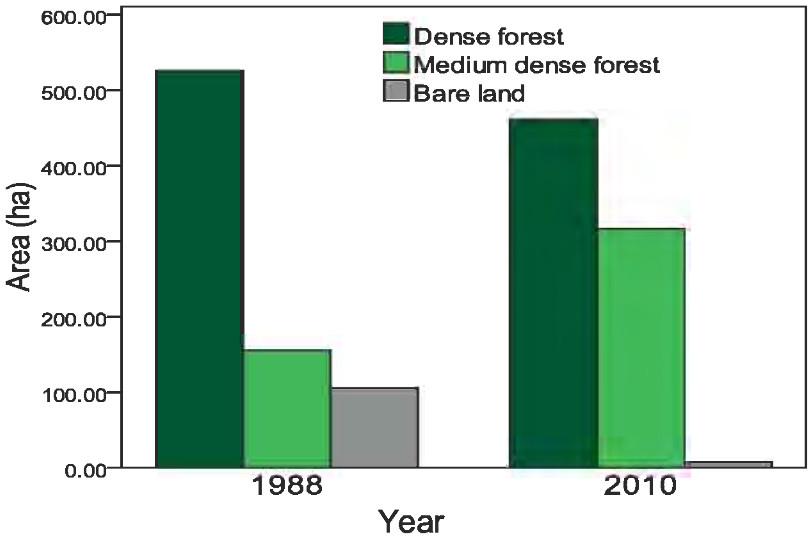

Figure 6. Bar chart of forest cover classes obtained from supervised classification

Forest cover areas resulted from the NDVI classification has been presented in Table 5 (and a diagrammatic representation of the same has been presented in figure 7). In this classification, from 1988 to 2010, dense forest has decreased from 524.88 ha (66.79%) to 420.93 ha (53.57%) whereas medium dense forest has increased from 252.81 ha (32.17) to 356.23 ha (45.33%). Bare land has remained unchanged.

Table 5. Area (in hectare) of forest cover classes resulted from NDVI classification

Year	Dense	Medium dense	Bare land	Total area
1988	524.88(66.79%)	252.81(32.17%)	8.19(1.04%)	785.88
2010	420.93(53.57%)	356.23(45.33%)	8.54(1.08%)	785.70
Change	13.22% (-)	13.16% (+)	0.04% (+)	

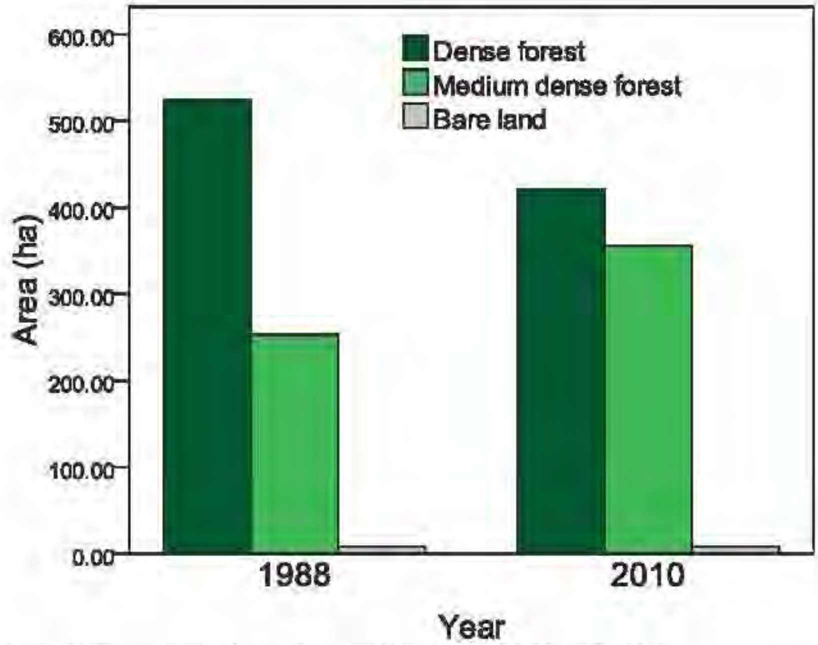

Figure 7. Bar chart of forest cover classes obtained from NDVI classification

Cover class statistics obtained from both supervised and NDVI image classification show similar trend of forest change i.e. decrease of dense forest and increase of medium dense forest. In supervised classification, dense forest decreased by 8.2%, where in NDVI classification, dense forest decreased by 13.22%. Medium dense forest has increased by 20.55% in supervised classification (Table 4) and 13.16% in NDVI classification (Table 5).

Forest change map (Figure 8) was prepared by differencing supervised classification maps of 1988 and 2010 images as before image and after image. Areas with 25% change have been marked as increase or decrease. Red areas correspond to decrease whereas green areas correspond to increase of forest cover. Areas marked white indicate no change.

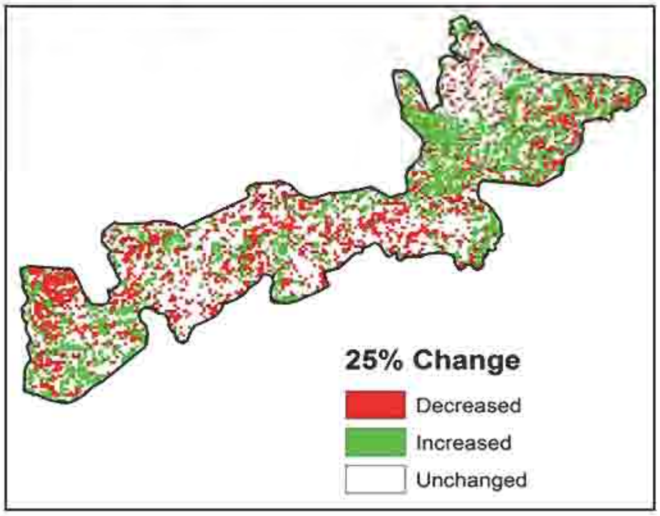

Figure 8. Forest cover change map obtained by differencing supervised classified 1988 image as before image and 2010 image as after image in ERDAS

Accuracy Assessment for Forest Covers Class

For assessing the accuracy of the forest cover maps, error matrices (confusion matrices) were generated. Error matrices of 1988 and 2010 maps have been presented in Table 6 and 7 respectively. Overall accuracy, user accuracy, producer accuracy and kappa statistic (or kappa coefficient) were calculated. The overall accuracy of 1988 map is 84.6% (with associated kappa value 0.75) and of 2010 map is 87.5% (with associated kappa value 0.80). Kappa is intended to give the reader a quantitative measure of the magnitude of agreement between observers. Kappa value 0.75, for example, indicates that produced map is 75% better than that would have been made by chance.

Table 6. Error matrix of forest cover map produced by supervised classification of 1988 image, with Overall Accuracy, Producer Accuracy and User Accuracy and Kappa statistic

Classified data	Reference data				
	Bare	Medium dense	Dense	Row total	User accuracy (%)
Bare	2	0	0	2	100
Medium Dense	0	4	1	5	80
Dense	1	0	5	6	83
Column total	3	4	6	13	
Producer accuracy (%)	67	100	83		

Overall accuracy: 84.6, Kappa statistic 0.75

Table 7. Error matrix of forest cover map produced by supervised classification of 2010 image, with Overall Accuracy, Producer Accuracy and User Accuracy and Kappa statistic

Classified data	Reference data				
	Bare	Medium dense	Dense	Row total	User accuracy (%)
Bare	3	0	0	3	100
Medium Dense	0	5	1	6	83
Dense	0	1	6	7	86
Column total	3	6	7	16	
Producer accuracy (%)	100	83	86		

Overall accuracy: 87.5, Kappa statistic 0.80

For 1988 map, 9 validation field samples out of 13 were correctly classified. 1 validation point belonging to bare land fall under dense forest class while 1 dense forest point fall under medium dense forest class (Table 6).

For 2010 map, 13 validation samples out of 16 were correctly classified. The main classification confusions were between dense forest and medium dense forest classes with 1 validation point of dense forest classified as medium dense forest while 1 point of medium dense forest classified as dense forest (Table 7).

Discussion

Distribution and Rate of Forest Cover Change at KNP

Both supervised and NDVI classification show similar trend of forest change over 22 years, i.e., relative decrease of dense forest and increase of medium dense forest classes. As the study area is constant both for 1988 and 2010, it can be said that dense forest has been converted to medium dense forest. Dense forest, as categorized in this study, include various important tree species with height range of 45-55 metre with 50-60 stem per 30m square plot along with undergrowths. Medium dense forest category has growing stock of 20-30 stems per plot with 5-18 metre height. The phenomenon of forest changes from dense to medium dense in majority areas of the park, what we say 'degradation' of growing stock can be attributed to several factors acting locally like close distance to settlements, absence of zoning, felling history, plantation rotation, illicit felling and also the management effort of the park.

Five tea estates are located adjacent to the national park in the range of 1-3 km and the rest are located outside the park in the range of 1-5 km. People of twenty two villages were identified having wide range of dependency on forest products for their daily need and alternate income generation (IPAC, 2009). The closer the settlements to the forest, the more are the disturbances. Unlike some other hill forests of Chittagong hill tracts and Cox's Bazar of Bangladesh with higher altitude and steeper terrain, KNP engulfs plain lands and undulated lower altitude hillocks (10-50 m) also known as 'tilas' where accessibility is much easier. Many researchers reported that the accessibility is an important factor determining forest degradation (Karia *et al.,* 2001; Bentum, 2009; Fraser, 2005). Since KNP is surrounded by tea estate, roads and transport systems are well developed by private and public entrepreneurship. Therefore, human interference is the vital issue of deforestation at KNP. Vina *et al.,* (2004) reported that 30% deforestation of Colombia occurred surrounding 5 km area of a road. Pong (2004) studying forest cover change at Bach Ma National Park in Thailand found distance of forest from village and population density negatively related to deforestation. Rahman (2000) denoted that the main causes of deforestation in Chittagong forest division, Bangladesh were settlement of rural people in and around the forest, logging practice and excess interference in the forest floor.

Initiation of co-management system has proven helpful in conserving forest. Some other studies in Bangladesh (Halim *et al.,* 2008; Quadir *et al.*, 1998) found forest cover was drastically reduced from the year 1988 to 1996, and gradually increased from 1996 after involvement of forest co management approach involving local people. Co-management approach initiated an alternative livelihood mechanism to motivate the people from encroachment, illicit felling and other misuse of forest product. One alternative forest management at KNP can be the introduction of co-management.

Zoning of protected area is one of the popular management strategies for sustainable forest management (Islam *et al.,* 2006). Buffer zone extensively manages to protect the ecosystem, forest stock, biodiversity as well as floral and faunal composition of the core zone. In KNP, no sound buffer zoning is established for which disturbances to mainstream forest resources are immense (Anon, 2010).

One of the reasons of increasing medium dense forest and decreasing bare land in KNP is the plantation activity undertaken by park authority. Plantation activities in KNP started from 1960s. According to PRA report of IPAC (2009), about 2090.50 acres areas have been planted by long rotation (LR) species from 1951 to 2004. Furthermore, 200 acres short rotation (SR) species have been planted from 1987 to 1989. From 1981 to 2004, different types of bamboo and cane plantation were established in 618 and 563.15 acres respectively. An extensive plantation including SR species (*Acacia auriculiformis, A. mengium, Eucalyptus camaldulensis, Pinus spp, Albizia chinensis*) and bamboo and cane species were established in a considerable area from 1980-1995. The LR plantations were felled periodically after maturity. In the meantime, several SR plantations (1991, 1992, 1993, 1994, 1987, and 1989) have grown up and identified as medium dense forest in the classified image of 2010. In the Northeast corner of the 1988 map (Figures 4 and 5) dense forest cover is noticeable but in 2010 map, the areas have been converted into medium dense forest. This area was planted with long rotation plantation in early 1960s and had matured enough in 1988 (Anon., 2010), as indicated dense forest cover in that year. On the other hand, after 1980 this area was gradually harvested and replanted with short rotation plantation of dhaki jam, chapalish, acasmoni, chompa, meheguni in 1991, 1992, 1993, 1994 plantation year (Anon, 2010). By 2010, the plantations were grownup and seemed as medium dense forest in 2010 map.

Similarly, decreasing bare land (indicated in supervised classification) can be attributed to the increased afforestation efforts by forest department with short rotation plantations. In 1988 map, much area in the North West part of the study area indicated as bare land. In that period, SR plantation of 1988, 1985 were established and LR of 1963, 1964 were harvested (Anon., 2010). But in 2010 image, those areas were indicated as medium dense, as the SR plantations got maturity. Again, bamboo plantation area seemed to be bare in 1988 image may be detected medium dense in 2010 image because of their natural regeneration.

Remote Sensing and GIS implications

To minimize error in estimating amount of change, satellite imageries used should be of same date of the year. Difference in irradiance recorded by the sensor at top of the atmosphere may vary due to change in land cover and other ancillary factors such as atmospheric condition, sun angle, soil moisture etc. However, it is difficult to obtain matching-date imageries, especially free of cost. Acquisition dates of the Landsat TM imageries used in this study are 10th November 1988 and 8th February 2010. Differential date imageries might have some implications in the accuracy of the forest cover maps. However, dry winter season prevails in the image acquisition months (November-February) in Bangladesh while no sharp change in the vegetation phenology is observed in the tropical monsoon forest of KNP. Therefore, error in image classification is expected to be minimal.

Supervised classification and NDVI methods were used for image classification. Both the methods are quit straightforward techniques and easy to use. We did not perform the accuracy assessment of cover maps produced by NDVI method, rather this approach was used as crosscheck to the statistics obtained by supervised classification. Both classification approaches produced similar statistics of forest change and therefore the statistics is confirmed. However, amount of bare land (104.94 ha) as indicated in 1988 map by supervised classification was many times higher than that resulted from NDVI classification (8.19 ha) of the same year. This might be the result of classification confusion between medium dense forest and bare land. In that case, NDVI classification is likely to be most trustworthy than supervised classification as NDVI is based on the spectral characteristics of vegetation and unbiased record of vegetation health.

Several areas belonging to dense and medium dense forest classes were mixed up in pixel level classification. This possibly happened for spectral overlapping resulted from the discontinuity of the forest cover classes. Also it was complicated to distinguish dense class from medium dense, probably due to reflectance of tall trees in the dense class sometimes more or less same in case of thick herbs and shrub of medium dense classes.

Map accuracies obtained by both the classification approaches were high. Accuracy of the change map depends on the accuracy of the independent maps from which it is calculated. Therefore, accuracy of the change map is also high too. Hence, use of medium resolution imageries like Landsat TM proves useful in estimating forest cover change in tropical monsoon forest like KNP. Numerous efforts have been recently undertaken in an attempt to document forest cover change detection using medium and coarse resolution imageries.

Error might propagate in image classification due to 'selective availability' (SA) error of GPS in field training and validation data collection. SA error for Magellan GPS as used in this study is 10 meter. Therefore, real position of field points might shift 10 meter away in any directions from the observed positions. To minimize this error to propagate in the image classification, stratified adaptive sampling strategy was applied and samples were taken such that there is continuation of similar cover class even 20-30 meter away in any direction from the observed points. A number of studies suggested similar sampling technique with increasing number of sample unit that providing more robust and precise change estimation (Achard et al., 2002; Eva et al., 2009). Use of differential GPS (DGPS) however reduces this SA error to centimeter level but present study could not avail DGPS due to unavailability of the machine and high cost involving its purchase.

Conclusion

Forest cover was mapped and the change estimated over 22 years from 1988 to 2010 of Khadimnagar National Park, Sylhet, using Landsat TM imageries and other ancillary GIS data with supervised and NDVI image classification approaches. Accuracy of the forest change map depends on the accuracy of the individual forest cover maps. Forest cover maps of 1988 and 2010 obtained by supervised classification possess high level of accuracy (overall accuracy 84.6% and 87.5% respectively). Accuracy of NDVI approach were not assessed, rather it was used as crosscheck to confirm the forest cover statistics obtained by supervised classification. Statistics of both supervised and NDVI approaches show similar trend of forest change i.e. decrease of dense forest and increase of medium dense forest. Bare land showed decrease in supervised classification but no change in NDVI classification, which might be caused by SA error of GPS field data in training imageries for supervised classification. Afforestation effort of the forest department in different years has contributed in the increase of medium dense forest while human interference and illicit felling are the principal causes of decrease of dense forest cover. Forest department should undertake appropriate measures to scientifically manage and conserve the existing forest stock at KNP.

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Community-led Monitoring Can Supplement Scientific Rigors

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Abstract

Enhancement of biodiversity conservation and local livelihoods entails active involvement of local communities in management as well as monitoring of the natural resources. Monitoring of ecosystem health typically envisages an expert-driven, highly technical and expensive endeavor Few such attempts of monitoring forest resources in Bangladesh are Permanent Sample Plots (PSPs) for plantations in hill forest divisions and the Sundarbans, nation-wide National Forest Assessment sample plots (FAO, 2007), etc.A consistent, regular and sustainable monitoring protocol is still a concern. Conversely, to supplement these, many recent experiences and development discourses reveal that community-led monitoring protocols can also be worthwhile and cost-effective to monitor natural resources which can reasonably be useful in participatory management of natural resources. To be more precise, a blend of community based monitoring protocol coupled with traditional methods, can ensure a sustainable monitoring process in collaboratively managed natural tracts. Nishorgo Network- a platform for collaborative management of natural resources in Bangladesh, has been promoting this venture with empirical evidences in the frame of community score-card, participatory bird monitoring, illegal felling monitoring and monitoring of regenerations in protected landscapes of Bangladesh. The study reveals that given adequate recognitions from public institutions and experts through adoption and promotion, community-led frameworks which are often easy and cost-effective, ensure sustainable natural resources monitoring process.

Key words: Collaborative management, Monitoring, Participatory monitoring, Protected area

Background

Bangladesh forestry sector appreciated people-oriented forestry and adopted 'social forestry in the forest reserves'. More recent initiative (since 2004) for 'collaborative management of protected landscapes' adds to the list of successful initiatives. The collaborative management exhibits a progressive pace in adaptive management of the orest resources of the country. Both the initiatives portray a preview of paradigm shift in forest management from traditional 'command and control' approach. Hence, it is evident that the Government, with the assistance from developing partners, came forward to mediate the interaction between the natural resources and neighboring communities. Due appreciation is echoed to the involvement of local communities in management and conservation of forest resources.

Alike, in many other developing countries, community based forest management has been a proven approach for biodiversity conservation and livelihoods improvement. Community forestry program in Nepal, since 1980s, brought significant improvement in social capital-through developing local institutions (forest user groups) as well as in natural capital-through improved forest health. Joint forest management (JFM) in India also contemporarily evolved through decentralization and devolution of forest management and policy supports from the Government. Few other examples of community-led natural resources regimes are community based forest management (CBFM) in the Philippines and Hutan Kemasyarakatan (social forestry) in Indonesia. These initiatives apply participatory learning in the context of social and biophysical challenges in resource management and local livelihood. While traditional forest monitoring approach is based on periodical data collection and analysis to facilitate a resources management plan, community based participatory learning is a continuous process and gives more focus on diagnosing prevailing threats, challenges and practical ways to resolute those challenges.

Community-led monitoring involves local active stakeholders who has been performing social roles and interests, bears site-specific knowledge, skills, and might not have sound scientific specialization in professional fields of interests. This process might enrich and empower the resource users in systematically record information about their forest patches and subsequently encourages them in reflecting information through management responses. Guit (2007) identifies that participatory monitoring shifts the emphasis away from externally defined and driven programs and stresses the importance of a locally relevant process for gathering, analyzing, and using the information.

Rationale of the study

Forestry sector in Bangladesh has gone through a number of site specific forest inventories namely Forestall Forestry inventory (GOB, 1960) in the Sundarbans Reserved Forests in 1960, inventory of Sitapahar, Kassalong and Rainkheong forest reserves in 1961-62 (GOB 1963), village forest inventory of Bangladesh (Hammermaster, 1981), 120 Permanent Sample Slots (established during 1984/45) ,inventory in the Sundarbans (ADB, 2008), forest inventory of the natural forests and plantations in the Sundarbans, Cox's Bazar, Chittagong and Sylhet Forest Divisions (Revilla, 1998), PSPs in the plantations under Cox's Bazar, Chittagong and Sylhet Forest Divisions, Forest Inventory of the Sal Forests of Bangladesh (Sylvender, 2000), National Forest and Tree Resources Assessment 2005-2007 (FAO, 2007), Bangladesh, Forest Carbon inventory in the Sundarbans 2009-2010 and five other protected areas, etc. These inventories paved a strong basis for developing forest management plans in the concerned forest reserves. However, varied methodologies are adopted during these monitoring. Almost all these approaches applied the traditional methods, and none of these is truly participatory. Consequently, forest dependent communities always remained aside from forest management. The major issue about these inventories is that no particular method can sustain for long-term monitoring of respective forest sites. All these inventories are project driven initiatives devoid of linking the previous inventories. However, it should be noted that since per hectare based results are drawn in almost all the cases, it was useful for later inventories.

Recent studies reveal that monitoring of forest ecosystems is of utmost importance and consequently, the paradigm shift in monitoring further reveals that it is not an exclusive arena for forest managers/ scientists rather local stakeholders are also an integral part of it. A blend of scientists' guidance and community led monitoring empowers the CMO actors to play vital management role in improving ecosystem health and their wellbeing based on forests. Through this, the stakeholders feel ownership to review the change in the ecosystem and respond adequately. Thus, community-led monitoring can be a process to foster adaptive learning and improvement (Evans, 2008) towards sustainable management of forest resources.

This study explores the events of community-led forest ecosystem health monitoring, recently applied in few protected areas whereby collaborative management is introduced. These initiatives are participatory bird survey, illegal felling monitoring in FD field management units, regeneration studies and participatory (CMOs) scorecard.

Methods

The study mostly bases on empirical evidence of community-driven initiatives of forest monitoring in Bangladesh during Nishorgo Support Project (2004-2008) and Integrated Protected Area Co-management (IPAC) Project (2008-2013), in particular and other developing country experiences, in general. Hence literature review, opinions from the active CMO members, GOB officials, practitioners and focus group discussions are accounted during the study.

Results and Discussion

CIFOR (2007) recognizes monitoring as a systematic gathering and analysis of information in order to gauge whether changes occurs and this is workable than a one-off assessment. It should be done at regular time interval and the information is analyzed, evaluated and be used for decision-making. Such monitoring assists resources users and managers to portray the concerns relevant to biodiversity conservation, community wellbeing, institutional processes and overall ecosystem health (Cunha dos Santos, 2002) It acts as a catalyst for adaptive learning in the process of collaborative management and as a cycle that generates systematic progress and adaptation to change (Colfer, 2005, Guijt 2007). It helps to further monitoring that can be a crucial mechanism for enforcing compliance with important forest management rules, such as resource access, use, conservation and benefit distribution (Evans, 2008).

Collaborative initiatives for resource monitoring, with scientific knowledge and local experience can bring a dynamic and adaptive management whereby local people are encouraged to ask how their ecosystem changed over time and what are the issues to be addressed. While a participatory monitoring mechanism is adequately onboard, it can bring some distinct outcomes like stakeholder empowerment, strengthening CMOs in decision-making, building social capital, reducing costs from highly paid consultants-which is often project-based. Above all, it can integrate indigenous knowledge into monitoring. However, Evans, (2008) considers planning and implementing participatory monitoring largely depends on issues like: (i) who participates and how? (ii) what will be monitored and how? (iii) how can a participatory monitoring program be developed and scaled up? and (iv) What are the pitfalls, and how can they possibly be avoided when implementing future programs? In the collaborative management regime of protected areas in Bangladesh, a wide segment of stakeholders are onboard in management and conservation of PA resources, including forest department as a legal custodian of forest reserves. Lessons learned, in this context, from the literature and experiences from the Nishorgo Support Project and consequent Integrated Protected Area Co-management (IPAC) project, are given below:

- In many cases of traditional scientists-led monitoring has been almost unsustainable and sometimes ethically problematic (Danielson *et al*,. 2005; Ghate and Nagendra, 2005; Garcia and Lescuyer, 2008), where the role of local people are kept limited to data acquisition merely. Contrarily, community-led monitoring ensures access of local people to resources and brings their time-efforts and knowledge.

  Co-management organizations (CMOs) showed their utmost enthusiasm in assisting site level personnel from forest department in all sorts of activities including monitoring ranging from information gathering to data analysis, interpretation in local context and learning to feed decision-making process.

- Through the Dry Zone Asia Process in 1999 (FAO, 2003) set criteria and indicators (C&I) for sustainable forest management in this region; C&I framework for participatory monitoring is yet to be well-shaped. Consequently Colfer *et al.* (2005) remarked that C&Is of sustainable forest management are complex and difficult to implement participatory monitoring with forest dependent communities, hard to measure and require too much professional expertise.

  Birds are one of the best indicators of the ecological changes (Johnston, 1956, Morrison, 1986, Welsh, 1987, Temple and Wiens, 1989, Canterbury *et al.,* 2000, Browder, 2002). Different species of birds occur in different strata of an area and are adapted to varied types of plant and animal food. Therefore, the avian population density and species diversity reflect the temporal changes of their habitat conditions. In other words, birds indicate the health of different strata of the forest. Determination of the extent to which ecological systems are experiencing changes is critical for long-term conservation of biotic diversity in the face of changing landscapes and land use (Canterbury *et al.* 2000).

  At this context, NSP and IPAC introduced participatory indicator bird monitoring at 10 forest PAs of the country which proved to be an easy tool to monitored ecosystem health by local people, particularly by the eco-tour guides and community patrol groups. With the guidance from bird monitoring specialist, CMOs are progressing with this approach in Bangladesh since 2004.

- A participatory monitoring program needs to be simple to measure, locally adaptable and relevant to particular site. Stuart-Hill *et al.* 2005 noted that information are needed to be returned back to the community so that they can be on the same page in terms of (program) relevance and can use in their decision-making process. However, adequate emphasis needs to be given for institutional development and capacity building of the CMOs.

Though volunteering by the CMO members for monitoring often brings challenges, CMOs' scorecards to review their institutional capacity has been well-adopted both in forest PAs and wetland RMOs in Bangladesh. This portrays their progress in terms of organizational, leadership, capital, skills, self-reliance, gender dimension, participatory planning and conflict resolution issues. Eventually, such scorecard enables the CMCs in strengthening particular aspects of their institutions. Similarly, another scorecard assessment protocols, for wetland RMOs, has been maintaining to evaluate their capacity for resource management, pro-poor stands to ensure equity, involvement of women, institutional perspectives, good governance, financial management and networking efficiency over time.

- Alike all other monitoring protocols, the biggest challenge for community-led monitoring is also long-term sustainability. The key concern is the method needs to be simple, locally appropriate and linkinged with their livelihood. Topp-Jorgensen *et al.* (2005) described a Tanzanian successful forest-monitoring program, where local communities were managing forests through joint initiatives, which tracked resource extraction and disturbance. This case study describes in details how and when the community monitored its management practices, with particular emphasis on transparency, social control and the monitoring system's economic sustainability.

  Danielsen *et al.* (2005) identified six principles that contribute to the sustainability of a locally-based monitoring program without external support. These are:

- Locally-based monitoring has to identify and respond to the benefits that the community derives from the habitat or population being monitored;
- The benefits to local people participating in monitoring should exceed the costs;
- Monitoring schemes must ensure that conflicts and politics between government managers and communities do not constrain the involvement of local stakeholders in the monitoring process;
- Monitoring should build on existing traditional institutions and other management structures as much as possible;
- It is crucial to institutionalize the work at multiple levels, from countrywide policies down to the job descriptions of local government officer;
- Data should be stored and analyzed locally, even if this means some loss of quality. It should also remain accessible to local people.

In the verge of above discussion, experiences from protected area co-management initiatives in Bangladesh, with their relevance to promote community-led monitoring are highlighted below.

Community scorecard- a conceptual framework for capacity and performance assessment of the CMOs developed (Khan, 2008) under the purview of Nishrogo Support Project, has been using to assess the capacity and performance of the CMOs in Bangladesh. This framework envisages that a number of complex issues and dynamics, at both ecology and entity level, regulates/affects the capacity and performance of the local institutions. These are (i) at the broader environmental level-'the Ecology' –as mentioned by Fred Riggs (Riggs, 1961; also Arora, 1990; Khan, 1998); (ii) at the more immediate level of the organization – 'the Entity' (particular CMC) and associated community- as referred by UNDP (UNDP, 1997; 1998).

This simple matrix for assessment is participatory, whereby representatives of the CMCs opined on a set of indicators (related mainly to soundness of the concerned CMC and its governance, quality of services/activities, and the impact) and assigned value to each indicator based on his/her own judgment. Average of the scores shows the status of the institution. The indicators set (10 points of measure each with maximum score 10) are as below:

- Extent of organizational development (within the CMCs);
- Leadership development;
- Formation and nurturing of (human, financial and social) capitals; capital formation;
- Development of self-reliance;
- Skills and awareness enhancement;
- Soundness in the conduct of routine tasks and operations; (Development Projects/Works);
- Status of poorest households in the community
- Women and gender development;
- Participatory planning and networking and relations with relevant agencies/organizations and
- Conflict resolution and benefit sharing

The score assigned by individual/sampled CMC members against each indicator gives a broad (indicative) impression of status of the concerned CMC.

Participatory bird monitoring- a tool to assess the impacts of collaborative management of selected protected areas in Bangladesh, in the frame of biophysical improvement of ecosystem health since 2004. As a tool for community-led monitoring of ecosystem health, birds are more visible, relatively fast-breeder, and more responsive to any change and community are well aware of the resident birds in their forests. Johnston (1956), Morrison (1986), Welsh (1987), Temple and Wiens (1989), Canterbury *et al.* (2000), Browder (2002) also identified birds to be one of the best indicators of the ecological change. Khan, (2008) reports that different species of birds occur in different strata of an area and are adapted to varied types of plant and animal food. Therefore, the avian population density and species diversity reflect the temporal changes of their habitat conditions. In other words, birds indicate the health of different strata of the forest. Determination of the extent to which ecological systems are experiencing changes is critical for long-term conservation of biotic diversity in the face of changing landscapes and land use (Canterbury *et al.,* 2000).

During 2005-2008, in five protected areas, namely Lawachara national park, Satchari national park, Rema-kalenga wildlife sanctuary, Chunati wildlife sanctuary and Teknaf wildlife sanctuary in Bangladesh, this tool has been applied. Since 2009 five more protected areas viz. Khadimnagar national park, Kaptai national park, Modhupur national park, Fasiakhali wildlife sanctuary and Medhakachapia national park have been brought under participatory bird monitoring approach. The local communities of concerned PA sites and members of Bangladesh Bird Club (BBC) actively participated in the surveys. About 40 transacts are identified for the survey during breeding season whereby population densities (number of individuals/km^2) of birds are recorded and compared over the year. Through continued on-site orientations, it is anticipated that over the years, community will lead this assessment and make this tool sustainable.

Monitoring of regenerations - Mark and McGean (1996), in the Village Voices, Forest Choices remarked, in the context of Joint Forest Management in India, that either all parties lose when the forest is destroyed or all benefit through its regeneration and sustainable management. In this latter win-win scenario, the empowerment of community management groups to take the lead reaffirms the forest department's role as state 'custodian,' overseeing and endorsing the work of local forest-user communities. Further, Ghate and Nagendra (2005) found that local enforcement has been most effective in the case where forest management was initiated by the community, with better regeneration, and negligible evidence of grazing and fire. Nishorgo Network- a platform for collaborative management of natural resources in Bangladesh, has been promoting sample plot based natural regeneration counts in selected PA sites involving communities to assess growth, abundance and diameter distribution of natural regenerations. This is a simple species-abundance count based enumeration whereby local community identifies abundance of seedlings by local name of the species and gets an impression of reduced disturbances in the PAs concerned.

Illegal Felling Monitoring- Since inception of forest regulation through declaration of forest reserves and protected areas, illegal poaching of forest produce have been a major challenges in forestry sector. In recent days, though there are forest management plans developed for major forest division, merely protection came in the forefront as a major activity in forests. And filing forest cases, in the frame of POR, UDOR found to be a significant time-burden to forestry personnel at field level. Nishorgo network, thus identified offence registrar monitoring as a tool for gauging effective collaborative management in some protected areas. Studies (site appraisal reports by Mollah *et al.,* 2004) found the illegal felling as a main threat to our Protected Areas.

Thus illegal felling was selected as indicator of increased levels of protection resulting in part in improved capacity of FD and community groups actively participating in the protection of the PAs. The data have been collectied from Forest Department's Offence Register on a monthly basis since 2004. Community patrolling groups (CPGs) including few women CPGs are participating in joint patrolling with forest guards in selected forest protected areas. This illegal felling monitoring has been applied as a tool to assess effectiveness of community patrolling groups and FD's enforcement in forest protection and overall impact of the co-management regime in Bangladesh.

Integration of scientific research into community-led monitoring- This is obvious that the choices and scale of stakes varies among the stakeholders participating in the co-management process and hence mere community driven monitoring program might not generate robust data to be useful for scientific research. There may be problems of conception, precision and might lack scientific rigors. Danielsen *et al.* (2005) confirms that there is a major gap in understanding the comparability of data between scientifically and locally-collected data. Based on the few comparisons of scientific and local monitoring that have been conducted, fewer amount of data are to be collected by local monitoring programs to generate the same results as with the traditional scientific methods. The authors observed that local monitoring on its own has the ability to detect qualitative changes in forest cover, abundance of wildlife, threats to forest conservation and wildlife habitats, and patterns of resource use adequate accuracy to serve for scientific decision-making.

Hence a blend of scientifically valid protocol, obviously easy to be used by the community, with adequate orientations and supports, can generate a cost-effective and sustainable framework whereby community-led monitoring can be useful to their management planning and would be invaluable information base for scientific communities.

Conclusion

Monitoring framework with active involvement of local communities, which is grounded on scientifically-designed and empirically proven, has manifold advantages, viz., cost effective, information with indigenous knowledge, encourages the local stakeholders in participating management planning, capturing historical perspectives and above all sustainability. In this context, the monitoring tools need to be locally developed; not too technical; should be simple to conduct, less expensive and locally relevant; benefits of monitoring be clear to the CMOs and linked to their livelihood. To ensure this, adequate nurture of the CMOs developed under Nishorgo Network in Bangladesh should be extended with strong commitment from GOB, researchers, NGOs, development partners.

"*By generating data, people become conscious of underlying problems, for example perceived or actual over-hunting of a certain species…Reflection processes can lead to preliminary management action that can be consolidated in an adaptive management process…Communal decision-making is the key, participatory methods provide the inputs and framework for discussion, and detailed scientific information with sophisticated analyses may not be essential, as long as we utilize information with which resource managers and assistants are familiar and confident.*" - from Noss *et al.* (2005)

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Sundarbans Mangrove Forest Carbon Inventory: An initiative towards REDD+

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Abstract

The Sundarbans, world's largest contiguous natural mangrove forest has drawn global attention in recent years. Unique natural beauty of Sundarbans represents Bangladesh to the globe. Out of nearly 10,000 square kilometers, Bangladesh encompasses 6,017 square kilometers. This reserve forest represents more than 40% of Bangladesh forests, and likely represents a key terrestrial carbon stock or sink/source for the country.

Three complete forest inventories were done for Sundarbans in 1959, 1983 and 1997. Reasons for these three inventories were similar in nature and that was: assessment of resources for felling prescriptions. Reasons for Sundarbans carbon inventory were different than those of previous three. It was done mainly to get a baseline carbon stock and make opportunity to sale Sundarbans carbon to international market.

A total of 155 sample plots were selected for the carbon inventory. These plots have been systemically extracted from 1,200 sample plots of 1997 inventory. Each plot was divided into 5 sub plots. Measurements were taken in these plots as per protocol.

For the SRF carbon assessment, in consultation with FD and USFS personnel it was agreed to measure trees, non-tree vegetation, dead wood and soil. Two inventory teams collected data during December 2009 to April 2010.

Mean total carbon (C) density (including soil) is 255.20 Mg/ha (95%CI: ±17 Mg/ha). Total SRF C was found 105.06 Mega ton. Mean C density without soil is 136 Mg/ha and mean soil C density is 119.2 Mg/ha. Total C density of non-soil pools ranged from a low of 20 Mg/ha in one gewa- dominated stand to a high of 446 Mg/ha in one Sundri-dominated stand. Trees constituted the bulk of the C density across the forest reserve, with a mean of 82 Mg/ha above ground and 36 Mg/ha below ground, which combines to account for 47% of total mean C. Result for C density without soil was compared with 1997 inventory and it is found that change in C density is 40.5 Mg/ha.

Change analysis was done and it is found that C density has increased by nearly 54% in 2010 than that of 1997.

Keywords: Carbon, Inventory, Sundarbans, C density, REDD+

Introduction

This document presents field-based carbon (C) stock estimates for the Sundarbans Reserve Forest of Bangladesh. First, it presents an estimate of current C stocks, obtained from the 2009-2010 field-based forest inventory. Second, it contains an estimate of change in C stocks since the previous inventory, which was conducted in 1996-1997. This latter analysis provides an estimate of certain "emission factors" over the recent past, which, when combined with remote sensing and other data on land-cover change ("activity data"), can be used to establish a baseline C trend against which future changes in C stocks can be evaluated.

This write up provides some of the quantitative information necessary for carbon market/monitoring projects (e.g., REDD+ proposals)—specifically current C stocks, their distribution among above ground and below ground pools, and recent trends in C stocks (relevant to baseline). Findings of this C inventory will enable FD to prepare a collaborative REDD+Integrated Forest Management Sundarbans Project.

Background Information

The current forest inventory began with an extensive training program led by the U.S. Forest Service (USFS) and USAID in November 2009, followed by a 5-month field campaign led by the Bangladesh Forest Department (FD) and the Integrated Protected Area Co-Management (IPAC) project, from December 2009 through April 2010. For this carbon inventory, a tier 3 approach (per IPCC sourcebooks) was considered most appropriate for the Sundarbans Reserve Forest. The reserve represents approximately half of all Bangladesh forests, and likely represents a key terrestrial carbon stock or sink/source for the country. In addition, the existing need for forest inventory data in support of an updated forest management plan already justified an intensive field campaign. The measurements required for a typical forest resource inventory and a tier 3 carbon inventory are generally quite similar. Finally, an existing forest inventory plot grid in Sundarbans provided an opportunity to leverage past data to compare historic and future carbon stocks and emissions.

Objectives

A specific objective is to establish a plan for a combined carbon and resource inventory of the SRF to support: a) entry into global carbon markets, and b) an updated forest management plan. Although there are a number of suitable methods for measuring forest carbon stocks, the focus here is to adapt international standards per guidelines of the Intergovernmental Panel on Climate Change (IPCC) and relevant sourcebooks. The aim is to provide instruction on field measurements and computations that will support entry into regulatory or voluntary carbon markets at a high tier. However, it should be noted that the technical aspect of quantifying forest carbon is one of several elements of carbon accounting schemes. These other important elements include social, political, and economic factors—for example, addressing permanence, leakage, governance, etc., are not covered here. Definitions and information on those topics can be found in the IPCC guidelines and associated sourcebooks.

Inventory of Current C Stocks

Project Area Boundary

The inventory area is defined as the Sundarbans Reserve Forest (SRF), the boundaries of which are well defined by relevant legislation and are well mapped. The aquatic portions of SRF, the rivers and sea channels are not considered with respect to carbon storage under current regulations or markets. Carbon accounting and markets are currently focused on terrestrial carbon stores only, particularly forests. This means that, although the total area within SRF is ~600,000 hectares, only the ~412,000 hectares of actual land area are currently eligible for carbon accounting and carbon markets. This means that total carbon stocks in SRF were computed over the 412,000 hectares of land, not by the 600,000 hectares of total area.

Stratification of the Project Area

For Sundarbans, it was recommended not to priori stratify the project area. This recommendation was for several reasons. First, an existing systematic sampling grid is already in place, with historic data available from those ground points. This will allow past, current, and future data to be evaluated in a consistent manner. Second, as long as a systematic sampling grid was started from a random point (which the SRF inventory grid was), that sample layout is considered the most rigorous and intuitive. Third, Sundarbans is a dynamic region, with short- and long-term changes in forest cover and biomass occurring due to changes in hydrology, sedimentation, disease, and human factors. Thus, a stratification employed today may not make sense in the future as vegetation communities and lands shift spatially. For information purposes, in addition to presenting reserve-wide estimates (non-stratified), we also present summaries by vegetation type and management unit.

Carbon Pool Measured

Most international standards divide forests into roughly five carbon pools: i) above ground and below ground biomass of live trees, ii) non-tree vegetation, iii) dead wood, iv) forest floor (litter), and v) soil. Not all pools are required to be measured in every project; decisions can be made at the project level to streamline the effort involved in carbon assessment. A pool should be measured if it is large, if it is likely to be affected by land use, or if the land-use effects or size of the pool are uncertain. Small pools or those unlikely to be affected by land use may be excluded. For the SRF carbon assessment, FD suggested a recommendation to measure trees, non-tree vegetation, dead wood, and soil. Trees are the most susceptible to land use activities, and soil may be the largest and most uncertain carbon pool in mangroves. Dead wood and non-tree vegetation may be a significant biomass component in SRF and may change significantly with logging activities. Forest floor is usually a minor or even negligible biomass component in Asian-Pacific mangroves; as SRF is similar, this pool was excluded.

Methods for measuring trees, non-tree vegetation, and dead wood were adapted from relevant IPCC-associated sourcebooks. In brief, trees were quantified by stem surveys for large and small trees, non-tree vegetation was quantified by counts combined with allometric destructive harvests, and dead wood was quantified by line-intercept transects. Because mangrove soils are often C-rich and vulnerable to land-use change to deeper layers, soils were measured to 1-meter depth rather than only 30 cm as commonly recommended. To reduce the amount of material to be processed, sub-sampling was employed, taking advantage of the fact that mangrove soils are typically non-differentiated over the top meter of soil. Thus, rather than taking a core of the entire top metre, manageable sub-samples of 5 cm were taken representing 0-30 cm depth and 30-100 cm depth, respectively.

Type, Number and Location of Measurement Plots

Plot Shape and Clustering

The shape and size of sample plots is a trade-off between accuracy, precision, time, and cost for measurement. Plots can either be one fixed size or 'nested,' meaning that they contain smaller sub-units for various C pools. Nested plots are generally more practical and efficient in forests with a range of stem diameters and densities, and were used in this inventory. Clustered plot designs (using multiple 'subplots') tend to capture more micro site variation in vegetation, soils, etc., thereby reducing among-plot variation (increasing overall precision). For the SRF carbon assessment, a clustered plot composed of five circular subplots was employed, thus taking advantage of the increased precision of clustered sampling, and the fact that this plot design was employed during the previous forest inventory for SRF.

Number and Location of Plots

The last SRF inventory conducted in 1997, sampled approximately 1,200 plots situated on a systematic grid at 1-minute intervals of latitude/longitude. Based on logistical constraints communicated by the Forest Department, approximately 150-300 plots were the maximum number that could be sampled in a given census effort (300 in two field seasons). Although 300 were the desired and recommended number, 150 were adequate to achieve reasonable precision. The lower number is still likely adequate for the C assessment given local circumstances, and is similar to plot densities in difficult-access, hard to reach areas that has been used by the United States' Forest Inventory and Analysis program. To facilitate these options, the original plot grid was sub-sampled by selecting every second plot in both the x and y directions. This yielded 295 plots (the full option). To attain a lower plot density, every second row of this new grid was sampled; this yielded 155 plots. Carbon inventory sample plots in the Sundarbans is shown in Figure 1.

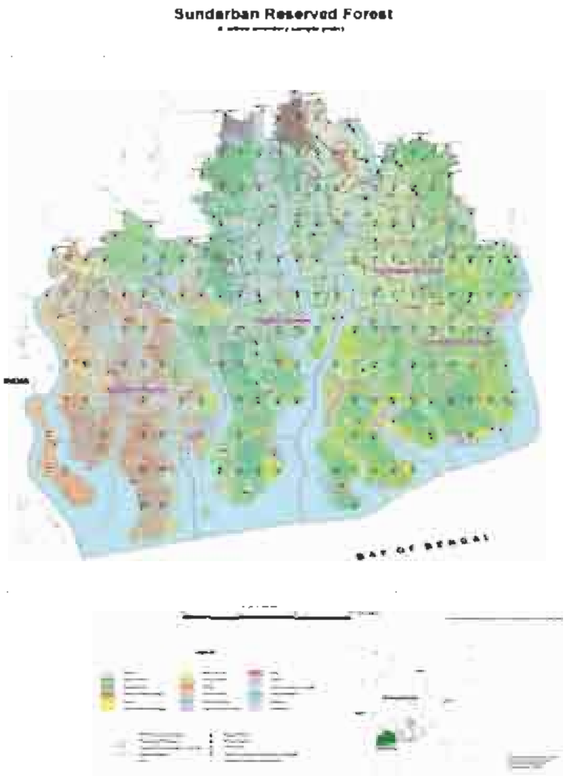

Figure 1. Carbon inventory sample plots in the Sundarbans.

Field Inventory

The field inventory started with four days of in-situ field training, during which the first plots were surveyed. Officials from the USFS, Bangladesh Forest Department, and IPAC accompanied the participants. Participants learned the field protocols, practiced the use of instruments, and discussed probable questions regarding the inventory process. The actual inventory started in December, 2009, led by two Assistant Conservator of Forests (ACFs).

Of the 155 inventory plots (originally established in 1996-97) targeted for re-sampling, 5 were now under water due to erosion, subsidence, or canal migration (and possibly sea-level rise). At least two of these five losses were apparently due to recent cyclone damage. Thus, a total of 150 plots were sampled in the 2009-10 inventory. Plots which were partially under large canals were recorded as such, with an estimate of the percent of the plot area under water and measurements taken as normal in above-water portions.

Quality Assurance / Quality Control (QA/QC)

- Quality assurance / quality control activities were emphasized from the outset of the 2009-10 inventory. Field procedures were subject to strict oversight and review by the project leaders. QA/QC had been maintained by following ways:The crew carried the protocol at all times in the field, and any confusion could be solved by referring to the protocols as well as the local knowledge of team members.
- Before starting the journey, the plot location and access route were thoroughly studied using GPS units and detailed maps.
- Re-arrangement of team composition was done weekly. In this way, any gaps or methodological differences were minimized

- Each completed data sheet was reviewed in the field. The bottom of every data sheet provides room to document quality control activities. At the end of every field outing, all data sheets were reviewed by a crew member for completeness, legibility and accuracy.
- At the end of the inventory, completed data sheets were photo-copied and stored in two physically separate secure locations (Forest Department and IPAC offices).
- Field data collection procedures were also observed and checked by higher officials of the Forest Department and IPAC. The officials accompanied the inventory team to a subset of plots to observe the data collection procedure.

The data entry process was conducted very carefully, with close supervision by the team leaders. Entered data were also checked and reviewed. After completion of data entry, a randomly selected 10% of plots were cross-checked for data entry errors, plus spot-checking of others. The observed error rate was less than 1%, which was deemed acceptable and unlikely to affect overall estimates significantly. The database was also checked for extreme outlier values (e.g., trees larger than 200 cm) to eliminate potentially influential errors. The final electronic data files, including one version with only field-collected numbers and one version with C computations, are stored with FD personnel, IPAC offices, and USFS personnel.

Data and Sample Management

Field data were entered into computerized spreadsheets periodically and backed up electronically in multiple physical locations. Completed data forms were checked and reviewed in the field and data entry was also reviewed. At the end of the inventory, completed data forms were photo-copied and stored in two physically separate secure locations (Forest Department and IPAC offices). The final electronic data files, including one version with only field-collected numbers and one version with C computations, are stored with FD personnel, IPAC offices, and USFS personnel. Soil samples were air-dried in the field, oven-dried to constant mass at 60°C at the Khulna IPAC cluster office, then sent to Chittagong. Soil carbon analyses were conducted in the laboratory of the soil science in Bangladesh Forest Research Institute (BFRI).

Data Analysis and Results

Above ground and root C pools were computed using both locally derived allometries (via destructive harvests of various shrub species outside the plots) and international standard common mangrove tree allometries, combined with local tables of wood density by tree species. Soil C storage was calculated as the product of soil C concentration (% of dry mass determined by wet oxidation techniques by BFRI), soil bulk density, and soil depth range. All plot-level computations were corrected for the portion of the plot falling on a canal >30 m width, so as not to bias the land-based C density estimates with areas that are officially considered water. The bulk density was estimated (by dividing the mass of the oven-dry soil sample by the volume of the sample) at the office whereas %OC carbon was estimated by the BFRI based on wet oxidation method. The following formula was employed for calculating soil carbon per ha :

Soil C (Mg/ha) = bulk density (g/m3) x soil depth interval (m) x %OC x 0.01

Carbon Density

Mean C density (including soil) was found as 255.20 Mg/ha (95%CI: ±17 Mg/ha). Total SRF C was 105.06 mega ton. Estimated current carbon pools are shown in Table 1. Mean total C density (excluding soil) was 136 Mg/ha (95%CI: ±16 Mg/ha), or moderate to high compared to other mangroves around the world. C density of non-soil pools ranged from a low of 20 Mg/ha in one gewa- dominated stand to a high of 446 Mg/ha in one sundri-dominated stand. Trees constituted the bulk of the C density across the forest reserve, with a mean of 82 Mg/ha above ground and 36 Mg/ha below ground, which combines to account for 87% of all non-soil C. Soil C density ranged from a low of 53 Mg/ha to a high of 438

Mg/ha. Both of them belong to Sundri-dominated stands. Soil C contributes 47% and the rest 53% coming from non soil pools of Sundarbans.

Table 1. Mean carbon pools in the Sundarbans Reserve Forest, 2009-10 inventory

Carbon pool	Carbon Density Mega gram/ hectare	Percentage
Trees aboveground (stems + foliage)	82.4	32.29
Trees belowground (roots)	35.9	14.07
Saplings + seedlings aboveground	1.4	0.55
Saplings + seedlings belowground	1.0	0.39
Non tree vegetationj	2.8	1.10
Goran	7.9	3.10
Down wood	4.3	1.68
Soil 0-100 cm	119.5	46.83
Total	**255.2**	**100.00**

Uncertainty estimates (95% confidence intervals, or 95% CIs) were computed using standard techniques outlined in the protocol. The 95% CI for the total C density was derived through basic error propagation (square root of the summed squares of component pools), as outlined in the protocol. Because some pools were highly correlated, those pools were aggregated in an ecologically sensible way for error propagation (e.g., tree above ground and below ground pools were obviously correlated and were combined into a single 'tree' pool for the uncertainty propagation step).
Although the plot sampling was not strictly stratified a priori, the grid-based sample covered all major land types and allowed post hoc analysis of different strata (e.g., vegetation types, management units). With respect to vegetation type, plots classified as sundri-dominated forest contained by far the highest C density at 169 Mg/ha, followed by gewa-dominated classifications at 102 Mg/ha . Low-stature goran-dominated vegetation contained the lowest C density at 64 Mg/ha.

Carbon stock of SRF

Total C stock and CO_2 equivalents across the Sundarbans Reserve Forest is given in Table 2.

Table 2. Carbon stock and CO_2 equivalents of SRF

Mean Total C Density (Mega gram/ha)	SRF land area (ha)	Total SRF C stock (Mega ton)	CO2 Equivalents (Mega ton)	95% CI of Total C stock (Mega ton)	95% CI for CO2 Equivalents (Mega ton)
255.20 (± 17)	411693	105.06	385.6	98-112	360-411

Notes: - 1 Mega tone = 10^6 Mg.
- Land area is from RIMS, FD GIS data.
- 95% confidence limits for total C stock and CO_2 equivalents are simple propagation of lower and upper confidence limits of C density multiplied by the land area. No uncertainty estimate was available for land area, precluding full error propagation incorporating uncertainties in both parameters

Assessing C Stock Change during 1997-2010

The current inventory re-sampled a subset of a previous field inventory, which was conducted in 1996-97. This allows a direct comparison between C stocks at the different time points, and an assessment of associated C emissions or uptake during the interim.

All efforts were made to conduct the change assessment using consistent methodologies. Computations of C density and C stocks in the 1996-97 inventory followed the exact same procedures as that for the 2009-10 inventory. For consistency, only the 155 plots in common between both the surveys were included in the change assessment (rather than using all 1,200 from the 1996-97 inventory). It should be noted that the re-sampled plots were in the same locations in both inventories, but some spatial errors likely existed.

Certain differences existed in the 1997 dataset, requiring some adjustment of method and limiting what could actually be compared between time points. Mainly, the 1997 inventory was largely a timber resource inventory rather than a carbon inventory, so effectively only trees were measured. Non-tree pools were largely ignored in the previous survey. Golpata *(Nypa Fruticans)* was measured in some plots in 1996-97, but the sample size was insufficient to include in the change assessment. Therefore, only tree pools (above ground and below ground) could be tracked over time. Trees are the most ready indicators of forest change and degradation, so this change assessment should still yield quite valuable insight.
For the five inventory plots, that were surveyed in 1996-97 but were under water in 2009-10 due to land subsidence, erosion, channel migration, or cyclone damage, were included these in the change assessment. The loss of standing C stock in these sites (reduction to zero tree biomass) was factored into the estimate of change. Because of the inclusion of these five plots, there was the need to use an adjusted estimate of mean C density for the 2009-10 dataset compared to the estimate presented above, which excluded areas now under large canals. This difference was relatively minor. Table 3 gives a comparison of mean C pools in SRF between the 1996-97 and 2009-10 inventories.

Table 3. Comparison of mean C pools in SRF between the 1996-97 and 2009-10 inventories

C Pool	1997 inventory		2010 inventory		Change(2010 minus 1997)	
	Cdensity (Mega gram/ha)	95% CI	Cdensity (Mega gram/ha)	95% CI	Cdensity (Mega gram/ha)	95% CI
Trees Above ground (Stem+ foliage)	46	± 4.3	80	±11	+34	±12
Trees below ground (Roots)	27.4	±2.3	35	±4.2	+7.6	± 4.6
Sapling+ Seedling (Above ground)	1.6	± 0.2	1.3	± 0.1	- 0.3	± 0.2
Sapling + Seedling (Below ground)	1.0	±0.1	1.0	± 0.1	0	± 0.1
Total (Trees, Sap-Seedling Only)	76	± 6.6	117	± 15	+ 41	± 17

Note: Only tree and sapling/seedling pools could be compared because these were the only pools measured in the 1996-97 inventory.
(+) and (-) in change column indicate increases or decreases, respectively, during the 1997 to 2010 time period. Estimates for 2010 pools are slightly adjusted from previous section because this analysis included plots that were land in 1997 but now submerged in 2010 (land subsidence, etc.). These were excluded from the land-based C density estimate for the current C stock analysis, but were included as negatively changing plots in the change assessment. The difference is minor.

It is clear from Table 3 that in 2010 C density has increased nearly 54% than that of 1997.

The change quantified (Figure 2) was strongly positive, with confidence intervals significantly different from zero. A significant portion of this difference could be an artifact of sampling error. Some of the changes in C density within particular plots were extremely high (e.g., >200 Mg/ha change in 13 years) and likely unrealistic in biological terms. Errors in re-locating exact plot locations could also play a role. In addition, metadata and protocol locating exact plot locations could also play a role. In addition, metadata and protocol descriptions for the 1996-97 inventory were lacking, meaning that the data had to be interpreted through the inventory report results only. , dead trees were not measured in that survey and adding those would have

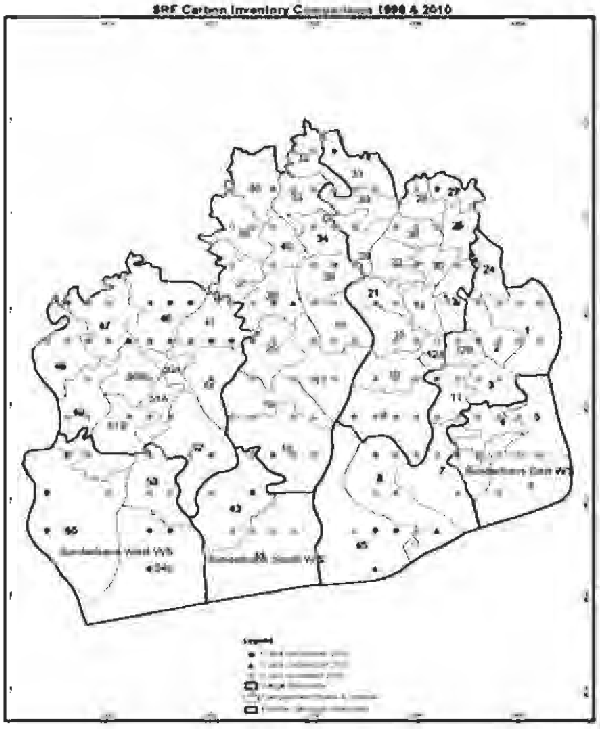

Figure 2. 2010 C inventory plots increased or decreased compared to 1997.

increased the 1997 C stocks and reduced the amount of positive change between surveys. The quality of the 2010 field data collection and data management was documented for the current inventory, but documentation of QA/QC for the 1996-97 inventory was not available. The degree to which any or all of these errors may have affected the change estimate is almost impossible to know with certainty.

The general pattern of observed change is ecologically sensible. In the absence of commercial harvesting, a typical stand development pattern is that tree densities thin out over time (through competitive exclusion and other mortality), with the remaining trees increasing in size. Indeed, compared to the 1997 data, the 2010 inventory showed lower stem densities, especially of small trees, but larger mean stem size and total basal area (Figure 7.2). The magnitude of this difference was large for a 13-year period, but the general pattern is fairly reasonable. Whether due to actual succession dynamics, sampling error, or some combination of the two, this difference is largely what explains the higher C stocks in 2010.

Estimation of Annual Growth

The Annual Allowable Cuts (AAC) have been prescribed in the IFMP based on the 1996-97 inventory. Based on 2009-10 inventory the AAC for different species in the Sundarbans Reserved Forest was estimated using the following formulae:

AAC = (Present standing mature volume+ ½ growth during the period) / Period of cutting cycle.

As per the Austrian formula:

$AAC = I + (Ga - Gr)/A$

where, I = annual increment,

Ga = present Growing stock,

Gr = desired growing stock (indicated by yield table or some other empirical standards)

A = an arbitrary adjust period, which may be a full rotation or any selected period

Here, if we consider Ga = Gr, then AAC approximates to the annual increment.

Table 4 . Annual growth statistics of different species in the SRF

Species	Growing Stock (V10/ha)	Increment (V10/ha)	AAC (V10/ha/year)	DBH limit (cm)	Total area (ha)	Estimated AAC (V10/ha/year)	Working Plan Suggested AAC (cum)	Removal of increment (cum)
1	2	3	4	5	6	7	8	9
Sundri	8.815	7.165	0.620	30	231159	143285	54000	82808
Gewa	0.462	0.410	0.033	15	296698	9887	53000	6081
Keora	0.945	-1.335	0.014	25	31920	4424	29852	-21308
Baen	4.601	2.914	0.303			0		0
Others	2.313	1.092	0.143	25	231159	33041	23000	12626
Goran (Volume)	1.357	0.346	0.077	2.5				0
Goran (kg)	1458	402	82.96					0

Estimates for Additionality for REDD+

The total annual increment (Table 4) for sundri, gewa, keora and other species (except goran) stand at 53,739 tons (=0.67x80,207 cu.m), whereas the annual harvests for goran averaged as 62,400 metric tons. This means that the annual biomass increment is approximately 116,139 metric tons or 58,068.5 metric tons of C. If multiplied by the molecular conversion factor of 44/12, the total annual CO_2e equivalent (CO_2e) is 213,115 metric tons. Thus for 30 years project the CO_2e will be 6,393,452 metric tons.

The above-derived estimates of the additionality do not include soil carbon additions; although it is found that 49 mega ton (47% of 105) of soil C is stored in this forest, which may be substantially reduced in case mangroves are degraded. Additionality of soil C needs to be considered and calculated on consideration of some references to achieve full advantages of REDD+.

Collaborative REDD+IFM Sundarbans Project, CRISP (Proposed)

The Collaborative REDD+IFM Sundarbans Project, CRISP (\proposed) is a project currently being designed to meet the requirements of an Agriculture, Forestry and Other Land Use (AFOLU) project. Specifically, CRISP is hoped to qualify for consideration under the REDD category of eligible activities aimed at avoiding unplanned frontier deforestation and degradation, and IFM category. In this case activities are aimed at conversion of logged forests to protected forests including protecting currently logged or degraded forests from further logging as defined in the Voluntary Carbon Standards (VCS) 2007.1 and VCS Tool for AFOLU Methodological Issues (published on 18 November 2008). The project document has been developed by largely following the approved VCS methodology : VCS Methodology VM0006 – Methodology for Carbon Accounting in Project Activities that Reduce Emissions from Mosaic Deforestation and Degradation. The CRISP is not being designed as a Grouped Project as defined in the VCS 2007.1.

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Application of Dendrochronological Techniques in Bangladesh Forests

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Abstract

Long-term tree growth data both in instrumental as well as proxy climate are scant in Bangladesh. This paper describes convenient strategies for application of dendrochronological techniques in Bangladesh forests. Preliminary step of applying this method is to asses the nature and periodicity of tree rings in the expected tree species growing here. Different strategies for the identification of tree ring boundary in different specie were discussed. Effective strategies include sampling useful tropical or subtropical species that extend naturally or planted into the country; sampling species of same genus that have already provided examples useful for dendrochronology; targeting deciduous species in seasonally dry forests. Next step is to proof the annual periodicity of the identified tree rings. A simple method for determining the periodicity of tree rings is counting rings in trees and to validate with plantation age, if reliable plantation history is known. Dendrochronology can also be used to test the annual nature of growth banding in tropical species. The cross-dating of long tree ring series between individual trees and between multiple sites in a region is strong evidence that the growth rings are indeed synchronized with the annual calendar. This can be confirmed by statistical test using GLK% and TBVP values. Another option is to check whether the ring-width data are correlated with long annual records of climate variability, for instance precipitation. Blind cross-dating to test the harvesting dates of known-age trees can provide another rigorous proof of annual growth rings in a particular species.

Keywords: Tropical dendrochronology, Tree ring, Periodicity

Introduction

Tropical forests are facing challenges due to overwhelming population pressure and rapid degradation of forest resources. Establishment of new management plan is essential to conserve rich biodiversity, and to ensure sustainable forest management. However, there is paucity of age, growth rate, age related yield data which are necessary basic information for sustainable silvicultural practice. Dendrochronology (tree-ring studies) is a powerful tool for developing high-resolution proxies for long-term growth dynamics and climate reconstruction in temperate and boreal forests (Schweingruber, 1988; Briffa, 2000). In the tropics, this method is not widely applied due to complex ring anatomy and in most of the species tree-rings are not distinct (Worbes, 1990; Sass *et al.*, 1995; Schmitz *et al.*, 2007). While rings are reasonably evident in some species, their periodicity is not tested to develop long chronologies because there is an assumption that tropical trees do not form annual growth rings (Whitmore, 1998). Moreover, the problem is aggravated by suppressed or senescent growth, particularly when attended by false rings, discontinuous rings, and other anatomical complications (Priya and Bhat, 1999; Détienne, 1989). Nevertheless, there is a growing interest in tropical dendrochronology globally, because of its potential benefits to climatology, forest ecology, and silviculture.

Development of tropical tree-ring chronologies of teak from India and Thailand was the land mark for stimulating dendrochronology in the tropics (Pumijumnong and Park, 1999; Shah *et al.*, 2007). Due to lack of seasonality, clear dormancy in cambial activity is absent and many tropical species fail to produce clear growth ring (Détienne 1989, Sass *et al.* 1995), which restrains dendrochronologists from using classical denrochronological method, for instance, tree-ring analysis (Worbes, 1990). Despite of these difficulties, distinct annual rings have been identified in a large number of tropical trees over past two decades (Brienen and Zuidema, 2005; Roig *et al.*, 2005; Verheyden *et al.*, 2005; Schöngart *et al.*, 2006), and their formation has been linked to local climatic factors, i.e., rainfall and temperature (Worbes, 1995), hydrological factors, i.e. flood (Worbes, 1989) or phenology of trees (Jacoby, 1989; Borchert, 1999).

Even though Bangladesh forest has been managed under scientific forest management plan from colonial period, the stock of timber has drastically declined. Due to the inverse trend of population growth, the country is facing to the challenge of a large gap between the supply of and demand for wood materials which is expected to be more acute in the near future (Chowdhury *et al.*, 2005). Previous management plans prescribed on the basis of volume estimation of the trees ignoring long-term intra-annual growth data (Pant, 1990). Dependable intra-annual growth data are also lacking for most of the species. Short-term growth data are available for few species (Siddiqi, 2001). But those were from few locations and collected by traditional dbh measurement where a considerable error may exist on those estimations. Without long-term intra-annual growth data, it is difficult to determine allowable annual cut, and thus management plans fail to ensure sustainable forest management. Proxy data is also scarce in the country which is an important requisite for past climate data reconstruction.

This paper attempts to summarize some of the useful strategies that have already been suggested, and explains how dendrochronology can also be used to provide rigorous testing for reliable annual ring formation in the tree species growing in Bangladesh. In addition, few applications of tree ring series have been discussed.

Strategies for Searching Potential Tree Species with Distinct Growth Rings

Primary step of applying dendrchronological techniques is to identify the distinct growth ring. However, tree ring characteristics in most of species growing in Bangladesh are so far unexplored. Therefore, some efficient strategies have been described here to identify growth rings.

One highly effective strategy is to simply identify those tropical or subtropical species of known dendrochronological value which have a distribution into Bangladesh. For example, *Tectona grandis* is distributed in Bangladesh and its potentiality and long-term chronologies have been developed in India and Thailand (Pumijumnong and Park, 1999; Shah *et al.*, 2007). Therefore, this species can be used for dendrochrnogical studies in Bangladesh. While there is no guarantee that the tropical members of a particular species will indeed be useful for this. For example, *Acacia auriculiformis* growing in India does not produce clearly distinct growth ring (Rao *et al.*, 2007), while samples of same species growing in Bangladesh show distinct growth ring (Chowdhury *et al.*, 2009a; Figure 1B).

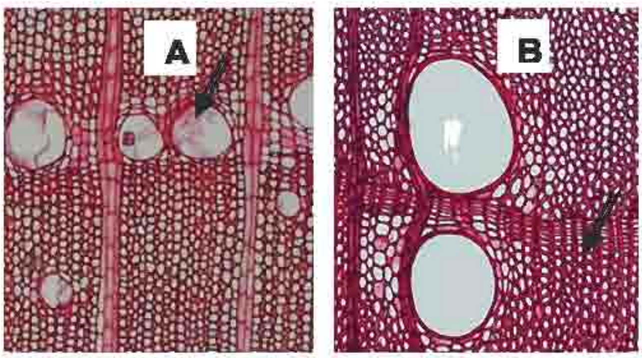

Figure 1. Microtome images showing wood anatomical nature of the distinct growth rings (arrow indicated). –A: *Tectona grandis* –B: *Acacia auriculiformis*; Scale bars = 200 μm.

Another strategy would be to build upon previous success in a particular genus. A few species of some genera have been shown to produce growth rings with specific boundary marker. And progress can be made searching species of same genus growing in Bangladesh. For example, *Sonnertia alba* is an important species of *Sonneratia* genus and growth rings can be delineated by flattened fibers (Rao *et al.*, 1987).

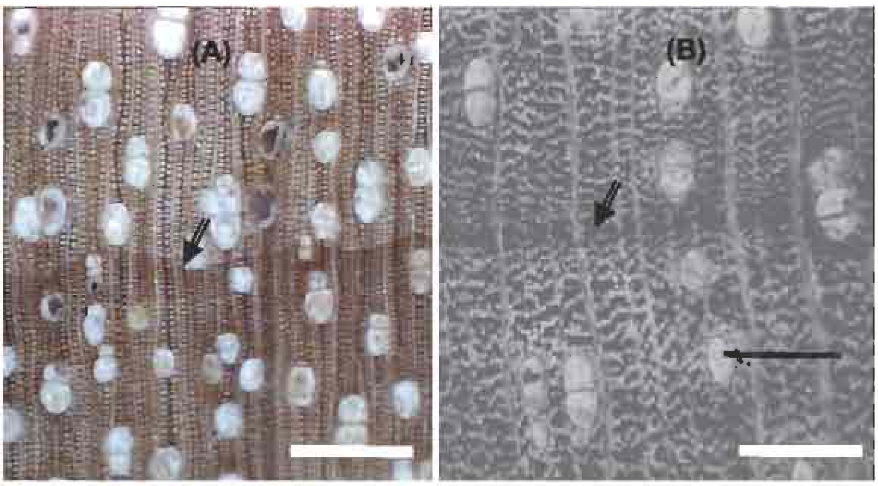

Figure 2. Detail of sanded stem discs showing wood anatomical nature of the distinct growth rings (arrow indicated). (A): *Sonneratia apetala.* (B): *Heritiera fomes*; Scale bars = 500 μm.

Another species of same genus, for instance, *S. apetala* growing in Bangladesh mangroves also shows distinct growth rings which also can be identified with same anatomical features (Chowdhury *et al.*, 2008; Figure 2A). This phenomenon is not common always. For example, the growth rings in *Heritiera littoralis* from the Philippines were reported to be delineated by an initial band of a high frequency of vessels (Panshin, 1932). On the other hand, distinct growth rings delimited, by a decreased frequency of parenchyma bands towards the latewood in *H. fomes* growing in mangroves of Bangladesh (Chowdhury *et al.*, 2008; Figure 1B). The difference in the anatomy of the ring border might be an inter-specific variation.

Another effective strategy would be to target the seasonally deciduous species in the effort to identify useful for dendrochronological study (Jacoby, 1989; Worbes, 1995), particularly those forests which experience a single prolonged dry season and wet season. Bangladesh climate is characterized by monsoon with one dry and a wet season (Figure 3). Therefore, this can be assumed that deciduous trees should show cambial dormancy in the dry season. Because those trees shed their leaves at the end of wet season and leaves flush at the beginning of wet season as an indicator of cambial reactivation. Borchert (1999) has also discussed the important aspect of phenology, and by inference moisture relations, of species in moist evergreen and dry deciduous forests in the tropics. In deciduous species, a clear seasonal segregation of leaf flush and leaf fall appears to be an important factor in the formation of distinct growth bands (Stahle *et al.*, 1997, 1999a). This trait is evident in the phenology of several broadleaf species growing in Bangladesh, and known to be useful for dendrochronology, for example *Tectona grandis.*

According to Troup (1921) the leafless period of this species is from November to March (Figure 3). Growth reactivates in this species might be started with onset of the rain and flushing new leaves. In this stage, earlywood (ring porous vessels) used to form in *T. grandis* and the growth ring boundary can be delineated easily with this anatomical feature (Figure 1A).

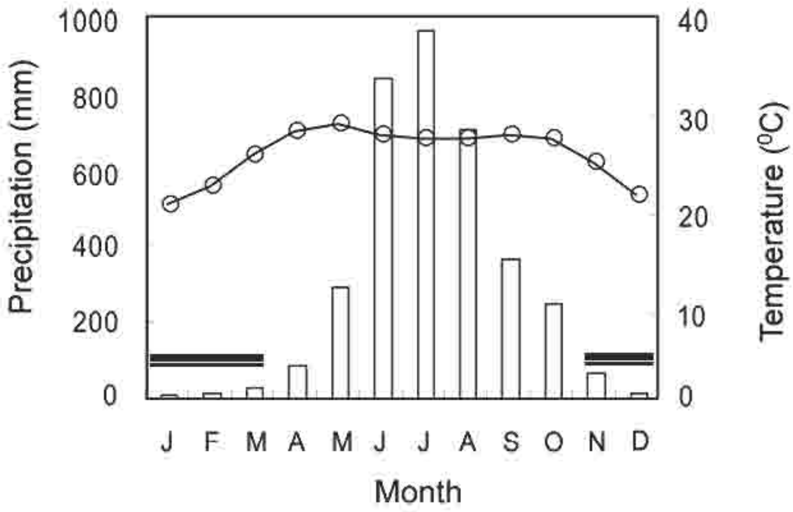

Figure 3. Climate diagram of Bangladesh. Open square, average monthly precipitation; open circle, average monthly temperature. Dash lines indicate the leafless period of *T. grandis*.

Other species which has not any existent clue about growth ring, ring formation can be checked through detailed anatomical studies. This could be a troublesome strategy and success may not be always achieved because indistinct tree ring boundary is also common in Bangladesh, for instance *Casuarina equsetifolia* (Chowdhury *et al.*, 2009b).

Strategies for Searching Periodicity of Growth Rings

Once distinctive growth ring banding has been identified in the minute cellular anatomy of a particular species, whether based on ring porosity, semi-ring porosity, marginal parenchyma, flattened fibers or other structures, it can be very difficult to prove that these growth bands are indeed reliable annual tree rings.

A simple method for determining the periodicity of tree rings is counting rings in trees of known age (Stahle *et al.*, 1999b). However, this method has limited scope and can be applied where exact plantation date is known, such as in trees from plantations and botanical gardens. In a recent study, (Chowdhury *et al.*, 2008) describes that the number of growth rings in plantation-grown *S. apetala* (sample location, Kumira, Chittagong, Bangladesh) corresponding with the plantation age. In this study, out of three sample trees of the 22-year-old plantation, one tree (Tw57952) only showed 21 tree rings. Vacancy filling used to be done after one year of plantation establishment can explain this time lag, although the possibility of a missing ring can not be excluded.

Dendrochronology can also provide a robust test of the annual nature of growth banding over the entire life span of tropical species. If the patterns of wide and narrow growth bands identified in a particular tropical species actually cross-date among all trees in a stand, and among trees of the same species at different locations in a given climate province, then there is little doubt that the growth rings are indeed annual and are not simply structural features of the xylem that fail to synchronize with the annual cycle. In a preliminary study (Chowdhury *et al.*, 2008) showed the annual periodicity of *S. apetala* and *H. fomes* on the basis of visual synchronization among the trees with the climate data. In this paper, we have assessed tree ring series using dendrochronological statistics, i.e., GLK% and TVBP values (Table 1). The ring chronologies of the three plantation-grown trees are very similar (Fig. 4a) and cross-dated very well (Table 1) indicating that the trees showed a common growth response towards external factors.

Table 1. GLK and TVBP values of crossdating

Species	Location	Samples	GLK%	TVBP
S. apetala	Plantation	Tw57952 & Tw57953	79	3.9
		Tw57952 & Tw57954	84	2.7
		Tw57953 & Tw57954	80	8.2
	Natural	Tw57955 & Tw57956	82	3.3
		Tw57955 & Tw57957	76	2.4
		Tw57956 & Tw57957	79	4.5
H. fomes	Natural	Tw58370 & Tw58602	76	4.9
		Tw58602 & Tw58601	73	3.1
		Tw58370 & Tw58601	70	4.1

Cross-dating exists because the growth of trees is periodical, tied to the annual calendar by the seasonality of climate, and synchronized among the trees. When considering *H. fomes*, visual synchronization (Fig. 4c) and statistical values (Table 1) show that all three trees have a similar ring width pattern indicating that the growth rings of this species are likely to be annual too. The lower synchronization and GLK% were found in *H. fomes*.

If the growth banding cannot be strictly linked to the annual cycle, then the width variations will not readily synchronize among trees and the ring sequences will not cross-date. Many tropical hardwoods are obviously quite old and have distinctive growth boundary (Goldsmith and Carter, 1981), but this boundary is usually sub-annual and the time series patterns created by these bands cannot be cross synchronized among opposite radii of the same tree, much less between different trees.

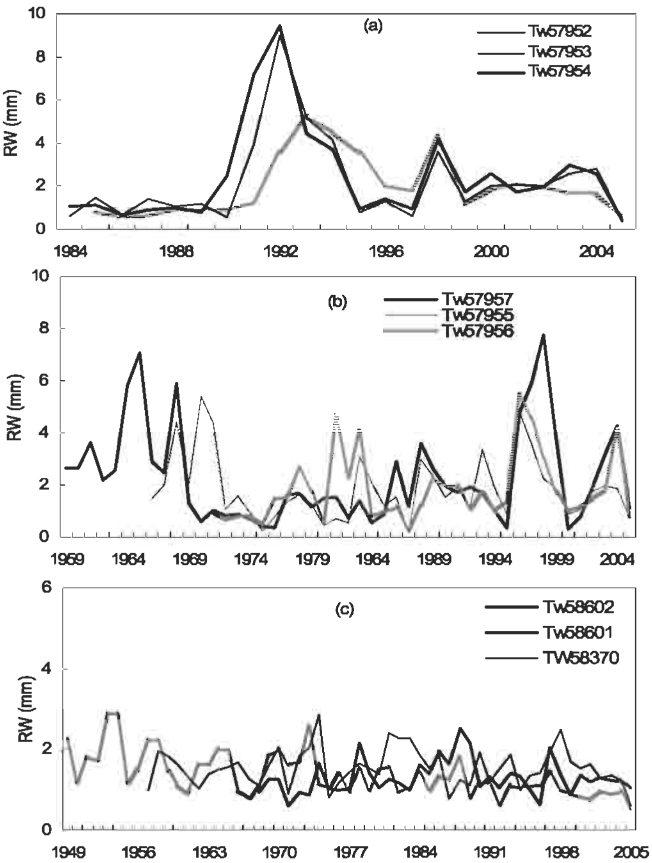

Figure 4. Ring width chronology of individual tree; *Sonneratia,* plantation(a) and *Sonneraita,* natural (b); *Heritiera* (c) (Adapted from Chowdhury *et al.*, 2008).

Examples of Application of Tree Ring Series

Even though previous examples (tree ring series of two major mangrove species) were based on limited number of samples, we tried to show some potential applications of those tree ring series as examples.

Correlation with Precipitation

The correlation of the average ring width with the annual precipitation is ($r = 0.43, p < 0.05, n = 22$) for *S. apetala* in the plantation, ($r = 0.29, p<0.05, n = 45$) in the natural forests and ($r = 0.35, p < 0.05, n = 52$) for *H. fomes*. Lower correlation values indicate that the formation of the growth rings is not primarily determined by the precipitation. This finding is in agreement with the ring formation in the mangrove *R. mucronata*. Here, it is the soil water salinity, and not the precipitation per site, that influences ring formation (Verheyden *et al.*, 2004a, 2005). Also rivers (channels inside the forests) water salinity in the Sundarbans is higher in the dry season compared to the wet season (Siddiqi, 2001) and can therefore trigger ring formation at the beginning of the wet season. The changes in salinity are due to a decreased water flow in the main river channel of the Sundarbans in the dry season (November to June) compared to the wet season (July to October) (Mirza, 1998).

Developing Growth and Age Curves

Growth and age curves were constructed from both mangrove species (Figure 5). The growth rate of the plantation-grown *S. apetala* was higher than that of the trees in the natural forest (Figure 5a). The growth rate of *S. apetala* (0.23 cm/year and 0.20 cm/year for plantation and natural forest respectively) was higher than that of *H. fomes* (0.14 cm/ year).

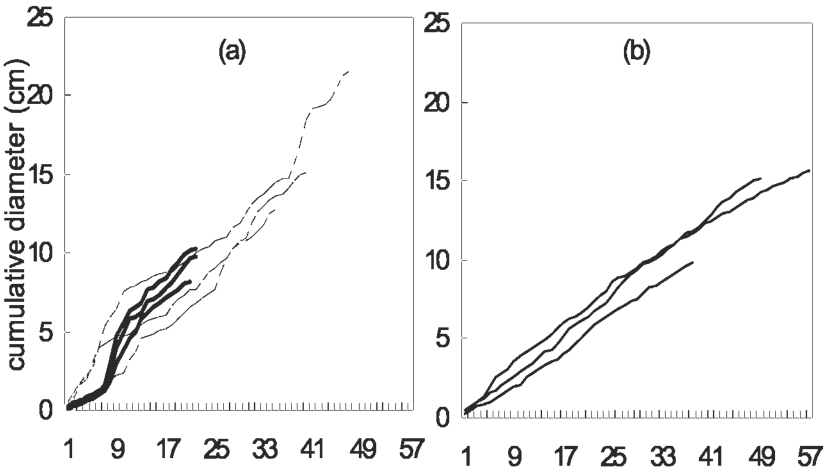

Figure 5. Cumulative diameter and age curve; *S. apetala* (a), plantation (bold lines) and natural forests (doted lines); *H. fomes* from the natural forests (b)

However, higher growth rate in the plantation trees might be due to the more favorable light conditions in the regular spaced plantation. *S. apetala* from the plantation grew much slower in the initial, i.e., juvenile phase as compared to *S. apetala* from the natural forest. After the initial phase of low growth, the plantation trees show a higher growth level than the naturally-grown trees. This can be explained by the fact that the 1-year-old seedlings after transplanting into the plantation need some time to adjust to the site conditions. However, in comparison between two species *S. apetala* has a higher growth rate due to its pioneer tree characters whereas *H. fomes* is a slow growing and shade tolerant species (Siddiqi, 2001).

Strategies for Searching Other Distinct Variables

When annual growth rings are identified, ring width series do not always cross-correlate (i.e. the ring width series of different trees show different patterns) or do not show a clear relationship with environmental variables (February and Stock, 1998). In this case, it is important to check for other proxy variable/s because environmental information can also be archived in the wood in a variety of other ways, such as in the stable carbon and oxygen isotope ratio composition (e.g. Farquhar *et al.*, 1982, Verheyden *et al.*, 2004), in the wood density (Schweingruber *et al.*, 1991) or in the wood anatomy (Baas and Carlquist, 1985; Baas, 1987). Only a limited number of studies have used wood anatomical features in tree rings in the context of a dendrochronological investigation. However, these studies have confirmed the great potential of time series of wood anatomical features, in particular vessel density and diameter, as a proxy for environmental conditions (Sass and Eckstein, 1995; Gillespie *et al.*, 1998; Pumijumnong and Park, 1999; García-Gonzales and Eckstein, 2003; Verheyden *et al.*, 2005; Eckstein, 2004; Schmitz *et al.,* 2006). In contrast to the expectations, all analysed vessel features, i.e. density, tangential diameter, radial diameter and percentage solitary vessels did not show a clear annual periodicity in species, *S. apetala* and *H. fomes* (Figure 6). In a previous study (Chowdhury *et al.*, 2008) noted similar opinion for another anatomical variable, i.e., vessel area.

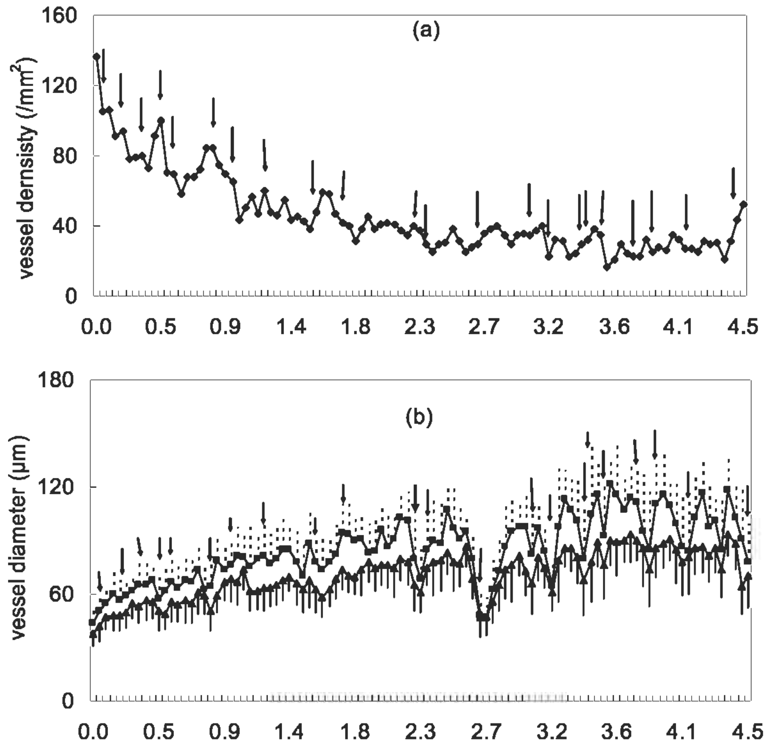

Figure 6. Vessel density (a) and diameter (b) curve of *S. apetala* from plantation sample; arrow indicates the ring border

There is a slight tendency in both species that abrupt changes in both vessel density and vessel size coincide with tree-ring boundaries, i.e., the location of the band of flattened fibres in *Sonneratia* or decreased frequency of parenchyma bands in *H. fomes.* This might be due to the climatic patterns. Arnold and Mauseth (1999) reported that plants can respond to changes in water availability by either changing the vessel diameter or vessel density strongly or by both weakly. The difference in mean diameters was therefore as a result of a higher percentage of small vessels produced during the dry season (Verheyden *et al.*, 2005). In our case ring boundary sometimes corresponded with higher number of vessel density and higher vessel diameter but not always. *S. apetala* and *H. fomes* samples from the natural forests also showed similar trend (data not shown). This might be due to shifting growing season in accordance with early and/or late precipitation.

However, vessel characters (vessel density and diameter) indicated an age trend (Figure 6). Meaning that for comparative anatomical study sampling should be done from similar age group. Vessel diameters also showed fluctuations in the life time of the trees. The larger diameter vessel might produce in the favorable season (especially in starting period of the growth) to meet the increasing demand of the water conduction of the developing crown (Verheyden *et al.*, 2005).

Conclusion and Perspectives

It is observed from the findings that the tree ring characteristics in many species growing in Bangladesh are so far unexplored from dendrochronological point of view. However, the data presented in this paper showed potentiality for future dendrochronological studies. Specially, both (*S. apetala* and *H. fomes*) could provide data on tree ages and forest productivity of stands with additional possibilities for reconstructing climate records. For this purpose, it is unquestionable that further dendrochronological studies are needed in order to explore in detail into the nature of the ring formation. The annuity of the growth rings is the necessary prerequisite for the success of the cross-dating approach and the development of climate reconstructions. As useful as these dendrochronological tests can be, it will be preferable to include as many independent lines of evidence as possible, including phenological studies and cambial activity analysis. The presented are data based on high resolution microscopic system, and it is a laborious to archive the dendrochronological data with bigger number of samples and with bigger size discs. In that sense dendrochronological potentiality assessment with radio-isotope studies and/or X-ray densiometric analysis might reveal another alternative solution.

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A Model House - Made of Cement Bonded Particle Board (CBPB), an Environmental Friendly Housing Material

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Abstract

Cement bonded particle board (CBPB) is an eco-friendly housing material. The main raw materials of cement bonded particleboards (CBPB) are wood chips and Portland cement, an inorganic binder. It is virtually incombustible and can be readily machined with normal tools. It also offers properties of excellent sound absorption, thermal insulation and structural performance. Wastage of wood based industries can be used for manufacturing cement bonded particleboard (CBPB) which ensures better utilization of forest produce. In the present study cement bonded particle board (CBPB) were made using wastage of rubber wood *(Hevea brasiliensis)* and veneer. To increase the bending strength, a frame made of bamboo strips was used in the middle portion of the board. Bending strength, internal bond strength, thickness swelling and water absorption of the board were determined. The values of bending strength and internal bond strength meet the British standards specification for cement bonded particle board (BS 3669). The laboratory tests show that the strength properties and dimensional stability of CBPB meet the standard of outdoor housing materials. Beside this, compressive strength, flexural strength, porosity and water absorption of the board were investigated in Housing and Building Research Institute and compared with the other building materials (mortar and concrete). It was found that values of compressive strength and flexural strength of CBPB were better in comparison with other building materials. The higher porosity and water absorption were slightly hogher in the board materials. To investigate the durability of the board as housing materials, a demonstration house was built using CBPB at Bangladesh Forest Research Institute (BFRI) campus in 2009.

Key words: Cement bonded particle board (CBPB), Static bending strength, Internal bond strength, Thickness swelling, Water absorption, Durability, Construction material.

Introduction

Bangladesh is an over-populated country. For the construction of houses, bamboo and other vegetable fibers are used extensively in rural area of Bangladesh. These materials are very susceptible to degradation by biological agents and damaged within 4-5 years. Besides these, in rural area peoples also live in mud houses. Bangladesh has a long rainy season with humid weather and encounters disaster like flood. In some low land area, corrugated iron sheets are used for the construction of houses which are very uncomfortable in summer season and also undergo damages due to rusting. In such circumstances cement bonded particleboard (CBP) is an alternative product, which is eco-friendly, waterproof and long lasting.

Cement bonded particleboard (CBPB) is a composite made of cement, waste wood and small amounts of additives. The manufacture and utilization of the cement bonded particle board as housing component is in practice around the world. Wood cement composites materials are gaining acceptance as construction housing material because this combines advantages of constituents, cement and wood. There are over 38 CBPB plants in operations throughout the world(Moslemi,1989). The first CBPB plant was built in Switzerland under supervision of the Durison engineer Hans's Knopfel who therefore can be considered as the pioneer of CBPB. People of Soviet Union, Japan, Germany, Italy, Malaysia, Philippines, France and Thailand prefer CBPB as low cost housing component. The low income house in Manila, is made of Elton board. It withstood the force of a 250 km/hr hurricane. Not only the walls but also the floors, doors, certain furniture and shingles on the roof are made of Elton board (Engand Elten, 1996).

CBPB is used in building construction because it offers properties of excellent sound absorption, fire resistance, thermal insulation, dimensional stability, and structural performance. Wang and Takashi (1997) showed that cement-bended particleboard had high biological resistance compared to other common wood-based composite materials. Some tests done in UK suggest that conventionally made CBPB is very resistant to attack by white and brown rot fungi as well as termites (Dinwoodie and Paxton, 1991). Stillinger and Wentworth (1977) pointed out that, in tropical and subtropical countries, the problem of building low cost houses can be solved by using high density wood-cement board at extreme climatic conditions.

Proper utilization of forests and forest produce are directly related to the economy of a country especially where such resources are limited. The inefficient use of these resources has adverse impact on the forest stock. To improve this situation, effective and economic utilization of forest produces is important. Wastage of wood based industries can be used for manufacturing cement bonded particleboard (CBPB), which ensures maximum utilization of wood forest produces.

The purpose of the present study is to fabricate big size (2 feet x 4 feet) cement bonded particle board using frame of bamboo strips inside the board and to determine the strength properties and dimensional stability of CBPB. To determine the durability (fungus and termite resistance, weather resistance), a model house was constructed at Bangladesh Forest Research Institute (BFRI) campus, Chittagong, using cement bonded particle board (Figure 1).

Materials and Methods

Raw Materials

The raw materials for making cement bonded particleboard are mainly wood chips, Portland cement, calcium chloride ($CaCl_2$) and water.

Figure 1. Model house-made of Cement bonded Particle Board

Preparation and Treatment of chips

Waste wood and veneer of rubber wood *(Hevea brasiliensis)* were converted to chips in a hammer mill machine. The chips were sieved through 20 meshes screen to remove dust and fines. The wood chips were submerged under water for 48 hours to remove water soluble extractives, which inhibit the setting of cement. The chips were then air dried to 12-15 % moisture content. Frame was made using bamboo strips and soaked under water for 24 hours to leach water soluble particles.

Amount of Raw Materials

Cement bonded particle boards were produced at normal board density of 1,100 kg/m^3. The cement particle ratio was 70:30. The dimensions of the board were 4ft X 2ft X 12 mm. Ordinary Portland cement was used as binder. Calcium chloride (2% by weight of cement) was added into the mixture of cement and chips as an accelerator to improve cement hydration. The quantity of water used for mixing cement and wood chips was calculated using the formula developed by Simatupang (1979).

Preparation of Board

The quantity of cement and wood chips required to make boards was weighed out and stored in polythene bag to control moisture content changes. The required quantity of calcium chloride was dissolved in the part of the measured quantity of water and then added to the wood chips and mixed thoroughly with hand. The mixture was allowed to keep for 2 minutes for the penetration of calcium chloride to the wood chips. After that, the required amount of cement was mixed with the chips gradually until all the chips were thoroughly covered with cement. The mixing time was 2-3 minutes. The mixture was spread into a mould to form a mat. Bamboo frame was kept
inside the mat, so that it was placed in the middle position of the materials. The boards were pressed under hydraulic cold press (140 psi pressure) for 24 hours. Thereafter, the board were removed from mould (cauls) and covered with a wet cloth wetting for 3-4 weeks. The boards were then subsequently trimmed and cut sample of different size according to standard BS 5669: part1: 1989.

Testing of Board

Samples were prepared from five replicate boards for determining static bending strength, nternal bond strength, water absorption and thickness swelling. These tests were performed according to British Standard 5669 part 1:1989.Thickness swelling and water absorption of CBPB were investigated after soaking under water for 1hour, 2 hours, 24 hours, 3days, 6 days, 9 days and 30 days.

Results and Discussion

Cement bonded Particle boards (CBPB) were made with rubber wood *(Hevea brasiliensis)* chips after 24 hours soaking to leach out the water soluble extractives which interfere the cement bonding. Researchers noted that setting of cement can be improved by reducing the extraneous matter with cold/hot water treatment (Zenglian and Moslemi, 1986). A cold water solubility test performed on the chips showed that they contained 2.97% soluable ingredients that could have inhibited the curing of cement (Akther, 1995). Browning (1967) observed that these water soluble extractives include sugars, gum, organic salts, tannins, cyclitons, galactons and pectin. Cold water treatment and the addition of calcium chloride generally reduced the retarding effect of extractive components (Moslemi *et al.* 1985)

Mechanical properties

The results of strength properties of five CBPB were determined and compared with the British standard (BS: 5669) are shown in Table 1.

Static Bending Strength

The bending strength (Modulus of rupture, MOR) of five CBPB, made of cold water treated rubber wood chips was investigated. Two categories of CBPB –using bamboo frame inside the board and without bamboo frame were made and investigated. The maximum average bending strength values was observed 51 kg/cm^2 for the board prepared without bamboo strips frame whereas the minimum values was found 45 kg/cm.^{2} The maximum average bending strength values was observed 62 kg/cm^2 for the board prepared with bamboo strips frame whereas the minimum values was found 51 kg/cm^2. The values are illustrated in Table 1. It was found that static bending strength (MOR) improved by using bamboo splits frame inside the board. But the bending strength of the two types of boards were lower than the acceptable limits of BS standard (Table 1).

Tensile Strength

It was found that the values of tensile strength (internal bond strength) were found 5.50 to 7.01 kg/cm^2 for the board without bamboo strips frame. The values of tensile strength (internal bond strength) were found 5.50 to 6.95 kg/cm^2 when the board was prepared using bamboo strips frame (Table 1). These values fulfilled the specification mentioned in the British Standard both for the two grades of board, namely T1 (low to moderate rate of performance in the presence of moisture) and T2 (high level to performance in the presence of moisture).

Bison-Werke and Greten (1977) noted that the cement/wood ratio of commercially produced CBPB ranged from 2.75:1.25 to 3:1 on weight basis. Oyagade (1990) reported that density of commercially produced CBPB ranged from 1100 to 1,300 kg/m^3. Therefore decreasing the cement in cement/wood ratio and density of the CBPB can reduce the problem of high weight.

In the present study, the board density was 950-990 kg/m^3. The boards were used in the wall and for making door and windows, not for use as roof. High weight of CBPB tests the problem in handling and application in situation such as ceiling construction.

Water Absorption and Thickness Swelling

Dimensional stability of the five boards is shown in Table 2. The average values of water absorption and thickness swelling after prolonged soaking in water for 30 days ranged for 15.66 to 34.73 and 1.57 to 3.47 respectively (Table 2). Thickness swelling increased initially with soaking time. Maximum increase in thickness swelling took place initially. With the increase of soaking period (after 3 days), there was slow increase of thickness swelling.

Fabiyi (2002) reported that an increase in board density resulted in a corresponding increase in MOR and IB but a decrease in WA and TS. The effect of density on MOR, WA and TS was in agreement with the findings of Fuwape and Oyadade (1993) on CBCP made from tropical hard wood species. Researcher explained (Huang and Cooper, 2000) that boards with high density were subjected to greater compression during production. Such high density boards may likely experience more spring back disrupting bonds between particle and cement and may result in higher WA and TS, compared with low density levels. The board density of CBPB made from rubber wood chips was 950 kg/m^3 and chips and veneer mixture 990 kg/m^3 which were lower than the board made of *Albizia falcataria* chips (Biswas *et al.,* 1997).

Report of Housing and Building Research Institute

The strength properties of CBPB were investigated at Housing and Building Research Institute (HBRI), Dhaka .It was reported that compressive strength and flexural strength of the CBPB were 3,057 psi, and 1,575 psi respectively, which are in acceptable range of building materials. The porosity and water absorptions of CBPB were investigated after 1 hour and 6 hour interval. It was found that porosity and water absorptions of CBPB are slightly higher comparative to other building materials (mortar and concreteIt was reported that the compressive strength and flexural strength showed inspiring result of the CBPB to use as a building material. It was noted that slightly higher porosity and water absorption could lead to physical deterioration after long time exposure in water or humid condition. So this material can be recommended for indoor using (ceiling material, partition board etc) as building material (HBRI Report, 2011).

In the present study, water absorption test was carried out for 30 days (Table 2) and found that initially the percentage of water absorption was remarkably high, but after 9 days, the water absorption increased slowly. It is recommended that the CBPB can be used as out door housing materials.

For durability test, a model house was constructed at BFRI campus using CBPB and service test data were collected periodically after three months.

Table 1.Strength properties of cement bonded particle board

Properties	Mean	Max.	Min.	SD	Standard requirement (BS 5669) T1	T2
Density((kg/m^3)	965	990	950	19.49	--	--
Thickness(cm)	1.45	1.40	1.38	0.028	0.6- 40	0.6- 40
Static bending strength (kg/cm^2) (with bamboo strips)	55	60	50	4.57	100	100
Static bending strength (kg/cm^2) (without bamboo strips)	46	50	38	4.75	100	100
Tensile strength(kg/cm^2) (with bamboo strips)	6.11	6.95	5.50	0.833		4.5
Tensile strength(kg/cm^2) (without bamboo strips	6.12	7.01	5.50	0.834	5	4.5

T1=CBP that has only low to moderate levels of performance in the presence of moisture.
T2=CBP that has very high levels of performance in the presence of moisture.

Table 2. Dimensional stability of cement bonded particle board after prolonged soaking in water

Water Soaking time	Water Absorption (%)				Thickness Swelling (%)				Standard requirement for TS(BS 5669)	
	M	Max	Min	SD	Mean	Max	Min	SD	T1	T2
1 hour	15.66	16.50	14.96	0.61	1.57	1.94	1.24	0.29	3	1.5
2hour	16.84	17.61	16.30	0.55	1.98	2.30	1.60	0.30	-	-
24hour	23.43	14.31	22.44	0.80	2.20	2.50	1.78	0.32	12	1.8
3 days	27.80	29.00	26.31	1.06	2.46	2.70	2.13	0.35		
6 days	31.27	33.89	29.50	1.85	2.53	2.78	2.37	0.38		
9 days	32.00	34.00	30.30	1.24	2.96	3.20	2.59	0.40		
30 days	34.73	36.03	33.50	1.07	3.47	3.70	3.20	0.42		

Conclusion

As Bangladesh is a low lying country, cement bonded particleboard (CBPB) will be useful in construction of houses, especially in rural area where most of the houses are made of bamboo, mud and corrugated iron sheet. It is virtually incombustible and can be readily machined with normal tools and suitable for exterior applications. It also offers properties of excellent sound absorption, thermal insulation and structural performance. The combination of wood chips and Portland cement produces a board, which is environmentally friendly. The production of CBPB using rubber wood *(Hevea brasiliensis)* chips is technically feasible. CBPB made from rubber wood chips can be used as housing materials. Large size board (4 feet X 2 feet) were made using bamboo strips frame inside the board which increased the bending strength and will decrease the risk during use as housing materials. The boards are water resistant and dimensionally stable and can be used in low lying flood affected area.

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Improvement of Traditional Extraction Technique of Agar Oil from Agar Wood (*Aquilaria malaccensis* Lam.)

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Abstract

Artificially and naturally infected agar chips were collected from Barolekha upazila of Moulavibazar district. Agar oil was extracted from agar chips using prototype distillation and Clevenger apparatus. Yield of oil varied from 0.001 to 0.09% when using prototype distillation apparatus. Extraction with Clevenger apparatus yielded 0.89% oil. The distillation technique was compared to the traditional extraction technique used by the agar traders. It was found that traditional extraction technique needs improvement to get better yield and quality of oil. Condensation, separation and purification techniques of traditional method were improved. One hundred and twenty numbers of agar traders of Barolekha upazila were trained on improved extraction technique. Extracted agar oil was analyzed through GC-MS chromatograph at BCSIR, Chittagong and major chemical constituents were identified.

Key words : Agar oil, Agar wood, Extraction, Perfume

Introduction

Agar oil and agaru or agarwood is one of the most valuable perfumery raw materials obtained from the infected wood of trees of the genus *Aquilaria*, a member of the Thymelaeceae family. *Aquilaria malaccensis* is one of 15 tree species of genus *Aquilaria*. According to Oldfield *et al.* (1998), *A. malaccensis* is found in 10 countries: Bangladesh, Bhutan, India, Indonesia, Iran, Malaysia, Myanmar, Philippines, Singapore and Thailand. *A. malaccensis* and other species in the genus *Aquilaria* sometimes produce resin-impregnated heartwood that is sweet-scented and highly valuable. This wood is in high demand for medicine, incense and perfume across Asia and the Middle East.

Several methods are used to extract agar oil from agar wood chips. The most common method is water or steam distillation method. Water distillation is the oldest method to produce essential oil from plants and herbs. This method produces the highest quality essential oil because it does not extract harmful components. Other methods of extracting essential oils are solvent extraction and supercritical fluid extraction. However, in pilot scale extraction, the later two methods are not found feasible. In Bangladesh, the major agarwood-based industries are located in the Barolekha upazila of Moulavibazar district. Most of the industries are following traditional method for agar oil production. Several visits were made to identify the limitations of the present extraction technique. A prototype extraction unit was designed and fabricated at Bangladesh Forest Research Institute by observing the limitations of traditional agar oil extraction units. Agar oil was extracted using the prototype extraction unit and improvement of the extraction technique was made. Training programme was arranged to train the agar traders on the improved method.

Previously it was believed that cause of agar formation was due to fungal attack. Gibson (1977) suggested that agar formation was not related to fungal activity. Rahman and Basak (1980) and Rahman and Khisa (1984) studied the relationship between fungal activities and agar formation. But they did not find any relationship between fungal activity and agar formation. However, Oldfield *et al.* (1998) states that resin production is responsible to fungal infection. Ng *et al.* (1997) stated three hypotheses regarding agarwood formation, that it is the result of pathological, wounding/pathological and/or nonpathological processes. Heuveling van Beek (2000) states that it is due to wounding. However, it is now believed that the production of the fragrant resin is associated with wounding and fungal invasion, possibly assisted by insects. As a response to the infection, the tree produces a resin high in volatile organic compounds that aids in suppressing or retarding the growth of the fungus or insects. Various fungi are associated with agarwood formation although it is still not completely clear which ones make the plant generate the resin (Gratzfeld and Tan, 2008).

The major constituents of agarwood oil are sesquiterpenes, the chemical structure of which makes them very difficult, hence extremely expensive, to synthesize. Although synthetic agar wood compounds are used to produce poor-quality fragrances and incense sticks, there are currently no synthetic substitutes for high-grade incense or oil.

Agarwood Trade

The international trade in agarwood involves wood, wood chips, powder and oil. Agarwood is currently traded in large quantities. Over 700 t of agarwood from *Aquilaria malaccensis* were reported in international trade in 1997. Twenty countries are reported to export/re-export, of which Indonesia and Malaysia are taking the lead. Agarwood chips of high quality is very expensive. It is reported that the price of per kilogramme of agar may sell for several hundred to several thousand US dollars. The price of oil distilled from agarwood is generally between five and ten thousand US dollars per kilogramme, (Barden, *et.al.*, 2000). Another report shows that one litre of agarwood oil can be sold for around $US10,000 - 14,000 (Vietnam Chemical Technology Institute, 2007). The main consumer of the agarwood in international trade is the Far and Middle East, including Saudi Arabia, the United Arab Emirates, Hong Kong and Taiwan.

Once Bangladesh was one of the important traders in the international markets, but the country is now facing serious shortage of raw materials, But no export data of the species is recorded from Bangladesh. The country appears as an importer of *A. malaccensis.* From CITES data, it is shown that the country imported a total of 10 112 kg of agar wood from Singapore between 1995 and 2001 (Anwar Faruque, 2003).

The agar industries of Bangladesh are exporting agar oil to the Middle East countries through their own initiatives and therefore no export records are available. However, Bangladesh Government has now taken initiative for agar plantation in large scale and it is expected that in future the industries will overcome the problem of shortage of raw materials. Therefore it is important to improve the present traditional method of oil extraction for optimum yield.

Materials and Method

Distillation of Agar Oil

A proto-type agar oil distillation plant has been designed, constructed and installed in the laboratory of Chemistry Division of Bangladesh Forest research Institute (BFRI). The plant was equipped with long condenser for complete condensation. In this type of distillation plant, both water and steam distillation processes can be performed well. At the end of the condenser, a separatory funnel was set. Water circulation system was designed for auto pouring of water in to the plant.

Agar chips were collected from Barolekha upazila of Moulavibzar districts. Two types of chips were collected- one was from artificially infected trees and another types from naturally infected agar trees. Chips were cut into smaller pieces and soaked in tap water at room temperature for 1 month. At the end of the soaking periods chips were subjected to steam distillation

Baseline Survey

Survey was made in Sylhet and Moulavibazar for collecting information on the present status of agar trade and applied techniques of agar distillation. Two well-known agar industries in Sylhet city, one in

Khadimnagar, and 10 of Dhakhinbhag, Barolekha and Kulaura areas were visited. Observations were made on types of distillation unit, condensation process, oil recover process etc. Some other relevant data were also recorded.

Training Programme for Agar Entrepreneurs

Training programmes on agar production, extraction and utilization were conducted for agar traders at Barolekha, Moulovi Bazar.

Results and Discussion

Extraction of Essential Oil by Prototype Distillation Plant

One prototype distillation apparatus was fabricated and oil was extracted in water distillation method. Yield of oil varied from 0.001 to 0.09% from artificial and natural grades of agar wood. Extraction with Clevenger apparatus yielded 0.89% oil from artificial grade of agar wood. Improvement was made on separation and purification technique of the oil.

During our field visit it was found that most of the plants are situated in Barolekha upzila of Moulavibazar district and are owned by private owners. At present 118 numbers of agar oil industries were recorded (Baksha *et. Al,* 2009). The trade associated with agar oil is inherited from their ancestors. But recently some of the new individual traders are also being involved in the business. The plants owners set up their factories adjacent to their house. The traders are associated in groups locally known as *Samity.* Three main individual Samity namely Barolekha Upazila Agar Attar Business Co operative Society Ltd., Patharia Agar Attar Manufacturers Co operative Society Ltd. and Jalalabad Agar Attar Co operative Society are actively working and negotiate to the appropriate authority to meet their demand.

Raw Material Collection and Traditional Extraction Method

The Plants owners plant agar trees in their homesteads and artificially inoculated these trees with nailing. Nailing starts at an age of 6-10 years of age of tree. After nailing treatment, trees are kept for 2-4 years. The trees are then felled for collection of raw material. Sometimes they purchase raw materials locally or import from Singapore.

From the collected agar wood, black portion of wood is separated and cut into smaller chips. The chips are then soaked in water for 15-30 days or more. At the end of soaking periods, chips is subjected to steam distillation in a big metallic retort locally known as *deg.* The capacity of deg vary from 40-60 litre. The chips and water are poured into the deg for water distillation. Distillation process is continued for 7-16 days without any break. The *deg* is equipped with a metallic condenser which passes through a tank of water. The end of the condenser is connected to a reservoir containing water. The distilled oil is set down above the water layer which is collected manually and stored.

Following observations were made

- In traditional process, fuel wood is used for heating purpose. Thus uniform distillation temperature cannot be maintained. This may cause incomplete condensation. It is recommended to use gas for continuous and uniform heating.
- Long condenser pipe is recommended instead of short condenser.

- Manual collection of oil results incomplete separation of oil from water. It is recommended to use separatory funnel for complete separation.
- During extraction process, it is necessary to add water into the *deg* to maintain water level. This is done by manually through funnel. The process needs extra labour.
- Collected oil is stored in bottle and remaining water is eliminated by sun drying. This may cause degradation of oil components. Use of anhydrous sodium sulphate is recommended for drying purpose.

Training Programme for Agar Entrepreneurs

Based on the field observations, the traditional oil extraction method was improved and disseminated to the agar traders through training programme. So far 3 training programme were arranged and 120 agar traders were trained on improve extraction technique. Recent field visit shows that some of the distillation plants are already using the improved method.

Conclusions

Trade of agar oil in international market is highly competitive. The quality of oil must be ensured while marketing of agar products. Therefore, during processing and distillation process it is essential to follow the standard and improved extraction method.

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Vietnam Chemical Technology Institute. 2007: *Chemists move toward production of valuable essential oil*

Congress Proceedings

Theme-7:
Sustainable forest management and resource utilization

Sustainable Homestead Forestry Development and National Forestry Policies in Bangladesh

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Abstract

This article stems from a critical review of the concerned policies and associated literature as well as an empirical case study. It is found that despite its great contribution to rural socio-economy, homestead forestry has historically remained unrecognised and ignored in governmental policy agenda and action. The national forest policies manifest a basic commercial-custodial orientation, and have remained largely unfavourable and unresponsive to the community-oriented afforestation programmes including homestead forestry. Farmers' daily experiences suggest that the support and services, promised in the policies, remain a far cry. The recommendations include (a) developing a more thorough understanding of the performance and contribution of homestead forestry through increased research; (b) revision of the concerned policy statements to make the government's stance on homestead forestry clear and unambiguous; and (c) developing a regular system of vigilance and monitoring, including long-term political commitment, from the central government leadership to ensure that the policy directives are implemented in the field, and the sub-national government agencies comply with the spirit of the policy.

Key words : Afforestation, Forest policy, Homestead forestry

Introduction

Homestead forestry has traditionally been practised in rural Bangladesh as a part of the country's heritage and culture (Abedin and Quddus, 1990; Dalmacio, 1989; Abedin *et al.*, 1990; Davidson, 2000, 1984; Task Force, 1987; Khan, 1998a). The contribution and significance of homestead forestry can hardly be overemphasised. The Forestry Master Plan (FMP 1993-2012), for example, estimates that some 10 million households, in over 85,650 villages of Bangladesh, annually supply about 5 million m^3 of wood and 0.53 million airdry MT of bamboo (FMP, 1993, p.77). Put differently, these forests account for 48% of the total supply of saw and veneer logs, 70% of fuelwood and 90% bamboo in Bangladesh (Hammermaster, 1981; Khan, 1998a; FMP, 1993; Millat-e-Mustafa *et al.*, 2000b). It is also argued that the average rate of increment of homestead forests is 5 m^3 per ha per annum, which is more than double that of the government forests (FMP, 1993). Notwithstanding the contribution and importance, as will be discussed in this article, homestead forestry has remained strikingly ignored and largely unrecognised in the governmental policies. As the Forestry Master Plan rightly observes:

Today, homestead forests are the most important source of wood, bamboo and other non wood forest products in the country....In spite of their importance, the homestead forests do not get the attention deserved in terms of research and extension support, credit facilities, and utilization and marketing facilities. There is no programme specifically targeted to improve the overall productivity of homestead forests (FMP, 1993, pp.77-78).

There has, however, been much rhetoric about homestead forests. In a typical statement, it has been claimed that these resources "offer last rays of hope in the otherwise dismal scenario of the forestry sector" (Millat-e-Mustafa *et al.*, 2000b, p.107). In public addresses, the country's political leadership, including the prime minister, regularly appeal for "transforming forestry into a social movement by wider participation of the common rural mass" (*The Daily Prothom Alo,* 6.6.2002; *The Bangladesh Observer,* 7.6.2002).

In the above context, this articles attempts to examine the treatment of homestead forestry in the stated forestry policies and principles in order to argue that beyond the official rhetoric, homestead forestry has received very little support and recognition from the national forest policies. The article is based mainly on a critical review of the concerned policies and associated literature. To complement the analysis of policy literature, a short case study on a homestead forest in the south-eastern Bangladesh has been included to provide empirical evidence in support of the core arguments of the paper. After this introduction, the next section presents an overview of the general features of homestead forestry in Bangladesh together with a reckoning of the state of research on the subject. The third section examines the historical evolution of national forest policies in Bangladesh in order to trace the basic trends in the governmental forest management and to locate homestead forestry's place in the policy statements. An empirical case study is presented in the fourth section, while the last section offers some recapitulative conclusions and clues on improvement.

Homestead Forestry: A Review

There is no universally accepted definition of homestead forestry in Bangladesh. Besides, different terms are in currency to refer to homestead forestry, such as 'home gardens', 'rural agroforestry', and 'household agroforestry'. In following the major literature (Leuchner and Khaleque, 1987; Abedin *et al.*, 1990; Akhter *et al.*, 1997; Siddiqui and Khan, 1999; Millat-e-Mustafa, 1996; Millat-e-Mustafa *et al.*, 2000a, 2000b), the term in this article to refers to an operational unit in which a number of crops including trees are grown with livestock, poultry and/or fish production, mainly for the purposes of satisfying the farmers' basic needs. Homestead forests cover about 0.27 m ha of land, which is nearly 11% of the total forest land of Bangladesh. Huda and Roy (1999) estimate that the productivity in homestead forests is 7 to 8 times higher than in the government-owned forests.

Homestead forests are usually developed on mounds to raise dwellings above the water level during annual flood. The extra earth for raising these mounds is generally obtained by digging ponds within the homestead. Trees or shrubs usually fence the forest. A typical homestead forest serves several houses of related families in a cluster, and has space for vegetable gardens and yard for threshing ground and communal activities, cattle shed, ponds, trees, shrubs and bamboo. The most frequently used plants are generally grown in the back yard, at the pond side and around the cow shed areas for the provision of fruit/food, fuelwood, timber and fodder both for domestic use as well as for cash. A wide variety of trees, shrubs and vegetables are grown in the homestead forests. Millat-e-Mustafa *et al.* (1996) recorded 92 perennial species in the set of 80 homestead forests surveyed in different physiographic regions of Bangladesh. The vertical stratification of vegetation is a major characteristic feature of homestead forests in Bangladesh. Millat-e-Mustafa (1998) provides the following general summary of the composition of strata: Less than 1 meter (m): vegetables, spices, tubers, roots, pineapple; 1-3 m: fruit/food plants (e.g., lemon, banana, guava); 3-5 m: saplings of fruit/timber trees all growing taller; 5-7 m fruit/timber trees, some growing taller; 7-9 m: a few fruit/timber trees; above 9 m: timber trees, bamboos. These strata are dynamic and there is constant recruitment from one stratum to the other. Farmers generally show an intimate attachment to homestead forests. The desperately poor farmers are often forced to sell croplands to fight against pauperisation, but they tend to retain the homestead forests unless absolutely unavoidable (Millat-e-Mustafa 2000a). Abedin and Quddus (1990) observed that even functionally landless farmers have their own homestead forests, where they grow the essential commodities for subsistence (for more description on the general features of homestead forest, the findings by Millat-e-Mustafa, 1996; Millat-e-Mustafa *et al.*, 2000a, 2000b; Khaleque, 1987; Leuschner and Khaleque, 1987 can be consulted).

Practical research on homestead forests is limited. Millat-e-Mustafa *et al.* (2000b) have provided a useful overview of the current status and trends in homestead forestry research in Bangladesh. Most studies have been overtly technical and 'scientific' in nature, focussing on such dimensions as species composition, wood properties, floristic characteristics, silvicultural practices (especially pruning and planting), adaptability to particular physiographic regions, diversity in usage, and production related complications (Siddiqui and Khan, 1999; Akhtar *et al.*, 1989; Islam and Ahmed, 1987; Abedin and Quddus, 1990; Alam and Mohiuddin, 1990). Farmers' ecological knowledge regarding homestead forestry and associated indigenous management practices have been documented by and Millat-e-Mustafa *et al.*

(1990, 2000b) and Leuschner and Khaleque (1987). Case studies to calculate economic contribution of homestead forests, especially towards meeting the household demand for fuel have been conducted by Momin *et al.* (1990), Miah *et al.* (1990), Khan *et al.* (1990), Islam *et al.* (1990) and Davidson (1984). Socio-anthropological studies are particularly rare. Millat-e-Mustafa (1997) and Hossain *et al.* (1988, 1990) have reported on gender dynamics in homestead forestry. Selected sociological dimensions of homestead forests, especially in the context of local socio-economy, have been explored by Khaleque (1987), Leuchner and Khaleque (1987), Akhter *et al.* (1997) and Siddiqui and Khan (1999). There has been no attempt to locate homestead forestry within the context of national forest policies and programmes in Bangladesh. Similarly, there has not been any comprehensive text to pull together varied technical and sociological dimensions of homestead forestry in the country.

Locating Homestead Forestry in the National Forest Policies of Bangladesh

This section critically probes into the historical evolution of national forest policies of Bangladesh in order to (a) trace the basic trends and philosophies of the government on forest management; and (b) locate homestead forestry's place in the policy statements. So far Bangladesh has witnessed the formulation of five national forest policies. The historical development and evolution of the public forest policies and practices in the region manifest a basic commercial-custodian orientation, which undermines the ability and role of local communities in forest resource use and management.[1]

The very first steps towards regular conservancy of forests in British India (which included the current territory of Bangladesh) were prompted by commercial motives. In 1800, for example, a Commission was appointed by the government to enquire into the availability of teak in Malabar forests for commercial exploitation (Padhi, 1982, p.37; Forest Research Institute, 1961, pp.72-73). In 1806, while wondering about "the question of regular supplies of timber to the Navy", the post of first Conservator of Forests in India was created; and "his work was to arrange the exploitation of forests" (Dwivedi, 1980, p.12). The need and forestry practices of the rural communities virtually had no place in the earlier forest policies.

On the 19th October 1894, the first Forest Policy of British India was promulgated. The policy's first stated objective read: "To constitute and preserve forest, the rights and privileges of the users of the forest area have to be restricted and regulated…Large forested tracts should be managed mainly on commercial lines as valuable properties and sources of revenue to the state" (Imperial Forest Department's circular no. 22-F). The policy did not say much about homestead forests or local community needs, except the following: "Forests capable of producing only small timber, fuelwood and fodder must be managed mainly in the interest of the local people" (Clause 8). However, the policy then took a rather contradictory stance elsewhere, and noted that "restrictions may be imposed on the full satisfaction of the needs of the people as may be necessary for the preservation of the forest" (Clause 7). The policy gave "preference to agriculture over forestry" and proposed that "demand for cultivable land can be, to some extent, met by clearing forest areas" (Hussain, 1992, p.18). In the process, it gave renewed impetus to the process of 'land-clearing' that had long been active in Bengal, causing considerable damage to forested tracts and forest-based local communities (Khan, 1998a). The policy made some provisions for "pasturage and grazing" and "fuelwood collection" to cater for "the local people's demand"; but at the same time it also made it clear that, "Royalty for the Government must be collected for various facilities enjoyed by people" (cited in Rahman, 1993, p.24; Wadud, 1989, p.5). In sum, the first policy had no specific provision as regards homestead forests and local demand, except by the way of selling the so called 'rights and concession'; the "overriding aim...was to collect revenue" (Rahman, 1993, p.24).

The independence of India and the formation of Pakistan (which included East Pakistan or afterwards, Bangladesh) in 1947 brought about little change in the nature of forest use and management. The Pakistani period (1947-1971) was a continuation and outcome of the colonial rule, and exhibited similar characteristics. Revenue-orientation of forest policies, isolation of government officers from people, emphasis on maximum economic return from forests, state patronisation of forest-based industries, maximum exploitation, and the expansion of state proprietorship over forests - were the main features of forestry during this period (Khan, 1998a; Roy, 1987).

The Pakistan period witnessed the formation of two forest policies. Although apparently it proclaimed to cater 'the need of a newly independent nation', the Forest Policy 1955 (announced on the 12th November 1955) depicted all characteristic manifestations of the colonial forest administration, including the expansion of state territories; "scientific" extraction of timbers; fortification of the bureaucracy by increased training and manpower; and managing all forests through rigid departmental plans (Hussain, 1992, p.18). There was only a partial statement which had some reference to rural communities' forestry practices and demands read: "Forest area should be increased by encouraging farm forestry on cooperative basis by village communities in compact block of crop land set apart for the purpose (Clause 7). In 1962, another Forest Policy (the second policy of the Pakistan period) was launched (issued by the Ministry of Agriculture and Works, Food and Agriculture Division vide letter No. F-4-30/62-p4 dated 20.6.1962). The major thrusts of the Policy are manifested in the following statements:

The management of forests was to be intensified to make it a commercial concern, utilization of forest produce be improved, regeneration speeded up to keep pace with increased harvesting, irrigated plantations primarily to produce industrial wood be included and *timber harvesting in Chittagong and Sundarbans be accelerated* (emphasis added).

This policy practically noted nothing about homestead forestry and community demands. It was relatively more technically focussed and made detailed prescriptions in matters of soil conservation, watershed management and range management.

Bangladesh surfaced as a sovereign state on the global map in 1971 following a historic civil war of independence. The first National Forest Policy in the Bangladesh period was announced in 1979 (vide Ministry of Agriculture and Forest, Section 1, Dated 8 July 1979 notification). This was "a two-page manifesto-type statement with obscure and generalised directions, mostly focusing on the Forest Department" (Anon., undated, pp.5-18). Its suggestions included "horizontal expansion of the forest area" under the government, which was to be "carefully preserved and scientifically managed" by a (centralised) "cadre of forest officers"; "setting up new forest based industries"; "optimum extraction forest produce"; and "protection of forests (from the so-called) encroachers" (Government of Bangladesh, 1979). Rural forestry and local people received no major attention, except in the form of a vague call for a "mass motivational drive for tree planting" (Statement J). In fact, the policy "expressed the views of the traditional foresters, overlooking the overall development strategy" (Roy, 1987, p.45); and was hardly adequate for addressing the needs and challenges of community participation in the forestry sector (Task Force, 1991, p.219; Anon., undated, p.18). Until recently, Bangladesh forestry showed little change from the traditional colonial-industrial approach to forestry. In following the spirit of the Forest Policy of 1979, the government has argued that 'sustained yield' is the main 'obligation' of the public forest management of Bangladesh (Khan, 1980; Zabala, 1990). Under the umbrella of "sustained yield", the objectives of forest management (for different categories of forests) are as follows: for the Hill Forests the "mainstay" of forest management is to "convert irregular forests by valuable and fast growing species", and "to derive maximum economic benefit under the principles of sustained yield". For Inland Sal Forests the objectives are "to bring the forest under scientific management" and "to create recreational facilities in these forests for town dwellers" (Zabala, 1990, pp.16-17). There has nearly been a complete lack of any significant provision for homestead forestry and/or rural people's involvement in forestry in pursuing the so-called 'sustained yield' principle.

The current National Forest Policy 1994 (announced on 31 May 1995, vide PBM/Pori-1/FSM/Kari-34[part]/109, Ministry of Environment and Forest, Planning Section 1) seemingly marks some degree of departure from the earlier policies. A careful examination of the policy can reveal the following major features, which may have a relevance and implication for homestead forestry and rural livelihood:

- It shows a commitment to sustainable development: "...meeting the basic needs of the present and future generations" (Objective 1).

- Here forestry is seen within the broader framework of integrated rural development and poverty alleviation: "by creating employment opportunities, strengthening the rural and national economy, the scope for poverty alleviation and forest based rural development sectors will be extended" (Objective 2); "encouraging labor intensive forest based cottage industries"(Statement16).

- As distinct from the historic dependence on state coercive forces, it seeks "participation of local people" in forest protection especially in curbing "illegal occupation of forest lands, illegal tree felling and hunting of wild animal" (Objective 6).
- It also pledges governmental support and encouragement for all forms of public and private afforestation programs, especially in the rural homesteads and institutional premises: "women will be encouraged to participate in homestead and farm forestry" (clause 21-Statements); "...technical and other support services will be extended for introducing agroforestry on privately owned fallow and hinter land" (Statement 3); "....effective measures will be taken to for afforestation in rural areas" (Statement 2).

- It also commits to establish 'a new Department of Social Forestry' and 'to strengthen the Forest Department' in order to respond to the demands of participatory forestry programmes (Statement 26).

Despite the above conducive commitments to rural development forestry, the policy's underlying commercial orientation is however manifested in such statements as: "the management of forest lands will be brought under profit-oriented business" (Statement 10); "steps will be taken to bring the state owned forest based industries to profit-oriented management system under the free market economy" (Statement 15); and "import policy on wood and wood based products will be liberalised,...import tariffs...will be levied appropriately" (Statement 17). Besides, the other historical-colonial trends are also noticeable in this policy. It proposes, for example, to consolidate the custodial approach to forestry by expanding the state ownership and authority over land. The policy plans to increase the "protected area by another 10% within 2015" (Statement 8). Although it vaguely commits to "extend the scope of poverty alleviation and forest based rural development", it does not say anything about the how it can actually be achieved, given the unfavourable features of Bangladesh society such as the skewed pattern resource distribution, residual degree of collectivism and rigidly hierarchical social stratification (for some intensive treatment of the rural Bangladesh society reference is made to White, 1992; Wood, 1994; Zaman, 1984; Zaman, 1979; Khan, 2001). The promise of setting up a Department of Social Forestry to intensify participatory forestry programmes has not been materialised until today. Except such rhetorical calls for "participation of local people in forest protection", or "increased participation of women in the homestead and farm based forestry", the policy hardly offers any avenue for the involvement of the forest-based and relatively marginalised section of rural communities, in the day-to-day management and operation of forestry programs. The policy promises to "strengthen the Forest Department", but remains silent about the crucial institutional reforms and capacity building issues concerning the government agencies. Of late, a number of studies have noted that the pace of institutional reform of the forest department is essentially slow and the bureaucratic constraints on community-oriented forestry remain a major problem (Khan, 1998a, 1998c, 2000). It does not propose any specially tailored and targeted forestry interventions for the most vulnerable sections of rural communities (e.g., destitute women, children, landless poor).

In sum, the above historical review reveals that governmental policies manifest a basic commercial-custodial orientation, and have remained largely unfavourable and unresponsive to the community-oriented afforestation programmes including homestead forestry. Against this background of largely unfavourable (macro) policy context, the next section focuses on the (micro) environment of a homestead forest in order to (a) develop a better understanding of homestead forestry in the field; and (b) explore the relevant empirical effects and implications of the policies.

A Case Study on Homestead Forestry: View from the Field

This purposive study was conducted in Chunati Union[2] (located between 21^{0}8' North latitude and 92^{0}20' East longitude) under Lohagara *Upazila* (subdistrict) of the District of Chittagong. The fieldwork has mainly relied on the anthropological tools of uncontrolled observation, unstructured interviews, and field diary[3].

In the study area, a typical homestead comprises of extended family houses, vegetable and horticultural gardens, trees, threshing grounds, livestock and poultry accommodation and rearing grounds, ponds and similar water reservoirs, bamboo, shrubs and bushes. Homestead forests are located close to the houses and form a part of the intensively managed household management system. The forests are characterised by a mixture of annual or perennial species grown in association with each other. Homestead plantations typically exhibit a layered vertical structure of diversified economic value and domestic usage. The upper stratum comprises of tree species, notably, sil koroi (*Albezia procera*), gamar (*Gmelina arborea),* udal (*Sterculia colorata),* jarul *(Lagerstroemia speciosa),* mehagony *(Swietena mahagoni)* and sishu *(Dalbergia sissoo).* Horticultural species, including fruit trees, mainly guava (*Psidium guajava*) ,lemon *(Citrus aurantifolia),* banana *(Musa paradiasiaca),* borio *(Zizyphus mauritiana),* gab *(Diospyros perigrina),* borta *(Artocarpus lacucha),* and bamboo clumps (*Melocanna baccifera* and *Bambusa tulda*), usually occupy the middle stratum. A range of vegetable species, such as lalshak (*Amaranthus gangeticus),* datashak *(Amaranthus lividus),* bean (*Dolichos lablab),* pumpkin (*Cucurbita pepo*), brinjal (*Solanum melongena),* chilli (*Capsicum annum),* and okra *(Abelmoschus esculentus)*, accounts for the lower stratum. Besides, in many homesteads Patipata (*Schumananthus dichotoma*) is grown at the water level on the inner side of the pond bank. Several other species such as bhadi *(Lannea coromandelica),* mandar *(Erythrina indica)* and supari (*Areca catechu)* are grown along the boundary lines of the homesteads.

As compared to other components, fruit trees dominate in the homestead forests. Farmers show a particular preference to fruit trees and assign the following reasons in support of their preference: (a) fruit trees provide immediate cash return; (b) they substantially contribute to household food and nutrition requirements; (c) they also support livestock; and (d) they can be used as 'gift' items on socio-religious occasions and as a mark of hospitality to guests.

Farmers plant timber tree species mainly to augment household income. Large households are especially interested in timber. The distribution of timber trees is significantly lower in landless and marginal households. Among other things, poorer farmers reported that they felt discouraged to grow timber due to (a) the threat of plundering by organised thugs and commercial loggers; (b) the problem and cost of regular protection; (c) the bureaucratic and procedural formalities and harassment in harvesting timbers (when they mature); and (d) financial hardship which does not allow the farmers to sustain through the long gestation period of, especially, the timbers of substantial economic value.

Farmers of landless and marginal households, however, grow higher percentage of fuelwood as they are unable to access the local fuelwood market owing to financial constraints. Likewise, non-timber forest products and vegetable gardens are also found more in poorer households as compared to the relatively affluent households.

Farmers in the study area typically follow a gender division of labour in managing the homestead forest activities. Women play a most active role in the development and maintenance of these forests by performing such tasks as (a) raising seedlings in poly bags; (b) collecting debris; (c) sowing or planting (as the case may be); (d) collecting cow dung as fertilizer; (e) making protective gabion; (f) watering; (g) weeding; and (h) mulching. Men are responsible for such tasks as (a) clearing (and, occasionally, burning) jungle, preparing the site; (b) staking; and (c) marketing and conveyance of products. The tasks which are jointly performed by men and women include (a) preparation of seedbed; (b) digging narrow ditches for watering; and (c) grafting particular plants.

Based on the interviews of the respondent farmers, the perceived benefits and preferred use of the homestead forests, in order of priority, are the following: (a) fruits as sources of food, nutrition and hospitality; (b) area demarcation and boundary lining purposes; (c) cash income generation; (d) fuelwood usage; (e) household wood and timber usage; (f) fodder and other livestock support roles; and (g) aesthetic purposes.

Governmental support and extension services are nominal in the study area. There are a number of Forest Department offices within close quarters of Chunati, including the Chunati Forest Range Office, Chunati Forest Beat Office, and a Nursery Centre in Lohagara. Except for occasional celebration of national and ceremonial events (e.g. the National Plantation Week, World Environment Day), the farmers report that they hardly come across the forest extension staff. Some of the farmers' comments are as follows:

If some 'big' officers come from the city, they [the local forest staff] arrange large meetings and call us to attend....We go sometimes...., drink tea—sometimes, they even give us biscuits, and then we come back...

Once a year, there is a 'Tree Fair', which is held in Lohagara. We go there re is a big meeting

The farmers generally hold forest officials in fear and distance. Chunati is surrounded by the government Reserved Forest and Wildlife Sanctuary Area. Most of the respondent farmers have personal experience of facing prosecution by the Forest Department. With this embittered background, the farmers, as the following comments reveal, hardly feel comfortable to approach the forest offices for support and services:

Last month they [the forest staff] took away two of my brothers when [they entered the forest] to get honey...They had beaten [and] locked him in a room for many hours....I had to pay Taka 1,500 to the boss [to get him released]...

[D]o you approach a stream when [you know that] there are crocodiles for sure?

Farmers also report that the Forest Department nurseries do not cater for the seedlings (or saplings), which are locally preferred and demanded:

They [local forest offices] cannot give us seedlings for fruit trees...They say: "is 'fruit tree' a 'tree'? [you should] plant trees"....

I sent my uncle to get some coconut [*Cocos nucifera*] and udal [*Sterculia colorata*] saplings. They did not have any. The *Mali* [nursery attendant] told to get teak.

Earlier the government nurseries only used to sell malariagach [Eucalyptus, *Eucaliptus camaldulensis*]; now they say: "this [Eucalyptus] is a bad tree; take minjiri [*Cassia siamea*]"....They keep changing their mind all the time!

Plunder of trees by armed group of local *maastans* (thugs, musclemen) from homestead forests is not uncommon. Farmers who grow economically valuable timber species are particularly vulnerable, and they do not generally get any protection from the concerned government departments of forestry and police. Help and cooperation from public offices are only available if the farmers can pay informal 'price' and/or negotiate with the officials through local elites or *Murubbi* (e.g., rich land owners, traders, money-lenders) (Khan, 2001, 2000, 1998a, 1998b). A good number of farmers report that they usually pay some *chanda* (toll, rent) to the *maastans*, rather than approaching the public offices (e.g. police, forest stations) for protection, because, as one farmer told me:

What is the point of going to the bigger *maastan* [i.e. the government officials]? Haven't you heard that the proverb: 'if a tiger touches you, you get 16 scratches; if the police touches you, you get 32 scratches'... ".

Harvesting, transportation and marketing of products grown in homestead forests are a major subject of concern and worry for the farmers. The National Forest Policy 1994 and associated regulations (notably, The Forest Act 1927 as amended up to 2000) are extremely complex in this regard, and make almost unlimited room for harassment and exhortation by the local forest and police officials. For example, the farmers need permission from the forest office to harvest and transport the timber grown in their own homesteads. The permission involves a plethora of bureaucratic steps such as: filing a formal application to the Divisional Forest Officer; the local forest office then sends the application to the division headquarters based in the Chittagong city; after approval of the divisional officer, the file is returned to the local office; the local Range Forest Officer then visits the homestead forests, physically verifies and marks the trees to be harvested; then he allows for the harvest; after the harvest, the local forest office again verifies the number and quality of logs; the local office then sends the file to the divisional head quarters for permission of transportation of the logs; and so on. Every step (or 'table'), as the farmers note, involves bribe, known as 'table *taka* [money]'. Instead of moving through this weary tunnel of red-tape and harassment, most farmers typically resort to, what they astutely call, the *gura saitan* (lesser evil); i.e., they sell the timber to the local agents of the commercial (illicit) loggers at a price much lower than the current market price.

In line the principles of the Forest Policy of 1979, the government put a complete ban on felling timber in all public forests in 1989, and reinforced the moratorium on extraction after the promulgation of the National Forest Policy of 1994. This ban does not take into consideration the great demand of forest products in the locality. As all legal or official sources of extraction of timber have been artificially suspended, this ban has put renewed impetus on illegal commercial logging and has jeopardised the existing forests including the homestead forests. The following observation, made by a study in the context of two community forestry sites in the eastern part of Chittagong, neatly applies to my study area:

This policy has put additional pressure on farmers. They are constantly approached by loggers for trees in their plots, and often loggers make sure that farmers cannot reach the open market. Loggers purposely create a situation that compels farmers to sell their products to them (loggers) at unjust process and terms. If farmers do not comply with their demands, loggers send armed *maastans* to plunder the trees (Khan, 1998a, p. 233)

Conclusion

The review of the national forest polices and the empirical case study lead to the conclusion that despite its great contribution to rural livelihood and socio-economy, homestead forestry has historically remained largely unrecognised and ignored in governmental policy agenda and action. Although there seems to be a degree of belated recognition of homestead forestry in the latest policy (1994), the policy directives, as the case study shows, have little effect in the field. Farmers' daily experiences suggest that the support and services, promised in the policy, remain a far cry. Besides, some policy directives are totally at odds with the realities of the field. The moratorium on timber extraction imposed by the policies, for example, has adversely affected the development of homestead forestry by making these forests vulnerable to increased threat of plunder. The government's role has been something of an "unfinished nature"[4]; most policies have failed to take into consideration the value and contribution of one of the most significant components of the country's forest sector, i.e., homestead forestry. Even where a superficial treatment of homestead forestry is observed in the policy statements, there has not been corresponding practical action towards implementation of these formulations.

Although it would be naive to suggest an overnight reshuffling of the situation and the historic pattern of neglect towards homestead forestry, it is high time to start thinking about some corrective measures. First, we need to develop a more thorough understanding of the nature, performance and contribution of homestead forestry. This will help to locate homestead forestry in its actual significance within the country's forestry sector and facilitate the process of better-informed policy revision and/or formulation. The current state of research and knowledge is clearly inadequate. Secondly, beyond the cloud of rhetoric, the concerned policy statements need to be revised to make the government's stance on homestead forestry clear and unambiguous. Third, and more importantly, a regular system of vigilance and monitoring, including long-term political commitment, from the central government leadership (e.g. at the level of Ministry of Environment-Forest and the Office of the Prime Minister) will be required to ensure that the policy directives are implemented in the field, and the sub-national government agencies comply with the spirit of the policy.

Notes

For some comprehensive treatment of these policy-induced trends with the principal effect of progressive neglect and alienation of local communities from forest management, see Guha, 1989; Gadgil, 1989; Khan, 1998a.

Union is an important sub-national local government unit in Bangladesh, located between *Upazila* (sub-district) and the proposed *Gram parishad* (village council).

For details of the research site and methodology, see Siddiqui and Khan (1999). The data used in this article is part of a long-term study that is still in progress.

The various manifestations of the "unfinished role" of the state(s) and the implications for community-based forestry have been observed in many parts of the developing world (Riddell, 1987).

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Needs Reviewing Some Forestry Sector Issues for Making Policy Decision Sustainable Supply of Fores Goods and Services are at Stake!

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Abstract

Bangladesh forestry sector is passing through a crucial stage because of some issues remaining unattended since long. It is affecting the economy and ecology of the country. Shifting cultivation by slash and burning of forest is a primitive way of living, scope of staying back with shifting cultivation is a rare possibility. Some forest based industries are dead and dying due to scarcity of raw materials. Some forest based industries have become dependent upon import for indefinite time period. Policy decisions to ban afforestation/reforestation with eucalyptus in the depleted public forest land have gone against the national interest. Any attempt to revise the decision is yet to be seen; inadequate attention to land use survey report of 1964- 66 has been affecting the ecology and economy of the country.

Rural development considerably depends upon transfer of appropriate technology for maximizing benefits through efficient management of valuable village tree resources. Village tree resource is the primary source of wood energy. About 87 % of biomass energy including village wood energy comes from the rural area; yet there is no bio-fuel energy policy. Public private partnership investment as per national policy is yet to be seen in forestry sub-sector though the scope exists. The 20 years National Forestry Master plan (1992—2012) appeared to be time befitting plan. If the master plan provisions would have been followed, the country would not have to be so much dependant upon import of forest products. Lack of required manpower, protection of forest land and the forest resources have become very difficult under severe population pressure

Until recently, the subject forestry was not made public; people in general are yet to become well aware of the necessity of knowing forestry. People's support for forestry cause is missing. Debates on forestry, forestry budget, development potential, etc., either in the parliament or in the tea stall are not talked about! The issues stated above are required to be reviewed (to be backed by research) in one platform by all concerned such as researchers, educationists, executives, industrialists, NGOs for evolving policy decisions and implementation strategies. Bangladesh Forestry Congress-2011 may be an ideal opportunity to make best use of resolving forestry issues.

Key words: Forest policy, Forestry sector. Review, Sustainable supply

Introduction

Bangladesh forestry sector is passing through a crucial stage because of some sectorial issues remains unattended since long. It appears that some vital issues are remaining unattended and thus affecting economy and ecology of the country. In one hand forest area is decreasing day by day, on the other hand usage of forest goods and services are increasing fast due to changes in living style. Land and man ratio is so disproportionate that the human population is normally beyond the carrying capacity of the limited available land mass. According to one estimate, 160 million people are living over an area of 14,757,000 ha, i.e., per capita total land is 0.09ha of which forest land is 0.011ha.This is one of the adversity where protecting the natural resources under population pressure is very difficult. Protection of forest resources is largely dependant upon Policy decision and implementation strategy. Age old traditional strategy has already proved to be a failure. In any case, the potential of forestry sector should fully be exploited through application of environment –friendly technology so that national economy and ecology are uplifted. An earnest approach is to impinge the latest knowledge base in development management particularly of forestry to the psychomotor of all people including personnel dealing with forestry. There is full confidence and hope of bringing remarkable prosperity in forestry sector if every thing is done as per development of latest international knowledge base. This in turn may contribute a lions share in the national GDP. To this end, all concerned with the forestry must review the performance of the sector and appropriate policy decisions are evolved and implemented through a collaborative effort. It is now a high time to take decision in this direction in the common platform of Bangladesh Forestry Conference-2011. A good number of senior forestry experts of Bangladesh Forestry and Environment Forum has committed to offer their voluntary service if asked for in doing any such exercise. It is to be remembered that this sector is still dealing with about 18% public land – a primary resource base. This land mass should contribute proportionately to the national GDP. All forestry value of goods and service, surface and sub-surface product, tangible and intangible benefits should be focused in the GDP.

Land Use Report not Followed

Sometimes during 60's Government hired M/s Forestall Forestry and Engineering International Ltd. Canada for land use survey of Chittagong Hill Tracts (CHT). They surveyed and classified the land into 4 classes: A, B, C and D according to capability and land use. The hills with steep slope and dissected topography comprising 77% of the land mass of the CHT were found as "D" grade lands and the firm recommended for afforestation/reforestation only because the same was not fit for any other use. It was unfortunate to find that the recommendation for afforestation of 77% D grade land was not implemented. Those D grade lands were mostly unclassed state forest remained under the control of the Ministry of Land Administration, excepting a few small chunk that was transferred to the forest department under the Ministry of Environment and Forests. This D grade land was once bearing very rich forest. Usufruct, a kind of right to harvest the forest resources was one of the causes of deterioration of both vegetation and the soil. Increase of population over the time has enhanced the process of deforestation and degradation of soil. Forest enriches soil formation and also protects soil against erosion by wind and rain water runoff. This soil loss adversely affects the fertility of remaining soil. The lost soil is deposited in the water channel like river, rivulet, stream, streamlet, reservoir, lake, etc. The cumulative effects of this soil deposit affect the bearing capacity of the water stream. The sedimentation by eroded materials over a time period, have already caused death and dying of many rivers. Thus, this situation very often causes flash flood. This flash flood is not a rare occurrence nowadays. It is affecting the navigability, fishery, irrigation, food production, etc. Thus unscientific approach towards land use has already jeopardized ecosystem of the country, This has considerably retarded economic growth of the country.

Forest acts as an umbrella to protect soil and water under cover of forest canopy. UNDP technical assistance project, participatory watershed management training in Asia (PWMTA) program (GCP/RS/181/NET, FAO/Netherlands), etc., were implemented in this region. Bangladesh was one of the beneficiaries where about a dozen of officers received training on watershed management. Bangladesh watershed is so fragile that top soil is easily liable to erosion. In the recent years, land slide is found to be occurring during rainy season. Research activities should immediately be undertaken to address this issue with particular emphasis on the hilly land.

Forested Watershed Management to Boost up Rice Production through Maximizing Surface Water Production for Irrigation

Forest cover acts as an umbrella and protect soil and water from sunlight, thereby reducing heat radiation and evaporation loss. In that case when the watershed is forested and has dense forest cover, plenty of rain water received during monsoon is conserved in soil and gradually releases by gravitational force and stored in the lake, *haor, baor,* and some other water reservoirs. The monsoon water so stored may be used during the dry period of the year. Otherwise, the same may be lost by evaporation. If adequate water is stored in the watershed, the river flow in the dry seasons is likely to be relatively adequate.

It appears that the use of water for rice production by irrigation has increased from 15 to 69 %, arise by 54% over a period of 20 years from 1986-07 to 2006-07(Statistical year book of Bangladesh, 1997 p 124 and 2005, p 137). This increase of rice over the period is definitely due to scientific water use in the production process. There is an increase of ground water use for irrigation from 11 to 67 %, an rise by 56% over the said period for increased food production, where as surface water use increased from 4 to 7% up to 94-95 ,and then decreased down to 02% in the year 2006-07. This is not desirable; this indicates a sign of retrogressive ecology- unattended watershed. This ground water utilization is a necessity for increased production of food growing population but care should be taken to see that unlimited ground

water utilization may bring about environmental hazards. Forest, water and soil conservation practices in the watershed are the needs of the people.
"Food will last so long as forests do" (M. ins , Sk. Nur UD Din Wali 1990/91. "Unysilva No160 – forestry and food security").

Shifting Cultivation / Hill Cultivation, Jhumia Rehabilitation

Shifting cultivation is a primitive agricultural system in which plots of hilly land is put under seasonal crop for 2-3 years, then abandoned. This system often involves clearing of a piece of land bearing virgin forest/secondary forest followed by burning of felled trees, brush wood (Figure 1). The site remains exposed to sun and rain causes severe loss of top soil. Whatever soil remains, soil fertility is exhausted, crop production falls drastically and thus the site is abandoned. The said abandoned site is normally invaded by bush, climber sun grass etc and sometimes desirable and or undesirable tree growth emerges back depending upon the natural seed source around. With the increase of jhumia population, there is scarcity of jhum land and therefore they resort back to the same left over plot within 4-5 years or so for jhum cultivation again. As a result production per unit gradually falls below sustainable crop yield (Golam Rasul-2009). Therefore jhumia people are to search for alternative source of income.

Figure 1.Photograph showing preparation of site for shifting cultivation

Due to continued negligence to land use policy, shifting cultivation is still in practice to some extent in the CHT. The British Administration condemns shifting cultivation as primitive and destructive land use (Lewin, 1969). In view of destruction of forest by shifting cultivation, a policy was adopted to replace it with sedentary agriculture. Captain Lewis, the British Deputy commissioner of CHT, in a letter to the Government wrote " our object should be to put a stop to jhum culture (shifting cultivation and induce the people to settle, and cultivate by the plough". (Hutchinson, 1906:49-50)

The adverse impact of shifting cultivation are damage to soil texture, structure, reduce water holding capacity, enhanced run off, soil erosion, sedimentation in water reservoir, riverbed, stream and streamlet, causing upland, plain land and the wet land hazardous from both economic and ecological point of view.

Scarcity of Raw Materials for Industries Based upon Forest Resources

Some industries such as Khulna news print mill and Sylhet paper pulp mills are closed since long due to shortage of bamboos and soft wood. Raw materials in hard board mills, tannin factories, some match box factories are collected at a higher price. Khulna newsprint mills under Bangladesh chemical industries corporation was once used to produce newsprint sufficient enough to meet the domestic requirement, and the surplus was exported. A block of gewa forest under Sunderban mangrove was tied with the chemical industries corporation for harvesting raw material-gewa wood to feed the newsprint mills. At one stage, the Chemical Industries Corporation increased its export of newsprint for some time. Later on, it was found that the mills were found closed sine die for dearth of raw material. It seems that the whole management systems are not based upon the principle of sustainable production and supply. Very recently, it is learnt that there is a demand/claim for revival of the newsprint mills. Unfortunately, no sign of revival of the mills has yet been noticed. Bangladesh is largely dependant on import of pulp, newsprint, constructional wood, railway sleepers and other forest product.

Karnafully paper mill was initially designed to use bamboos as materials for making pulp and paper. When bamboo fibre was found suitable for making rayon, a rayon mill was installed at the same campus of Karnafully paper mill. The paper mill was then redesigned to use soft (light) wood as raw materials. The Karnafully complex is now running shortage of bamboos and soft wood. They are now resorting to import of pulp.

The supply of pulp wood to the paper mill is neither sufficient to meet the demand nor the supply is uniform. The mill is running below the production capacity. As the rate of literacy has increased, the development activities are also increasing, the lifestyle is also changing. Therefore, the use of paper and newsprint are increasing for various purposes. To meet the demand, small scale paper mills and pulp mills have emerged in the private sectors. This is good but all these private mills are largely dependent upon import of pulp and pulpwood from abroad. Very little attention has been given to utilize the available land for the production of pulpwood. The Government,in collaboration with the local people and the entrepreneur should work out an appropriate strategy to utilize all available land for the production of pulpwood on the principle of sustained yield.

Banning Eucalyptus Plantation was a Wrong Decision

It was alleged by some in Bangladesh that Eucalyptus pumps out excessive ground water and causes immense damage to the environment. In fact, it is not, it rather uses less water per unit weight of biomass produced than other kinds of trees and many agricultural crops. Davidson J (1989) reported that on a "leakproof hectare" at Nekemet(with annual rainfall of 2158mm), E. saligna and E. grandis could produce 46.6 m^3/ha/yr without drawing on water reserves(rainfall only) compared to 16.4, 16, 12.4 m^3/ha/yr biomass production in coniferous, acacia and broadleaf species, respectively. These figures reveal that for the same amount of water consumed eucalyptus produce higher amount of biomass which is economically profitable and acceptable.
Most eucalyptus species need on average 785 litres of water/kg of biomass produced as opposed to 3,200 liters/kg cotton/coffee/banana, 2,400 liters/kg sunflower, 2,000 liters/kg field pea,1,667 liters/kg cow pea, 1,430 liters/kg soyabean,1,000 liters/kg potato,1,000 liters/kg sorghum and 1,000 liters/kg maize produced(Davidson, 1989).

FAO dealt with Eucalyptus conflict:

The first large scale eucalyptus plantations in the region were established in India. During the 1980s serious criticisms arose first in India and later elsewhere in the South East Asia region concerning alleged adverse effects of Eucalyptus plantations on environment. In Bangladesh also, it was alleged that eucalyptus tree pumps out ground water excessively and thereby water-table goes down. In 1985, FAO reacted to this debate by commissioning a study, funded by Swedish International Development Agency SIDA, entitled "The Ecological Effect of Eucalyptus" published as FAO Forestry Paper 59. This publication and others which followed stimulated further discussion and a number of new studies on the various effects of Eucalyptus planting. The regional Expert Consultation on Eucalyptus, sponsored by FAO, held in Bangkokduring 4-8 October, 1993, reviewed recent findings on the social, economic and environmental effect of Eucalyptus plantings. The Expert Consultation did not discourage Eucalyptus planting, rather encouraged for meeting the increasing demand of various woods, other derivatives and by-products of eucalyptus. In Bangladesh, planting of Eucalyptus was banned in public forest land and 1995, whereas FAOs expert consultation decided to encourage Eucalyptus in 1993.

Procedure for Introduction of Exotic Species

National experts, researchers, field workers worked hand in hand with the expatriate experts over a period of about 25 years with the Eucalyptus provenance trial, introduction, plantation establishment and maintenance. They acquired sufficient knowledge and practical experience in respect of site specific Eucalyptus tree species and established plantation under World Bank supported project from 1985 to 1993. In addition to industrial wood pulp, site specific energy wood and constructional wood were also successfully established over depleted site condition.

Uses of Eucalyptus

Nowadays China is producing 2000 tonnes of Eucalyptus oil per year or 40% of the international essential oil in the market. In the Eucalyptus forest of China, oil production is very attractive since it can represent 20% of the total income from these trees. By further processing the eucalyptus oil- citronellal, menthol, thymol and roseol are obtained which are used widely in the pharmaceutical industry for the manufacture of throat lozenges, candy for cough relief, oil balms, cooling ointments for bums, cold ointments, etc. These are also used as a composition for tooth paste, perfume, toilet soap, etc. Effort is being made to manufacture artificial fibre rayon and derivatives from *Eucalyptus globulus* in China for use in fabrics, felts, blankets and handicrafts. In China, for more than a century, Eucalyptus had been planted, establishment cost was relatively low.

Worldwide over 18 million ha of eucalyptus are estimated to be under cultivation in plantations. This latest estimate is more than double than that was made in 1985 (7 million ha: Davidson 1985a, 1988) and already exceeds the prediction made in 1988 of 10 million ha. by the year 2000 (Davidson 1988). The genus today still represents 15 % of all plantations worldwide (excluding most of Europe which comparatively hardly has any *Eucalypt* plantations). Regionally *Eucalyptus* represents 36% of African, 8% of Asian and 43% of American plantations. Brazil being the world's largest eucalypt planters have eucalypt plantation of 3 million hectares in the year2000 .It started planting eucalypt centuries ago. The average annual growth stands at 40-45m^3.Whereas in Bangladesh it is 2.5m^3 only. China is the second largest have 460000ha and 1.5 billion individual trees. It introduced Eucalyptus in 1890. Eucalypt has a long history in India. It was first planted around 1790 by Tippu Sultan, the ruler of Mysore in his palace garden on Nandi hills near Bangalore. According to one version he received seed from Australia and introduced about 16 species (Shyam Sundar, 1984). Bangladesh under second forestry project had grown a total of 66,773 hectares Eucalyptus plantation which grew during 1985– 95. It is learnt that those plantations have been sold out because of imposition of ban on Eucalyptus.

Bio-chemicals from *Eucalyptus*

Prickly heat powder to flotation of metals, industrial solvents, insecticides and fungicides as additives in small quantities are produced as wood extracts. China started its research on preparation of plant growth regulators from eucalyptus leaves in 1981 and achieved some significant results (Song Yong Fang,1992). Factories have been set up for the production of the growth regulators (phyto-hormones) which have been applied experimentally in the field on large areas. These confirmed their effect in increasing the growth rate and yield of vegetables, grapes, rape, cotton, as well as in the protection of the plants from insects and diseases (Zheng Haishui 1987, Song Yong Fang 1992). As a product of natural origin, the growth regulator has great potential for decreasing chemical pollution and reducing toxicity in agriculture. In the past, the residues left after distillation of oil from Eucalyptus leaves has been used as fuel or compost. In China, now this residue is crushed, chemically treated and washed to produce an additional extract which when evaporated and dried contains 45% of mixed tannin with a purity of 48%. This product is used for decreasing the coagulation of drilling mud, for metal flotation and tanning of light leather. Cooking the left residues in the presence of NaOH and Na_2SO_3, these produce another product used as a water reducing agent for cement. It is an additive in the ceramics industry for increasing anti-abrasion strength during ball milling, a thinner for drilling mud and component of a boiler anti-scaling product. Studies on the feasibility of manufacturing additives from eucalyptus leaves have been in progress in China since 1986. Since 1992, the biochemical analysis and nutrition evaluation of 25 Eucalyptus species have been completed and many feeding experiments have been made on chickens. Song Yong Fang (1992) stated that the varied anti-microbial substances in the eucalyptus promote vigorous growth and provide protection from diseases in chickens and domestic animals. To improve

Eucalypt bark utilization, attempts have been made to prepare adhesives from poly phenols extracted from the bark to be used as alternatives to phenol or phenol-aldehyde resins. The preliminary results show that the bark powder of *Eucalyptus citriodora* has the most active reaction and can replace 40% of phenol.

Tissue culture is a very important technology for the research and development of *Eucalyptus* plantation. Up to date, about 60 *Eucalyptus* species have been studied with tissue cultural methods including use of tissues, cells or organs from seed, shoot, floral bud, lignotuber, callus, root, anther, suspension, protoplast and somatic embryo. Plantlets have been obtained for most of the species studied. (Source: EUCALYPTUS (pp 128-137) Author(s): Yaojian Xie, China Eucalypt Research Center, Zhanjiang 524022, Guangdong, China*)*

In the Asia Pacific region, countries participated in the UNDP/FAO regional project on forest tree improvement and propagation (RAS/91/004), (Bangladesh, Bhutan, India, Indonesia, Nepal, Malaysia, Pakistan, Philippine, Sri lanka and Thailand) ranked *E camaldulensis* first, then *E. europhylla*, hybrid such as *E. europhylla x grandis* and *E. deglupta xpellita*, then *E. globulus*, *E. grandis* and *E. deglupta* in that order as regardsregional importance (Davidson. 1993). In Bangladesh, top priority was attached to *E. camaldulensis* Petford and whatever Eucalypt planted were mainly *E Camaldulensis* petford

The following exotic tree species were successfully introduced in Bangladesh, contributing to the economy of the country.

Teak (sehgun) *Tectona grandis*
Mehagony,(Mehagoni) *Swetenia mehaginy*
Rubber, (Rubber) *Hevea brasilensis*
Tea (Chaa*) Thaea sinensis*

Imposing restriction on Eucalyptus plantation, the nation has incurred economic loss. Over the last several years European policy makers and environmental NGOs have criticized palm oil plantations in the Asian tropics. They asserted that the conversion of tropical peat lands to oil palm plantations releases enormous amounts of green house gases (GHG) contributing to man-made global warming. Citing the threat of climate change, European policy makers and NGOs have been pushing for severe restrictions on the production and trade in Malaysian and Indonesian palm oil (global oils & fats business magazine – vol-7, issue-4, 2010 p-6). In Bangladesh, nobody said that importing pulp was better than planting.

Village Tree Resources have High Potentiality in Rural Economy

Due to recent development of communication system, gap between urban and rural Bangladesh has reduced. Considerably, the rural people have now a much better opportunity to learn things. Farming system has improved and farmers are growing high yielding staple food and other cereal crops. They are well aware of their harvesting, processing, storage, transportation and marketing. They have easily adopted the technology for producing high yielding rice.

Technology is available for growing fast growing high yielding trees. Tree farming has become very popular in Bangladesh and the tree farmers have recently built up huge forest resources / tree resources in the rural areas. But they are yet to be well aware of better technology for growing tree resources and their maintenance, harvesting, processing, storage, utilization, transportation marketing, etc. These parts of their knowledge along with knowledge of choice of species are limited. Therefore available environ-friendly technology is required to be transferred to the tree farmers for obtaining maximum benefits.

In recent assessment it is learnt that out of a total land area of 14,757,000ha almost 50% of the area of Bangladesh has some kind of tree cover. (National Forest and Tree Resources Assessment 2005-2007 by BFD, SPARSO and FAO pp7-8) but the statistical year book (2005) revealed that the area covered was 19.5%, i.e., state forest area is 2,597,284 ha (17.60 %), village forest 286,200 ha i.e. (1.93%). So there is an increase of 30.5% area of tree resource mostly of rural area outside state forest area. This is a great achievement in creating rural resource. In order to obtain maximum benefit from this resource, government should extend both technological and financial support to the village entrepreneur for setting up small and cottage industries. Improved saw milling, packaging boxes, furniture factory, charcoal manufacturing , pencil, tea chest, fruit crate, leaf compost, wood pellets, briquette factory, etc., are the options for the for development of village economy. Besides small and cottage industries, the assessment of carbon sequestration and storage in the tree resource may carry additional financial benefits to the tree farmers. Most of the new districts and Upa-zilla are still without district and Upazilla level forest officers who can transfer make access of information the technologies. to the rural people. Therefore, transfer of technology and information has not happened in this sector.

Rural energy is primarily the bio-fuel . The sources of the bio-fuel are mostly fuel wood and, agricultural residues and cow-dung. Both cow-dung and agri-residues have better use as manure and wood for paper pulp. Yet they are used mostly as a source of energy. According to master plan assessment (1992), Bangladesh needs 8.0 million m^3/annum wood fuel. Domestic use was at estimated 63% i.e. 5.1 million m^3/ a. If gas and other energy supply does not increase, it was estimated that by 2013, wood fuel requirement will be 11.6 million m^3/a. Yet there will be deficit of 3.11million m^3/a in 2013. There was a provision in scenario-2 of the master plan that the production target was 15m^3/a. Fuel wood is used in brick burning, road tarring, paddy parboiling, sugar cane gur, palm gur, bakery, soap making, pottery burning, lime processing, and hotels and restaurants amounting to 2.9 million m^3/a. As much as 87% of all wood fuels originate from sources other than forests, i.e., rural area. Imposing ban on felling of state trees has drastically reduced supply of wood fuel and thus pressure on natural gas is on the increase in the rural areas. Still Bangladesh has not evolved any wood energy policy!

As world population is estimated to be triple in the next 100 years, the continued stable supply of non-renewable fossil-based fuels become dubious particularly due to environmental concerns. While electricity is a multipurpose resource, millions of families in Asia will never be able to afford to use this as primary cooking fuel in their lifetime due to poverty. Wood and biomass will persist to be the source of cooking and heating energy for households and many industries in the developing world. Wood and biomass also serve as feedstock for electrical generation. Environment-wise, wood and biomass are neutral carbon-based renewable energy sources FAO RWEDP.

Public Private Partnership Investment as per National Policy is Yet to be seen in Forestry Sector though the Scope Exists

Initiative should have come from persons aware of the opportunity available and can convince the entrepreneur for making profitable investment on the principle of sustainable yield. Here we may follow the Chinese approach in promoting public private investment in forestry. Some of the salient features adopted in public –private investment in Chinese forestry may be noted here.

(1) making the most national forest tenure reform;
(2) rethinking forestry taxation;
(3) promoting company-community deals;
(4) payment of environmental services involving private players;
(5) forest certification- a new market based policy tool;
(6) an array of policy opportunity.

Bangladesh Forestry Master Plan not Followed Properly

After a long cherished necessity, Government of Bangladesh, assisted by the Asian Development Bank and the United Nations Development Programme initiated preparation of Forestry Master Plan. Plan preparation was by a 26 man team of local counterparts, national and international consultants spanning a 20-month period from October 1991 to May 1993. Bangladesh Forest Department, Forest Industries Development Corporation, Forest Research Institute were involved in preparing the plan while FAO and SandWell Inc. and Reid Collins Ltd. supplied one Team Leader and other expatriate experts. The Project Director was from the Forest Department. The GoB formed steering committee, consisting of nine permanent and 10 ad-hoc members, chaired by the Secretary MoEF, guided the planning team.The process of preparation of the plan involved mass people's participation. Several workshops at different forest sites and seminars were held and opinions of the cross-section of people were incorporated in the decision making. There were some very important recommendations in the 20 year's forestry master plan (1993 to 2012). The master plan recommendations provided warnings as to what would happen if the proposed programs are not implemented. The warnings now appear correct to a great extent.

The 20 years master plan was phased out into 4, each with a 5 years period. The master plan had two investment options- Option I (scenario-1) had investment proposal of Tk 35,910.5 million over a land area of 1,334,100 ha while option 2 (scenario-2) had Tk 85.715.07 million over a land area of 1,964,700ha. In option-1 wood harvesting targets were @162,500 m^3 ,@ 164,250 m^3 ,@ 181,500 m^3 and @ 223,250 m^3 /annum for 1st , 2nd ,3rd and 4th 5 years periods respectively. While in option-2 the targets were @241,500 m^3, @249,750 m^3, @262,500m^3 and @333,500m^3/annum for 1st ,2nd ,3rd and 4th 5 years periods respectively.

The investments of both the options included the costs of producing timber, pulpwood, bamboo, energy wood, murta, medicinal plants, hogla, rattan, lac, lali, catechu, etc. It also included the cost of all consultancy, equipment, vehicles, research, education, training in home and abroad, institutional strengthening, forest industries, etc. The implementations of master plan laggard much behind, and so the wood out-turn is not visible. Rather the country has become largely dependent on wood import. It is unfortunate to see that the country is gradually inclined to more and more on import of forest based product, and by now it is learnt that as many as 18 items are being imported. To reduce this import items in future, it is not yet heard from any source that a calculated plan is under preparation. This is not the end, a day may come when it is likely to be seen that no land is available for establishing state forests. Such anticipation will not be a surprise under prevailing land grabbing picture of the country. Thus there may be a severe deterioration of environment and ecosystem. To supplement the shortfall, the import of forest produce may become a severe problem as there is wood crisis all over the world. It may so happen that in near future, wood is not available in the world market or we cannot afford pay the high price.

Protection of Forest

Impact of overpopulation on forestry in Bangladesh

Bangladesh with her 14.7 million hectares of land areas has a population of about 162 million. This appears to be unbelievably a unique example in the world population status where so much people can live on such a small area of landmass. The country's economic base is still agriculture, where about 55 % land is under agriculture, and about 18 % land is under forestry. The topography of the forest land though rugged and undulating, not much of it is steep slope. Thus, afforestation in steep slopes is not difficult. In fact, in Bangladesh legally declared reserved forests, protected forests, vested forests, acquired forests or unclassed state forests are not at all found protected and undisturbed. The reserve forests are even found with thoroughfare, and controlling passersby is almost impossible nowadays. The scope for natural regeneration is shattered by grazing and trampling. Artificial regeneration sometimes is also difficult because of pressure by wood cutters and pressure of grazing. According to the household expenditure survey conducted in 1995-96 by the Bureau of Statistics of the Government of Bangladesh, about 47 % of the rural households were below the poverty line who had less than 21.22 k.cals of food per day Whatever poverty alleviation takes place is offset by swelling population growth in Bangladesh. In fact the population growth is engulfing all developments including development of forests. The limited forest areas under all efficient management and maximum growth rate cannot meet the increasing demand of the galloping increase of population. Moreover, instead of expanding forest areas there is a better chance of forest areas are being transferred to agriculture or other uses. So, we find that unless population growth is not controlled, the forest areas will be diminishing. The forest growing stock will be diminishing at an alarming rate in our country and there is already a crisis in the forestry sector. In future the situation is beyond imagination, the diminishing of forests has already jeopardized the total environment and created a severe imbalance in the social system. We at the moment depend quite considerably upon import. World forestry situation, excepting few countries, is also deteriorating fast, and export –import of timber may be at stake. We now need to develop a strategy to control population, lessen pressure upon forests and forest produce .

Limited Forestry Education Hinders Economic Growth in Bangladesh

Until recently, forestry subject was not made public; people are yet to become well aware of forestry. There is no forestry curriculum taught in the school and colleges in our country. As a result the school and college going students are not aware of forestry: others have practically no scope of knowing forestry. Therefore exploration of forestry potentiality could not be fully tried and so potential development of forestry sector without the participation of mass people could not be achieved. We hardly do find any debate on forestry, forestry budget allocation, development potential in forestry, protection mechanism of forest resources, etc., in the parliament in the tea stall or in the street corner like others, until and unless people shout or give loud voice for claiming forestry or forestry budget, forestry programme. The authority is normally reluctant to allocate even minimum budget for the sector; forestry education in fact was restricted to the only forestry personnel. During British period, members of the imperial forest service used to be educated and trained in forestry from England, later on, from Dehradun Forest College in India. There were no educational facilities for forestry in Bangladesh except only departmental training schools, colleges or institutes. Government Forest Department officers were given training after recruitment. It was a compartmentalized system of education; no one other than forestry personnel could know what was forestry. This is definitely a serious shortfall and the country is practically being deprived of the potential contributions towards sustainable development of the country. Recently, Government Forest Department has set up a school for diploma course in Chittagong for open education with a very limited intake of students. This is a barrier to the development of forestry sector. Whatever has been achieved by now in the forestry sector is due to the idea conceived by the limited forestry personnel. Private individuals are hardly found to take initiative in establishing any forestry entrepreneurship, any development or sustainable development is not possible without the participation of mass people. It is possible only when people are in the know of forestry opportunities.

Again the national policy makers, if not well aware of the subject, can hardly formulate perspective policy decisions. So, the question of incorporation of forestry education in the policy decision does not arise. They do not get any feed back from other sources. There is hardly anybody advocating for forestry, contributing for the cause of developing potential forestry cum environment-friendly sustainable economy.

In fact, lack of awareness of the people of Bangladesh in forestry education, forest land, forest crops, forest industries, forestry practices and the forestry linkage with economic efficiency, income growth and protection of the environment limits our forestry achievement far behind international standard.

We have lost huge potential productive capacity through depletion of forest growth, biodiversity, watershed, water, lean period water flow, soil and soil nutrient status of our forest land and consequently the growth rate of the forest trees has decreased alarmingly. For example, Eucalyptus plantation yields 40-45 m^3 wood/annum in Brazil by private company whereas it is only $2.5m^3$ in Bangladesh. The occurrence of landslide, soil erosion and flash flood are also on the increase. To arrest further deterioration and to reverse the process, public awareness is to be built up through expansion of open forestry education in the country.

People's participation in some small parts of forestry without being properly educated in forestry has already brought some success in our social forestry and proved to be one of the best ways of achieving the success in people's oriented forestry. So forestry education, if made available in a broad spectrum, the socioeconomic and environmental success will hopefully be much better.
Moreover, Village/Urban Forestry has proved to be one of the strategies for poverty reduction in our country (benefit sharing forestry). Under the circumstances, it goes without saying that easy access to forestry education in the country is a bare necessity for all of us, rich and poor in order to tackle the deteriorating physical, biological, social and financial features of the country. It may also inspire small and big industrialists for setting industries.

<u>FAO in its report on the state of the world's forests, 2003 noted:</u> "Forestry Education, coping with new demands, education concerning forests and trees is crucial to achieving sustainable management and national sustainable development goals. Fundamental changes in forest policies, in the role of forests and, hence, in approaches to forestry, proper education is needed. Forestry education is undebatable because of increasing demands for forest goods and services, growing recognition of the contributions that trees outside forests make in rural and urban areas, the active participation of multiple stakeholders in forestry, the recent emphasis on food security and poverty alleviation, and the need to comply with legally binding commitments.

Expert meeting on forestry education organized by FAO in Rabat, Morocco in 2001 identified the following needs for improving the forestry education:

- Regional networking to support forestry education institutions and more institutional exchange of knowledge and experience;
- Improved coordination among forestry education, research and extension so that, needs becomes better known to all, and knowledge is more accessible to wider people;
- More use of innovative and interactive methods of teaching and learning, for example, approaches that enable communities to use their own knowledge and to experiment with new management techniques;
- Greater attention to distance learning and the use of new information technologies;
- Raising awareness of the trees and forests, for example, by increasing access to knowledge about forests and forest-related issues for the students of primary and secondary levels.

Wood Energy in Forestry-related Education

Wood energy has taken the first steps into the `life' of educational development processes. Several attempts at reviewing forestry and agro-forestry curricular programs in the countries of South and Southeast Asia were carried out at the close of the 20th century. The results revealed minimal or no inclusion at all across and within forestry-related curricular programs of wood energy as a science or as an independent subject matter. The Food and Agriculture Organization Regional Wood Energy Development Program in Asia (FAO-RWEDP) initiated these development efforts and made a remarkable heritage of information pertaining to wood energy education.

More than half of the world population (three billion) live in South and Southeast Asia Majority of these people live in dire poverty, and the households use biomass (including wood) resources as fuels for their daily needs. Despite this importance, much of what is understood about wood energy is surrounded by gaps and misinformation. The new millennium is the millennium of knowledge; forestry education in Bangladesh under no circumstances be forgotten to be incorporated in our education policy.

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Sustainable Forest Management Vis a-Vis Bangladesh Forestry

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Abstract

This paper while referring to the formal enunciation of Sustainable Forest Management (SFM) at international level has briefly described SFM. The paper has given a description of prevailing forests and forestry practices in Bangladesh. It has cited resultant impacts of such management practices and has indicated that the growing stock of Sundarbans is continuously getting depleted and deteriorated at the rate of about 1% per year. It stated that the natural forests under Cox's Bazar forest division declined by about 12% between 1984 and 1998. In Chittagong forest division the number of trees (30 cm and above at DBH) per hectare in the natural forests declined from 40 in 1984 to 13 in 1996, which is a 67% decline. In Sylhet forest division, the natural forest has decreased by about 17% during the last 12 years (between 1984 and 1996). While citing the declining growing stock, it has appreciated the coastal afforestation and community forestry for enhancing the tree cover. This paper has expressed concern for not having management plans for many forestry tracts and for non compliance management plan prescriptions because of paucity of funds. It stated that, in fact FD at present implement development projects, which though can be viewed as one of the components of forest management, is not true forest management. Thus at present Forest Management is almost absent in Bangladesh Forestry and the management of forest land under the control of FD is not subjected to SFM of any form. In brief sustainable forest management in its true sense of the term is yet to be initiated in Bangladesh. In view of the analyses and reporting of the facts and figures, this paper has finally given 8 recommendations for stepping into the SFM. The recommendations limits the project implementation scopes, suggested for capacity building and emphasized on the preparation and implementation of management plan prescriptions. At the same time it has given a broad outline on fund allocation aspects of the GOB to the FD.

Key words: Community forestry, Forestry practices, Growing stock, Sustainable forest management

Background

Bangladesh is a signatory of Earth Summit 1992, wherein the Principles of Sustainable Forest Management was enunciated for the first time. The sum and substance of these principles is to manage the forest resources and forest lands of the country sustainably so that it meets the social, economic, ecological, cultural and spiritual needs of the present and future generations. The details of the principles are given in Annexure I. This is the first global consensus on sustainable forest management. Though not binding, all the signatories are expected to practice afforestation and forest conservation as per the principle enunciated. Sustainable forest management is the stewardship and use of forests and forest lands in a way, and at a rate, that maintains their biological diversity, productivity, regeneration capacity, vitality and their potential to fulfill, now and in the future, relevant ecological, economic and social functions, at local, national and global levels, and that does not cause damage to other ecosystems.

Till date (year 2011), many of the forests, especially in the tropics and subtropics around the globe, are not managed according to the UNCED 1992 principles of sustainable forest management. Many developing countries do not have adequate funds and skilled manpower for the preparation, implementation and monitoring of sustainable forest management plans, and lack mechanisms to ensure the participation and involvement of all stakeholders in forest planning, development and monitoring. In addition, many countries lack appropriate forest legislation, regulation and incentives to promote sustainable forest management practices. Bangladesh is no exception of this said situation.

Definition

Sustainable Forest Management aims to ensure that the goods and services derived from the forest meet present-day needs while at the same time secure their continued availability and contribution to long-term development. In its broadest sense, forest management encompasses the administrative, legal, technical, economic, social and environmental aspects of the conservation and use of forests. It implies various degrees of deliberate human interventions, ranging from, actions aimed at safeguarding and maintaining the forest ecosystem and its functions, to favoring specific socially or economically valuable species or groups of species for the improved production of goods and services.

Sustainable Forest Management

Recently, governments, the forest industry sectors, private forest owners and other relevant parties are expressing their concern on prevailing forest management approaches vis-a-vis Sustainable Forest Management (SFM). Bangladesh is no exception either. This is in advantage towards sustainability and may be put to use in achieving SFM. The principles of sustainable forest management stated above, need to be rewarded for a given country; may be at global, national and regional levels. Under these principles criteria and indicators are required to be identified so that these may be used for monitoring SFM. Many of the regions and countries have already initiated this task and enunciated the relevant criteria and indicators for SFM. Some of these examples are as under:

- Regional Initiative for the Development and Implementation of National Level Criteria and Indicators for the Sustainable Management of Dry Forests in Asia:
  The "Regional Initiative for the Development and Implementation of National Level Criteria and Indicators for the Sustainable Management of Dry Forests in Asia" identified 8 national level criteria and 49 indicators for dry forests in Asia. The member countries are **Bangladesh**, Bhutan, China, India, Mongolia, Myanmar, Nepal, Sri Lanka, and Thailand
- African Timber Organization (ATO):
  The African Timber Organization's (ATO) main priority since 1994 has been to "promote the implementation of sustainable forest management in ATO member countries", and "in accordance with recommendations made at international level, specially by the Intergovernmental Panel on Forests" it has chosen to use for its work five Principles, two "Sub-principles", 26 criteria and 60 indicators at the regional and national levels. The member countries are Angola, Cameroon, Central African Republic, Congo, Cote-d'Ivoire, Democratic Republic of Congo, Equatorial Guinea, Gabon, Ghana, Liberia, Nigeria, Sao Tome et Principe and Tanzania.
- The Dry-Zone Africa Process on Criteria and Indicators for Sustainable Forest Management:
  The Process identified 7 criteria and 47 indicators for sustainable forest management at the national level. The member countries are Burkina Faso, Cape Verde, Chad, Gambia, Guinea Bissau, Mali, Mauritania, Niger, Senegal, Djibouti, Eritrea, Ethiopia, Kenya, Somalia, Sudan, Uganda, Angola, Botswana, Democratic Republic of Congo, Lesotho, Malawi, Mauritius, Mozambique, Namibia, Seychelles, South Africa, Swaziland, Tanzania, Zambia and Zimbabwe.
- International Tropical Timber Organization (ITTO):
  The Process identifies 7 criteria and 66 indicators applicable both at the national and forest management unit levels in humid tropical forests of member tropical countries. Member countries are Australia, Austria, Belgium/Luxembourg, Bolivia, Brazil, Cambodia, Cameroon, Canada, Central African Republic, China, Colombia, Cote-d'Ivoire, Democratic Republic of Congo, Denmark, Ecuador, Egypt, European Union, Fiji, Finland, France, Gabon, Germany, Ghana, Greece, Guyana, Honduras, India, Indonesia, Ireland, Italy, Japan, Liberia, Malaysia, Myanmar, Nepal, The Netherlands, New Zealand, Norway, Panama, Papua New Guinea, Peru, Philippines, Republic of Congo, Republic of Korea, Spain, Suriname, Sweden, Switzerland, Thailand, Togo, United Kingdom, Unites States of America and Venezuela.

- Lepaterique Process of Central America on Criteria and Indicators for Sustainable Forest Management:

  This process identified 4 criteria and 40 indicators at the regional level and 8 criteria and 53 indicators at the national level. It was initiated in January 1997 with Tegucigalpa and Honduras, and later expanded. The member countries are Tegucigalpa, Honduras, Belize, Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua and Panama.
- Montreal Process on Criteria and Indicators for the Conservation and Sustainable Management of Temperate and Boreal Forests:

  The "Montreal Process" deals with criteria and indicators for sustainable forest management in temperate and boreal forests in 12 countries outside Europe. The 12 participating countries have agreed on a set of 7 non-legally binding criteria and 67 indicators for sustainable forest management for national implementation. Participating countries have agreed to review and consider possible elements for criteria and indicators at the forest management unit level. Member countries are Argentina, Australia, Canada, Chile, China, Japan, Republic of Korea, Mexico, New Zealand, Russian Federation, Uruguay and USA.
- The Pan-European Forest Process on Criteria and Indicators for Sustainable Forest Management:

  The "Pan-European Forest Process" (previously known as the Helsinki Process) is overseen by the Ministerial Conferences on the Protection of Forests in Europe. It focuses on the sustainable development and sustainable management of forests in Europe. It includes boreal, temperate and Mediterranean-type forests. The European countries and the European Community have agreed on six common criteria, twenty-seven quantitative indicators and 101 descriptive indicators for sustainable forest management at the regional and national levels. Operational Level Guidelines for application at the sub-national level have also been developed. Member countries are Albania, Austria, Belarus, Belgium, Bosnia-Herzegovina, Bulgaria, Croatia, Czech Republic, Denmark, Estonia, European Community, Finland, France, Georgia, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Liechtenstein, Lithuania, Luxembourg, Monaco, Netherlands, Norway, Poland, Portugal, Romania, Russian Federation, Slovak Republic, San Marino, Slovenia, Spain, Sweden, Switzerland, Turkey, Ukraine, United Kingdom and Yugoslavia.
- The Tarapoto Proposal of Criteria and Indicators for Sustainability of the Amazon Forest:

  The "Tarapoto Proposal of Criteria and Indicators for Sustainability of the Amazon Forest" is sponsored by the Amazon Cooperation Treaty. The 8 participating countries propose 1 criterion and 7 indicators at the global concern. Furthermore, it identifies 7 criteria and 47 indicators for implementation at the national level. For the forest management unit level, the process recognizes 4 criteria and 22 indicators. Member countries are Bolivia, Brazil, Colombia, Ecuador, Guyana, Peru, Suriname and Venezuela
- The Near East Process:

  This process identified 7 criteria and 65 indicators for sustainable forest management at the regional and national levels. The guidelines are intended to assist countries in assessing and measuring the sustainability of forest management activities. The member countries are Afghanistan, Algeria, Azerbeijan, Bahrain, Cyprus, Djibouti, Egypt, Islamic Republic of Iran, Iraq, Jordan, Kuwait, Kyrgyz Republic, Lebanon, Libya, Malta, Mauritania, Morocco, Oman, Pakistan, Qatar, Kingdom of Saudi Arabia, Somalia, Sudan, Syria, Tadjikistan, Tunisia, Turkey, Turkmenistan, United Arab Emirates and Yemen.
- CIFOR:

  This process includes 6 main principles, 24 criteria and 98 indicators. These criteria and indicators are not intended to be used as a tool to directly assess either the sustainability of forest management practices or the performance of a particular forest management unit. They are intended to be used as a "starting platform" for countries to formulate their own, more locally sound set of criteria and indicators. The member countries are Australia, Austria, Belgium, Bolivia, Brazil, Brazil, Cameroon, Canada, China, Costa Rica, Cote d'Ivoire, Finland, France, Gabon, Germany, India, Indonesia, Japan, Malawi, Malaysia, Mesico, Nepal, Netherlands, Philippines, South Africa, Sweden, Tanzania, Thailand, United Kingdom, USA, Zambia and Zimbabwe.

Though Bangladesh has signed the "Regional Initiative for the Development and Implementation of National Level Criteria and Indicators for the Sustainable Management of Dry Forests in Asia" no substantial step has been taken by the government of Bangladesh (especially the FD) in enunciating the 'principles of sustainable forest management', 'criteria and indicators' matching the country context.

Forestry Practices in Bangladesh

Most of the forest land in Bangladesh belongs to the government, of which the major portion, about 1.52 Million hectares, is under the control of the Forest Department (FD), while a small portion, about 0.73 Million hectares of Unclassed State Forest (USF) land, is under the control of the district administration. The forest department has a set of professionally and technically skilled forestry personnel while the district administration does not.

The forests though under the management of FD having professional and technical manpower, have deteriorated at large. FAO led outlook studies, namely Millennium Ecosystem Assessment 2005, Global Environmental Outlook 3 (UNEP, 2002) has reported that deforestation continues at an alarming rate in several regions and countries and shows no sign of slowing down at the global level and in every year the primary forest is decreasing by about 6 Million hectares. In Bangladesh the forest is declining @ of 0.015 Million hectare every year.

The FD managed forests in Bangladesh are broadly divided into three, namely Mangroves, Hill Forests and Plain Land (Sal) Forests. Mangrove forests are located in Sundarbans and along the coast. Plain land forests are mostly degraded Sal forests, situated in the central and northwestern part of the country. Hill forests are located in Chittagong, Chittagong Hill Tracts and Sylhet. Besides the FD managed 1.53 (Ishtiaq 2007) Million hectares of government forest lands, there are about 761,924 hectares of government forest land mostly in Chittagong Hill Tracts (CHT), designated as USF and the tree growth in 15.4 million homesteads. The map of Bangladesh given in Annexure II will elucidate the locations of the government forests.

The following inventory data (Table 1) will give a picture of the deterioration of the Sundarban mangroves.

Table 1. Growing Stock of Sundarban at Different Inventory

Sl No	Inventory done by	Year of publication of Inventory Results	Sundri (Number of Trees per hectare, having DBH 15 cm and above)	Gewa (Number of Trees per hectare)	All Tree Species (Number of Trees per hectare)
1	Forestal and Forestal Engineering, Vancouver, Canada.	1959	211	61	296
2	Overseas Development Authority, UK.	1983	125	35	180
3	Forest Resource Management Project (FRMP) Forest Department, Government of Bangladesh	1996	106	20	144

Source: FD, Government of Bangladesh

The FRMP inventory (1996) further indicated the following:

- There are 144 trees per hectare which are 15 cm or above at DBH, contributing 27.4 Cu.M./ha,
- The number of trees having 10 cm and above at DBH are 561 per hectare,

- There are more than 2860 numbers of small poles per hectare,
- The number of saplings per hectare is 7500,
- The number of seedlings per hectare is 33200.

Examination and analyses of the above said data and information resulted the following:

1. The sundri growing stock (DBH 15 cm and above) has declined by 50% in 37 years (between 1959 and 1996),
2. The growing stock of gewa has gone down by 67% during 37 years (between 1959 and 1996),
3. On an overall basis for all species together the growing stock has declined by 51% (between 1959 and 1996).

Thus it can be stated without any doubt, that the growing stock of Sundarban is continuously getting depleted and deteriorated. The rate of depletion is roughly 1% per year. The major causes of such depletion may be enumerated as under:

- Over extraction: more than the quantity prescribed in the management plans were permitted for extraction,
- Change in edaphic and salinity conditions: Due to the Frrakka Barrage, the salinity increased and that in turn enhanced the siltation. These caused the clogging of pnumatophores probably leading to the top dying of the Sundri trees,
- Climate change: Higher inundations under the influence of the sea level rise, coupled with the increased salinity are causing change in the species composition. Goran[1] has already started to exhibit higher proportion on the south and south-west of Sundarban than what it was couple of decades back.

This depletion of the growing stock clearly indicates that the FD has failed technically to manage the mangroves of Sundarban on a sustained basis. A credit however goes to FD for protecting the territory of Sundarban intact for over 100 years. There was no loss of land and/or there were no encroachment. This whole area has the legal backup of 'Reserved Forest' and on the top of that because of numerous creeks and adverse environment, especially the man-eater tigers on land and dangerous crocodiles in the water coupled with the non-availability of fresh water, acted in favor of protecting Sundarban from encroachment.

The satellite based image generated cover-maps of Chakaria Sundarban given in Annexure III, indicated that about 8,400 hectares of natural mangroves got completely lost mostly to shrimp culture between 1974 and 1984. The imageries may be seen in Annexure III. At present (2011) hardly couple of hectares of mangrove vegetation are left here and there as witness of this devastation.

Regarding **Cox's Bazar Forest Division**, Revilla, et. al. (1998) stated the followings:

- The natural forests of Cox's Bazar forest division declined by 12% between 1984 and 1998,
- The plantation area of Cox's Bazar forest division increased by 8% between 1984 and 1998,
- The number of trees, measuring 30 cm or more at DBH, decreased by 36% between 1984 and 1998 and the tree volume decreased by 19%,
- The poles were about 162.5 (ranging from 127 to 198) in number per hectare in 1984. This number increased to 203 in 1998. This is an increase by about 25%,
- The volume per hectare of the two important teak strata also decreased from about 80.5 (ranging from 43 to 118) Cu. M./ha in 1984, to 52 Cu. M./ha in 1996; and from about 47.5 (ranging from 35 to 60) Cu. M./ha in 1984, to 34 Cu. M./ha in 1996.

Regarding **Chittagong Forest Division**, Revilla, et. al. (1998) stated the followings:

- The plantation area has increased from 13,223 ha in 1984 to 14,109 ha in 1996

[1] Goran is a mangrove species found in Sundarban on sites that receives inundation of more saline water.

- The number of trees (30 cm and above at DBH) per hectare in the natural forests declined from 40 in 1984 to 13 in 1996. This is a 67% decline,
- The pole size trees also decreased from 148 (ranging from 128 to 168 in different strata) in number per hectare in 1984 to 50 in 1996,
- The number of trees (stems) per hectare in one teak stratum decreased from 425 (ranging from 220 to 630) in 1984 to 145 in 1996,
- The number of trees (stems) per hectare in another teak stratum decreased from 755 (ranging between 470 & 1040) in 1984 to 83 in 1996.

Regarding **Sylhet Forest Division** Revilla et. al. (1998) stated that the natural forests and plantation area are 23,693 and 17,871 ha respectively. Compared with the 1984 inventory (FAO/UNDP) data; the natural forest has decreased by about 17% during the last 12 years (between 1984 and 1996). Revilla et. al. (1998) reported that the number of trees (30cm and more at DBH) in the natural forest decreased slightly but the pole size trees (10 to 30 cm at DBH) have decreased by more than 65% during this 12 year period.

Regarding **coastal afforestation**, over 0.1 Million hectares of mangrove plantations have been successfully established as a pioneering venture of the FD, on newly accreted mud flats along the coast, prior to its formal declaration as Reserved Forest. Since these lands were not declared as "Reserved Forest" the Forest Act was not strictly applicable on these lands. Consequently the FD in most of cases failed to provide the required protection because of the land litigations and poor legal back up supports from other government agencies such as district administration, police, etc. Many of the good coastal plantations established in Chittagong and Noakhali got lost to shrimp farms with direct and indirect indulgence of other government agencies such as Deputy Commissioners (DC) and land administrating agencies. Ultimately the wish of the DCs prevailed since they are most powerful and is highly favored by the political personnel such as ministers, members of the parliament, etc. Thus many of the coastal plantations got devastated.

Revilla (1998) during the FRMP inventory reported the following growing stocks from mangrove afforestation areas Table 2).

Table 2. FRMP Inventory Results of Coastal Afforestation Divisions

Sl No	Description	Noakhali Coastal Afforestation Division	Chittagong Coastal Afforestation Division	Bhola Coastal Afforestation Division	Patuakhali Coastal Afforestation Division
1	Area in hectares	34223	20042	12420	9848
2	Sample size	289	408	225	168
3	Number of trees with DBH 15 cm and above	172	10	58	156
4	Basal Area in Sq.m per hectare for trees 15 cm and above	5.26	0.29	1.96	5.86
5	Volume in Cu. M. per hectare contributed by trees having DBH 15 cm and above	25.69	1.02	9.31	36.40
6	Poles per hectare	13360	15228	641	5840
7	Sapling per hectare	3151	2202	185	967
8	Seedlings per hectare	1864	373	551	572

Source: FD, Government of Bangladesh

Besides the poles and undergrowth, the wood volume in the coastal afforestation areas is about 1.37 million Cu. M. over an area of 76,533 hectares, which means that the average growing stock in the mangrove afforestation area is 18.94 Cu. M./ha.(1996 data). The growing stock estimates are good and satisfactory. Patuakhali Forest Division has the highest volume of growing stock per hectare. Since only one-inventory results are available the trend cannot be estimated. However, it may be seen from these studies that the natural regeneration has started to come up in all most all places and is best in Noakhali. The next best regeneration is in Patuakhali. These are indications of the fact that the prevailing ecosystem is in the process of accepting this human intervention of mangrove afforestation. This is an indication of positive biological trend. The other factors that are affecting these plantations, as described in the earlier paragraph, are not congenial towards the growth, establishment and sustainability of these plantations. Even though the rate of depletion cannot be calculated, the net impact does not appear to be positive at all. Many of these plantations have already succumbed to prawn farming (some time white fish) and all of these plantations are subjected to similar serious threats.

The natural high forests[2] all over the country has depleted alarmingly. Gain (1998) stated that in Tangail district alone the sal forests shrunk to 1,000 hectares in 1990 from 20,000 hectares in 1970. In the recent past (1999) the rich and beautiful grajan forests of Tulatoli Block (in Cox's Bazar North Forest Division), the giant teak at Farua (CHT South Forest Division) and many such areas have got completely denuded. National Biodiversity Strategy and Action Plan for Bangladesh (October 2006) has pointed out that the forests cover has come down to 6% from 10% (of the area of the country). Development Perspectives of the Forestry Sector Master Plan, Bangladesh (March 2005) has stated, "It is obvious that unless concentrated efforts are made to reverse the situation, deforestation will steadily continue until there are no forests left". The estimates of forest depletion and land degradation vary from 3 to 6%. The fact remains that a serious depletion of forests is an ongoing process. All of these, firms up the fact that, severe depletion of forests cover has taken place in the recent past, especially in the natural forest areas in Bangladesh.

On the other hand, in some areas especially in the degraded sal forest areas of Dhaka, Tangail, Mymensingh, Dinajpur and Rangpur, massive afforestation was done by the FD especially through social forestry programs under an ADB funded Forestry Sector Project. The project was completed in June 2006. About 35,100 hectares of degraded and encroached sal forest area (FD controlled land); 23,200 seedling km.[3] (marginal land owned by other agencies such as R&H, BWDB, etc.) and 1,850 hectares of charland (*khasland* under the control of District Administration) have been brought under tree cover involving about 177,100 numbers of poor local people as participants of which 39,579 were women (data obtained from the office of the PD, FSP). The Coastal Green Belt Project also caused similar afforestation but in a smaller scale in the coastal areas of Bangladesh. Forest cover has thus changed in both the directions, namely increased and decreased, but there is every reason to believe that till date (April 2011) the net impact continued to be negative.

The FD has the mandate to manage the forest land underits control. The FD is supposed to manage its forest land through a management plan, which is commonly known as "Working Plan". Generally one working plan is promulgated for the territory under one forest division. Though the working plan is written for a period of ten years, it provides all the details of the interventions to be under taken, year wise, at least for the first five years. After the first 5 years, the working plan prescriptions may be revised if required, based on the implementation achievements and performances of the management plan prescriptions, through evaluation. Most of these working plans emphasize on sustained yield. At present, out of the 46 number of forest divisions, hardly 10 forest divisions have working plans that are currently valid. The forest divisions that have currently valid working plans do not, rather cannot, execute or implement the prescriptions of the working plans, mostly due to the paucity of funds.

Sustainability in Bangladesh Forestry

Forest management is being practiced in this country for over 100 years. Till recent time the basic concept of forest management was to get sustained yield, i.e., almost equal quantum of harvest every year. For the purpose of sustained yield it is important to sustain the growing stock at a given level, preferably at least (if not enhanced) at the level when the first management plan was prepared. In case of

[2] Forests of seed origin or some what virgin in nature.
[3] Planting of every 1000 seedlings is one seedling kilometre.

Sundarbans the growing stock has declined from 20.3 million cubic meters in 1960 to 13.2 million cubic meters in 1984. In case of Chittagong Hill Tracts, the growing stock decreased to 19.8 million cubic meters in 1985 from 23.8 million cubic meters in 1964 (ADB 1993).

The sustainability of the ecosystem was of no major consideration in Bangladesh while preparing the management plans. The recent concept of sustainability in forest management is to ensure the sustainability of the ecosystem. This involves some sort of ecosystem management. This sort of ecosystem management since deals with the biological indicators, the prescriptions cannot be rigid. They need to have a bundle of "do-ables" along with a set of "non-do-ables" for the purpose of management. These will involve a continuous monitoring and evaluation mostly based on criteria and indicators. This sort of management is yet to be initiated in Bangladesh.

Forest management plans while prescribes some harvests (goods and services) also asks for a set of interventions, including replanting of the site. The harvest generates revenues for the government, while the set of prescriptions calls for some sort of investments as well. This involves the budget allocations to FD from the Government. In the past, FD experienced situations where the felling was deferred for want of replanting and maintenance funds. This sort of delays triggered the chain reaction of short supply, higher demands, higher prices, allured illicit felling, etc. and ultimately led to the depletion of resources and degradation of sites.

ADB rightly resolved this problem in the FSP program areas by pressurizing the Government to accept the provisions of TFF through the amendment of Forest Act and promulgation of Social Forestry Rules 2005. According to these rules 10% of the harvest sale proceeds will not be deposited in the government treasury but shall be retained in the field to meet at least part of the replanting costs. It has been observed that the amount is inadequate but somehow encourage replanting with community supports.

Whatever be the situation, the existing provisions ensure some replanting-fund in social forestry areas. And since there is direct involvement of participants, the labor force required for replanting is a matter of contribution, to let the area get replanted. This will help secure "continuity" but may not be "sustainability", especially of the ecosystem. The emphasis of the participants will be for more benefits and that will lead to fast growing species, may be pure plantations and more intensive forestry practices. Ecosystem sustainability features are not expected to get the required priority under such 'continuity of plantation re-establishment' through TFF.

The question of ecosystem sustainability needs to be viewed more rigorously in case of Protected Areas (PA). In the past the PA areas used to be included with other areas of the production forestry and management prescriptions used to overlap. Only recently (since 1997) attempts are being made to prepare separate management plans for the Protected Areas. During 1997 for the first time, separate management plans were prepared for each of the Protected Areas under the control of FD.

Since then, till 2011 however, three sets of management plans have been written for each of the five protected areas namely Lawachara, Chunati, Rama-Kalenga, Satchari and Teknaf Game Reserve. One such set was written under the Forest Resource Management Project (FRMP), next management plans were written under Forestry Sector Project (FSP) and the latest ones were written under Nishargo Support Project (NSP, US Aid funded) in 2006. It may however, be noted that the management plans prepared by Mandala Agricultural Development Corporation (MADCor) in 1997 were not at all exhaustive and the prescriptions were scanty in nature. The basic approach was conservation only. The second set was prepared by TECSULT under Forestry Sector Project during 1999. These had objectives such as sustainable management through community association, poverty alleviation, etc. It suggested buffer zone planting and sharing of tangible benefits. As some activities were started as per these prescriptions, new program and thought emerged as "Co-Management" of protected areas under Nishargo Support Project and that led to the preparation of the latest set of management plans for the Protected Areas. The basic difference is sharing of the responsibilities between Forest Department (FD), Nishargo Support Project (NSP) and stakeholders. The prescriptions are not arranged on year wise frame, nor has any budget or projection/commitment as such, in the management plans. These management plans appear to be too ambitious to materialize and more so because of the fund constrain.

Similarly while the Integrated Management Plan of Sundarbans is yet to expire, another management plan has been written under an US Aid project without under-taking any new forest inventory. It is being learned that World Bank is going to write another management plan for Sundarbans. Under an UNDP project 4 management plans have been prepared for 4 Upazilas, namely Charfassion, Borguna Sadar, Hatya and Anwara. These have been designated as community oriented integrated management plan wherein forest, fish, agriculture, etc., will be approached and managed especially towards adaptation to climate change impacts.

In the recent past it has become a trend to write multiple management plans for a given site. Such situation will cause confusion as to which one is to be implemented. On the top of this, commitment of funds for the implementation of either management plan beyond project period is absent, jeopardizing the sustainability and the situation remain as it is, the previous hurdles in implementing current working plan.

The USF land is under the control of the district administration. A portion of this chunk of USF land has been leased out to private entrepreneurs for establishing rubber gardens. So far about 1,000 hectares of land has been given to the private entrepreneurs for establishing rubber gardens. All most all of these leases have chopped off the tree growth on these lands soon after receiving lease and sold them off with permissions from the district administration and hardly 10% of these leases have raised rubber gardens on those lands. The village forest extended over 0.27 Million hectares of land is privately owned and mostly comprised of tree groves, in and around the homesteads. With the increase of population new homesteads are built, very often at the cost of these tree groves. The private ownerships however, led to manage these tree groves to harness the best possible socio-economic benefits, which may or may not fit the principles of SFM. The tea gardens have some forests, mostly on sites that are not suitable for growing tea plants. In the past these forest land used to be maintained for harvesting ancillary products such as thatching materials for labor colony cottages, bamboos for basket making, fodder for cattle, etc. In the recent past, a trend is seen wherein the managers have started to convert these lands to rubber plantations to earn more of the economic benefits. None of these have any management plan to follow.

An important aspect that needs to be mentioned herein is that the FD receives funds from the government, but under two different major heads, namely "Revenue Budget" and "Development Budget". Till 1971, the FD had been receiving reasonably adequate allocations under revenue budget and it was more than that under development budget. The scenario changed over time. The allocations under revenue budget gradually shrunk, at times to such a small amount that could hardly meet the obligatory expenditures of payroll of the permanent staff and officers only. The funding for the implementation of working plan prescriptions is supposed to come from the revenue budget. With the reduction of the revenue budget, the implementation of the working plan prescriptions suffered the most and at present, hardly the working plan prescriptions are followed. Thus the management plan has lost all its importance in the management of forests in Bangladesh.

At present all most all the activities of the FD are 'project' oriented. Development Projects are prepared for a given period of time and the activities stated in the project are implemented by the FD. The project period in the past used to be 5 to 7 years and used to be funded by donors such as ADB, World Bank, etc. Since 2004, the government allocates small funds from its development budget to formulate and undertake projects having duration of one to two years. These are termed as "*Kormoshuchi*", i.e., working scheme.

In fact FD at present implement development projects, which though can be viewed as one of the components of forest management, is not true forest management. Thus at present Forest Management is almost absent in Bangladesh Forestry and the management of forest land under the control of FD is not subjected to SFM of any form. In brief sustainable forest management in its true sense of the term is yet to be initiated in Bangladesh.

Under the above said context it may be stated that the sustainable forest management is almost absent in Bangladesh Forestry.

Recommendations

Though Bangladesh is the signatory of both, the 'UNCED 1992' and 'Sustainable Management of Dry Forests in Asia' protocol, till date (year 2011) no substantial steps have been taken towards SFM. More over there are serious constrains in adapting SFM as well. In view of the existing holistic situation the followings are recommended so that the FD, Government of Bangladesh steps into the SFM:

1. FD shall have to shake off the practice of encompassing all the different types of forestry activities under development projects. Only the Management Plan prescriptions should be followed, in case of any intervention on any ecosystem or program of actions with respect to natural resources.

2. Very intensive and strong capacity building of both professional and technical staff should be incorporated in the personnel management system of the FD, by tagging examination, evaluation, etc., at every step of promotion, pay enhancement, benefit award, etc., to the person concerned. Regular refresher courses should be run in the forestry schools, college and FDTC. Every professional personnel at 7th year of his service, must be capable of writing management plans (Working Plan), monitoring the technical aspects of forestry practices using scientific monitoring tools and get well acquainted with the latest forestry knowledge.

3. Development projects have become the major activity areas for the FD at present (year 2011). This sort of funding for a given period of 2 to 7 years generates some activities no doubt, but never ensures continuity. As soon as the project expires or is completed, all the activities get to a standstill situation, including the retrenchment of staff recruited against the project. Most of the experiences acquired through the project get lost. Such an output can never bring in sustainability what to speak about SFM. Under this given circumstances, FD needs to ensure that project activities remain confined in the following areas only.
    a. Capacity building of the staff and officers including educations abroad
    b. Support to develop and build roads, bridal paths, buildings, setting of laboratories, etc.,
    c. Support the supply of logistics such as vehicles, water transports, equipment, etc.,
    d. Support forest inventories and monitoring of the forestry programs,
    e. Support all sorts of short term and long term researches related to forests and forestry.

    Besides these, the FD while embracing a project should cross check with the relevant working plan of the given territory to ensure corroboration of the project activities with the prevailing working plan prescriptions for the given territory. Under no circumstances the project activities should be conflicting with the management plan prescriptions.

4. The funds that are now being given to the FD under various projects and/or *Kormoshochi* (Annual Development Program) for forestry activities such as afforestation, biodiversity conservation, ecosystem management, etc. should be allocated as Revenue Budget allocations, so that the FD can use that funds towards implementation of the management plan prescriptions. Besides these the GoB need to ensure the allocation adequate funds so that the management-plan-prescriptions can be applied and implemented every year at full professional satisfaction.

5. FD will have to set the principles of forest management, identify the criteria and indicators as per the protocol "Regional Initiative for the Development and Implementation of National Level Criteria and Indicators for the Sustainable Management of Dry Forests in Asia", which has already been signed by the government of Bangladesh. The preparation of working plans should abide by the principles of forest management set by the FD, GoB. The monitoring should revolve around the criteria and indicators indentified.

6. FD needs to take necessary steps to prepare management plan on a routine basis so that each of its Forest Divisions has a current management plan. The present system of depending on only a couple of Working Plan Divisions for the preparation of working plans should be changed. Preparation of a management plan should be a special tasks assigned to a particular officer, who

should work in the office of the concerned DFO for preparing the working plan. Preparation of working plan should be initiated at least a year before the expiry of the current management plan. At the same time a strong monitoring system has to be placed in position, having qualified personnel to accomplish the desired. They must possess the capacity and capability of undertaking the monitoring activities using the best available scientific knowledge. The existing working plan divisions may be entrusted with this assignment of monitoring. At the same time other stakeholders, interested in national forestry affairs needs to identified, listed, communicated and a networking established so that they contribute beneficially towards SFM.

7. By now however, it has got established that participatory afforestation program involving the local people will be able to maintain continued tree cover through TFF. The present 10% apportioning of the sale proceeds towards the TFF seems to inadequate. To initiate a new program of afforestation with community involvement will definitely need an initial budget outlay. From 2nd rotation however, the TFF will take care of the continuity of tree cover at least. Once initiated and if the TFF[4] is enhanced from 10 to 20%, it is expected that the tree cover loss will be stopped. The built in process of replanting, by using the TFF under the provisions of the Social Forestry Rules 2005, will ensure at least the continuity of tree cover, if not SFM. At present however, there is a serious shortage of funds to initiate participatory afforestation programs.

8. One of the major requirements of SFM is to have the blessings of the political personnel. The nation should have political commitment for the SFM. At the same time the FD needs to have the capability to convenience the political leaderships so that the later get inclined to SFM. The serious image crisis of the FD (Khan et. al., 2004) is definitely a serious hurdle in this given context.

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[4] TFF (Tree Farming Fund) is the amount that is kept aside from the sale proceeds of the plantations established under participatory approach. At present this is 10% of the sale proceeds. This amount is used in conjunction with the participants' labor, for replanting the area felled, as per the provisions of the Social Forestry Rules promulgated by the Government of Bangladesh in 2004. Usually this 10% is not adequate to meet the material costs of replanting. It has been opined to enhance this amount to 20%.

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Annexure I

REPORT OF THE UNITED NATIONS CONFERENCE ON ENVIRONMENT AND DEVELOPMENT
(Rio de Janeiro, 3-14 June 1992)

Annex III

NON-LEGALLY BINDING AUTHORITATIVE STATEMENT OF PRINCIPLES FOR A GLOBAL CONSENSUS ON THE MANAGEMENT, CONSERVATION AND SUSTAINABLE DEVELOPMENT OF ALL TYPES OF FORESTS

PREAMBLE

a) The subject of forests is related to the entire range of environmental and development issues and opportunities, including the right to socio-economic development on a sustainable basis.

b) The guiding objective of these principles is to contribute to the management, conservation and sustainable development of forests and to provide for their multiple and complementary functions and uses.

c) Forestry issues and opportunities should be examined in a holistic and balanced manner within the overall context of environment and development, taking into consideration the multiple functions and uses of forests, including traditional uses, and the likely economic and social stress when these uses are constrained or restricted, as well as the potential for development that sustainable forest management can offer.

d) These principles reflect a first global consensus on forests. In committing themselves to the prompt implementation of these principles, countries also decide to keep them under assessment for their adequacy with regard to further international cooperation on forest issues.

e) These principles should apply to all types of forests, both natural and planted, in all geographical regions and climatic zones, including austral, boreal, sub-temperate, temperate, subtropical and tropical.

f) All types of forests embody complex and unique ecological processes which are the basis for their present and potential capacity to provide resources to satisfy human needs as well as environmental values, and as such their sound management and conservation is of concern to the Governments of the countries to which they belong and are of value to local communities and to the environment as a whole.

g) Forests are essential to economic development and the maintenance of all forms of life.

h) Recognizing that the responsibility for forest management, conservation and sustainable development is in many States allocated among federal/national, state/provincial and local levels of government, each State, in accordance with its constitution and/or national legislation, should pursue these principles at the appropriate level of government.

PRINCIPLES/ELEMENTS

1. (a) States have, in accordance with the Charter of the United Nations and the principles of international law, the sovereign right to exploit their own resources pursuant to their own environmental policies and have the responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment of other States or of areas beyond the limits of national jurisdiction.

   (b) The agreed full incremental cost of achieving benefits associated with forest conservation and sustainable development requires increased international cooperation and should be equitably shared by the international community.

2. (a) States have the sovereign and inalienable right to utilize, manage and develop their forests in accordance with their development needs and level of socio-economic development and on the basis of national policies consistent with sustainable development and legislation, including the conversion of such areas for other uses within the overall socio-economic development plan and based on rational land-use policies.

   (b) Forest resources and forest lands should be sustainably managed to meet the social, economic, ecological, cultural and spiritual needs of present and future generations. These needs are for forest products and services, such as wood and wood products, water, food, fodder, medicine, fuel, shelter, employment, recreation, habitats for wildlife, landscape diversity, carbon sinks and reservoirs, and for other forest products. Appropriate measures should be taken to protect forests against harmful effects of pollution, including air-borne pollution, fires, pests and diseases, in order to maintain their full multiple value.

   (c) The provision of timely, reliable and accurate information on forests and forest ecosystems is essential for public understanding and informed decision-making and should be ensured.

   (d) Governments should promote and provide opportunities for the participation of interested parties, including local communities and indigenous people, industries, labour, non-governmental organizations and individuals, forest dwellers and women, in the development, implementation and planning of national forest policies.

3. (a) National policies and strategies should provide a framework for increased efforts, including the development and strengthening of institutions and programmes for the management, conservation and sustainable development of forests and forest lands.

   (b) International institutional arrangements, building on those organizations and mechanisms already in existence, as appropriate, should facilitate international cooperation in the field of forests.

   (c) All aspects of environmental protection and social and economic development as they relate to forests and forest lands should be integrated and comprehensive.

4. The vital role of all types of forests in maintaining the ecological processes and balance at the local, national, regional and global levels through, inter alia, their role in protecting fragile ecosystems, watersheds and freshwater resources and as rich storehouses of biodiversity and biological resources and sources of genetic material for biotechnology products, as well as photosynthesis, should be recognized.

5. (a) National forest policies should recognize and duly support the identity, culture and the rights of indigenous people, their communities and other communities and forest dwellers. Appropriate conditions should be promoted for these groups to enable them to have an economic stake in forest use, perform economic activities, and achieve and maintain cultural identity and social organization, as well as adequate levels of livelihood and well-being, through, inter alia, those land tenure arrangements which serve as incentives for the sustainable management of forests.

(b) The full participation of women in all aspects of the management, conservation and sustainable development of forests should be actively promoted.

6. (a) All types of forests play an important role in meeting energy requirements through the provision of a renewable source of bio-energy, particularly in developing countries, and the demands for fuel-wood for household and industrial needs should be met through sustainable forest management, afforestation and reforestation. To this end, the potential contribution of plantations of both indigenous and introduced species for the provision of both fuel and industrial wood should be recognized.

(b) National policies and programmes should take into account the relationship, where it exists, between the conservation, management and sustainable development of forests and all aspects related to the production, consumption, recycling and/or final disposal of forest products.

(c) Decisions taken on the management, conservation and sustainable development of forest resources should benefit, to the extent practicable, from a comprehensive assessment of economic and non-economic values of forest goods and services and of the environmental costs and benefits. The development and improvement of methodologies for such evaluations should be promoted.

(d) The role of planted forests and permanent agricultural crops as sustainable and environmentally sound sources of renewable energy and industrial raw material should be recognized, enhanced and promoted. Their contribution to the maintenance of ecological processes, to offsetting pressure on primary/old-growth forest and to providing regional employment and development with the adequate involvement of local inhabitants should be recognized and enhanced.

(e) Natural forests also constitute a source of goods and services, and their conservation, sustainable management and use should be promoted.

7. (a) Efforts should be made to promote a supportive international economic climate conducive to sustained and environmentally sound development of forests in all countries, which include, inter alia, the promotion of sustainable patterns of production and consumption, the eradication of poverty and the promotion of food security.

(b) Specific financial resources should be provided to developing countries with significant forest areas which establish programs for the conservation of forests including protected natural forest areas. These resources should be directed notably to economic sectors which would stimulate economic and social substitution activities.

8. (a) Efforts should be undertaken towards the greening of the world. All countries, notably developed countries, should take positive and transparent action towards reforestation, afforestation and forest conservation, as appropriate.

(b) Efforts to maintain and increase forest cover and forest productivity should be undertaken in ecologically, economically and socially sound ways through the rehabilitation, reforestation and re-establishment of trees and forests on unproductive, degraded and deforested lands, as well as through the management of existing forest resources.

(c) The implementation of national policies and programmes aimed at forest management, conservation and sustainable development, particularly in developing countries, should be supported by international financial and technical cooperation, including through the private sector, where appropriate.

(d) Sustainable forest management and use should be carried out in accordance with national development policies and priorities and on the basis of environmentally sound national guidelines. In the formulation of such guidelines, account should be taken, as appropriate and if applicable, of relevant internationally agreed methodologies and criteria.

(e) Forest management should be integrated with management of adjacent areas so as to maintain ecological balance and sustainable productivity.

(f) National policies and/or legislation aimed at management, conservation and sustainable development of forests should include the protection of ecologically viable representative or unique examples of forests, including primary/old-growth forests, cultural, spiritual, historical, religious and other unique and valued forests of national importance.

(g) Access to biological resources, including genetic material, shall be with due regard to the sovereign rights of the countries where the forests are located and to the sharing on mutually agreed terms of technology and profits from biotechnology products that are derived from these resources.

(h) National policies should ensure that environmental impact assessments should be carried out where actions are likely to have significant adverse impacts on important forest resources, and where such actions are subject to a decision of a competent national authority.

9. (a) The efforts of developing countries to strengthen the management, conservation and sustainable development of their forest resources should be supported by the international community, taking into account the importance of redressing external indebtedness, particularly where aggravated by the net transfer of resources to developed countries, as well as the problem of achieving at least the replacement value of forests through improved market access for forest products, especially processed products. In this respect, special attention should also be given to the countries undergoing the process of transition to market economies.

(b) The problems that hinder efforts to attain the conservation and sustainable use of forest resources and that stem from the lack of alternative options available to local communities, in particular the urban poor and poor rural populations who are economically and socially dependent on forests and forest resources, should be addressed by Governments and the international community.

(c) National policy formulation with respect to all types of forests should take account of the pressures and demands imposed on forest ecosystems and resources from influencing factors outside the forest sector, and intersectoral means of dealing with these pressures and demands should be sought.

10. New and additional financial resources should be provided to developing countries to enable them to sustainably manage, conserve and develop their forest resources, including through afforestation, reforestation and combating deforestation and forest and land degradation.

11. In order to enable, in particular, developing countries to enhance their endogenous capacity and to better manage, conserve and develop their forest resources, the access to and transfer of environmentally sound technologies and corresponding know-how on favourable terms, including on concessional and preferential terms, as mutually agreed, in accordance with the relevant provisions of Agenda 21, should be promoted, facilitated and financed, as appropriate.

12. (a) Scientific research, forest inventories and assessments carried out by national institutions which take into account, where relevant, biological, physical, social and economic variables, as well as technological development and its application in the field of sustainable forest management, conservation and development, should be strengthened through effective

modalities, including international cooperation. In this context, attention should also be given to research and development of sustainably harvested non-wood products.

(b) National and, where appropriate, regional and international institutional capabilities in education, training, science, technology, economics, anthropology and social aspects of forests and forest management are essential to the conservation and sustainable development of forests and should be strengthened.

(c) International exchange of information on the results of forest and forest management research and development should be enhanced and broadened, as appropriate, making full use of education and training institutions, including those in the private sector.

(d) Appropriate indigenous capacity and local knowledge regarding the conservation and sustainable development of forests should, through institutional and financial support and in collaboration with the people in the local communities concerned, be recognized, respected, recorded, developed and, as appropriate, introduced in the implementation of programmes. Benefits arising from the utilization of indigenous knowledge should therefore be equitably shared with such people.

13. (a) Trade in forest products should be based on non-discriminatory and multilaterally agreed rules and procedures consistent with international trade law and practices. In this context, open and free international trade in forest products should be facilitated.

(b) Reduction or removal of tariff barriers and impediments to the provision of better market access and better prices for higher value-added forest products and their local processing should be encouraged to enable producer countries to better conserve and manage their renewable forest resources.

(c) Incorporation of environmental costs and benefits into market forces and mechanisms, in order to achieve forest conservation and sustainable development, should be encouraged both domestically and internationally.

(d) Forest conservation and sustainable development policies should be integrated with economic, trade and other relevant policies.

(e) Fiscal, trade, industrial, transportation and other policies and practices that may lead to forest degradation should be avoided. Adequate policies, aimed at management, conservation and sustainable development of forests, including, where appropriate, incentives, should be encouraged.

14. Unilateral measures, incompatible with international obligations or agreements, to restrict and/or ban international trade in timber or other forest products should be removed or avoided, in order to attain long-term sustainable forest management.

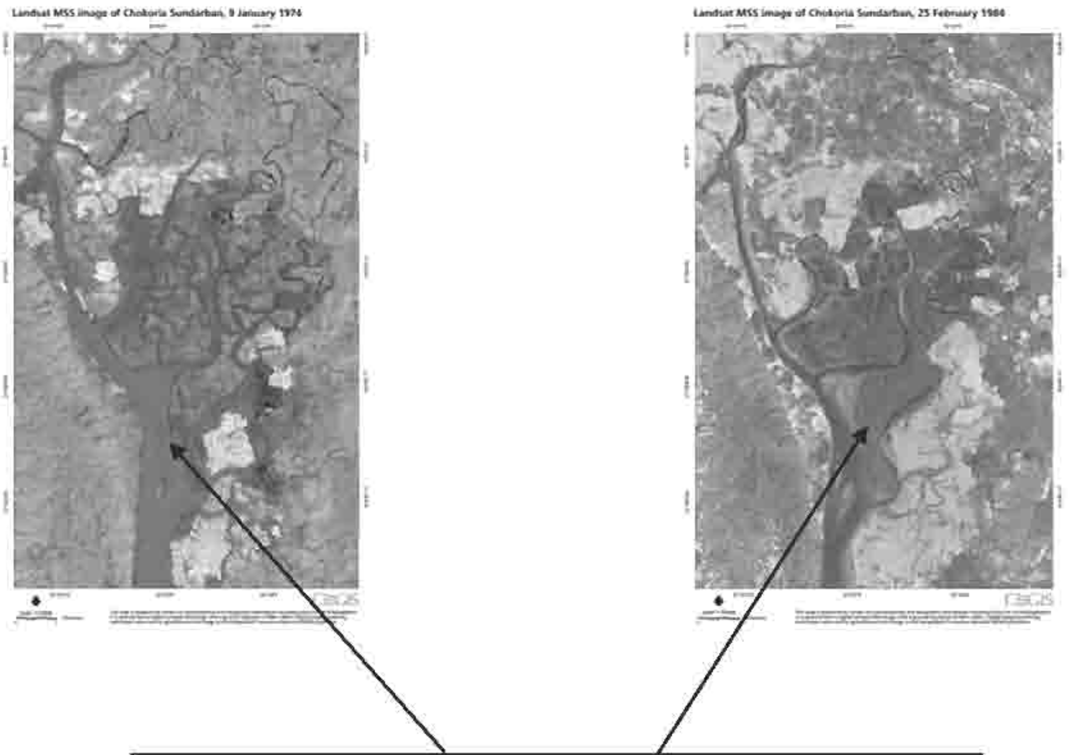
15. Pollutants, particularly air-borne pollutants, including those responsible for acidic deposition, that are harmful to the health of forest ecosystems at the local, national, regional and global levels should be controlled.

Annexure II

Map of Bangladesh Showing the Forests and the locations of Protected Areas.

Annexure III

Change in the vegetative cover of Chakaria Sundarbans Forest between 1874 and 1984
(By courtesy of IUCN, Bangladesh)



These areas were covered with very good growth of natural mangroves as is seen in 1974 imagery. The same area on the right hand imagery of 1984 exhibits the serious depletion of these mangroves. At present (2011), the whole area has been converted to "SHRIMP FARMS".

Present Status and Diversity of Medicinal Plants in Bangladesh

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Abstract

Bangladesh is rich in medicinal plant diversity. People of Bangladesh use herbal medicine for curing diseases, relieving physical suffering and primary health care both rural and urban areas. Though in the recent past, use of herbal medicine declined due to modern allopathic medicine facilities, now a days interest in traditional treatment by herbal medicine has increased considerably in Bangladesh. *Ayurvedic* and *Unany* system of medicine are the part of heritage in Bangladesh '. The medicinal plants are generally used for medicine but many of them are also used as vegetables, fruits, spices, food, dye, etc. Sustainable management is need for the medical used for medicinal purpose.

Key words: Floral diversity, Herbal medicine, Medicinal plant

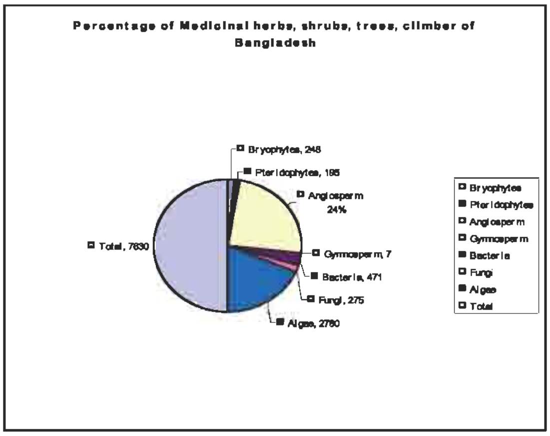
Floral Diversity of Bangladesh

Bangladesh is a country of floral diversity due to its favorable environmental conditions. The Encyclopedia of Flora and Fauna of Bangladesh (2009) described 471 species of bacteria, 275 species of fungi. 2,780 species of algae, 248 species of bryophytes under 34 families (Table-1). On the other hand, 195 species of pteridophytes have been also identified under 41 families. The number of Gymnosperm species is 7 in Bangladesh.

About 3,654 species of flowering plants have been identified under about 199 families. Out of which about 2,623 species under 158 families belongs to dicotyledons and about 1,031 species under 41 families belong to monocolylendens. All these angiospermic species are native or alien to Bangladesh.

Table 1. Floral Diversity in Bangladesh

Type	Number of species
Bacteria	471
Fungi	275
Algae	2780
Bryophytes	248
Pteridophytes	195
Gymnosperm	7
Angiosperm	3654
Total	**7630**



Medicinal Plant Diversity in Bangladesh

Several scientists from time to time described medicinal plants in Bangladesh. Yousuf *et al.* (1994) listed 546 medicinal plants for the first time in Bangladesh. Rashid *et al.* (1988), Ghani (1998) and Haq (2008) described 160, 449 and 400 medicinal plants of Bangladesh respectively. Traditional practitioner Dr. Bhagadatta Khisa (1996) recorded more than 500 plants species of traditional medicinal use. Out of which 135 species are botanically identified. Yousuf (2000) noted that indigenous people of the Chittagong Hill Tracts use more than 300 medicinal plants for the treatment of different diseases. Anon. (2006) listed 697 medicinal plants and their uses. But not enough work has been done to explore and exploit the valuable potential resources as yet. Hence, a comprehensive study was carried out throughout the country from 2004-2008 to explore and identify more potential medicinal plants being present in rural and forest areas.

Method of Study

The method of the study included survey, interview of local communities, businessmen, field visit including visit toProtected Areas and literature review. The survey of medicinal plants was carried out in government forests, private forests, village groves and homestead forests.

Results and Discussion

The present study found 1,595 medicinal plants in Bangladesh (Table-2) which is 17% of total flora (Fig.1). Out of which 56 species are pteridophytes, 1,533 species are angiosperms and 6 species are gymnosperms. Among angiospermic, 1,293 medicinal plants are dicotyledons and 240 are monocotyledons. Family wise medicinal plants in Bangladesh are given in Tables 3-6.

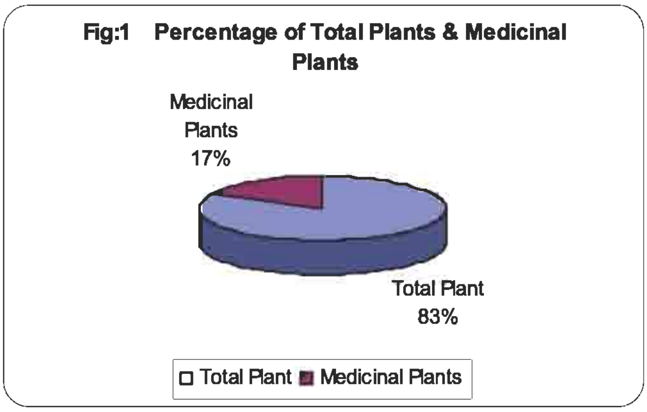
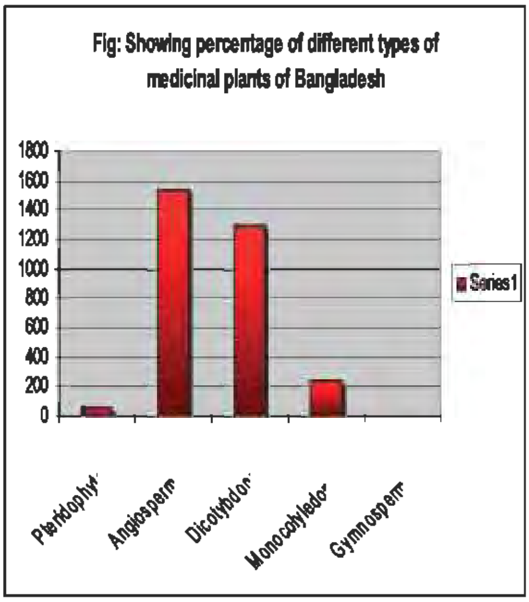


Fig:1 Percentage of Total Plants & Medicinal Plants

The study also showed that the medicinal plants constitute 43.5% herbs, 21% shrubs, 25.5% trees and 10% climbers (Fig.2) in Bangladesh. The medicinal plants that fall under herbs are 693, shrubs 338, trees 411 and climbers 154.

Table 2: Medicinal Plants of Bangladesh

Sl.No.	Kinds	Number	Herb	Shurb	Tree	Climber
1.	Pteridophyte	**56**	56	-	-	-
2.	Angiosperme Dicotybdons Monocolyledons	1293 240	447 189	326 12	397 8	123 31
	Total	**1533**	**636**	**338**	**405**	**154**
3.	Gymnosperme	6	1	2	2	1
	Total=	**1595**	**693**	**340**	**407**	**155**



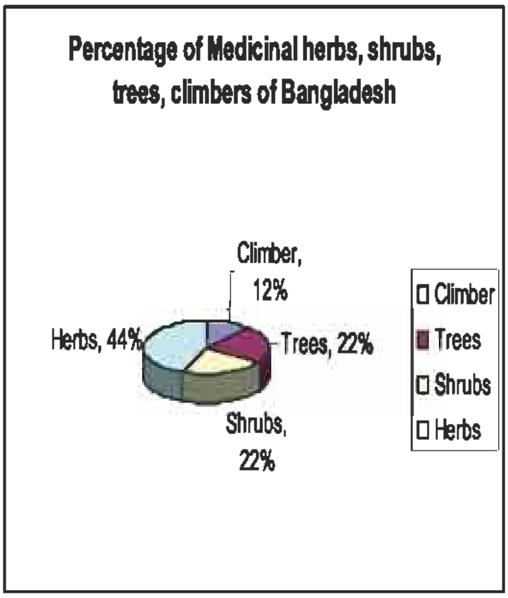


Table 3.Familywise Pteridophytic Medicinal Plants of Bangladesh

Sl. No.	Family	No. of Genus	No. of Species
1.	Adiantaceae	1	6
2.	Acrostichaceae	1	1
3.	Angiopteridaceae	1	2
4.	Aspleniaceae	1	3
5.	Athyriaceae	1	1
6.	Azollaceae	1	1
7.	Blechnaceae	1	1
8.	Bolbitidaceae	1	1
9.	Cryptogrammaceae	1	3
10.	Dennstaedtiaceae	2	2
11.	Equisetaceae	1	2
12.	Gleicheniaceae	1	1
13.	Hemionitidaceae	1	1
14.	Helminthostachyaceae	1	1
15.	Hymenophyllopsidaceae	1	1
16.	Lycopodiaceae	2	2
17.	Lygodiaceae	1	5
18.	Marsileaceae	1	2
19.	Salviniaceae	1	1
20.	Selaginellaceae	1	1
21.	Sinopteridaceae	2	3
22.	Stenochlaenaceae	1	1
23.	Thelypteridaceae	3	3
24.	Parkeriaceae	1	1
25.	Polypodiaceae	6	6
26.	Psilotaceae	1	1
27.	Pteridaceae	1	3
	Total =	36	56

Table 4. Gymnospermic Medicinal Plants of Bangladesh

Sl.No.	Family	Herb	Shrub	Tree	Climber	Total
1.	Chperaceae	1	1	-	-	-
2.	Podocarpaceae	-	-	1	-	1
3.	Ci[ressaceae	-	-	1	-	1
4.	Gnetaceae	-	1	-	1	1
	Total =	1	2	2	1	6

Table 5. Family wise number of medicinal Plants in Bangladesh (Monocot)

No	Family	Herbs	Shrubs	Trees	Climber	Total
1	Agavaceae	5	1			6
2	Alismataceae	1				1
3	Aloceae	2				2
4	Araceae	27			9	36
5	Areceae		2	6	4	12
6	Bromeliaceae	1				1
7	Cannaceae	1				1
8	Commelinaceae	6				6
9	Costaceae	1				1
10	Cyperaceae	14				14
11	Dioscoreaceae	3			10	13
12	Flagellariaceae		1			1
13	Hacemodoraceae	1				1
14	Iridaceae	2				2
15	Lemnaceae	3				3
16	Liliaceae	8	3		2	15
17	Marantaceae	1				1
18	Musaceae		3			3
19	Orchidaceae	22				22
20	Pandanceae		2			2
21	Poaceae	51		2		50
22	Pontederiaceae	3				3
23	Smilacaceae				5	5
24	Stemonaceae				1	1
25	Taccaceae	3				3
26	Typhaceae	1				1
27	Xyridaceae	2				2
28	Zinigiberaceae	31				31
	Total :	**189**	**12**	**8**	**31**	**240**

Table 6. Family wise number of medicinal Plants in Bangladesh (Dicoteledons)

No	Family	Herbs	Shrubs	Trees	Climber	Total
1	Acanthaceae	23	15	-	2	40
2	Actinodiaceae	1	-			1
3	Aizoaceae	1				1
4	Alangiaceae		1			1
5	Amaranthceae	11	3			14
6	Anacardiaceae		1	9		10
7	Annocaceae		3	6	1	10
8	Apiaceae	11				11
9	Apocynace	1	14	9	1	25
10	Araliaceae			2	2	4
11	Aristolochiaceae		1		2	3
12	Asclepiadaceae	7	10		2	19
13	Asteraceae	39	4	1	1	45
14	Balsaminaceae	3				3
15	Basellaceae	1				1
16	Begoniaceae	5				5
17	Bignoniaceae		1	7		8
18	Bixaceae		1			1
19	Bombacaceae			4		4
20	Boraginaceae	5	1	2		9
21	Brassicaceae	13				13
22	Buddlejaceae		1			1
23	Burseraceae		1	4		5
24	Cactaceae		1			1
25	Caesalpiniaceae	7	10	28	6	51
26	Campanulaceae	3				3
27	Cannacaceae	1				1
28	Capparaceae	2	2	1	1	6
29	Caprifoliaceae		4			4
30	Caricaceae		1			1
31	Carophyliaceae	2				2
32	Casuarinaceae			1		1
33	Celastraceae			2		2
34	Ceratophyllaceae	1				1
35	Chenopodiceae	3	1			4
36	Chloranthaceae	1	1			2
37	Clusiaceae		1	8		9
38	Combertaceae		2	6	3	11
39	Connaraceae		1		1	2

Table 6. Family wise number of medicinal Plants in Bangladesh (Dicoteledons)

No	Family	Herbs	Shrubs	Trees	Climber	Total
40	Convolvulaceae	20	1		3	24
41	Crassulaceae	5				5
42	Cucumbitaceae			30		30
43	Cuscutaceae	2				2
44	Datiscaceae			1		1
45	Dilleniaceae		2	2		4
46	Dipterocarpepaceae			6		6
47	Droseraceae	2				2
48	Ebenaceae			5		5
49	Eleocarpaceae			5		5
50	Erythoxylaceae		1			1
51	Euphorbiaceae	19	31	40		91
52	Fabaceae	50	30	17	26	123
53	Flacourtiaceae		1	6		7
54	Fumariaceae	5				5
55	Gentinnaceae	8				8
56	Eesneriaceae	2	2			4
57	Hippocnateceae				2	2
58	Hydrophyllaceae	1				1
59	Maliaceae	30	8			38
60	Lauraceae	1		14		15
61	Lecythidanceae			4		4
62	Leeaceae		7			7
63	Lentibulariceae	1				1
64	Linaceae	1	2			2
65	Longaniaceae			1	1	2
66	Oranthaceae	3	1			4
67	Lythraceae	1	2	2		5
68	Magnoliaceae			3		3
69	Malpoghiaceae		1		1	2
70	Malvacxeae	17	10	3		30
71	Melastomataceae	1	5			6
72	Meliaceae		1	13		14
73	Menispermaceae		1		12	13
74	Menyanthaceae	2				2
75	Mimosaceae	6	3	17	5	31
76	Moraceae		5	19	3	27
77	Mynsinaceae		9	2		11
78	Moringaceae			1		1
79	Myricaceae			1		1
80	Myrtaceae	1		10		11
81	Nelumbonaceae	1				1
82	Nyetaginaceae			1	3	4
83	Nymphaceaceae	6				6

No	Family	Herbs	Shrubs	Trees	Climber	Total
84	Ochnaceae		1	2		3
85	Olacaceae		1		1	2
86	Olaceae		5	1	1	7
87	Onagraceae	5				5
88	Opiliaceae		1			1
89	Orobanchaceae	1				1
90	Oxalidaceae	3		2		5
91	Papaveraceae	3				3
92	Passifloraceae				3	3
93	Pedaliaceae	2				2
94	Piperaceae	1			9	10
95	Plumbaginaceae		1		2	3
96	Polygalanceae	3				3
97	Polygonaceae	20	1			21
98	Portulaceae	4				4
99	Primulaceae	1				1
100	Punicaceae	1				1
101	Ranunculaceae	2			1	3
102	Rhamnaceae		3	2	1	6
103	Rhizophoraceae			9		9
104	Rosaceae	2	4		1	7
105	Rubiaceae	15	32	19	5	72
106	Rutaceae		12	10	2	24
107	Sabiaceae		1			1
108	Salicaceae			1		1
109	Santalaceae			1		1
110	Sapindasceae		2	11	1	14
111	Sapotaceae			5		5
112	Schisandraceae				1	1
113	Scrophulariceae	23				23
114	Simaroubaceae		1	2		3
115	Solanaceae	13	11			24
116	Sonneratiaceae			1		1
117	Sterculiaceae	2	2	8	2	14
118	Symplocaseae			5		5
119	Tamaricaceae		4			4
120	Theaceae		2	2		4
121	Thymelaceae	1		1		2
122	Tiliaceae	5	7	7		19
123	Trapaceae	1				1
124	Ulmaceae			2		2
125	Urticaceae	9	4	1		14
126	Verbaneceae	3	26	11		40
127	Violaceae	1	1			2
128	Vitaceae				15	15
129	Xanthophyllaceae	23	105	88	26	292
	TOTAL :					**1293**

Causes of Medicinal Plants Diversity Loss in Bangladesh

There are several reasons of shortage of medicinal plants and their diversity loss in Bangladesh. The important ones are discussed below.

Habitat loss : Undisturbed habitat is primary requirement of every species. But now- a- days people are altering habitat, where habitats are completely destroyed, they are fragmented into smaller patches. Fragmentation exposes the species to more light, wind and temperature effects than in the natural condition , thus affecting the species survival. In fragmented landscapes, many species soon become isolated from others of their own kind resulting in inbreeding loss of genetic diversity. Encroachment of forest land for agriculture and human settlement, intensification of shifting cultivation in hills, indiscriminate feeling of trees are thereby reducing the tree cover, habitat loss and fragmentation.

Encroachment of forest land : Many forests were encroached by the people. They destroyed forests and converted to homestead, agriculture, market and educational and religion institutes, industry, etc. As a result vegetation including medicinal plants were destroyed.

Shifting Cultivation: Illicit shifting cultivation or Jhumming is the most common and destructive ways of damaging hill forests. In the practice of shifting cultivation or jhumming the process is to clear fell and burn an area to grow agricultural crop. Once the harvesting is done the area is abandoned and new area is taken up for fresh cultivation. The area thus left fallow is invaded with a mass of weeds and sungrsas. Jhumming resulted destruction of vegetation, hindrance to forest regeneration, acceleration of soil erosion and siltation of the agricultural land and navigable rivers.Monoculture plantations with teak, gamar, akashmoni, etc., were raised in different forests by clearing of natural forests. As a result medicinal plants in such areas became extinct or reduced.

Invasive species: Purposely or accidentally, people often bring non-native species into new areas. These invasive species, also called alien or exotic species, are considered as second most important cause of biodiversity loss including medicinal plant diversity after habitats destruction.

Over Use of Medicinal Plants: Peoples use some medicinal plants at a greater rate than the species can replace themselves which can lead to extinction.

Pollution : The more we consume, the more we generate waste and pollution that threatens the biodiversity including medicinal plant diversity and our health. Pollution comes in many forms such as use of insecticide and chemical fertilizers, due to industrial wastes, exhaust gases from transport, etc. Pollution can outright kill organisms, cause reproductive abnormalities or create anomalies in ecosystem, thus causing loss of biodiversity including medicinal plants.

Conclusion

Bangladesh has a great treasure of medicinal plants. We have both indigenes and exotic medicinal plants. Soil, water and environment are favorable for growing a verity of medicinal plants in Bangladesh. Hence, we have to protect and conserve forests as well as medicinal plant diversity for ourselves and our future generation .

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Paradigm Shift of Madhupur Forest Managemnt

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Abstract

Madhupur Sal forest is popularly known as Madhupur Gar comprising an area of 45,565 acre located at the middle part of Bangladesh. Conflict over land ownership, insufficent staff, complete dependency of people for fuelwood over forest, firewood for brick field, saw mill and furniture mart and other forest dependent industries are chiefly responsible for destruction of Modhupur forest. Traditional management fails to address local situation and consequently, forest coverage come down 10,000 acre.

Forest department has launched a project title "*Revegetation of Madhupur Forest through Rehabilitation of Local and Ethnic communities* by introducing a new management technique. "The vision of the project is to get back green coverage of Madhupur forest. The forest dependent peopled who were once engaged in illegal felling have been trained in different income generating courses including motivational issues who are now called "Community Forest Worker (CFW)". After getting training, these CFW are now committed to protect Madhupur forest and vowed not to fell any trees and not to allow anybody to fell any trees from Madhupur forest. Due to their activities, illegal felling from Madhupur forest has been totally stopped.

Rehabilitaion of forest dependent people is another component which will not only assist this vulnerable group but also bring encroach land under tree cover. Each family will plant trees of fruit , forest, and fuel wood species in their own land and will get different others benifits. In the long run, the forests dependent people will get fruit, timber and fuel wood from their own premises. Conseqently, the dependency over forest will be reduced gradually. Another notable feature of the project is to established 1,000 ha plantation with mostly native speices in land which has been encroached for long period.

The new policy has been able to lessen the gap between local ethnic and Bengali community and build up confidence. Positive attitude has been developed among people of Madhupur. Forest offence has been reduced dramatically. Forest floor has now been rejuvenated with numerous species which is a good sign of regaining biodiversity. The increase number of wildlife and birds are finding their secure home. Any residence of Bangladesh can now have sweet dream of having a rich floral and faunal home of Madhupur in near future.

Key words: Biodiversity, Community forest worker Green cover, Maadhupur forest,

Introduction

Madhupur Sal forest is popularly known as Madhupur Gar comprising and area of 45,565 acre located at the middle part of Bangladesh. Madhupur forest is among the most biodiverse and valuable terrestrial ecosystems on the planet and vital for livelihood of the people. It is a historical deciduous forest of Bangladesh. But the forest has been degenerated and reshaped with commercially planted pineapple and banana and plantation with commercial species. Madhupur forest could have been a unique shelter for the future generation, not just protecting them environmentally but a hub of aesthetic enjoyment. A sustainable and pragmatic policy as well as awareness is urgent to save the forest.

Early Forest History

The present reserved and protected forest controlled and manage by forest department was under the proprietorship of Atia and Kagmari *Zamindars* before 1925.The government took over the management of these forest and first declared these forests as protected forests in their notification no 1878 for, dated the 16 February 1925. Soon after, the government wanted to constitute certain areas as Reserved Forests. When the Forest settlement officer started his enquiry into the rights, an organized opposition from amongst the tenants started. Moreover, it was found that two thirds of the shareholders of the many *mouzas* (cluster of villages) did not sign the original petition. After protracted litigation, long enquiries continued agitation and Araipara Chakra, consisting of 26 *mouzas* was finally declared as Reserved Forest.

From the time of *Naib Nazim* of Dhaka to the last day of the East India Company rule, Rani Bhavani of Natore and her successors and the *Pannis* of Karatia and the *Zamindar* ofDhanbari was the custodian of Madhdhupur Forest. After enactment of East Pakistan Forest Act of 1949 (Act 1950), the Atia forest became vested forest under section 7 of East Pakistan Private Forest Act 1949. East Pakistan State Acquisition and Tenancy act was enacted in 1950 and since 1951 many of the vested forests have been acquired by the government under the act.

After independence, Bangladesh government has taken initiative to convert these forests into Reserve forest in early eighties. For this purpose these forest has been declared as proposed reserve forest under section of 4 & 6 of Forest Law. Unfortunately, even after three decades, the process of declaring reserve forest has not yet been completed. On the other hand, this land has been leased out by respective department sporadically. The lease owner cleans forest after getting legal document. Protest of forest department obliged the relevant authority to cancel the lease. But it was too late because forest department come to know regarding leasing only when the lease owner started to clear forest land.

Previously, Madhupur Forest consisted of 70 to 75% sal(*Shorea robusta*). According to Mr. M. R. Chowdhury, *gazari* bearing forests of this belt was essentially malformed,croocked and defective coppice stands resulting from the wrongful method of exploitation and unscientific managements prior to taking over of the forest by forest department. Some of the the patches have exhausted their coppicing power and there are patches where coppices are unsuccessful due to exhaustion of stumps. There are also indiscriminate felling of sal trees under private ownership because of the partition of the sub-continent and also for fear of introduction of private Forest Act and State Acquisitition and Tenancy Act of 1950. So the excessive and irregular fellings under the management of private owners have resulted in this type of degenerated forest. A comparison of the Satellite image of 1962 and 2003 clearly shows 85% greenery of the core area of Madhupur national park has disappeared during the last 40 years.

Issuses and Problem Sitution Relevant to Madhupur Forest Management

Several reasons are attributed to the destruction of Madhuprur Sal forest. Broadly these are:

- Absolute dependency of local people over Madhupur forest
- Scarcity of alternative firewood
- High demand of house holds implements
- Uses of firewood in brick kilns
- Dispute and complicacy over land ownership
- Encroachment of forest land
- Absence of political commitment and non-cooperation of the politican and local elite
- Non-pragmatic approach of forest department to address the local problem.
- Filing of huge forest litigation cases.

Local people have no other alternative but to collect firewood, house post, pole and other necessary implements from Madhupur forest. People of Madhupur consume approximately 18,000 tons firewood per year, the major source of which is Madhupur forest. The forest has to compensate 39,000 ton firewood per year for brick kiln which is equivalent to 1,000-1,200 acre shrinkage of tree cover. The unresolved issues contributed a lot for forest destruction of Madhupur. Moreover, forest department is poorly staffed. It is impossible for around 50 personnel to manage a large forest where demand for forest is unlimited. Some local elites are deliberately destroying Madhupur forest using the poor local people by encroaching the forest land. The local demand for forest resources in saw mills and furniture mills and other forest dependent industries are also responsible for destruction of Madhupur forest, \ Local elites and political figures always consider forest as a mean of local support instead of conservation. Forest department also fail to address the local problem and improvised the approach in accordance with local problem. Consequently, Madhupur forests come down from 45,565 acre to 10,000 acre. The real cause of destruction of Madhupur forest has not been rightly diagnosed. Only those who fell trees in the forest have been blamed for forest destruction. Huge litigation cases have been filed in court against them. But this effort fails to stop illegal felling in forest. Why these vulnerable groups enter into forest and destroy forest has not been realized. The forest dependency of these people has not been tried to lessen. As a result, traditional approach failed to address the problem of Madhupur forest. Consequently, illegal felling and encroachment was a familiar picture of Madhupur forest.

Shifting of Management of Madhupur Forest

Considering the causes of depletion of Madhupur forest, Forest department has taken a new initiative to save Madhupur forest in March 2010. By introducing new management technique a project title "Revegetation of Madhupur Forest through Rehabilitation of Local and Ethnic communities " has been launched. The visions of the project are chiefly:

- Ensuing to get back green coverage of Madhupur forest
- Ensuring that local forest dependant families have better access to and control over forest resources upon which they depend
- Raising awareness of the power of trees and to change life
- Ensuring that forest dependant families can increase their capacity to generate reliable income by improving their skill
- Reducing the dependency of local people by improving their standard of life and enabling them self-dependant
- Ensuing secure habitat of wildlife by planting native and fodder species
- Reduction of carbon sequention
- Adapting to climates change.

Extensive training of two month duration covering different income generating courses including motivational issues have been conducted. Specialists of relevant disciplines rendered the training. After getting training, these forest dependant people are now called "Community Forest Worker (CFW). Once these CFW were involved in illegal felling, encroaching forest land and involved other illegal activities. Official records shows that forest cases have been filled in court against 361(66%) of such CFW. Till now 550 such people have been trained as CFW. During the training period, each participant has received Tk. 9000 as training allowance. These participants have also been given uniform, identity card, training complition certificate, etc. CFW also received grant for involving themselves in income generating activities. CFW are now acting as local guards of the Madhupur forest. Life standard of 5,000 forest dependent people are being improving on getting 50 fruit bearing trees; 50 timber yeilding trees; 100 fuel wood species; and grants for cattle purchase, composting, vegetable cultivation, converting environment friendly homesteads . Such forest dependant family is getting Tk. 11,000 each for elevating their life standard. The forest land which was converted into banana and pineapple has been brought under plantation coverage. Some 1,020 ha of such type of land are been planted with native and fodder species involving local people.

Impact Assessment of Shifting Management

The forest dependent people who called CFW are patrolling Madhupur forest. Involvement of these people in conservation of Madhupur forest has already shown tremendous impact. The CFW are now committed to protect Madhupur forest. They vowed not to fell any tree from Madhupur forest illegally. At the same time, they will not allow anybody to destroy Madhupur forest. They are now confident enough to survive without entering into the forest. Accused in 107 cases for stealing trees from Madhupur forests, Hasan Ali of Gachhabari village of Madhupur upazila under Tangail district, who now serves as a community forest worker is grateful for the initiative of forest department to restore the traditional sal forest. He said "Forest officials told me and others about the importance of forest and environment. Now I am very tired of the cases filed by forest department and want to live a tension-free life," Another CFW, Nobi Hossain who is 45yearsold used to collect trees illegally from Madhupur forests for around 30 years. He told "Now I want to contribute to protecting the forests which I had been damaging for longtime. No matter how much money it brings me, but I am now enjoying mental peace. Local influential people provoked me for collecting trees illegally from Madhupur forest but I could not realise that it was wrong. I have agreed to the proposal of forest department officials as they have taken responsibly of all my 79 cases"

CFWs have already given up their old illegal habit of stealing of forest resources. They have now merged in the mainstream of the society. Through training their income generating skill has been developed. They are now working as fire watcher, daily laborer, mushroom cultivator, vegetable gardener, van puller, small businessman. As soon as they will receive grant from forest department for alternative income generation, they will involve themselves in more viable income generating activities. The Table 1 shows the change in profession of CFW.

Table 1. Change profession of CFW

Description of profession of CFW	Prior to June 2010	After June 2010
Illegal felling and other illegal activities relating to forest	67%	1%
Agriculture and other non- forest profession	33%	99%

The activities of CFWs have prevented illegal felling from Madhupur forest. Consequently, forest offence has reduced dramatically. Table 2 and bar diagram (Figure1) describes the forest cases reduction rates.

Table 2. Number of forest offences in Madhupur Forest

Decrease in number of Forest Offence

Year	Modhupur Range	Jatiya Uddayn Sadar Range	Dokhola Range	Aronkhola Range	Total
2001-2002	13	108	17	32	170
2002-2003	43	73	23	18	157
2003-2004	35	145	25	11	216
2004-2005	11	61	1	4	77
2005-2006	32	31	11	16	90
2006-2007	53	66	2	7	128
2007-2008	47	85	29	6	167
2008-2009	82	238	26	30	376
2009-2010	81	227	35	18	361
2010-2011	11	5	3	4	23

A positive attitude regarding conservation of Modhupur forest has been created among all sections of the people. Involvement of CFW with continuous monitoring restored Madhupur forest from destruction by fire which was a regular phenomenon of the forest during dry season. This also facilitated to develop and grow different species naturally. Undisturbance of Madhupur forest resulted the forest floor to be rejuvenated with numerous species which is a good sign of reviving biodiversity. Wild lives are getting Madhupur forests as their secured home. Forest dependant people are experiencing the increase number of wildlife.

Some 5,000 Forest dependant family have planted 11,00,000 trees in their own premises, ensuring increased green coverage in Madhupur forest. In the long run, when these trees will be established, these forests dependent people will get fruit , timber and fuel wood from their own premises. Consequently, the dependency on forest will reduce gradually, and these people will be self-sufficient with fruit, timber and fuel wood.

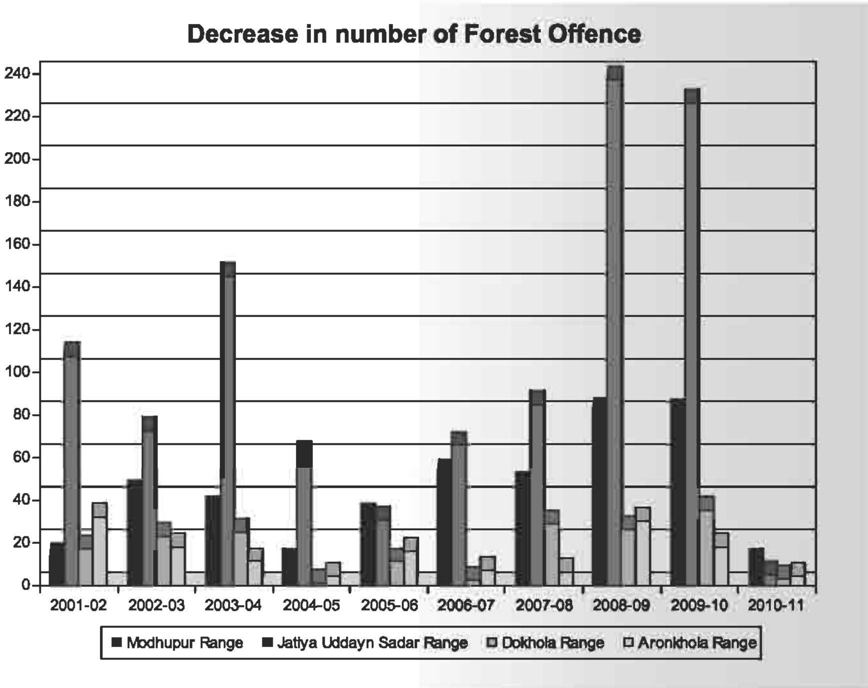

Figure 1. Graphical reprentation of forest offences in Modhupur forest

Moreover, each of the selected forest dependent family will enjoy environment friendly home by eliminating all wastes and taking all sanitation measures. They are going to be self dependant by involving themselves in different income generating activities which will graduallyminimise poverty of forest dependent Bengali and ethnic people. In addition, use of compost fertilizer will reduce the use of chemical fertilizer and retain fertility of land . Hence, the rehabilitation effort of " Revegetation of Madhupur Forest Through Rehabilitation of Local and Ethnic communities " will not only ensure better life of forest dependent people but also secure forest and promote forest cover.

Issues to be Addressed to Sustain the Presrnt Effort

The official record shows that 1,765 litigation cases have been filled in court during last 10 years. These cases are under trial. Most of the CFWs are worried about the future of these cases filed against them. Huge costs are involved to deal with these cases. Settlement of these cases are very much imperative to sustain the present initiative.

Closed monitoring is essential to ensure involving CFW in alternative income generating activities. Stability in this regard is very much essential.

Different government and non government organizations are working with the distress people. These organizations should take initiatives to serve family planning, education, health care, sanitation and other civic facilities to these families.

Conclution

The "Revegetation of Madhupur Forest Through Rehabilitation of Local and Ethnic communities "Project has been able to lessen the differences between local ethnic and Bengali community and build up confidence. Positive attitude has been developed among all corners of people of Madhupur. Positive mental change has been observed among community forestry workers. With the involvement CFW, forest floor has been covered with a large number of unknown species. The increased number of wildlife and birds are finding their home secured in Madhupur forest. Bangladesh can expect of a rich floral and faunal home in Madhupur forest in near future.

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Conservation Status of Medicinal Plants at Bangladesh Forest Research Institute

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Abstract

Bangladesh Forest Research institute (BFRI) was established as a forest products research laboratory (FRL) in 1955. Consequently, in the year 1968 the forest management branch was created under FRL and was renamed as BFRI. In 1985 the BFRI was separated from the Forest Department as a separate entity under the Ministry of Environment and Forest. Minor Forest Products (MFP) Division is a component of forest management branch. In fact, this division began to conduct research activity from 1991.The division is working on raising nursery techniques and silviculture aspects of rare and threatened medicinal and other economic plants like rattans, patipata, sungrass, etc. Medicinal plants are the important resource which is used traditionally by Bangladeshi over five thousand years back. The importance of medicinal plant is increasing day by day. Out of the total 4,20,000 flowering plants more than 50,000 are used for medicinal purpose. Bangladesh Council of Scientific and Industrial Research (BCSIR) identified 747 medicinal plants. Herbal drug processing companies are using 220 medicinal plants. Out of 220, twenty nine species are imported from neighboring countries like India, Nepal, China and other countries, and rest 191 species are harvested in country from nature. Now, most of the medicinal plants have lost in the nature with their roots. But at present, our need is growing. Minor Forest Products Division (MFPD) has conserved 85 annual and perennial medicinal plants species and has developed and also documented their nursery, plantation and management techniques. Many scientific papers (national and international), bulletins, folders and leaflets have been published on the subject by the scientists of this division. Training programmes on medicinal plants to the interested cultivators are going on throughout the year.

Key words: Bangladesh Forest Research Institute, Conservation status, Herbal medicine, Medicinal plants

Introduction

Being a tropical country, Bangladesh was rich in medicinal plants and these were in use all over the country. With the introduction of synthetic medicine, the ethnic medicare with herbal medicines has remained neglected. Aside exploitation, proper exploration of various medicinal plants and their thorough stock assessment were not carried out inthe country. Meanwhile, a considerable number of these plants species became threatened and/or extinct. Since inception of BFRI, the research activities were mainly dealt with timber for very many reasons. No attention was paid for the non timber forest products (NTFP) or medicinal plants. to the *Ayurvedic* and *Unani* in the country used to prepare herbal drugs collecting 80% of medicinal plants from the natural forests and only 20% from import. At present this scenario has changed and got a reverse trend. Nonetheless, due low side effect and user's friendly safe usage, herbal medicines are gating importance all over the world including Bangladesh.

Activities on Medicinal Plants

Medicinal plants are a valuable resource in the present world. Minor Forest Products Division in BFRI has started research activities on medicinal plants since 1991. The supply trend of medicinal plants to the herbal drug processing companies has been import dependent. In this circumstances, the initial research target in Minor Forest Division at BFRI was concentrated on development of conservation plot of germplasm and raising nursery and management techniques. Subsequently, dissemination of the knowledge to interested farmers to supplement their income from medicinal crops and to reduce the import dependency has been a continuous process. In the initial stage, the knowledge of various aspects of medicinal plants particularly on their availability, cultivation and its usage as curative was scanty. As a first attempt, a market survey was undertaken by this division in 1990. The survey showed that 185 plant species are used for the preparation of herbal medicines. A considerable proportion of these plants had been imported from foreign countries. Based on the experience and observations, activities started to collect germplasm of rare medicinal plant species throughout Bangladesh. The collected germplasms have been conserved for raising nursery techniques. Subsequently, nursery technique was established for each medicinal plant species. In MFP conservation plot in BFRI there are now 85 germplasms of medicinal plants. Nursery techniques of some important species have been developed and documented, and some are in the process of completion. According to the demand of herbal drugs processing companies, the nursery raising techniques of tulsi, basak, satamuli, arswagondha, pepul, kalomegh, grito kunchon, bhui kumra, brammi, thankuni, etc., were developed. Folders, bulletins, booklets and scientific articles related to medicinal plants have been published. Research on nursery, plantation and management techniques is going according to the priority list of medicinal plants species. Training on cultivation of medicinal plants has been conducted to the farmers in Rajshahi Division who are engaged in cultivation of medicinal plants. Many of them have established market channel to sell the raw materials to the herbal drug processing companies. They are cultivating medicinal plants as an additional crop and getting financial benefits.

Information on fifty useful medicinal plants established at BFRI campus are given in Table 1.

Table 1. Bangla, English and scientific name with family, type of plant, propagation system, useable parts and medicinal use of fifty medicinal plants

Bangla/ English Name	**Scientific name**	**Family**	**Type of plant**	**Propagation system**	**Useable part**	**Medicinal use**
নিম / Neem	*Azadirachta indica* A. Juss	Meliaceae	Medium to large sized evergreen to semi-deciduous tree	Seed	Leaves, fruits and bark.	Fresh leaves are a slight anti-septic and are used in skin-disease and ulcers. Bark is maturant, anthelmintic, fever, fatigue, thirst and cough. Fruit is purgative, tumour, piles and toothache.
নিশিন্দা / Chaste tree	*Vitex negundo* Linn.	Verbenaceae	Evergreen to semi-evergreen small tree.	Cutting	Leaves	Leaves are antiseptic. Leaf juice removes foetid discharges and worms from ulcers.
নাক্স-ভমিকা / Snack wood	*Strychnos nux-vomica*	Loganiaceae	Small deciduous tree.	Seed	Seeds	Dried seeds are powerfulas a nerve tonic in small doses. Seed extracts are much used in homeopathic medicine.
আমলকি / Emblic myroba-lan	*Phyllanthus emblica* L.	Euphorbiaceae	Medium sized deciduous tree	Seed	Fruits	Fruits are useful in vomiting; diseases of the heat and liver,

Bangla/ English Name	Scientific name	Family	Type of plant	Propagation system	Useable part	Medicinal use
						skin problems and leucorrhoea.
হরিতকি / Black myrobalan	*Terminalia chebula* Retz.	Combretaceae	Medium sized to large deciduo-us tree	Seed	Fruits.	Fruit is useful in asthma, leucoderma, constipation, chronic ulcers and wounds.
বহেরা / Belaric myrobalan	*Terminalia belerica* Roxb.	Combreta-ceae	Large deciduo-us tree	Seed	Fruits	Fruits are laxative, useful in heart disease, hepatitis, bronchitis, and asthma.
রিঠা / Soap nut	*Sapindus mukorssi*	Sapindaceae	Medium sized deciduo-us tree	Seed	Fruits and seeds	Fruits are used in the treatment of excessive salivation, epilepsy and chlorosis, paste of fruit is also used in fever. Powdered seeds are insecticidal &are employed in the treatment of dental caries.
দাদমর্দন / Ringworm shrub	*Cassia alata* Linn.	Caesalpin-iaceae	Large shrubs	Seed	Leaves, flowers & bark	Leaves are purgative. Leaves and flowers are used as a mouth wash. Stem bark is also used in eczema.
অর্জুন / Arjun	*Terminalia arjuna* W &A	Combreta-ceae	Large deciduous or sami-deciduous tree	Seed	Bark	Bark is a cardiac tonic, useful in heart-disease anaemia .
দাঁইফুল / Fire flame	*Woodfordia fruticosa* Kurz	Lythraceae	Perennial shrub	Cutting	Leaves, bark and flowers	Leaves are used in bilious sickness while brak used in uterine sedative and as antheheminitic and flower used in treating dysentery, diarrhea, leucorrhoea and wounds.

Bangla/ English Name	Scientific name	Family	Type of plant	Propagation system	Useable part	Medicinal use
তুঁত/ Malberry	*Morus indica* L.	Moraceae	Small deciduous tree	Seed/cutting	Leaves, fruits,bark and roots	Fruits are cooling and laxative, bark is to be vermifuge and purgative,roots are considered anthelmintic and astringent.
বেল / Wood Apple	*Aegle marmelos*(L.) Corr.	Rutaceae	Medium sized deciduous tree,	Seed	Leaves and fruit.	Fruits are used in diarrhea and dysentery. Fresh leaves, juice is useful in ophthalmic and inflammations
হরবরই / Goose berry	*Phyllanthus acidus* Skiels	Euphorbia-ceae	Small deciduous tree	Seed	Roots and fruits	Fruits are used for treating bronchitis, biliousness and piles. The root and seeds are cathartic
গন্ধভাদুলি / Chinese moon creeper	*Paederia foetida* L.	Rubiaceae	Climber	Cutting	Leaves	The leaves are used in epistaxis; good for liver and stomach troubles Leaves are cooked and taken as a remedy for indigestion and loose motion.
পাথরকুচি / American life plant	*Kalanchoe pinnata(Lam)* Pers.	Crassulaceae	Succulent, glabrous herb	Leaves	Leaves	Leaves are useful in bronchial affections, kidney stones, blood dysentery, gout and jaundice.
পিপুল / Long Pepper	*Piper longum* Linn.	Piperaceae	Much-branched slender creeper	Seed/ Cutting	Fruits, roots and leaves	Fruits are used in the treatment of dyspepsia coughs cold and pain in the joints.
গুলঞ্চ / Tinos pora	*Tinospora cordifoli* (Willd) Hook. f.	Menisperm-aceae	Large climber	Seed/Cutting	Stem and leaves	Stem and leaves are used for the treatment of acidity, jaundice chronic

Bangla/ English Name	Scientific name	Family	Type of plant	Propagation system	Useable part	Medicinal use
						dysentery and diarrhea.
উলট কম্বল / Devil's cotton	*Abroma augusta* Linn.f.	Sterculiaceae	Large shrub	Seed	Leaves and stem	Leaves and stem are demulcent. Petioles are useful in dysentery, weakness and burning urination.
উলট চন্ডাল / Superb Lily	*Gloriosa superba* L.	Liliaceae	Herbaceous branching climber	Seed	Tuberous root and leaves	Tubers are used in stomachic and anthelmentic in small doses but intensely poisonous in large doses. Leaf juice is used to destroy lice in the hair.
নাগেশ্বর / Ceylon Iron wood	*Mesua nagessarium* (Burm) Kost.	Clusiaceae	Medium size to large evergreen tree.	Seeds	Flower & seed oil	Flowers are used for cough especially when attended with much expectoration. Seed oil is used in itch & in rheumatism.
হস্তিকর্ন-পলাশ /	*Leea microphyla* Roxb.	Leeaceae	Low-shrub	Seeds/ Sucker	Tuberous roots	The tuberous roots are used to kill guinea worm and applied externally to stop the effusion of blood
স্বর্পগন্ধা / Snake root	*Rauwolfia serpentina* (Linn.)	Apocynaceae	Small woody shrub.	Seed / Cutting	Roots	Roots are sedative. It is also used in high blood pressure.
শতমূলী / Asparagus	*Asparagus racemosus* L.	Liliaceae	Prickly climber	Seed/Rhizome	Roots	Root is useful in Kidney and the liver.
বাসক / Basak	*Adhatoda zeylanica* Medic.	Acanthaceae	Evergreen shrub	Cutting	Root, bark and leaves	Root, bark and leaves are useful in cough, asthma, ague and phthisis.
থানকুনি / Indian penny wort	*Centella asiatica* (Linn.)	Apiaceae	Creeping herb.	Rhizome	Leaves	Leaves are antipyretic, tonic and used in blood dysentery,

Bangla/ English Name	Scientific name	Family	Type of plant	Propagation system	Useable part	Medicinal use
						mouth sores and eye diseases.
ব্রাহ্মী / Indian pennywort	*Bacopa monniera* (Linn.)	Scrophulariaceae	Creeping herb.	Cuttings	Whole plant	The plant is bitter diuretic, laxative and brain tonic.
কারীপাতা / Curry leaf	*Murraya koenigii* (L.) Sprang.	Rutaceae	Strong smelling shrub	Seeds	Leaves, bark and root	Green leaves are eaten raw to cure dysentery; bark and root are used as stimulants. Roots are slightly purgative.
ঈশ্বরমূল / Aristolochia	*Aristolochia tagala* Cham.	Aristolochia-ceae	Perennial twiner.	Seeds	Roots	Root is considered tonic and emmenagogue and used as antifertility drug.
কালোমেঘ / Creat	*Andrographis paniculata* (Burm.f.)	Acanthaceae	Annual herb	Seeds	Whole plant	The plant is used in liver complains mainly of children. Leaf juice against fever, headache and skin disease.
তুলসী / Holy Basil	*Ocimum tenuiflorum* Linn.	Lamiaceae	Aromatic annual herb	Seeds	Leaves	Leaf juice is used for the treatment of coughs, colds, catarrh and bronchitis.
চা / Ayapana tea	*Eupatorium ayapana* Vent.	Asteraceae	Perennial herb	Cuttings	Leaves	The leaves are stimulant, antiseptic and haemostatic and stomach-ache.
একাঙ্গী / Ekangi	*Zingiber Zerumbet* Sm.	Zingibera-ceae	Rhizomatous herb	Rhizome	Tubers	Tuber is used for cough, asthma, worms, leprosy and other skin diseases.
মিছরিদানা / Kaempferia	*Kaempferia galangal* L.	Zingiberaceae	Annual herb	Rhizome	Tubers	Tubers are stimulant, carminative and diuretic. It is also used as a hair wash in dandruff.
নয়নতারা / Periwinkle	*Catharanthus roseus* G. Don	Apocynaceae	Annual herb	Seed	Root and leaves	Leaves are used as a folk remedy for diabetes. The

Bangla/ English Name	Scientific name	Family	Type of plant	Propagation system	Useable part	Medicinal use
						root is considered tonic and stomachic.
বনধনে / Sweet broom weed	*Scoparia dulcis* L.	scrophulariaceae	Much branched herb	Seed	Whole plant	The plant is used in diabetes and to control bleeding.
বনআদা / Ginger	*Zingiber montanum* (Koenig) Dietrich.	Zingibera-ceae	Rhizomatous herb	Rhizome	Tubers	Tubers are used as a carminative and stimulant in diarrhea & colic.
মেন্দা / Grey Mango	*Litsea monopetala* (Roxb.) Pers.	Lauraceae	Medium sized evergreen tree.	Seed	Bark	Extract of the bark is given with sugar to treat diarrhoea and dysentery. It is also stomachic and stimulant.
বিসল্যাকরনী / Justacia	*Justacia gendarussa* Burm.	Acanthaceae	Erect slender under shrub.	Cuttings	Bark and leaves	Bark is emetic; leaves are used in chest pain and rheumatism.
খনাছাল / Indian Trumpet Flower	*Oroxylum indicum*	Bignoniaceae	Medium deciduous tree	Seeds	Fruits, Seeds and bark	Tender fruits are expectorant and stomachic; useful in leucoderma. Seeds are purgative. Root bark is stringent to the bowels, tonic and vulnerary.
ধুতুরা / Datura	*Datura metae* Linn	Solanaceae	Small deciduous shrub	Seeds	Leaves, seeds and roots	Plant as whole has narcotic, anodyne and antispasmodic properties. Leaves are used for rheumatic swelling. Seeds used externally for piles.
মেসতা / Red Sorrel	*Hibiscus sabdariffa* L.	Malvaceae	Tall shrub with prickly stems	Seeds	Leaves, flowers and seeds	Leaves are used in dysentery. Flower juice is a popular remedy for biliousness with acidity. Seeds are used as appetizer, fattening and aphrodisiac.

Bangla/ English Name	Scientific name	Family	Type of plant	Propagation system	Useable part	Medicinal use
ইরিয়া / Aerva	*Aerva sanguinolents* (L) Bl		Small herb	Cutting of stem	Leaves	Leaves are used to control bleeding.
মারহাটিঙ্গা / Spilanthes	Spilanthes paniculata Wall.	Compositae	Annual herb	Seed/ Cutting	Flowers	Flowers head are given to toothache and to the defect of stammering. It is also used as a powerful mosquito larvicide's. Crushed plant is used as fish poison.
মহাভৃঙ্গরাজ / Wedelia	Wedelia calendulaceae Lees	Compositae	Annual herb	Seed/ Cutting	Leaves	The leaves are used for promoting hair growth. It is used in cough, cephalagia disease of skin.
কালোকেশী / Eclipta	*Eclipta alba* Hassk	Asteraceae	Annual herb	Seed/ Cutting	Whole plant	Whole plant is tonic and use in improving colour and promotes growth of hair.
বচ্ / Sweet flag	*Acorus calamus* Linn.	Acoraceae	Aromatic marsh herb	Rhizome	Rhizomes	Rhizome is emetic and used as a remedy for throat sore, asthma and bronchitis.
বনঢেঁড়শ / Musk-mallow	*Abelmoschus esculentus* Moench	Malvaceae	Tall annual shrub	Seed	Fruits	Fruits are used in chronic dysentery, gonorrhea and diarrhea.

Importance and Need for Medicinal Plants Conservation

- Increase regeneration capacity;
- Conserve genetic pole;
- Meet up the local demand of raw materials;
- Ensure the supply of raw materials to the herbal drug processing companies in our country;
- Reduce dependency on import;
- Reduce soil erosion;
- Conservation of better environment;
- Reduce dependency on synthetic drug.

Recommendations to Improve Conservation Status of Medicinal Plants

- The first step for medicinal plant conservation in the country would be the preparation of an inventory of its medicinal plant and monitor their change through time;
- Awareness creation and information dissemination to the public level about conservation of medicinal plants;
- One of the best ways of medicinal plant conservation is to protect area of a particular ecosystem in the natural condition;
- Next to conserve genetic material outside the natural condition and they may use propagation materials of individuals out site of the parent population;
- Establishment of networking among commercial farmers, herbal drug producers and research institution for participatory research.

Conclusion

Medicinal plants are the source of drugs for the treatment of human and various livestock diseases all over the world from the ancient time to the present. But in the advancement of synthetic drug, the practice of using medicinal plants dropped significantly. Mean while, considering the less side effect of herbal drugs its use is getting momentum again all over the world. So, it is the right time to initiate inventory to assess the status, initiate conservation activities of all diverged resources of medicinal plant, develop their nursery techniques, maximize its production and promote herbal drug production in the country. The plantation of medicinal plants in forest area plays an important role for conservation of environment, nature and biodiversity. To promote cultivation of potential species of medicinal plants in Bangladesh, it is needed to develop awareness and provide cultivation facilities to the rural communities and commercial cultivators

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