নিসর্গ নেটওয়ার্ক

Project Concept Note
Bangladesh REDD+ARR Protected Areas Project
(BRAPAP)

September 2011
Government of Bangladesh
Ministry of Environment and Forest
Forest Department

TABLE OF CONTENTS

Acronyms

A/R	Afforestation/Reforestation
ASA	Association for Social Advancement
ACF	Assistant Conservator of Forests
AFOLU	Agriculture, Forestry and Other Land Uses
ARR	Afforestation, Reforestation and Revegetation
BWPO	Bangladesh Wildlife (Preservation) Order, 1973
BFRI	Bangladesh Forest Research Institute
BRAC	Bangladesh Rural Advancement Centre
BRAPAP	Bangladesh REDD+ARR Protected Areas Project
C	Carbon
CDM	Clean Development Mechanism
CEGIS	Center for Environmental and Geographic Information Services
Cm	Centimeter
CMC	Co-management Committees
CO_2	Carbon dioxide
CO_2e	Carbon dioxide equivalent
CPG	Community patrol groups
DDWS	Dudpukuria-Dhopachari Wildlife Sanctuary
FAO	Food and Agriculture Organization of the United Nations
FD	Forest Department
FSP	Forestry Sector Project
FUG	Forest user groups
FWS	Fasiakhali Wildlife Sanctuary
g	Gram
GHG	Green House Gases
GOB	Government of Bangladesh
GPS	Global Positioning System
ha	Hectare
HQ	Headquarters
INP	Inani National Park
IPCC	Inter-Governmental Panel on Climate Change
IPAC	Integrated Protected Areas Co-management Project
IRS	Indian Remote Sensing Satellite
IUCN	International Union for Conservation of Nature
LGED	Local Government Engineering Department
m	Million
MAI	Mean Annual Increment
MOEF	Ministry of Environment and Forests
MNP	Medhakachapia National Park
MP	Member of Parliament
MRV	Monitoring, Reporting and Verification
NGO	Non-Government Organization
NSP	Nishorgo Support Program
NTFP	Non Timber Forest Product
OC	Organic Carbon
OD	Over Dried
PA	Protected Area

PCN	Project Concept Note
PDD	Project Development Design
PF	Peoples Forum
PMARA	Performance Monitoring And Applied Research Associate
QA	Quality Assuarance
QC	Quality Control
REDD	Reduction of Emissions from Deforestation and Forests Degradation
REDD+ARR	Reduction of Emissions from Deforestation and Forests Degradation + Afforestation, Reforestation and Revegetation
RF	Reserved Forests
RIMS	Resources Information Management System Unit
SKEP	Sitakunda Eco Park
SKRF	Sitakunda Reserved Forests
SPARRSO	Space Research And Remote Sensing Organization
t	Ton
Tk.	Taka
TM	Thematic Mapper
TWS	Teknaf Wildlife Sanctuary
USAID	United States Agency for International Development
USD	US Dollar
VCF	Village Conservation Forum
VCS	Voluntary Carbon Standard

LIST OF TABLES

LIST OF FIGURES

1. Project Overview

This document, entitled Bangladesh REDD+ARR Protected Area Project (BRAPAP), is a Project Concept Note (PCN) for a proposed reduced emissions from deforestation and forests degradation (REDD), and carbon stock enhancement through afforestation, reforestation and revegetation (ARR) project under development in the six protected areas (PAs) in the hill forests ecosystems of south-eastern Bangladesh. As such, it is a precursor to a formal Project Development Design (PDD) that may be submitted for validation under one or more of the international carbon standards being used for greenhouse gas (GHG) emissions reductions or removals within the frameworks of voluntary (or eventual) compliance markets for carbon offsets. Further development of the initial design presented in this Project Concept Note (PCN) requires broader stakeholder consensus (including civil society and co-management committees) on proposed project activities, appropriate monitoring systems, and finalization of community benefits sharing and distribution mechanisms, and participatory monitoring processes.

It is a proposed Agriculture, Forestry and Other Land Use (AFOLU) project consisting of activities related to REDD through avoiding unplanned frontier and mosaic deforestation and degradation, and activities related to ARR through establishing, increasing or restoring vegetative cover through the planting, sowing or human-assisted natural regeneration of woody vegetation to increase carbon stocks in woody biomass in the project area. From the project area of 33,344 ha, the project will generate an average of 10.37 million tons CO_2e annually over a 40-year project period, for total project emissions reductions of 414.87 million tons CO_2e.

1.1 Title of Project

Bangladesh REDD+ARR Protected Area Project (BRAPAP)

1.2 Type/Category of the Project

The project currently is designed to meet the requirements of an AFOLU project. Specifically, the project is hoped to qualify for consideration under the REDD category of eligible activities, in this case activities aimed at avoiding unplanned frontier deforestation and degradation, and the ARR category of eligible activities, in this case activities aimed at establishing, increasing or restoring vegetative cover through planting, sowing or human-assisted natural regeneration of woody vegetation to increase carbon stocks in woody biomass as defined in the Voluntary Carbon Standards (VCS) and VCS Tool for AFOLU Methodological Issues (published on 18 November 2008). This document is developed by following mainly the approved VCS methodology: VCS

Methodology VM0006 – Methodology for Carbon Accounting in Project Activities that Reduce Emissions from Mosaic Deforestation and Degradation. The project is 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 representatives of neighboring populations and local Government, and other key stakeholders including local Forest Department (FD) field staff.

1.3 Estimated Amount of Emissions Reductions Over the Crediting Period

The project is anticipated to generate GHG emissions reductions or GHG removals and carbon stock enhancement totaling 414.87 million tons of carbon dioxide equivalent (CO_2e) during 40 years of project implementation, compared to the baseline scenario. This equates to an average of 10.37 million tons CO_2e annually.

1.4 Host Parties

The host party for the project is the Government of Bangladesh, represented by the Forest Department, the statutory body authorized, empowered, and accountable for the 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 proposed six PAs, which were gazetted as Reserved Forests (RF) under the Forest Act.

1.5 Background and Context

Forests in Bangladesh, which account for approximately seventeen percent of the country's land cover[1], harbor rich biodiversity as well as resources upon which millions of people rely for their livelihoods. Moreover, they are important sources of fuel[2], and other inputs needed for domestic, industrial, and commercial use, such as poles (e.g., for

[1] Bangladesh FD (2010: http://www.bforest.gov.bd/land.php).
[2] In 2010, the Food and Agriculture Organization (FAO) of the United Nations estimated that 70 percent of fuelwood use was for domestic purposes, 28 percent for industrial, and two percent for commercial. The same study reported that 100 and 70 percent of rural and urban households respectively use fuelwood for cooking (FAO 2000: 44).

electrification purposes), pulpwood, and timber[3]. These factors, together with stressors such as population growth, migration, and changes in land use, have led to severe deforestation and degradation in many of the country's forest areas. According to the Food and Agriculture Organization (FAO) of the United Nations, between 1986 and 1996 forest cover in Bangladesh decreased, with more than half of the medium to good density forests degraded to poor density forests, deforested, or encroached[4].

In an effort to stem the deforestation and degradation of forests, the Government of Bangladesh (GOB) has placed 15 national parks[5] and 13 wildlife sanctuaries[6] under protected area status; these areas are legally protected specifically under the Bangladesh Wildlife Preservation (Amendment) Act of 1974. Furthermore, in order to address the primary drivers of deforestation and degradation, and promote peoples' participation in the sustainable management of forest resources, the GOB has adopted a social forestry approach in the protected areas as laid out first in the Forestry Master Plan completed in 1993, followed by inclusion in the revised Forest Act of 2000 and Social Forestry Rules of 2004 and 2010. This has facilitated collaboration between the GOB through the Forest Department and the local communities to enhance conservation, even while striving to meet the latter's consumption needs.

Recently, in recognition of the risk that climate change poses to forests and the communities that rely on them as well as of their potential role in mitigation, the government has begun to explore means to access conservation and carbon financing opportunities by leveraging partnerships with key stakeholder groups through co-management organizations. The United States Agency for International Development (USAID) has supported these endeavors, through the Nishorgo Support Program (NSP) and its follow up project, the Integrated Protected Areas Co-management Project (IPAC).

Part of USAID's support through IPAC has been a series of trainings offered to FD officials. While the first two in October 2009 and March 2010 focused on providing an overview of the international framework and introducing key concepts, the writeshop in August 2010 was targeted at providing Assistant Conservators of Forests (ACFs) an understanding of the steps required to carry out carbon pools assessment in their respective protected areas and to develop draft profiles of the relevant social, economic, and environmental factors. Thus, this project concept note represents an important

[3] FAO (2000: 44-45).
[4] FAO (2000: 20-21).
[5] National Parks are 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" (paragraph (p) of Article 2, the Bangladesh Wildlife (Preservation) Order (BWPO) 1973).
[6] Wildlife Sanctuary refers to "an area closed to hunting, shooting or trapping of wild animals and declared as such 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" (paragraph (p) of Article 2, BWPO 1973).

component in the broader context of Bangladesh's efforts to prepare for REDD+ARR by simultaneously beginning to identify the steps necessary to put in place an appropriate policy, and building local capacity to design, implement, and manage forest carbon activities.

This project concept note focuses on the following six protected areas located in the southeastern and eastern parts of Bangladesh: Teknaf Wildlife Sanctuary (TWS), proposed Inani National Park (INP), Sitakunda Reserved Forests (SKRF), Dudpukuria-Dhopachari Wildlife Sanctuary (DDWS), Fasiakhali Wildlife Sanctuary (FWS) and Medhakachapia National Park (MNP). Where applicable, such as in the discussion of project activities and costs, information has been broken out by protected area. However, where conditions or circumstances are similar across the protected areas, an overall picture has been presented in order to avoid unnecessary repetition, with specific references to any exceptions.

It is important to note that the development of this project concept note into a project development design, and ultimately into a successful project will be contingent upon:

- Emergence of a real international market for REDD+ARR credits
- Development of an appropriate policy framework and registry
- Broader consultations with the local co-management entities, the CMCs in the protected areas included in the project
- Independent validation and verification of the project's baseline land use and carbon emission scenario as well as additionality generated under with-project scenario
- Successful design and implementation of project activities, including the ability to work with local communities to stem the causes of deforestation and degradation that threaten the forest reserves, and taking up reforestation and revegetation activities
- Development of robust forest monitoring and carbon accounting systems
- Measures to adequately address possible leakage and permanence concerns.

1.6 Project Aims and Goals

Main goals of the project are to achieve climate change mitigation and adaptation, through avoided deforestation and forests degradation, and through establishing, increasing or restoring vegetative cover through the planting, sowing or human-assisted natural regeneration of woody vegetation to increase carbon stocks in woody biomass, and carbon sequestration with livelihoods improvements through community participation in forestry activities as well as conservation of flora and fauna species through measures including habitat improvement. The emissions reductions will be achieved through avoided deforestation and forests degradation in selected forests areas subjected to mosaic biotic interventions, and the sequestration and storage of carbon will be achieved through reforestation and revegetation, in the core zone taken as project area. The interface landscape zone (a 5-km band around the core zone) is taken as reference region. The proposed REDD+ARR activities will be implemented by the FD in conjunction with the CMCs, the later playing a particularly important role in joint community forests patrolling, social mobilization and participatory monitoring, and the implementation of conservation-linked value chain and alternative income generation activities. Effective involvement of the CMCs will not only help to strengthen local governance but also promote empowerment of the local communities and conservation of biodiversity harbored by the forests of the 6 PAs. The FD and CMCs will be responsible for project implementation and management, and an important focus will be on building their capacity by leveraging the training that has already been provided to a group of the ACFs in October 2009, and in March and August 2010 under the IPAC project. Moreover, the design and implementation of the project will contribute to the development of strategies and methodological tools that can be used to inform future REDD+ARR projects.

Specifically, the following three goals will be targeted during the project implementation:

1. **Climate:** to mitigate greenhouse gases through both emissions reductions and enhanced removals of carbon dioxide from the atmosphere. That is, to slow or reverse documented deforestation and forest degradation, and generating higher carbon intensities per hectare across more hectares through reforestation and revegation.

2. **Community:** to assist the communities living within the 5 km zone of influence (hereafter referred to as the reference region or interface landscape zone) upon the project area by providing alternative livelihood options and conservation-linked value chain development to reduce forest dependency for daily needs and to ensure awareness raising and education facilities for adults and children to increase motivation about the importance of forests as well as carbon reserve for climate change mitigation and adaptation.

3. **Biodiversity:** to conserve the habitat for several Red List endangered species, including elephants, and other important species of bird, fish, reptile, and other wildlife.

1.7 Project Objectives and Target Groups

The primary objective of the project is to sequester, store and enhance carbon in forests through avoided deforestation and forests degradation, and through the application of reforestation/revegetation technologies as well as to generate alternative livelihoods options for local communities and conserve biodiversity in the 6 protected forest areas included in the project. The proposed forests conservation interventions will be implemented by the staff of FD and CMCs in the 5 protected areas (the sixth PA, SKRF does not have a CMC), with the later playing a particularly important role in participatory monitoring, forests protection and alternative income generation activities. Active involvement of the CMCs will not only help to strengthen local governance mechanisms, but also promote empowerment of the CMCs and the surrounding communities and conservation of the biodiversity and other natural resources harbored by the forests. The FD will be responsible for the project implementation and management, and an important focus will be building their capacity by leveraging the training that has already been provided to a group of the ACFs in October 2009, and March and August, 2010 under the IPAC project. Moreover, the design and implementation of the project will contribute to the development of methodological tools that can be used to inform future REDD+ARR projects in Bangladesh.

Specifically, the project objectives are to:

- Achieve emissions reductions through avoiding deforestation and forests degradation
- Sequestering, storing and enhancing CO2 by improving degraded habitats through reforestation and revegetation
- Provide income and empowerment opportunities to people from the landscape villages, particularly members of co-management organizations and indigenous community, by engaging them in forests conservation and participatory monitoring activities
- Conserve biodiversity by safeguarding the habitats of key species such as the Asian Elephant
- Develop a methodology for REDD+ARR projects that can serve as a model for similar other projects in the country.

Local community represented by the members of Village Conservation Forum (VCFs), Community Patrolling Groups (CPGs) and Nishorgo Shahayaks identified amongst the respective Peoples Forum (PF) will be gainfully involved in the project implementation.

1.8 Project Activities

Carbon emission reduction benefits, leading to avoided deforestation and forests degradation, and carbon sequestration and storage benefits leading to well stocked forests, will be attained through a suite of forests protection, and reforestation and revegetation activities focused on the development of forests of mixed native and naturalized species in the six protected areas. Project activities are discussed in greater detail in Chapter 6 on the proposed project design.

1.9 Additionality Analysis

To demonstrate the additionality of the proposed project, the project tests under the Clean Development Mechanism (CDM) and the Voluntary Carbon Standard are utilized. The proposed REDD+ARR project is not mandated by any enforced law, statute or other regulatory framework. Without interventions, the state of deforestation and degradation of the protected areas is not expected to improve. However, due to resource constraints, there are not likely to be substantial initiatives on the part of the GOB to sustain and enhance the forests. Moreover, in terms of investment barriers, the GOB currently lacks access to the international forest carbon markets, and with the exception of the IPAC, there are no donor funded initiatives in the six PAs. Given the status of the proposed project areas as reserve forests, the alternative to the proposed forest carbon project would be deforestation and forests degradation. In addition to overcoming investment barriers, the project would generate livelihood benefits for the local communities through participation in forests protection and reforestation/revegetation, monitoring and conservation activities, as well as enhance the biodiversity of the forest ecosystems by promoting the habitats of unique flora and fauna.

1.10 Project Participants

The Government has declared the co-management approach for managing the protected areas through co-management councils and committees. The CMC is an authorized entity established from among nearby residents and other key stakeholders for the purpose of management of a PA. Members of a CMC are drawn from different strata of society, including local government, public representatives, concerned GOB departments, and others. The CMCs, having resource management planning and conservation responsibility, are working under a national network of protected areas known as "Nishorgo Network" with technical support from the IPAC. Other donor projects are supporting the network in establishing co-management and scaling up natural resources co-management in Bangladesh. Thus the CMCs are increasingly going to have resource conservation and local development initiatives and responsibilities.

In addition to the CMCs, other co-management organizations including VCFs, PFs, CPG and other local stakeholders from the project villages will be project participants.

Table 1.1: Project Proponents

Proponent	Type of Organization	Nationality
Forest Department of the Government of Bangladesh	Host government	Bangladesh
Co-management Committees of Dudpukuria-Dhopachari Wildlife Sanctuary, Teknaf Wildlife Sanctuary, Fhasiakhali Wildlife Sanctuary, Inani	Local governance entity, representing community interests	Bangladesh

National Park and Medhakachapia National Park. Sitakunda Reserved Forests will be represented by FD		

1.11 Project Boundaries and Maps

Project activities will take place in the six protected areas located in the southeastern and eastern portion of the country: Dudpukuria-Dhopachari Wildlife Sanctuary, Teknaf Wildlife Sanctuary, Fashiakhali Wildlife Sanctuary, Inani National Park, Medhakachapia National Park and Sitakunda Reserved Forests. A more detailed description of the locations and boundaries of the protected areas can be found in Table 1.2 as below:

Table 1.2: Coverage, Location and Boundaries of Project Protected Areas

Protected Area	Project Coverage (ha)	Location and Boundaries
DDWS	4,717	Located in the reserve forests of Khurusia and Dohazari under Chittagong (south) Forest Division (between 22°09´ to 22°22´ north latitude and 92°05´ to 92°10´ east longitude), DDWS is situated along the borders of Chittagong, Rangamati, and Banderban Districts. Specifically, on the north, it is bounded by Khurusia Forest Beat and Sukhbilas Forest Beat of Khurushia Forest Range, Naricha Forest Beat of Rangunia Range, and Padua Union of Rangunia Upazila; on the south by Lalutia and Sangu of Banderban Hill Tracts; on the west by Sremai and Barguni Forest Beats of Patiya Forest Range, Kanchanabad Union of Patiya Upazila, and Hashempur Union of Chandanaish Upazila. Administratively DDWS lies in Rangunia and Chandanish Upazilas.
FWS	1,303	FWS falls under Fasiakhali Range of Cox's Bazar (North) Forest Division, and consists of one Range with two Beats (Fasiakhali Beat and Dulahazara Beat). The sanctuary lies between 21°45' to 21°40' north latitude and 92°4' to 92°8' east longitude.
INP	7,092	Located in Cox's Bazar (South) Division, about 26 km south of Cox's Bazar town, the Park lies between $21^{0}6$' to $21^{0}17$' north latitude and $92^{0}3$' to $92^{0}7$' east longitude. It comprises the RFs of Swankhali, Inani, Jalia Palong and Raja Palong Beats of Inani Range.

Protected Area	Project Coverage (ha)	Location and Boundaries
MNP	397	MNP is located in Medhakachapia Block, Medhakachapia Beat, Fulchri Range, in Cox's Bazar (North) Forest Division, and covers Khutakhali Union of Chakaria Upazila. The park is situated at 21°45' to 21°40' north latitude and 92°4' to 92°8' east longitude. The western side of the park is bounded by Bakumpara, South Medhakachapia and Middle Medhakachapia villages; the southern side by Khutakhali High School, Khutakhali and Nolbuni; the northern side by Paglir Beel & North Medhakachapia; and the eastern side by Jungle Khutakhali Reserve Forest.
SKRF	8,220	Sitakundu Reserve Forest consists of two Ranges (Baraidhala and Kumira), five Beats (Kumira, Barabkundu, Sitakundu, Baraidhala, and Barataki), and Sitakundu Eco-park (SKEP). The location of the SKEP is 22°30 to 22°46'40 N and 91°43'20 to **91**°36'40 E. The north side of SKEP is bounded by Gobania Beat under Mirsarai Range, Mirsarai, Upazila; the south portion Shitolpur Beat under Kumira Range, Sitakundu Upazila; the East side Hathhazari, Mondakini, Hazarikhil, Fotikchari, and Balukhali Beats under Hathhazari and Fotikchari Upazila; and the west side by the Bay of Bengal, ship breaking yards, and the Coastal Forests Division's plantations under Sitakundu and Mirsarai Upazila.
TWS	11,615	The Sanctuary, located in Cox's Bazar (South) Division within $21^{0}00'$ north latitude and $92^{0}20'$ east longitude, occupies the middle part of the Teknaf Peninsula from Ukhia, south to the Teknaf town. It is near to Myanmar border in the country's far south-eastern corner. TWS covers 10 RF blocks spread over 3 Ranges (Teknaf, Silkhali and Whykong). It is situated in Ukhia and Teknaf Upazilas and lies in between the Naf river on the eastern side and Bay of Bengal on the western side. It is part of a linear hill range (reaching an altitude of 700m), gently sloping to rugged hills and cliffs running down the central part of the peninsula, with a north-south length of nearly 28 km and an east-west width of 3-5 km. Its northern boundary starts near Whykong town (which is nearly 50 km from Cox's Bazar town), extending in south upto Teknaf town. A metalled road connecting Cox's Bazar with Teknaf town runs in between the Naf river and the eastern boundary of the TWS.

The maps of six PA are presented in Figures 1.1 – 1.6 as below.

Figure 1.1: Dudpukuria-Dhopachari Wildlife Sanctuary

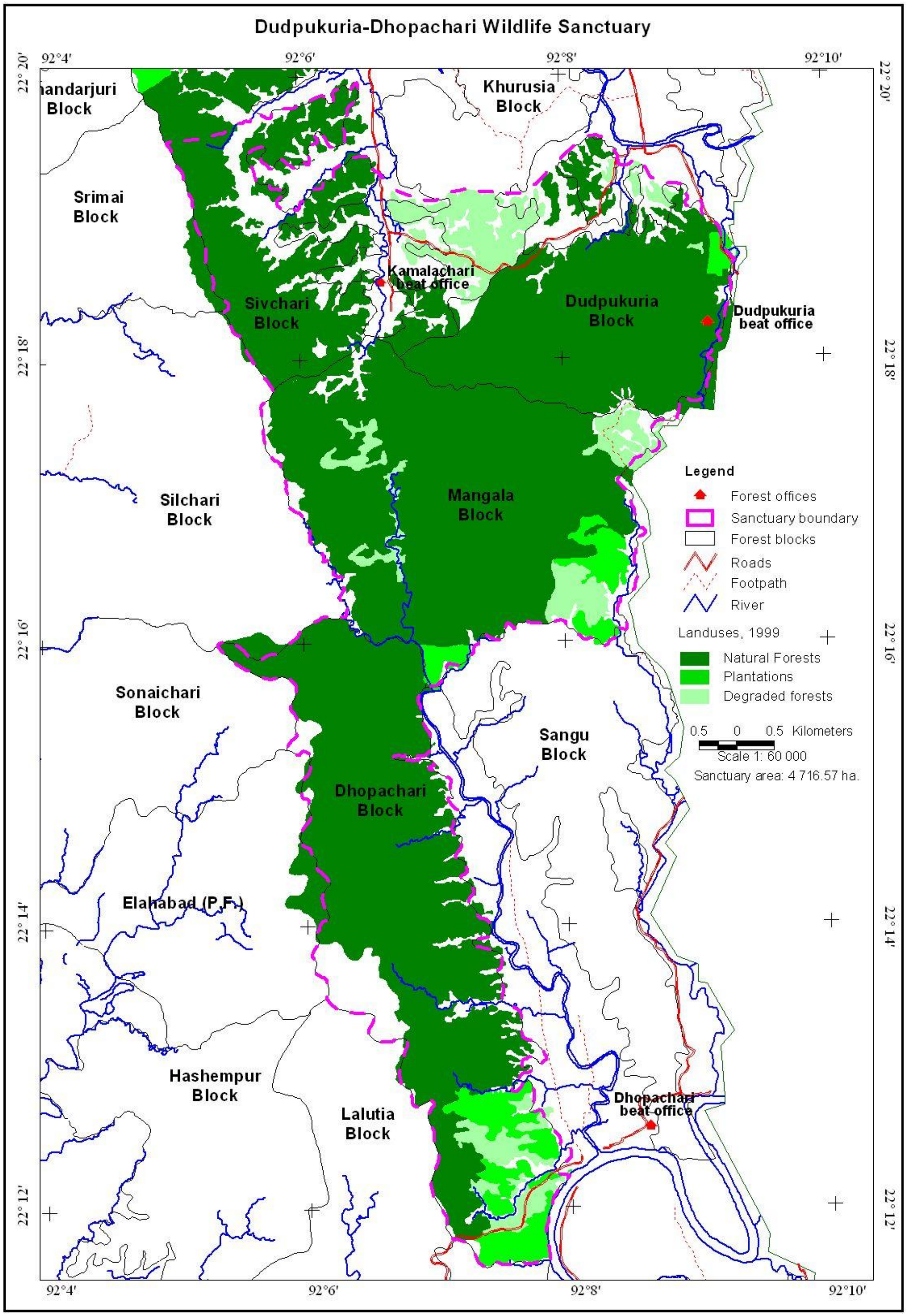


Figure 1.2 : Teknaf Wildlife Sanctuary

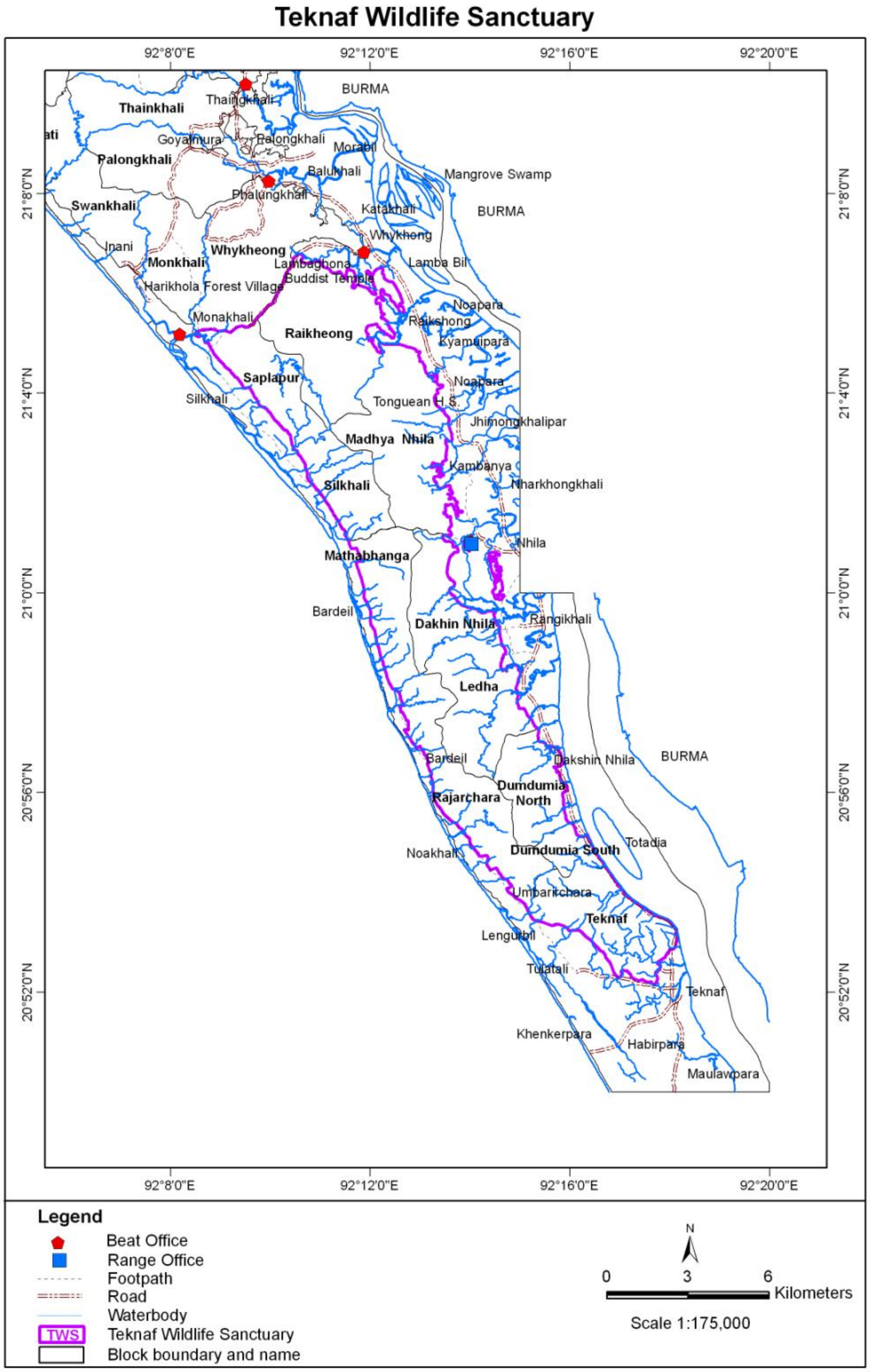


Figure 1.3: Fasiakhali Wildlife Sanctuary

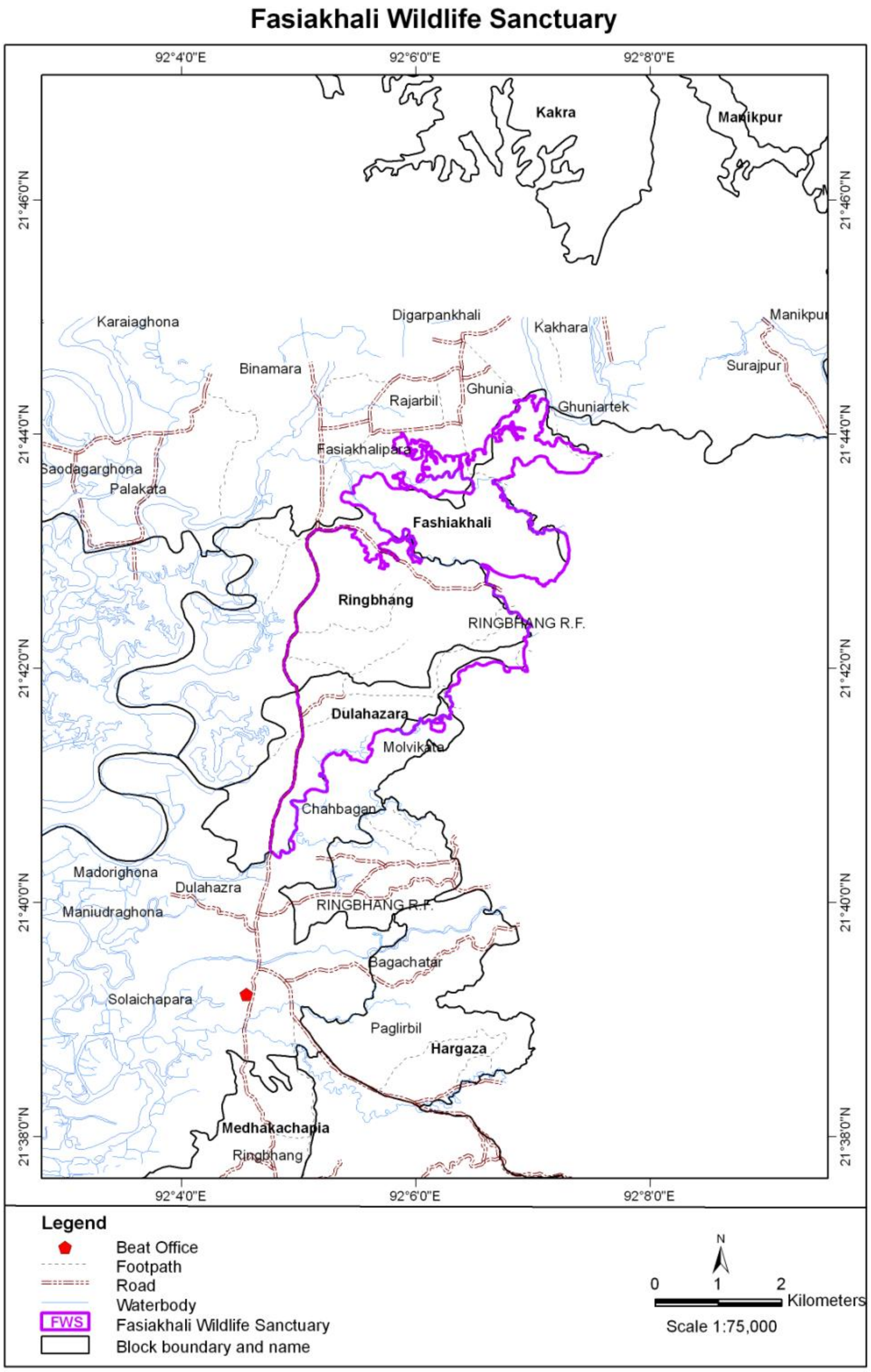


Figure 1.4 : Inani National Park

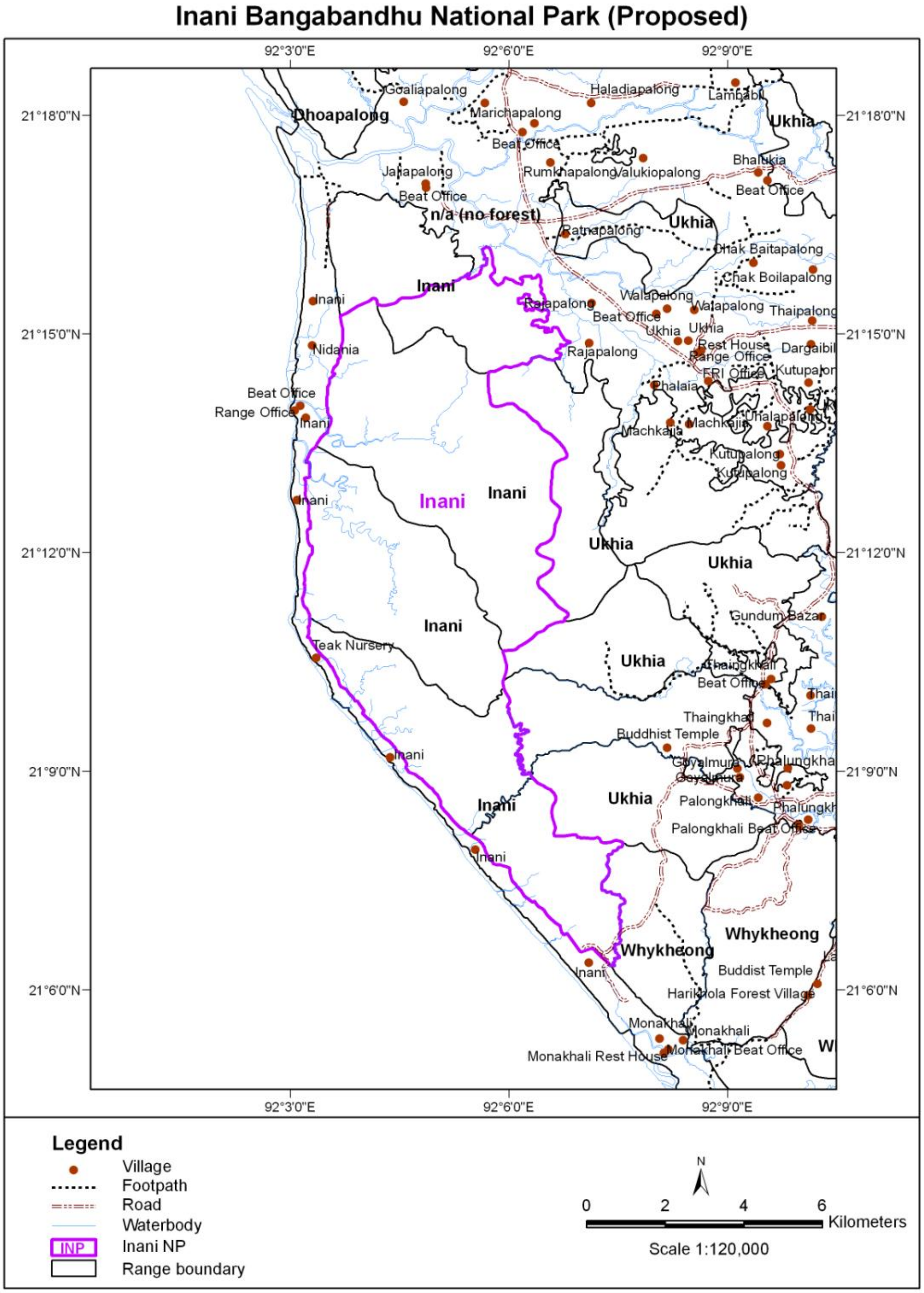


Figure 1.5: Medhakachapia National Park

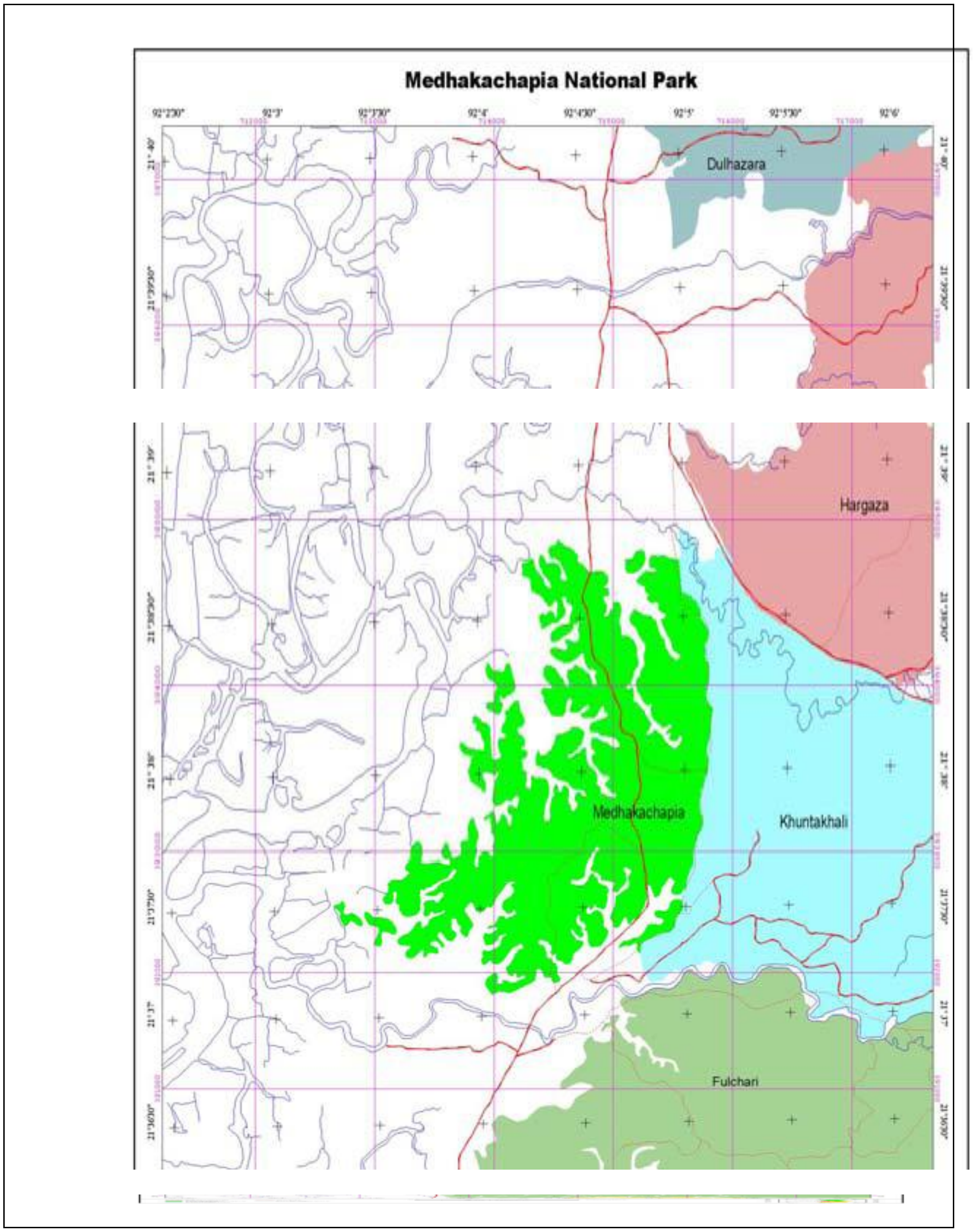
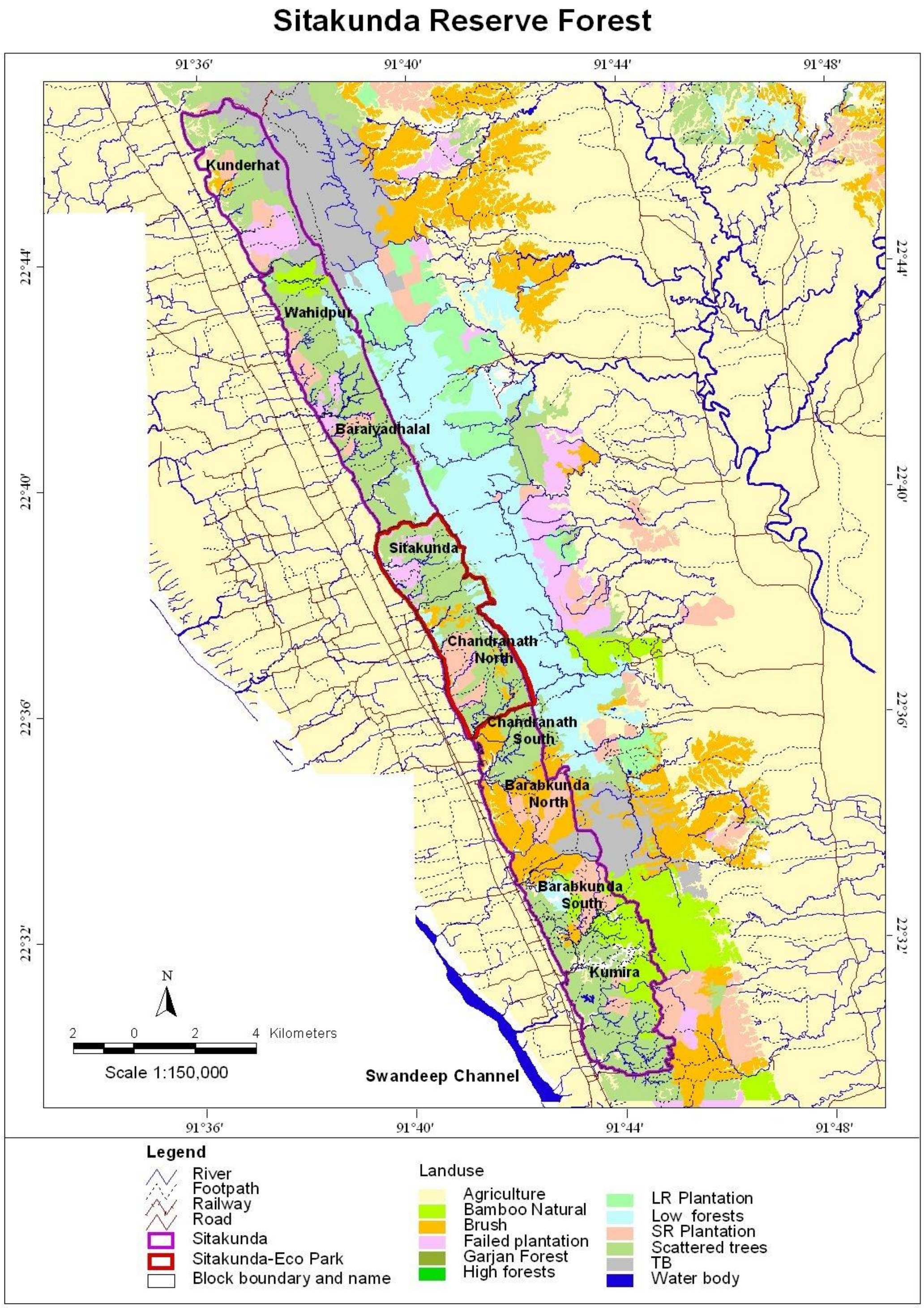


Figure 1.6: Sitakunda Reserved Forests



2. Current Conditions

The protected areas included in this project comprise of national parks, wildlife sanctuaries and reserved forests : Medhakachapia National Park, Inani National Park (proposed), Dudpukuria-Dhopachari Wildlife Sanctuary, Teknaf Wildlife Sanctuary, Fasiakhali Wildlife Sanctuary and Sitakunda Reserved Forests. Due to the similarities across protected areas, a general overview has been provided of climate, environmental, and socio-economic conditions, with exceptions in different protected areas highlighted. In past the six PAs supported mixed tropical evergreen and semi-evergreen forests, which over the period have been substantially altered due to heavy biotic pressure. At places forest land encroachment has resulted in land-use changes through conversion of foothills and low areas into paddy cultivation and settlements. However, at places good natural regrowth, particularly of ground flora and middle storey, has come up due to favorable climatic and edaphic conditions, thereby enhancing the conservation values of the six PAs. Old plantations in some forest areas have grown up in shape of multi-storied structure with regrowth of naturally occurring species.

2.1 Biodiversity Significance

The forests of the six PAs, comprising wet evergreen and semi-evergreen forests, are rich biologically, located as they are in one of the most dynamic bio-geographic zone with high rainfall and good soils. Socio-economic values of these PAs are important as some of them are home to indigenous communities with their traditional lifestyles and with high dependency on neighboring natural resources. Biological values include providing shelter to biodiversity, elephant habitat connectivity, presence of threatened and endemic species, and habitat restoration. Main ecological functions are catchment and coast conservation, climate change and ecological security, environmental amelioration, irrigation and food security.

These PAs provide significant scope for wildlife education and research, nature interpretation and conservation awareness. Their fragile landscapes with rich bio- and cultural-diversity, if not conserved, may be lost for future generations. They are potential sources of eco-tourism, nature-based recreation, aesthetic values, historical and cultural values, dense evergreen forests, and scenic beauty. Accordingly, the six PAs attract national attention whenever the status of the country’s forests come under scrutiny. Being predominantly undulating and hilly in terrain, the forests-water interactions are pronounced in these PAs, where the forests play an important role in regulating water flows, checking soil erosion and protecting watersheds, waterbodies and coasts. TWS, INP and DDWS are part of watersheds that have regional and transnational implications. The protection and conservation of these forests is particularly important in view of significant loss of the country’s hill forests. Although degrading, the comprising forests in these PAs have high level of biodiversity comprising important flora and fauna in a variety of habitats.

2.2 Biophysical Attributes

2.2.1 Climate

Generally, the areas in which the six PAs are located are characterized by a humid, tropical climate, little temperature variability, and rainfall concentrated between the months of June and October, with some differences between protected areas. These protected areas are subject to three seasons, summer (March-May), monsoon (June-September/October), and winter (November-February). Temperatures remain high, with some seasonal and regional variability, and mean monthly temperatures range from 52° F in January to 95° F in May, with variation of about 10° F. Although in some instances, such as DDWS in the summer season, humidity can be relatively low (relative minimum of 28.6 percent), it tends to high throughout most of the year in the protected areas : In TWS the monthly average humidity varies from 27.6% in April to 98.6% in August. Rainfall is heaviest during the monsoon season, with pre-monsoon rains beginning in April-May, and post-monsoon rains lasting until October, and November to March-April is usually relatively dry period. There is heavy dew during winter when rainfall is low. The water condensation is thus distributed throughout the year in different forms and greatly influences plants and wildlife.

As nearly 80 percent of the country is located in a floodplain[7], flooding is a common occurrence[8]. The south-eastern coastal region in which Teknaf, Inani, Medhakachpia, Fasiakhali, Dudpukria and Sitakunda are situated is also frequently affected by cyclones, most frequently between May and October. Pre-monsoon Nor'westerly and cyclonic storms are accompanied by high speed winds and rains, which do considerable damage to property and biotic life. The International Disaster Database lists 157 cyclones between 1900 and 2009 for Bangladesh, with the three most devastating ones, in terms of numbers killed, occurring in 1970 (300,000 people), 1991 (138,866), and 1942 (61,000)[9]. Floods and cyclones have both direct and indirect repercussions for the forests. In addition to direct destruction, flood- and cyclone-induced migration can act as an additional stressor on forest resources, which both DDWS and MNP experienced pursuant to the 1963 and 1991 cyclones.

[7] GOB National Adaptation Plan of Action (2005: 1).

[8] The country experienced major floods in 1954, 1974, 1984, 1987, 1988, 1998, and 2004, resulting in 55 and 58 percent respectively of the country being affected in 1954 and 1974, and over 60 percent of the country being inundated in 1987, 1988, 1998 GOB National Adaptation Plan of Action (2005: 6, 7).

[9] EM-DAT (2010: http://www.emdat.be/search-details-disaster-list)

2.2.2 Forest geology and rock

In terms of topography and geology, the project areas are largely made up of gently sloping hills and comprise several different geological formations, Pleistocene, Pliocene, Mio-pliocene, and Miocene. The hills of TWS and INP are composed of upper tertiary rocks (Pliocene and Miocene) with 3 representative series – Surma, Tipam and Dhuptila. Pleistocene is a complex of alluviums, terraces, and old terraced fans made up of unconsolidated sediments including sand, sand loam, and loamy clay resulting from the erosion of Duptila and Tipam formations. Pliocene is Duptila formation which consists primarily of folded, fine to course sandstone, mixed with mottled siltstones and shales, plinthitic, and lateritic layers. These sediments are strongly erodible. Mio-pliocene is Tipam formation composed of a succession of consolidated, folded and fine grained sandstones, layered with folded sandy shales, siltstones, and shales. Miocene is the oldest Surma formation, and is situated in the centre of the anticlimes and surfaces at the bottom of valleys.

2.2.3 Forest soils

The soils in the project areas range from clay to clayey loam on level ground and from sandy loam to coarse sand on hilly land. The clayey and sandy loams are fertile, and the sandy soil is often impregnated with iron resulting in red or yellowish tinge. Soils developed in the hills from un-consolidated rocks are moderately well to excessively well drained, generally deep, and probably the oldest soils in this region, while those occurring on hills from consolidated rocks tend to be formed in weathered sandstones, shales, and siltstones. The soils developed in weathered sandstones tend to be sandy loams to clay loams, and those in shales silty clay loams. In areas where slopes are steep and blue shales appear at the surface, the shallow surface soil hinders the penetration of deep roots, and is not conducive to tree growth. In general, the soils of Tipam Surma formations are less acid in reaction relative to the soils of Dupi Tila formations.

2.2.4 Hydrology

Surface water hydrology of the project areas is regulated by good rainfall, runoff from adjacent uplands, and the relief pattern of the plains. All the 6 protected areas feature *charas*, or streams, which help to drain water from the surrounding hilly terrain into nearby bodies of water, such as the Sangu river (Dudpukria-Dhopachari and Sitakunda), Matamuhuri river (Fasiakhali and Medhakachpia), Naf river (Inani and Teknaf), and the Bay of Bengal (Inani and Teknaf). A part of the project area is traversed by numerous creeks that are clear with gravely and stony beds that flow down to rivers. A number of other small streams and shallow depressions provide wetlands to migratory birds, and fish for local livelihood. They provide good habitat, drainage and drinking water source for wild animals and local people. So aquatic habitats associated with forests and riparian vegetation and animals are important part of overall habitat composition.

2.2.5 Forests

The forests of the six PAs were reserved mainly in early nineteenth century under the Forest Act of 1927. Before reservation, many forests were cleared for jhum (shifting cultivation) but secondary vegetation developed subsequently. However, many forests of mixed indigenous species were cleared for raising plantations, mainly of commercial species, in sixties and seventies. The conversion of high biodiversity value natural forests to commercial plantations was not justified in view of ecological disturbances to the forests ecosystems, brought first by clearfelling natural forests and followed by planting activities. Many of these plantations suffered heavily from storms and cyclones, and pilferage from mature plantations has been substantial.

Tropical evergreen forests in the 6 PAs are found in deep valleys where wet conditions exist with shade, whereas tropical semi-evergreen species predominate on hills and flat lands. Evergreen tree species are more frequent in lower stories, and upper stories have a high proportion of species that are deciduous during dry season. Shrubs, bamboo, cane and a number of fruit and fodder bearing plants occur naturally. Savannah areas of sun grass occur in large patches as intensive human use has resulted in the degradation or conversion of much of the original wet forest cover. The proportion of semi-evergreen scrub forests and grasslands are increasing in those areas where forests have become heavily degraded due to high biotic pressure. Few patches of evergreen and semi-evergreen forests have, however, developed in few degraded forest areas due to reduced biotic pressure and favorable moisture conditions as a result of high rainfall. Plantations of commercial species have been raised under different projects such as the World Bank supported Forest Resources Management Project and the Asian Development Bank funded Forestry Sector Project.

2.2.6 Ecosystems and biodiversity

A number of different ecosystems harboring rich biodiversity can be found in the protected areas covered by the project, including tropical evergreen and semi-evergreen mixed forests; grasslands, bamboo and cane; short and long-rotation plantations; small streams; homesteads and settlements; waterbodies; and cultivated lands. The first four are the largest in extent and the most important from a biodiversity perspective in the six protected areas, although the cultivated fields harbor some species of mammals and reptiles. Some of the forests still support natural vegetation, with the dominant tree species including *Dipterocarpus turbinatus*, *Artocarpaus chaplasha*, *Hopea odorata*, and *Syzygium cuminii* (See Annex 1 for local names, and Annex 2 for a listing of species by protected area). Plantations of species such as *Tectona grandis* and *Acacia auriculiformis* account for a small portion of cover. In some sites, bamboo and cane have also been planted, while in others, there is natural cover. The small streams enabling the drainage of water that collects in the depressions and valleys in the hilly landscape serve as important habitats for flora and fauna, as well as provide drinking water for both human and animal populations. In DDWS and SKRF, some patches of these fertile lands are cultivated by local communities during the dry season.

Each of the protected areas supports hundreds of species of flora and fauna : mammal species such as *the Elephas maximus, Aonyx cinerea, Canis aureus, Cuon alpine, Muntiacus muntik, Sus scrofa, Hylobates hoolock*, and *Macaca mulatta*; bird species such as *Dicrurus aeneus*, *Pycnonotus cafer*, *Psittachula alexandri*, *Dinopium bengalense*, *Nectarinia zeylonica, Psittacula alexandri, and Gallus gallus*; reptile species such as *Mabuya carinata*, *Gekko gecko, Chrysopelea ornata*, *Cuora amboioensis*, and *Varanus bengalensis*; and amphibian species such as *Rana cyanophyctis*, *Garrulax moniligerus*, and *Bufo melanostictus*.

Most of the protected areas also serve as habitats for flagship and endangered species such as the Asian Elephant in Dudpukria, Inani and Teknaf. Table 2.1 provides illustrative lists of species that fall under the International Union for the Conservation of Nature's (IUCN) threat categories of critically endangered, endangered, or vulnerable.

Table 2.1: Illustrative list of IUCN Threatened Species by Protected Area

Protected Area	Biodiversity type	Threat categories (Local/common name (Scientific name)		
		Critically Endangered	Endangered	Vulnerable
DDWS	**Flora**	Telly Garjan (*Dipterocarpus turbinatus*); Kali Garjan (*Dipterocarpus gracilis*)	Dhully Garjan (*Dipterocarpus alatus*); Baitta Garjan(*Dipterocarpus costatus*)	Telsur (*Hopea odorata*)
	Fauna		Asian Elephant (*Elephas maximus*) (population trend decreasing); Ram kukur (Dhole) (*Cuon alpinus*) (population trend decreasing)	
FKWS	**Flora**	Telya Garjan (*Dipterocarpus turbinatus)*	Dhalya Garjan (*Dipterocarpus alatus);* Baittya Garjan (*Dipterocarpus scabar)*	Telsur (*Hopea odorata)*
	Fauna		Asian Elephant (*Elephus maximus);* Fishing Cat (*Prionailurus viverrinus);* Jungle Fowl *(Gallus gallus);* Barking Deer (*Muntiacus muntjak);* Kalij Pheasant (Mothura) (*Lophura leucomelanos);* Python (*Python molurus)*	Capped Langur (*Trachypithecus pileatus);* Stump-tailed Macaque (*Macaca arctoides)*
MKNP	**Flora**	Telya Garjan (*Dipterocarpus turbinatus)*	Baittya Garjan (*Dipterocarpus scabar);*	Telsur (*Hopea odorata)*
	Fauna		Asian Elephant (*Elephus maximus);* Fishing Cat (*Prionailurus viverrinus*)	Capped Langur (*Trachypithecus pileatus);* Stump-tailed Macaque (*Macaca arctoides)*
INP	**Flora**	Telly Garjan (*Dipterocarpus turbinatus*); Kali Garjan (*Dipterocarpus gracilis*)	Dhully Garjan (*Dipterocarpus alatus*); Baitta Garjan (*Dipterocarpus costatus*)	Telsur (*Hopea odorata*)
	Fauna		Asian Elephant (Hati) (*Elephas maximus*); Dhole (Ram Kokor) (*Cuon alpinus*) (trend: decreasing)	
SKRF	**Flora**	Telya Garjan (*Dipterocarpus turbinatus)*	Baittya Garjan (*Dipterocarpus scabar)*	Telsur (*Hopea odorata)*
	Fauna		Wild Boar (*Sus scrofa*)	
TWS	**Flora**	Telly Garjan (*Dipterocarpus turbinatus*); Kali Garjan (*Dipterocarpus gracilis*)	Dhully Garjan (*Dipterocarpus alatus*); Baitta Garjan (*Dipterocarpus costatus*)	Telsur (*Hopea odorata*)

	Fauna		Asian Elephant (Hati) (*Elephas maximus*); Dhole (Ram Kokor) (*Cuon alpinus*) (trend: decreasing)	

The degradation of the forests and wildlife habitats have resulted in the extinction of numerous species, and several are at risk. Flora consists of both more common as well as unique species of tropical evergreens (*dipterocarpus*, *syzygium*, *Artocarpaus chaplasha*, *Hopea odorata*, *Tetrameles nudiflora*, *Aphanamixis polystachya*, *Cedrela toona*, *Dillenia pentagyna*, *Stereosperlum personatum*, *Terminalia balerica*, and horitaki), deciduous trees (*Albizia procera*, *Lannea coromandelia*, *Bombax ceiba*, *Ficus bengalensis*, *Dipterocarpus turbinatus*), shrubs, bamboos, canes, vines and climbers, ferns, grasses, and herbs.

2.2.7 Description of Socio-economic Context

The majority of communities in the project villages and in surrounding the protected areas are Bengali, mostly Muslim with a smaller number of Hindus and Buddhists, and the Muslim Bengalis tend to be the most affluent (see Table 2.2 for numbers of households in each of the areas). There are also a number of religious and ethnic minorities which differ from area to area. For instance, in Teknaf and Inani, these ethnic groups include Tonchoinga, Chakma, and Rakhain. In some cases, these groups migrated from nearby areas, as in DDWS and MKNP from Badarkhali, Dhemosia, Kutubdia, Moheshklhali, and coastal Chakaria, when severe cyclones in 1963 and 1991 left them homeless.

The status and role of women differ depending on the protected area. In DDWS and MKNP, which are less conservative, despite the fact that most wear veils outside their home, they benefit from a high degree of mobility, and participate in social activities and events. Even within the same protected area, however, some groups are more conservative than others, with middle-class women having the latter tendency. Some evidence of empowering factors exist, with a higher percentage of women having access to credit than men, the former from NGOs such as Bangladesh Rural Advancemtn Center (BRAC), Association for Social Advancement (ASA), Proshika, Coast, and Digonta, and the latter from banks such as Grameen, Krishi, and Islami. Additionally, 60 percent of women claim that their opinions are considered by the head of the family or other male equivalent. In MKNP, a higher percentage of girls obtain *madrassa* education than boys.

Village society is divided into a few small *samaj* (community groups) with its informal (e.g. Imams) and formal (elected representatives of Union Parishads) leaders. They play an important role in the motivation of local people as well as in conflict resolution; consultation with them is often required before the introduction of a forest activity in the areas. Within the tribal communities, traditional forms of governance still prevail, and the Headman and Karbari in each of the forest villages are the most politically powerful persons.

Most of the communities surrounding the protected areas tend to be poor, and landless (approximately 60 percent), with up to 70 percent of the households falling into the extremely poor category, and the remainder into the poor or middle-class. Illiteracy rates are approximately ten to fifteen percent, with women experiencing higher rates than their male counterparts. Government facilities for formal and nonformal education, and awareness raising initiatives by NGOs have led to reductions in illiteracy : 70-80 percent attain primary education, fifteen to twenty percent secondary, and the remainder tertiary. However, many households cannot afford to educate their children beyond the primary level, due to lack of resources.

Although the predominant livelihoods vary depending on the protected area, local people are largely dependent upon agriculture (e.g. nearly 70% in Inani), salt cultivation (e.g. nearly 45 percent in DDWS, MKNP), or livelihoods based upon forest resources such as illegal harvesting of forest produce (e.g. nearly 30 percent in DDWS, MKNP) and fuel wood collection, with a smaller percentage finding employment as agricultural day laborers (e.g. nearly 20 percent in DDWS, MKNP), rickshaw pullers (e.g. nearly 3 percent in DDWS, MKNP), or bamboo mat weavers. A small percentage is employed overseas. Some seasonal variation exists, particularly for day laborers, who may only find work in the salt fields for six months out of the year, and unemployment ranges from 20-40 percent (DDWS), with higher rates prevalent during the rainy season. Collection and sale of fuel wood serves as an alternative when day labor is not available.

Most villagers are dependent on forest resources not only for their employment and livelihoods, but also for vegetables and fruits integral to their diets, household materials, and fuel wood for domestic use. The responsibility for their fuelwood collection usually falls mainly on women, children, and occasionally elderly members; it tends to be collected during the day, and saplings and seedlings are the most common source. Illegal harvesting, motivated by lack of alternative sources of fuel, have disturbed the natural regeneration of the forests, contributed to their considerable degradation, and negatively affected wildlife habitats. Some individuals also engage in the sale of fuel wood, and substantial quantities are transported daily from some of the protected areas to fuel wood traders or local markets, as in the cases of DDWS and MKNP. In terms of the movement of fuel wood, the first entry point is usually a small market, although the final destination may be a much larger market.

Illegal tree felling has contributed to a reduction in forest cover and resources, and is carried out both by local people as well as outsiders, oftenly under the influence of local elites, sometimes supported by outsiders. Most tree felling takes place at night, and is either used by villagers for building material or furniture, or is sold in markets nearby or in other big districts such as Chittagong and Dhaka.

Table 2.2: Households in the Protected Areas

Protected area	Household estimates
DDWS	As per the PRA report there are 20 villages or paras (with 2,400 households) in and around the PA.
FWS	As per the PRA report there are 31 villages or paras (with 9,700 households) in and around the PA.
INP	As per the PRA report there are 20 villages or paras (with 2,400 households) in and around the PA.
MKNP	As per the PRA report there are 16 villages or paras (with 3,000 households) in and around the PA.
SKRF	As per the PRA report there are 36 villages or paras (with 9,700 households) in and around the PA.
TWS	Nearly 113 villages or paras are identified, hosting a population about 150,000, either inside or adjacent or close to the Sanctuary.

2.2.8 Land Ownership and Tenure

The land category of the 6 protected areas is reserved forest land, with the legal title of land ownership held by the Government of Bangladesh through the FD. Although formal ownership of the protected areas rests in the hands of the GOB, their management has been vested with the recently established co-management councils and committees. Thus, land tenure is clear, and rather than land disputes being the greatest source of these conflicts, forest resources and the FD's and CMC's attempts at preventing their exploitation through poaching and illegal harvesting are. While most disagreements are resolved by Union Parishad (UP) members or the Chairman, in the case of serious conflicts, the police and local Member of Parliament (MP) may be asked to intervene. If the conflicts arise from nearby forest land disputes, people often go to nearby forest office to resolve the conflict.

3 Project Baseline

3.1 Land-use Cover

Forest cover in the six protected areas varies and a diversity of land cover can be found in the project reserve forests. Those that account for the greatest proportion of land-use include: forests including plantations, herb-shrub-bush, fallow or agricultural land, bamboo, and settlement and homesteads vegetation. The Tables 3.1 and 3.2 below overview FAO forest cover information in the Chittagong and Cox's Bazar forests, where DDWS and SRF; and FWS, INP, MNP, and TWS respectively are located.

Table 3.1:Forest Cover in the Chittagong Forests[10]

Category	**Land-Use Area in 000 ha**			
	1984	**1996**	**2000**[11]	**2005**
Natural Forests	30.003	22.224	19.631	16.390
Bamboo		3.299	3.299	3.299
Sub Total Forests	**30.003**	**25.523**	**22.930**	**19.689**
Scatter trees (other wooded lands)	22.468	34.157	36.750	39.991
Plantation	13.223	14.109	14.109	14.109
Total	**65.694**	**73.789**	**73.789**	**73.789**

[10] FAO (2005: 9, 13-14).

[11] The 2000 and 2005 data has been generated through interpolation and extrapolation methods based on the 1984 and 1996 inventory data. As there was only one data point for bamboo, the same figure was used for 1996, 2000, and 2005. Plantation data for 2000 and 2005 was also assumed to be the same as in 1996. The area under scattered trees in 2000 and 2005 has been treated as a remainder area, so that the total does not increase the original level of 1996.

Table 3.2 : Forest Cover in the Cox's Bazar Forest[12]

Category	Land-Use Area in 000 ha			
	1984	**1996**	**2000[13]**	**2005**
Natural Forests	31.294	26.867	25.391	23.547
Bamboo			0	0
Sub Total Forests	**31.294**	**26.867**	**25.391**	**23.547**
Scatter trees (other wooded lands)	3.205	3.532	5.008	6.852
Plantation	18.044	19.439	19.439	19.439
Total	**52.543**	**49.838**	**49.838**	**49.838**

Small proportions of the forests are used for agricultural purposes (e.g. 5 percent in DDWS, and 10 percent in MNP) by forest villagers; to cultivate crops such as betel leaf and betel nut; to develop homestead gardens; and to graze cattle. Prior to the establishment of protected area status, shifting cultivation and grazing were common in the forest reserves, and these activities continue to be practiced only in small parts. Over the past few decades, land cover has changed significantly due to anthropogenic pressures, such as migration, illegal felling and harvesting, conversion of land to agricultural uses, and encroachment. The FAO estimates, based on inventories in 1985 and 1996, that in the Chittagong forests, closed forest declined from 30,003 to 22,223 ha between 1985 and 1996, and total volume decreased from 2.27 million m^3 in 1985 to 0.648 million m^3 in 1996[14]. In the Cox's Bazar forests, inventories in 1985 and 1996 indicated that closed forest went down from 31,295 ha in 1985 to 26,867 ha in 1996, while the total volume declined from 3.70 million m^3 in 1985 to 2.2 million m^3 in 1996[15].

3.2 Deforestation Rates in the six Project Areas and Reference Regions

Over the past several decades, different types of biotic and natural disaster pressures have led to the degradation of most of the forest areas. Although activities contributing to

[12] FAO (2005: 9, 14).
[13] As in the case of the Chittagong Forest, the 2000 and 2005 data has been generated through interpolation and extrapolation methods based on the 1984 and 1996 inventory data. Plantation data for 2000 and 2005 was assumed to have remained constant from 1996. The area under scattered trees in 2000 and 2005 has been treated as a remainder area, so that the total does not increase the original level of 1996.
[14] FAO (2000: 22).
[15] FAO (2000: 22).

deforestation and forest degradation have decreased in some of the reserve forests due to initiatives such as the NSP and IPAC, in most of the protected areas, a number of stressors continue to affect land cover and quality. Factors that have contributed to the deforestation and degradation of these lands include cyclone devastation, such as in 1991, 1994, and 1996 in INP, as well as population growth and migration, such as that of the Rohinga refugees from Myanmar into the areas surrounding INP and TWS. In some cases, migration has been fueled by movement away from areas hit by natural disasters, as in DDWS, which experienced an influx of migrants pursuant to the cyclone of 1964. These increases in population have resulted in or contributed to fuelwood collection for personal use as well as for sale; illicit felling and logging; destructive tree bark collection from species such as *Dillenia pentagyna*; betel leaf cultivation; and clearing undergrowth, sometimes through the use of fires, to convert forest lands into agricultural lands and settlements.

Encroachment of forest land after deforesting is also a critical issue in all the six protected areas. There are two forms of forest land encroachment: 1) by local communities, including cyclone and flood victims in the vicinity, wealthy influential individuals, and refugees from Myanmar, expanding into frontier forest areas, and 2) by forest villagers moving beyond the areas allocated to them by the FD. Forest villages were set up at different times in some of the reserve forests by the FD (e.g. in 1920s in Teknaf), under which a certain number of households were each leased 2 acres of land within the reserve forests. In return, the villagers were expected to help the FD with plantations and patrolling. However, there is evidence of encroachment beyond their allotments, and of migration of forest villagers' family members into these areas. For example, in TWS, the total number of registered and enlisted forest villagers is about 350, but local estimates suggest the number of people claiming to be forest villagers is closer to 5,000 households. These anthropogenic pressures have contributed to the significant deforestation and degradation of the forests, and poverty and limited livelihoods options are important factors in local community members' willingness to participate in these illegal activities. These stressors are further exacerbated by the weak law-enforcement capacity of the FD, as well as high demand for the forest products by sawmill owners and illegal timber traders.

The task of conducting trend analyses of land-use change and assessing deforestation rates in the 6 PAs (project areas) and their surrounding landscapes (reference regions) was completed by the Center for Environmental and Geographic Information Services (CEGIS, a specialized agency that has required remote sensing facilities and expertise) by acquiring Landsat 5 Thematic Mapper (TM) satellite images in 7 spectral bands for 1989, 2000 and 2009. The TM is a scanning optical mechanical sensor that records energy in the visible, reflective infrared, middle infrared and thermal infrared regions of band-6 which has a 120 m resolution. Vegetation absorbs much of the incident blue and red radiation for photosynthesis and reflects approximately half of the incident near-infrared radiation causing it appear bright in the band (near infrared) image. Multispectral time series satellite images were collected, imported, enhanced and georeferenced, after which they were classified using ISODATA clustering technique. Ground data were collected for supporting digital classification and accuracy assessment. Using expert knowledge of CEGIS experts, RIMS experts, FD field staff and IPAC staff, time series and land use/cover maps of each PA were prepared and time series analyses were carried out to identify changes of land use/cover within the 6 PAs (Table 3.1) and their reference regions within 5 km band around their gazetted boundaries (Table 3.2).

Table 3.3 : Land-use/cover in six Protected Areas (Project Area)

PA	Year	Area (in ha)				
TWS		Forest	Herb/shrub/bush	Fallow & Ag. land	Settlement & homesteads	Total
	1989	3304	6263	1106	942	11615
	2000	2812	6994	635	1174	11615
	2009	1794	7824	558	1438	11615
INP	1989	4161	1885	636	411	7092
	2000	3280	3119	280	413	7092
	2009	2249	3683	723	437	7092
MKNP	1989	140	91	82	84	397
	2000	114	115	75	93	397
	2009	112	95	82	108	397
FWS	1989	300	692	272	39	1303
	2000	392	695	175	41	1303
	2009	301	767	190	45	1303
DDWS	1989	2398	1943	352	24	4717
	2000	2632	1803	254	28	4717
	2009	2653	1751	266	47	4717
SKRF	1989	1269	3882	3019	50	8220
	2000	1525	3559	3084	52	8220
	2010	2461	4776	915	68	8220

From Table 3.1 it is evident that the forests covers showed decreasing trends during the period 2000-09 in TWS, INP, MKNP and FKNP, whereas in DDWS forests are stabilized but in SKRF forests cover showed increasing trend due mainly to plantation projects under which some degraded areas have been planted over the period. The same trend is noticed during the period 1989-2000, except that there is slight increase in forests in FWS again due to planting. As VCS requirement is to estimate forests cover changes during the previous 10 years, only the later period will be relevant in estimating deforestation rates. Except slight decrease in DDWS, area under herb/shrub/bush category has increased over the period in all the PAs mainlyas a result of deforestation.

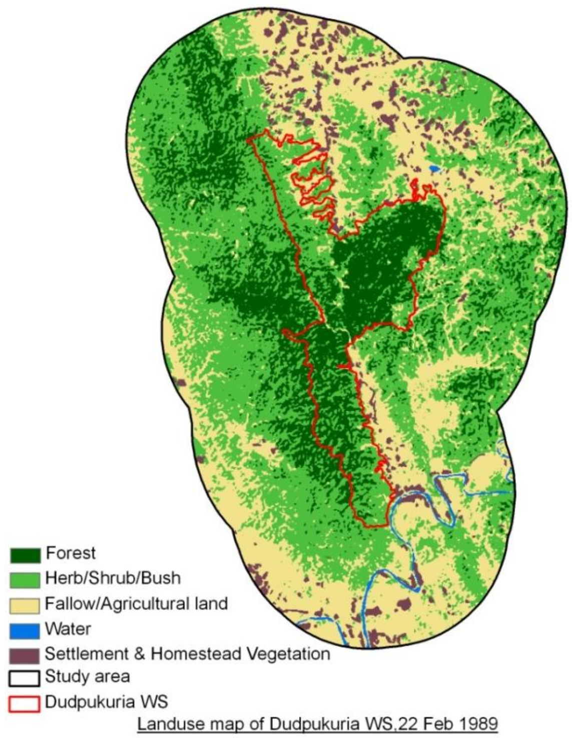
Table 3.4 : Land-use/cover in the Reference Regions of the six Protected Areas

PA	Year	Area (in ha)				
TWS		Forest	Herb/shrub/bush	Fallow & Ag. land	Settlement & homesteads	Water
	1989	3,406	8,722	8,730	4,672	17,082
	2000	3,392	9,277	7,790	4,995	17,158
	2009	2,089	9,864	8,749	5,884	16,026
INP	1989	7,508	6,119	4,800	5,986	12,930
	2000	5,293	8,796	4,661	6,144	12,459
	2009	2,728	9,290	6,600	6,392	12,339
MKNP	1989	651	3,704	7,262	1,313	
	2000	1,132	3,182	7,045	1,571	
	2009	1,011	3,116	7,048	1,755	
FWS	1989	1,402	5,202	9,632	2,788	
	2000	833	5,907	9,267	3,018	
	2009	675	6,202	8,940	3,208	
DDWS	1989	6,526	15,999	10,920	1,552	199
	2000	6,037	19,916	7,407	1,647	189
	2009	6,465	18,814	7,788	1,870	259
SKRF	1989	9,707	12,732	19,223	8,994	3,114
	2000	8,260	11,505	22,028	8,857	3,120
	2010	12,696	16,104	12,608	9,205	3,157

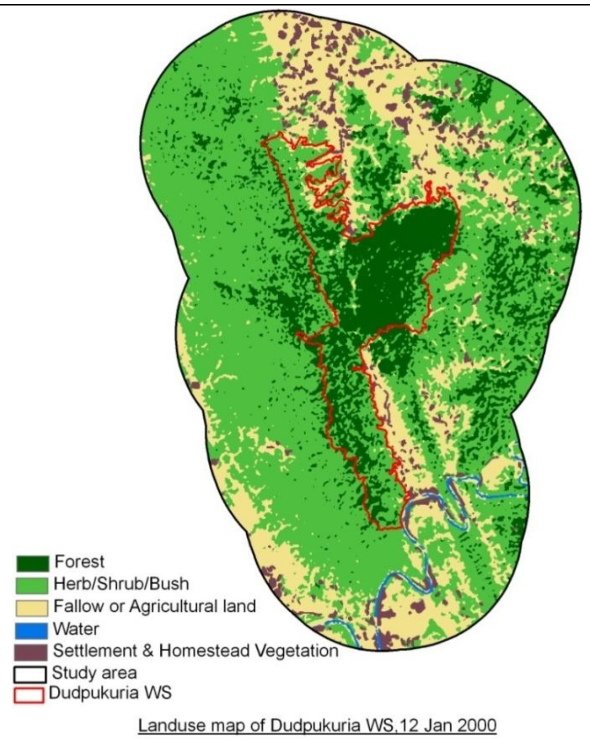
From Table 3.2 it is evident that the forests covers decreased during the period 2000-09 in TWS, INP, MKNP and FKNP, whereas in DDWS and SKRF forests covers increased due mainly to plantation projects under which some degraded areas have been planted over the period. The same trend is noticed during the period 1989-2000, except that there is slight increase in forests in FWS and MKNP again due to planting, and decrease in forests in DDWS and SKRF. As VCS requirement is to estimate forests cover changes during the previous 10 years, only the later period will be relevant in estimating deforestation rates. Except slight decrease in MKNP and DDWS, area under herb/shrub/bush category has increased over the period as a result of deforestation.

Land-use maps for the six PAs for the study period 1989, 2000 and 2009 are presented in the following six Figures 3.1 – 3.6.

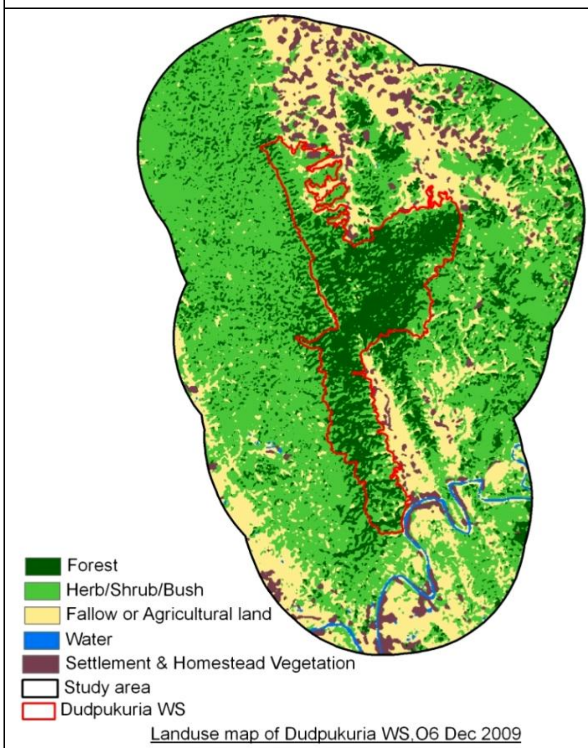
Figure 3.1 Time series landuse/landcover map of Dudpukuria-Dhopachari Wildlife Sanctuary



(a) Landuse/landcover map 0f 1989

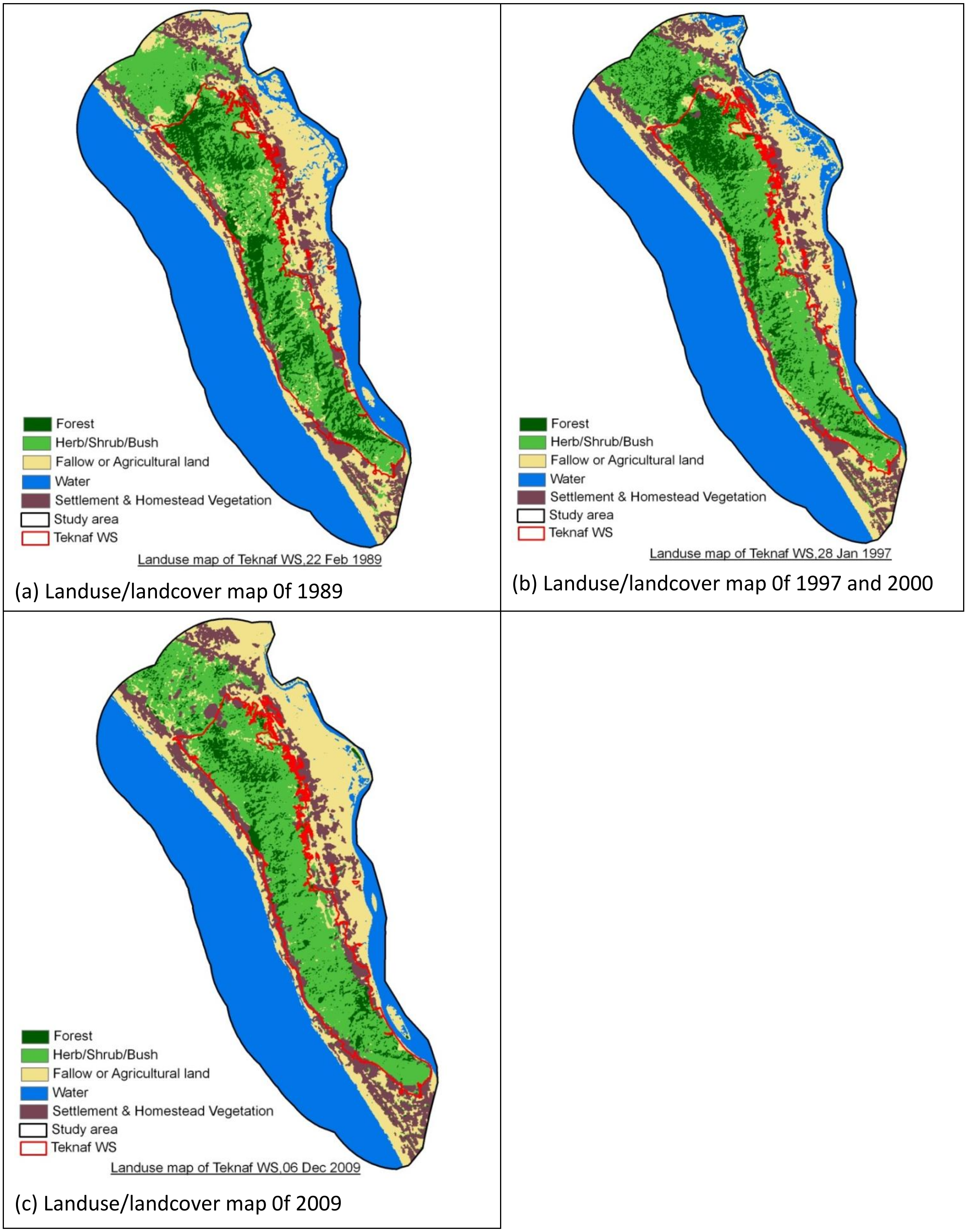


(b) Landuse/landcover map 0f 2000



(c) Landuse/landcover map 0f 2009

Figure 3.2 Time series landuse/landcover maps of Teknaf Wildlife Sanctuary

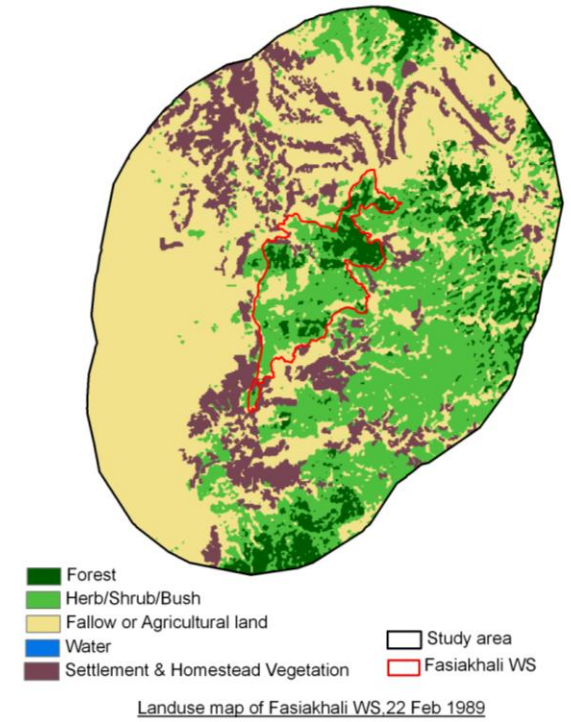


(a) Landuse/landcover map 0f 1989

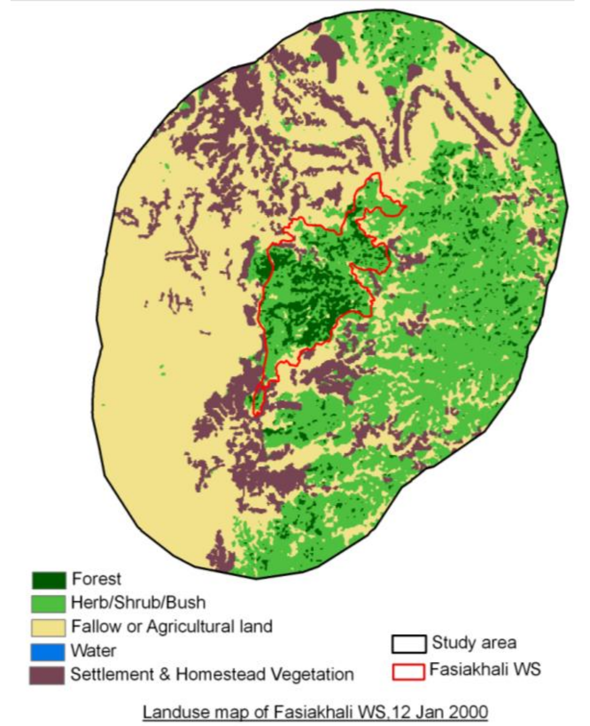
(b) Landuse/landcover map 0f 1997 and 2000

(c) Landuse/landcover map 0f 2009

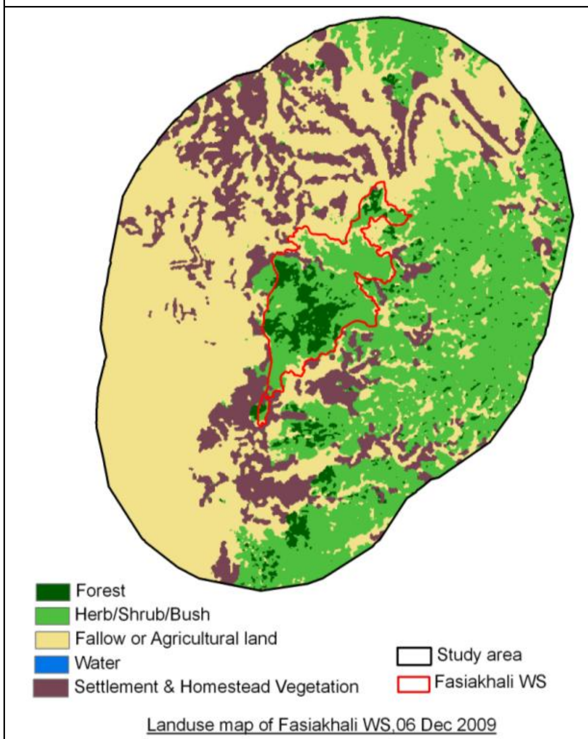
Figure 3.3 Time series landuse/landcover map of Fasiakhali Wildlife Sanctuary



(a) Landuse/landcover map 0f 1989

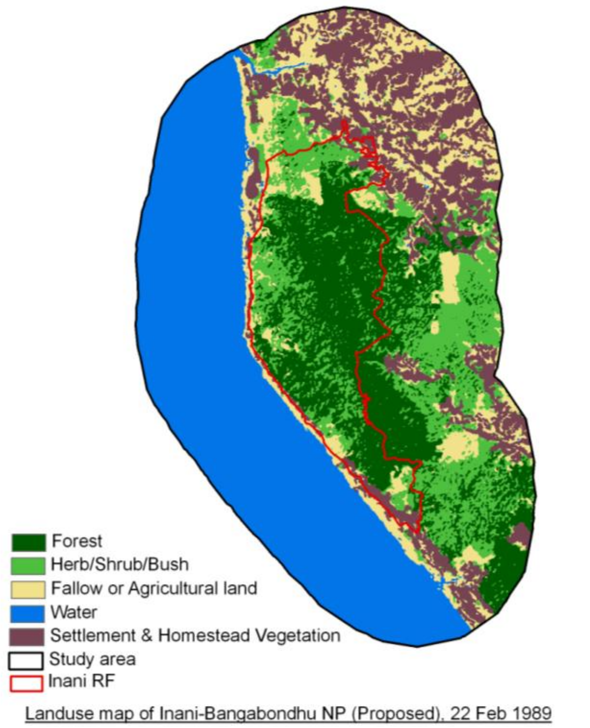


(b) Landuse/landcover map 0f 2000

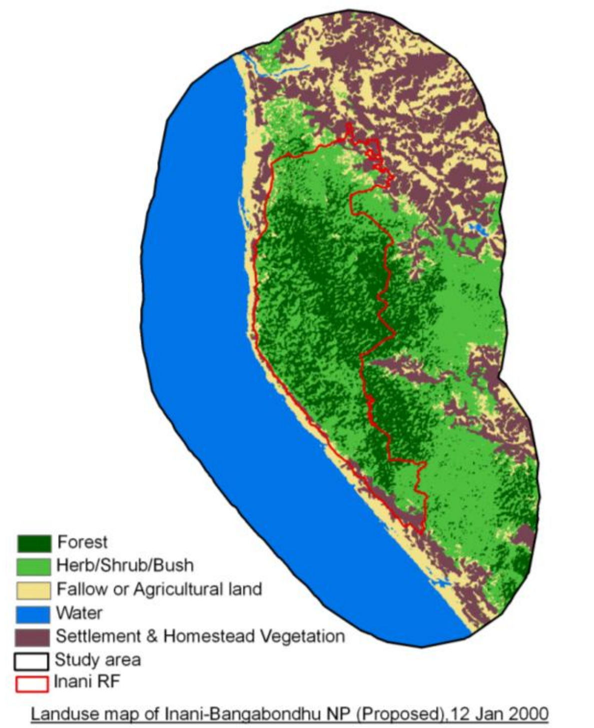


(c) Landuse/landcover map 0f 2009

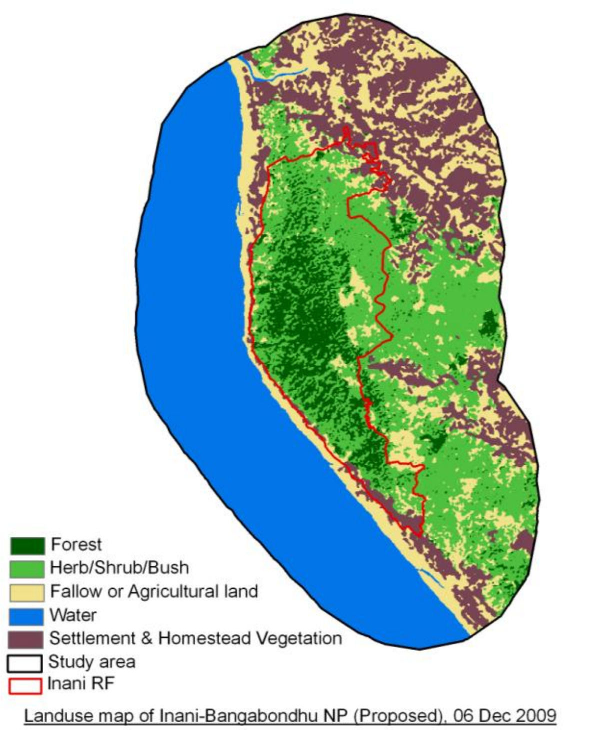
Figure 3.4 Time series landuse/landcover map of Inani-Bangabondhu National Park



(a) Landuse/landcover map 0f 1989

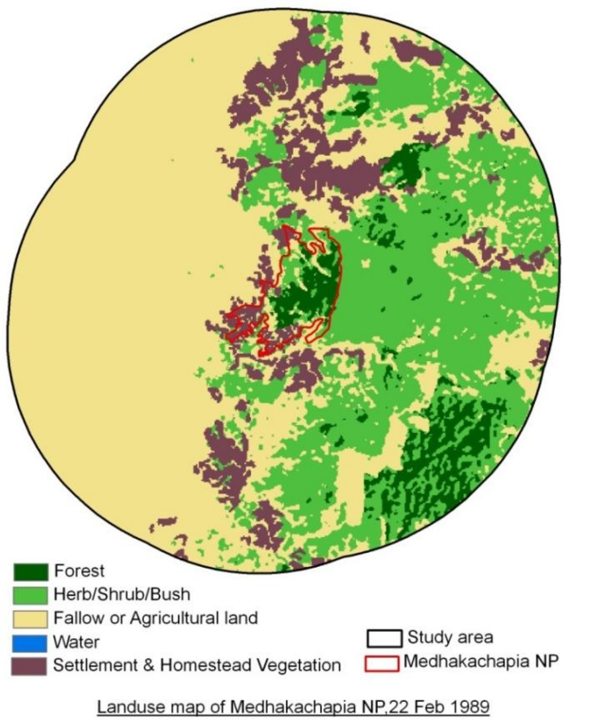


(b) Landuse/landcover map 0f 2000

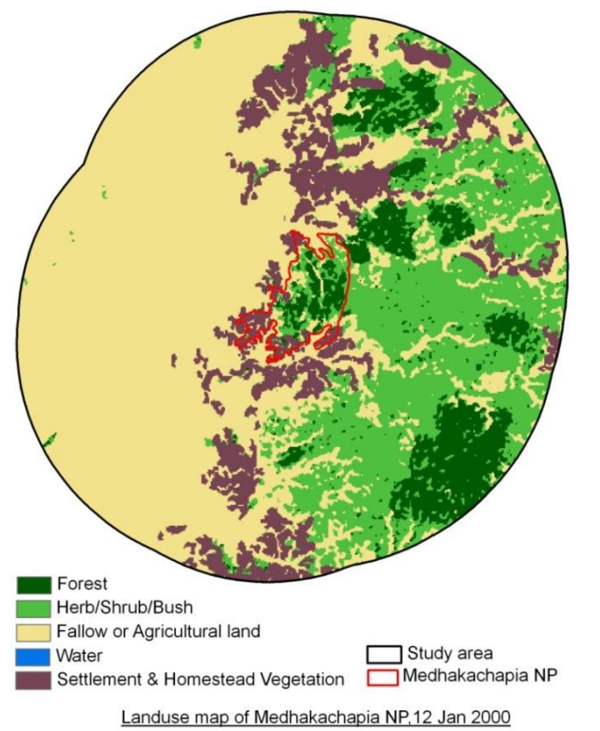


(c) Landuse/Landcover map 0f 2009

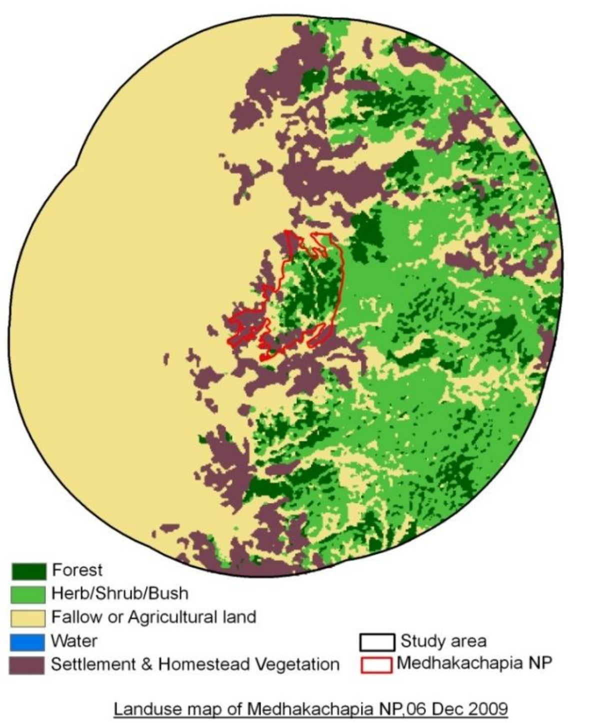
Figure 3.5 Time series landuse/landcover map of Medhakachapia National Park



(a) Landuse/landcover map 0f 1989

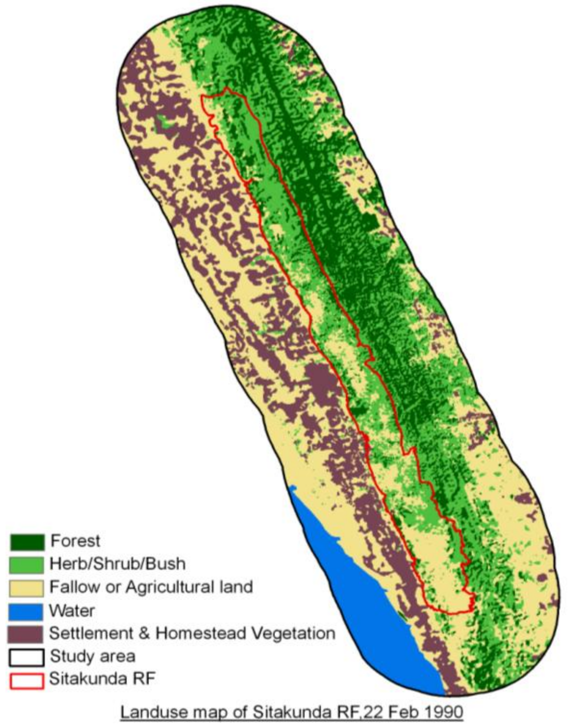


(b) Landuse/landcover map 0f 2000

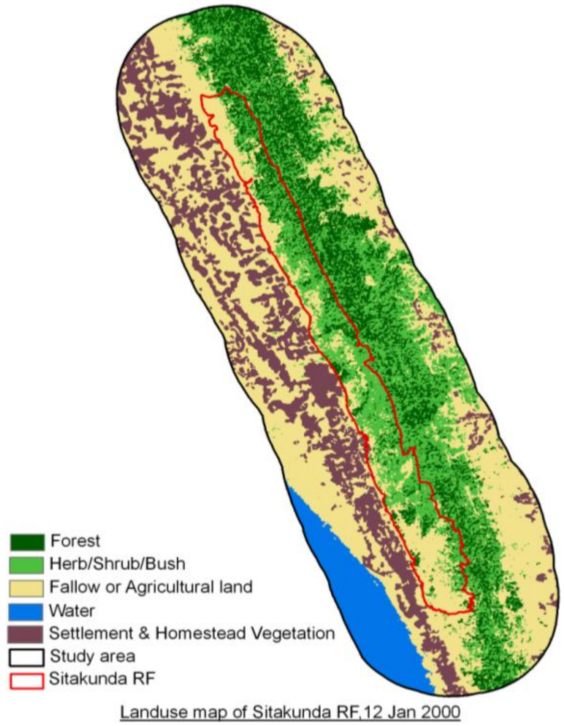


(c) Landuse/landcover map 0f 2009

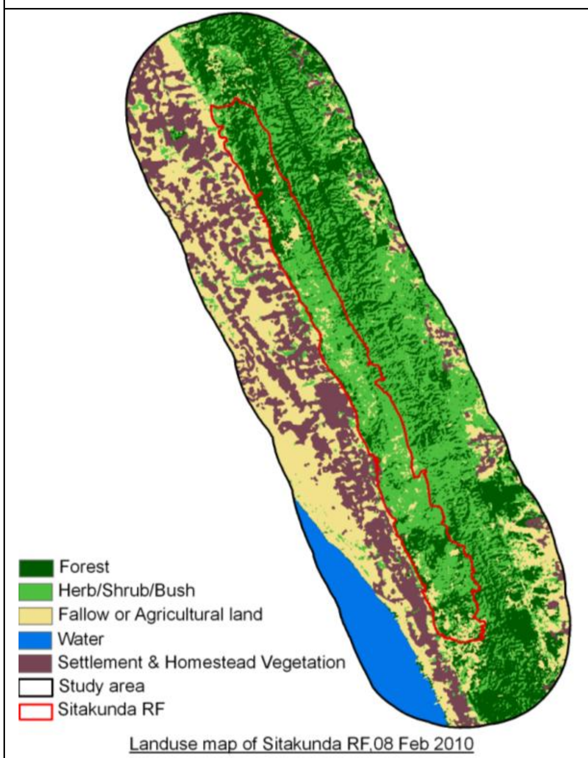
Figure 3.6 Time series landuse/landcover map of Sitakunda Reserve Forest



(a) Landuse/landcover map 0f 1990



(b) Landuse/landcover map 0f 2000



(c) Landuse/landcover map 0f 2010

3.3 Carbon Pools

Most international standards divide forests into roughly four carbon pools: 1) aboveground and belowground biomass of live trees, 2) non-tree vegetation, 3) forest floor (litter and dead wood), and 4) forest 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 six PAs carbon assessment, consultation with FD personnel suggested a recommendation to measure trees, non-tree vegetation, leaf litter and dead wood has substantial biomass, and forest soil. Trees are the most susceptible to land use activities, forest floor including dead wood, and non-tree vegetation may be a significant biomass component which may change significantly.

Methods for measuring trees, non-tree vegetation, and leaf litter and dead wood were adapted from relevant IPCC-associated sourcebooks (see the manual, IPAC 2010, for full descriptions of measurements for each C pool). 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, leaf litter and dead wood samples were collected and weighted, and soil samples were collected for the sample plots and analysed in the soil laboratory of the BFRI at Chittagong.

3.4 Determining Type, Number, and Location of Measurement Plots

Sourcebooks describe options for ‘permanent’ sample plots, in which all trees within plots are tagged and tracked through time, or ‘temporary’ sample plots, in which trees are not tagged. In the latter method, trees are treated like other C pools and are tracked at the plot level over time, rather than as individuals. For the time and logistical constraints imposed by field work, it was recommended here that trees are not tagged.

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 microsite variation in vegetation, thereby reducing among-plot variation (increasing overall precision). For the six PAs carbon assessment, a clustered plot composed of five circular subplots was employed, thus taking advantage of the increased precision of clustered sampling.

3.5 Field Inventory Design

Field inventory design and planning was very important for arriving at precise estimates of baseline carbon pool in the project area (co-terminus with the gazetted PA area) and so a Tier 3 approach (per IPCC sourcebooks) was adopted for field inventory and carbon assessments. A rigorous carbon inventory was designed and implemented by FD and IPAC field staff. A field manual (IPAC, 2010) with required formats was developed in Bangla and training was imparted to the field crews including the six ACFs who acted as team leaders of the field inventory teams. It may be desirable to stratify the project area into subpopulations or strata that form relatively homogeneous units. Fewer plots may be needed to achieve the same precision because each stratum should have lower variation within it. Stratification could be based on, for instance, land-use or vegetation type, but should be carried out using criteria that are directly related to the variables to be measured, in this case, the carbon in forests of the six PAs. Based on field assessments and discussions with the local FD field staff, the entire PA area was divided into two strata of good forests and degraded forests of herbs/shribs/bush. Carbon results from similarly located Chunoti Wildlife Sanctuary (a CDM A/R proposal was developed under NSP, FD 2008) were used in estimating the mean and standard deviations (s) based on which number of sample plots (n) were estimated for each of the six PAs by employing the following formula:

$$n = [(N_1 \text{ x } s_1) + (N_2 \text{ x } s_2)]^2 / [(N \text{ x } E)^2/t^2 + (N_1 \text{ x } s_1^2) + (N_2 \text{ x } s_2^2)]$$

where, N = Total no. of plots

N_1 = No. of plots in stratum 1

N_2 = No. of plots in stratum 2

s_1 = standard deviation in stratum 1

s_2 = standard deviation in stratum 2

E = standard error

Total no. of plots were estimated for different PAs as : 41 plots for MKNP, 72 plots for FKWS, 62 plots for DDWS, 56 plots for INP, 35 plots for SKRF and 54 plots for TWS. Suitable square grids with appropriate minute intervals were laid out on the maps (developed by the Resource Information Management System, RIMS of FD) depicting these plots. Plot locations can be selected randomly or systematically (plot grid with random origin). However, if some parts of the project area have higher carbon content than others, systematic selection usually results in greater precision than random selection. As systematic sampling is also easily recognized as credible, it was adopted for the field inventory.

3.6 Field Inventory

Forest field inventory, was conducted by six inventory teams, each headed by the concerned ACF from the Divisional Forest Office, between April and July 2010 in each of the protected areas to collect data on growing stock, biomass, litter and dead organic matter, and soil required for establishing the carbon baseline. The field inventory teams started field training, during which the plots were surveyed for understanding the use of field equipments and methods. Officials from the 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. IPAC organized the logistics including the hiring of labor for the team, medical support, and purchasing miscellaneous supplies. Six field inventory groups, each consisted of one ACF, two foresters/FG, two students, two laborers, and the concerned Performance Monitoring And Applied Research Associate (PMARA) of IPAC. The team leaders and some of the students had participated in the training. Some of the students had earlier participated in similar inventory in the Sundarbans (FD, 2011). The team leaders worked mostly as recorders and reviewers of data. The foresters and students worked as enumerators. Before starting field work each day, the groups sat together with detailed maps and GPS units to plan for the next plots. Local knowledge of laborers, guards, and FD staff aided the crews' efforts to find suitable routes to plots and minimize hiking time. Generally each group completed 2-3 plots per day, but often this pre-planning activity helped the groups to complete more than 3 plots a day.

3.7 Data and Sample Management

Field data were entered into computerized spreadsheets and backed up electronically in multiple physical locations. Strict precautionary measures were taken in the process of data collection and data entry to minimize error (see QA/QC section below). Completed data forms were checked and reviewed in the field. The data entry was reviewed by the IPAC staff. At the end of the inventory, completed data forms were stored in physically secure locations (Forest Department/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 and IPAC offices. Soil samples were air-dried in the field, oven-dried to constant mass at 60 °C at the IPAC cluster office, then sent to Chittagong for carbon analysis. Soil carbon analyses were conducted in the laboratory of the soil sciences division of the BFRI.

3.8 Baseline Carbon Stocks

A manual (IPAC, 2010) was developed, both in English and Bangla, for field inventory by the field crew and different estimation methods adopted for assessing baseline carbon stocks. Aboveground and root carbon pools were computed using both published documents mainly of the BFRI and FD and locally derived allometries (via destructive harvests of various shrub species outside the plots). Local tables of wood density by tree species as published by the BFRI were used in estimation of biomass whereas internally accepted conversion factors were used for the estimation of carbon. Based on the analyses of the data collected, the carbon baseline was established, which is summarized in the Table 3.3 as below:

Table 3.5 : Baseline carbon in different pools of the six Protected Areas

PA	Live trees (Ct/ha)	Dead trees (Ct/ha)	Saplings (Ct/ha)	Seedlings (Ct/ha)	Bamboo (Ct/ha)	Cane (Ct/ha)	Leaf litter (Ct/ha)	Below ground (Ct/ha)	Total C (Ct/ha)
DD WS	**65.306**	**0.555**	**5.209**	**0.022**	**16.05**	**0.081**	**1.252**	**16.98**	**105.46**
FWS	**74.848**	**0.524**	**5.418**	**0.357**	**1.770**	**6.232**	**1.554**	**19.46**	**110.16**
INP	**7.093**	**-**	**7.870**	**0.001**	**8.350**	**0.015**	**0.822**	**1.84**	**25.99**
MK NP	**126.93**	**5.96**	**9.85**	**0.01**	**10.31**	**0.12**	**1.57**	**33.00**	**187.75**
SK RF	2.06	0.12	19.09	0.00	0.00	0.00	0.70	0.54	22.51
TWS	9.56	-	7.96	0.004	20.90	0.24	1.93	2.49	43.08

3.9 Soil Carbon Stock

Forest soils of the six PAs occur with different soil associations under the Agro-Ecological Zone-29. Textural class is sandy loam to clay loam, and the reactions of all the soil profiles are moderately to strongly acidic. Soil color in the field conditions is light yellowish brown to yellowish red and topsoil is mostly brown. Land capability classes of the sites are poor to moderate.

Biological factors contribute in the rapid breakdown of litter. Organic matter, a carbonaceous substance, is the remains of plants, animals and microorganisms, which are continuously assimilated/decomposed into the soil by other microorganisms. The decomposition of organic matter starts increasing from the onset of monsoon, reaches its peak during October-November and then continues declining up to April when it stabilizes. Organic matter acts as depository of plant nutrients and increases water holding capacity of soils, thereby enhancing water availability to plants. Over a period, organic matter is gradually lost from the soil as carbon dioxide, produced by microbial respiration. To compensate that loss the soil needs repeated addition of new plant and/or animal residues. Sequestered CO_2 in plant tissue eventually becomes part of soil organic matter. If biological sequestration does not take place then more CO_2 would accumulate in the environment, causing warming of climate.

Three parameters (soil depth, soil bulk density and organic carbon concentration) were evaluated to accurately quantify the soil carbon pool. The grid maps of the 6 PAs were used in carrying out the soils survey in the core zones. Since most soil carbon is in the top horizon and this is the most vulnerable to land-use change, a 30 cm soil profile was considered most appropriate. The top 30 cm is where much of the soil carbon resides – especially near the surface, and tapering quickly with depth. Two soil samples from the soil depth of 0-15 cm and 16-20 cm were taken from each of the subplots of all the plots with the help of a slide hammer (cylindrical augur).

A core sample is taken near the center of each subplot with the goal of obtaining a sample as undisturbed as possible. The field crew moved 1 meter from subplot center in a random direction and removed any organic litter from the surface of the sample point. Then steadily the team inserted the auger vertically into the soil by using the sliding hammer until the top of the sampler is level with the soil surface. When the augur did not penetrate to the full depth, the team tried another nearby location. After pulling out the augur out of the soil, the two cylindrical rings from the middle (one from 10-15 cm and another from 16-20 cm) were removed and soil samples taken out for keeping in numbered polythene bags.

Soil samples were air dried as much as possible before storage and transport to the FRI laboratory where they were combined (5 subplot samples combined each for 10-15 cm and 16-20 cm soil depth), oven dried (soil sample kept in a foil and dried at $60^{o}C$ for % organic carbon and bulk density), weighted and analyzed for bulk density and organic carbon (OC) percentage. The samples were dried for at least 48-72 hours (until a constant mass is attained, meaning no more water is present), weighed on a digital scale, and sent to laboratory for carbon analysis.

Considering morphological properties, texture and color, the samples were processed and analyzed for organic carbon determination and bulk density assessment. Organic carbon was determined by wet oxidation method. The air-dried samples were used for carbon determination. Organic matter content was determined by multiplying organic carbon by the constant factor 1.724. Per hectare organic carbon/matter was estimated by employing the furrow slice soils quantity per hectare (i.e. $2.2x10^6$ kg/ha). Bulk density (g/cm^3) was assessed from oven dried (OD) weight - O.D weight of the soil divided by the volume of the cylinder with 5 cm height, and radius as 0.0240 meter.

Bulk density relates to the combined volumes of the solids and pore spaces. Soils with a high proportion of pore space to solids have lower bulk densities than more compact soils having less pore space. So any factor that influences soil pore space will affect bulk density. Increase in bulk density usually indicates a poorer soil environment for root growth, and reduced aeration and infiltration. Fine textured surface soils such as silt loams clays, and clay loams generally have lower bulk densities than sandy soils. The solid particles of the fine textured soils land are organized in porous grains or granules, especially if adequate organic matter is present. This condition assures high total pore space and a low bulk density. In sandy soils, however, organic matter contents are generally low, the solid particles lie close together, and the bulk densities are commonly higher than in the finer textured soils.

The analytical results of %OC and soil bulk density of the six PAs are presented in Table 3.4. The average bulk density was found in both 10-15 cm and 16-20 cm sub-stratum of all the six PAs. In the topsoil many fine roots were found, which might have effect in lowering bulk density. The analysis showed that surface soils contain more organic matter and pore space than that of sub-surface and sub-stratum soils. The soils of same location showed different bulk density. Even in soils of same profile, significant differences in bulk density were found. This means that bulk density varies from soil to soil, and also with soil depth (the bulk density is higher in lower strata of the profile).

Heavy rainfall in monsoon influences the eluviations of finer soil particles that might cause higher bulk density of lower strata of the soil profiles. Bulk density values for the crop combinations of paddy, paddy and other cereals, banana, and forests showed the values as 1.45, 1.52, 1.39 and 1.53 g/cm^3 respectively (Anon., 2007). The study areas have similar bulk densities as in case of the depleted shifting cultivation (locally known as *jhum*) fields of hilly areas. Very compact sub soils have bulk density of 2 or more, whereas a typical arable surface soil may have bulk density as 1.1 g/cm^3. The bulk density values estimated in this soil study indicate the stage in between the 2 and 1.1g/cm^3.

Table 3.6: Soil Organic Carbon in Six Protected Areas

Protected Area	Soil depth (cm)	Bulk density (gm/cm^3)	% Organic carbon	Soil carbon (ton/ha)	Average soil carbon (ton/ha)
DDWS	10-15	1.50	0.820	5.99	5.33
	16-20	1.48	0.640	4.67	
FKWS	10-15	1.53	0.625	4.56	4.56
	16-20	1.58	0.625	4.56	
INP	10-15	1.21	0.615	4.49	4.19
	16-20	1.21	0.532	3.88	
MKNP	10-15	1.64	0.402	2.94	3.03
	16-20	1.60	0.426	3.11	
SKRF	10-15	1.10	1.170	8.54	7.78
	16-20	1.27	0.960	7.01	
TWS	10-15	1.48	0.948	6.92	6.23
	16-20	1.29	0.757	5.53	

3.10 Quality Assurance / Quality Control

Quality assurance / quality control activities were emphasized from the outset of the field inventory. Field procedures were subject to strict oversight and review by the project leaders. 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. The latitude/longitude points in the GPS were duly checked by the team leaders. Each completed data sheet was reviewed in the field. The bottom of every data sheet provided 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. Once satisfied by the quality of data recorded, the data reviewer recorded their name and the date of the review, along with any notes on issues that were noticed during the check so that they can be prevented in the future. The soil samples were re-packed from the plastic sample containers to whirl packs/zip bags after air drying. The team leaders monitored these processes to minimize mistakes. Completed data sheets were filed separately by plot and stored in a safe location. Upon return from sampling trip, a copy of each data sheet was made and kept in the IPAC offices. 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. They also visited a subset of plots from where data had already been collected two months earlier, to check for actual visitation and accuracy of measurements (the plots were re-sampled by the crew with the officials present). It was found correct with the previous data, and the marking tape was found precisely at the center of the plot. The officials were satisfied with the quality of inventory work.

The data entry process was also conducted very carefully. 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 highly 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 and IPAC offices. For data analysis, all data steps were recorded in understandable fashion in spreadsheet files, with separate meta-data documenting how various decisions and approaches were arrived upon during the computations.

4 Project Impacts

Both environmental and socio-economic impacts of the project interventions are assessed for the six PAs as discussed below:

4.1 Environmental Impacts

By protecting existing forest patches and by targeting degraded areas within the forest reserves for reforestation and revegetation through enrichment planting of indigenous species and assisted natural regeneration, the project is expected to have numerous positive environmental impacts, including an increase in forest cover in the protected areas; improvements in natural regeneration through aided regeneration techniques; decreased soil erosion in the identified micro-watersheds; improved control of illicit felling, forest fires, poaching, and grazing; conservation of unique ecosystems and biodiversity, including the habitats and breeding grounds of endemic, rare and endangered species, such as the Asian Elephant in TWS, MKNP, Inani and DDWS; and enhanced aesthetic value of the protected areas for eco-tourism.

The project also will have the following beneficial environmental impacts related to project planning and design:

- Multi-story natural and enriched vegetation
- Retention of ground flora stemming from prevention of clear felling and burning during enrichment planting
- Retention of dead or hollow trees suitable for wildlife habitat
- Bush thinning *in lieu* of bush clear cutting during enrichment planting and weeding
- Wildlife fruit species as included in the species mix
- Micro-watershed identification, and water and soil conservation measures implemented by local communities
- Restoration of forests, promotion of aesthetic and recreational values, environmental improvement, and pollution abatement
- Poverty alleviation, improved governance, community empowerment, and enhancements in women's welfare, and gainful involvement of ethnic minorities.

The following beneficial environmental impacts will result from the operation of the project:

- Better stocked forests and constituent biodiversity
- Enhanced forest land productivity and soil fertility, and efficient nutrient cycling
- Effective community protection of forests
- Improved drainage and hydrological regime with watershed functions
- Livelihood and income support for local people
- Wage employment in project activities and self-employment as a result of livelihood activities
- Environmental amelioration
- Enhanced community participation in the protected area management
- Enhanced resilience and reduced vulnerability to climate change.

No significant adverse environmental impacts are foreseen, due to appropriate preventative and mitigation measures incorporated into the design of the project. For example, no exotic species are included in design of the enrichment plantations, and chemical fertilizers, pesticides and herbicides will not be used. Burning of vegetation before taking up any planting activities will be prohibited. Contour planting will be suggested, wherever appropriate, in identified micro-watersheds. As per the Wildlife (Amendment) Act, 1974, no commercial harvesting is allowed in the sanctuary and national park, and so no felling related damages are envisaged. Appropriate conflict resolution mechanisms will be put in place to enable the CMCs to resolve and manage conflicts. As enhancement of the protected areas is expected to lead to a rise in tourism to the forest reserves, efforts will be made to build CMC's capacity and involve them to a greater extent in tourist management to ensure that eco-tourism needs are met.

4.2 Socio-economic Impacts

This project seeks to use existing co-management mechanisms to implement forests protection, and reforestation and revegetation activities that mitigate greenhouse gases through avoided deforestation and forests degradation, and carbon sequestration and enhancement. By managing and implementing activities in conjunction with the co-management committees in the six PAs included in this project, several direct and indirect positive, and no negative, socio-economic impacts are anticipated. In terms of direct effects, the involvement of local communities through CMCs, VCFs, PFs and CPGs in the implementation (e.g. forests protection, enrichment planting, mulching, weeding, cleaning, coppicing, pruning, etc.) and monitoring of project activities will provide alternative income streams, and offer a disincentive for engaging in illegal exploitation of forest resources. Protection and enhancement of the forested areas will enhance their attractiveness to tourists and promote the development of eco-tourism, which will also provide members of local communities with alternative employment options. With more reliable incomes, the local communities will be able to reduce their livelihood reliance on forest resources. Moreover, any proceeds from carbon sales will be reinvested in the communities to address key needs identified by the CMCs, which will further advance poverty alleviation goals.

Regarding indirect impacts, leveraging the existing co-management committees will facilitate the engagement of different user groups, including marginalized segments of the population such as women, and ethnic, religious, and cultural minorities. Their engagement in project activities will serve the dual purpose of reducing their reliance on forest resources, thereby mitigating an important cause of deforestation and forests degradation, and empowering them to give them a more active voice in community decision-making. Furthermore, reforestation and revegetation will decrease erosion, bettering the quality of watersheds in hill forests, and act as a buffer from climate change impacts such as storms in coastal areas, enabling improvements in the health and security of forest villagers and of the communities in areas surrounding the protected area.

5 Project Design

5.1 Project Management Units

The BRAPAP is proposed to cover 33,344 hectares of forests in six project management units; each of the six PAs being treated as a separate unit having a project area and a reference region.

5.2 Problem Statement

Heavy biotic pressure brought by manifold increase in human population and consequent demand for agriculture and settlements have in past resulted in the loss and degradation of the country's forests in general and the six PAs in particular. Effective protection of the six PAs is necessary for ensuring the country's ecological and food security, conserving biological diversity and controlling adverse impacts of climate change. The ecological security of all the PAs needs to be ensured as habitat degradation and loss of wildlife have over the period taken place in the PAs as elsewhere in Bangladesh. The reserved forests of the 6 PAs were first established in early nineteenth century, during British colonial rule over India and what are now Pakistan and Bangladesh. The results of the PA mapping and carbon inventory conducted in 2010 show that the overall carbon stocks of the six PAs have decreased as these PAs have been subjected to frontier deforestation and mosaic forest degradation over the past couple of decades. It is this frontier deforestation and mosaic forest degradation that motivated the Forest Department to undertake the BRAPAP to reduce biotic pressures on the PAs, increase the ability of the Forest Department to achieve higher levels of protection and conservation, and to restore the areas which have experienced declining forests quantity and quality by implementing forests protection and carbon stock enhancement practices such as forests protection, reforestation through enrichment plantations, and revegetation through establishment of natural regeneration.

As one of the world's most impoverished countries, facing a wide range of development challenges and budgetary pressures, the Government of Bangladesh lacks the required resources to accomplish these goals using standard mechanisms of financing. A low level of value-added production both in the agricultural and industrial sectors combined with a difficult environment for tax collection limits the generation of adequate revenues to internally fund these activities. International donors concentrate their efforts on assisting Bangladesh in a range of initiatives from health and education to food security, and mitigation and adaptation to climate change.

The international carbon markets – whether voluntary markets in either the pre-compliance or social responsibility segments, or compliance markets searching for offset credits from non-traditional sources – provide potential means for Bangladesh to finance protection and restoration of the largest six PAs while also alleviating poverty among the communities in the project areas and the reference regions. The possibility exists to create a virtuous cycle of improving forests habitats, leading to improving livelihoods, leading to greater school enrollment, leading to smaller portions of the population relying on the forests, and leading to even more improvements in the habitats. Absent the revenue stream from sales of carbon offsets, the six PAs are likely to experience accelerating forests degradation and deforestation. This scenario could produce a greater challenge for Bangladesh in adapting to the impacts of climate change, as declining stocks of forests and forest produce including fuelwood, bamboo, grasses, leaves, roots, seeds, and medicinal herbs and shrubs will force people to cut more of the forest in a downward cycle of worsening poverty.

5.3 Proposed Solution to Problem

In order to accentuate the virtuous cycle of habitat and livelihood improvements, and to avoid the negative cycle of increasing deforestation and forests degradation and worsening poverty, the Forest Department on behalf of the Government of Bangladesh proposes a set of activities that will reduce deforestation and degradation through effective joint community patrolling, enhance carbon stock through reforestation, restore degraded forest areas through revegetation, improve livelihoods through conservation-linked value chains and alternative income generation activities, and increase biodiversity conservation both in the project area and reference region. These activities include the following:

1. Improved environmental governance of the six PAs through:
    a. Improved enforcement of existing laws and policies related to forests protection, leading to restored and revegetated forests;
    b. Strengthened capacity of Forest Department and CMC personnel responsible for managing the six PAs, including human resource skills, financial and communication resources, physical assets, and scientific knowledge; and
    c. Broader local community gainful involvement in the overall governance of the six PAs for climate, community and biodiversity objectives.
2. Socio-economic growth options for communities living within the project and reference regions, primarily through the following:
    a. Implementing identified conservation-linked value chains and livelihood activities including tree nurseries, improved horticultural and agricultural practices, handicrafts, fisheries and eco-tourism; and
    b. Equitable benefits sharing with local communities from the government revenues accruing through entry fee to PAs/forests
3. Improved functionality and delivery of tangible and intangible ecosystem services through:

a. GHG removals and carbon enhancement through habitat restoration from improved conservation by gainfully involving local communities in forests and biodiversity protection; and

b. Biodiversity protection and conservation with specific actions linked to key Red List species.

4. Enhanced forests and carbon stocking through:

a. Reforestation through enrichment planting in identified patches; and
b. Revegetation by establishing natural regeneration through assisted natural regeneration technologies

5.4 Land Ownership

The six PAs are owned by the State, represented by the Forest Department as the authorized agency acting on behalf of the Government of Bangladesh in management and operation of the PAs under the Forest Act, 1927 and its amendments and the Wildlife (Preservation) (Amendment) Act, 1974. Permanence of emission reductions and removal enhancements will follow from increased and effective enforcement of existing laws and policies, as well as reduced pressures by involving local community through livelihood interventions to be implemented by the CMCs.

5.5 Participatory Monitoring

The proposed project monitoring activities will be implemented by the Project Proponent, the Forest Department, collaborating with the co-management committees, representing the communities in the project and reference regions. Increased enforcement will include joint community patrolling along vulnerable boundaries by FD field staff in collaboration with the members of community patrolling groups and the CMCs, with the co-benefits of contributing to emissions removals through carbon sequestration and enhancement, and providing skill development and grants in kind for conservation-linked livelihood enterprises for the community members. To the extent possible, members of the communities within the project and reference regions will be engaged in the project activities, including undergoing training and providing with equipments necessary for participatory monitoring of carbon stocks, populations of at-risk species, and violations of law enforcement.

5.6 Community Benefits

Majority of the people in the project and reference regions are primarily poor and ultra-poor households engaged in subsistence agriculture, artisanal fishing, and non-commercial extraction of natural resources. The livelihood enhancement component will generate greater household revenues for many of the villages, with the target being to have a critical mass of households earning tangibly greater revenues from livelihood activities that they are less inclined to engage in natural resource extraction from the six PAs and neighboring forests that might result in their degradation. Non-destructive extraction of non-timber forests products (NTFPs) in the six PAs will be among the options to be pursued during the project implementation period for the benefits of local community, based on an equitable benefits sharing mechanism.

5.7 Biodiversity Benefits

The principal biodiversity benefits from the BRAPAP will be the conservation of habitat for several keystone species that are Red Listed as Critically Endangered, including the Elephant. Main biological diversity values of the six PAs include providing suitable habitat to the biodiversity of global significance, comprising both terrestrial and aquatic flora and fauna; habitat connectivity; and sustenance of threatened and endemic species. Important ecological functions of the six PAs include climate change mitigation through carbon sequestration, enhancement and storage; conservation of waterbodies; coastal protection and climate change adaptation of forests ecosystems and local communities; inland and coastal fisheries; amelioration of environment; ecological and food security; etc. The six PAs provide significant scope for outdoor recreation, nature interpretation, conservation awareness, and wildlife education and research. They also are good sources of eco-tourism, aesthetic values, dense forest patches, elephant habitat, historical and cultural values, and scenic beauty. Their ecosystems are, however, fragile with rich biodiversity, which if not conserved timely, may be lost for future generations. Many conservation values of the six PAs can be characterized as regional public good but also have significant national and local conservation values.

5.8 National and Regional Benefits

As the project PAs are ecosystems of national significance, their conservation under BRAPAP will result in the flow of benefits that will mitigate climate change far and wide. The conservation of the project areas and their reference regions is critical for ensuring the country’s ecological, climate and food security. The forests and waterbodies of the six PAs are significant carbon sinks, necessary for addressing climate change both nationally and regionally. The forests of some of the PAs are not only the last remaining habitats of elephants but also important for other wildlife including birds and mammals. Intense forests-water interactions in some PAs such as TWS and INP result in high productivity, making the ecosystem very dynamic and useful both ecologically and socio-economically. Transnational biodiversity values ensue from the fact that the forests of some of the PAs such as TWS, INP and DDWS are in contiguity with similar transnational ecosystem values and significance.

5.9 Project Organizational Structure and Governance

The following management structures will be in place:

- As important platforms for local community participation recognized by the Ministry of Environment and Forests, the project will be implemented through the relevant CMCs; and
- As owners of the forest land in the protected areas, the FD will be responsible for the management of the forest lands and assets under the proposed project.

While the CMCs will largely be responsible for the implementation, management, and participatory monitoring of project activities, they will be supported by the FD, who will lead and/or guide the technical aspects of implementation of forestry related activities as well as provide necessary training to members of the CMCs, villagers, and other local communities involved in project activities. Partner organizations may also be involved in discrete implementation and monitoring activities as needed. One potential partner is the Community Development Centre (CODEC) which has, under IPAC, been interacting with the CMCs since their inception. It has extensive experience in transparent project management on behalf of poor communities in the country, and has the potential to play an important role supporting the CMCs and the FD.

In terms of financial management, in recognition of the CMCs still limited, but increasing, experience in this area, the FD and/or a partner organization with an experience of interaction with the CMCs as well as relevant grants management experience, may help with coordination of investor related activities. Assistance may include receipt and allocation of funding received from investors; monitoring of carbon prices; and financial transaction reporting. However, identification and selection of the beneficiaries would be done by the CMCs. Several layers of participatory monitoring will take place under the project. While the CMCs, with support from the FD, will be responsible for regular monitoring of project activities, including those in place to minimize leakage and the drivers of deforestation forest degradation, partner organizations will periodically assess impact, administration, and management as well as provide monitoring reports as per agreement with the FD and the CMCs, and based on approval from investor(s)/donor(s). In terms of financial management, there will be strict adherence to the transparency guidelines as required by the investor(s)/donor(s), and the Committees accounts will be audited as per the regulations of the Government Gazette establishing them. During meetings with the FD field staff and CMCs and other local stakeholders, they expressed general support for the idea of a carbon project, which they saw as a way of improving their livelihoods, increasing enforcement to exclude outsiders, and increasing ecotourism.

6 Project Interventions

The proposed project activities will focus on i) forests protection through joint community-FD patrolling of the remainder forests to avoid further deforestation and forests degradation, and ii) the application of reforestation (enrichment plantations) and revegetation (assisted natural regeneration) technologies. Project activities will result in protecting forests, establishing enrichment plantations using native and naturalized species, and revegetating through assisted natural regeneration by focusing on site-specific silvicultural and conservation practices.

6.1 Forests Protection

Main objective of forests protection measures is to provide effective protection to the constituent forests of the six PAs by following a co-management approach that will focus on establishing gainful partnerships with local stakeholders, but also simultaneously strengthening FD protection and communication mechanisms, and improving environmental governance. Main factors and actors responsible for deforestation and forests degradation, as identified below, will be validated and refined further after due field discussions with local stakeholders. Mitigation measures against the identified factors will be implemented by collaborating with local stakeholders by employing co-management platform developed under IPAC.

6.1.1 Main Drivers of Deforestation and Forests Degradation

A number of factors and actors contributing to forest degradation continue to adversely affect forest land and forest cover in the six PAs. Main factors that have contributed to the deforestation and degradation of these lands include heavy biotic pressure brought by high population growth and migration. These increases in population have resulted in or contributed to fuelwood collection for personal use as well as for sale and illicit felling of timber mainly for constructions. These anthropogenic pressures have contributed to the degradation of the forests, and poverty and limited livelihoods options are important factors in local community members' willingness to participate in these illegal activities, oftenly at the instigation of local elites, who sometimes advance resources including money to poor villagers *in lieu* of illicitely felled logs. These stressors are further exacerbated by the weak law-enforcement capacity of the FD, as well as high demand for the forest products by sawmill owners and illegal timber traders. The need for timber for boat making and fishing by local community is substantial and most of it is met through unauthorized removals, sometimes in connivance with local FD field staff. Poor facilities and salaries of the FD field staff in some cases exacerbate the illegal harvesting. Peripheral deforestation is threat due mainly to land hunger for cultivation and settlements for the growing population. Organized smuggling of timber occurs in forests that still have commercially important species such as teak and garjan and are located nearby big cities such as Chittagong and Cox's Bazar.

6.1.2 Controlling Deforestation and Forests Degradation

Though natural features demarcate parts of the six PAs, most of the boundaries of the six PAs are open and so accessible for illegal removals of timber and other forest produce. The boundaries of the PAs not covered by the natural features, will be surveyed, delineated and marked on the ground with concrete pillars (see NSP, 2007 and FSP, 2001 for the guidelines) at all important and/or turning points and will be labeled. The boundaries of the project areas and reference regions will be defined, mapped and marked on the ground by associating local stakeholders under the supervision of the concerned CMCs, preferably with wooden posts having legible inscriptions in Bangla for easy differentiation. While carrying out the demarcation, advantage of natural features (i.e. rivers, streams/creeks/khals, ridge, roads, etc.) will be taken, wherever possible. All the locations where primary access routes cross the PAs' outer boundaries will be clearly marked with signs indicating the name and summarizing key regulations in written text and symbols. Two types of signboards will be used, i) a well designed, large wooden signboard at Park and Sanctuary HQs, and ii) concrete signboard at other identified locations. A regular maintenance program by associating CMCs will be necessary for boundary and pillar renovation as some areas are vulnerable to natural calamities such as storms and cyclones.

Effective conservation of the PAs requires protection of forests and comprising biodiversity against illegal removal of the resources by employing local community and FD field staff. The FD posts responsible for protection are categorized as Forest Camps, and Range and Beat Offices. Forest Camps are exclusively tasked with patrolling whereas Range Offices and Beat Offices, in addition to patrolling and patrol monitoring, carry out forestry and land administration activities. As the existing staff are not adequate to provide effective protection to the forests, it is necessary to employ community patrolling groups for joint forest patrolling by following community patrolling guidelines (IPAC, 2011). The GOB has agreed to implement a co-management approach for managing the 6 PAs by involving key stakeholders. Accordingly, CMCs have been functioning to manage the 5 PAs, except SKRF. An equitable sharing of benefits of the forests protection and management among the stakeholders is an important part of a co-management approach. Establishing effective linkages of socio-economic and ecological incentives and biodiversity conservation is instrumental in eliciting stakeholders' participation in protecting, rehabilitating, conserving and sustainably managing the forests by building gainful partnerships based on shared rights and responsibilities.

Field monitoring will be employed as a tool for effective forests protection by employing selected indicators and taking corrective actions. Main participatory monitoring interventions will focus on, i) improving monitoring of field staff patrolling activities for controlling illicit felling and poaching effectively, and ii) establishing monitoring units in the identified areas. Monitoring by senior FD staff such as DFO and ACF will be strengthened by providing adequate equipments including vehicles, GPS, life saving devices and arms. Suitable monitoring indicators would include patrolling frequency, patrolling coverage and distance from the posts, quantity and quality of seizures, and the number of offence cases booked and offenders prosecuted.

A number of existing posts are lying vacant due to frozen recruitment of subordinate field staff. Main staffing recommendations focus on, i) recruiting field staff to fill all the existing vacancies particularly at the level of Forest Guards and Beat Officers, iii) and promoting/redeploying all the Malis as Forest Gaurds. Under physical work, main recommendations focus on, i) to establish adequate number of FD patrol vehicles, and provide for their regular maintenance and running costs in annual budget, and ii) to improve infrastructure including patrolling equipments such as GPS, flashlight, uniform, footwear, map and stationary, first aid box, and arms for defense. Main telecommunication recommendations for forests protection focus on, i) strengthening existing communication system by establishing walkie-talkie system and mobile phones for improved coordination for forests protection, and ii) providing GPS and laptops for internet access wherever feasible.

Enhanced protection by FD is needed particularly for combating organized smuggling by outsiders who are often armed and operate in groups. The strengthening of protection infrastructure and enhanced presence of field staff with local community including CPGs will help control organized smuggling. However, the protection of accessible forests cannot be ensured without gainfully involving key stakeholders including local community in the project areas and reference regions. Existing CPGs will be empowered and new CPGs will be formed whenever required by following the approved joint patrolling guidelines (IPAC, 2011).

Conservation-oriented management of the forests in the PAs with restrictions on the informal harvesting of forests through enhanced protection will result in high opportunity costs to local poor in terms of foregone benefits, which they were hitherto deriving from the unprotected forests before the implementation of strict protection/enforcements practices. Sustainable use of identified NTFPs including grasses and fish will, therefore, be allowed wherever possible for bonafide consumption *in lieu* of their protection efforts and increased opportunity costs. The protection efforts will be augmented through communication and outreach activities, public awareness, stakeholders' access to conservation-linked livelihood and value chain activities in the interface landscape zone.

6.2 Reforestation and Revegetation Technologies

Carbon sequestration activities for the six protected areas encompassed by the project would focus on reforestation and re-vegetation of degraded forest areas. Reforestation is defined as the direct human-induced conversion of non-forested land to forested land through planting, seeding and/or human-induced promotion of natural seed sources on land that was forested but converted to non-forested land, with many international standards using ten years as the minimum period for the duration of non-forested land. Enrichment of existing vegetation is required in those areas where natural regeneration can be accelerated by adopting appropriate silvicultural practices. Revegetation of degraded areas would be achieved through assisted natural regeneration technologies. Land-use assessments indicate that in all six protected areas, due to the level of degradation, reforestation through enrichment plantations activities are appropriate where currently neither forests/plantations exist nor natural regeneration comes up adequately. Suitable areas for enrichment plantations of indigenous species of trees and shrubs are where some vegetation currently exists due to natural processes of forest regeneration or where planting had been previously carried out but are presently degraded due to pressures such as illicit felling.

Successful implementation of this project would result in the re-vegetation of forests both through enrichment plantations and natural regeneration of indigenous tree species. With protection by the CMCs through employment of the existing CPGs, over the maturity period the forest cover would be enhanced by the development of mixed forests of indigenous species, resulting in a rich assemblage of vegetation with a top canopy of trees, semi-evergreen flora in the middle storey, and ground flora of herbs and shrubs. Enrichment plantations of indigenous and naturalized species are expected to develop a multi-storey structure with good vegetation over the project period. The enrichment plantations guidelines discussed in this section will be used for establishing and managing enrichment and block plantations for reforestation in the six protected areas, and will achieve the following objectives:

i. Encourage natural processes for regeneration and rehabilitation of forests ecosystems by providing effective protection against anthropogenic interference including illicit removals of forest produce, encroachment, poaching, grazing, and fire;

ii. Conserve constituent biodiversity by developing and maintaining enriched forests able to serve as habitats favoring wildlife, and

iii. Establish and manage enrichment plantations of local species through local stakeholders consultations and participation.

Project activities will focus on protecting forests and establishing enrichment plantations using native and naturalized species such as *Terminalia balerica, Melia azedarach, Artocarpaus chaplasha, Syzygium grande, Gmelina arborea, Dipterocarpus turbinatus,* *Terminalia chebula*, *Anthocephalus chinensis*, *Bombax ceiba*, and *Tectona grandis* in the case of the former, and *Artocarpaus chaplasha*, *Syzygium grande*, *Gmelina arborea*, *Lagerstromia speciosa*, *Shoria robusta*, and *Tectona grandis* in the latter. Enrichment plantations of species such as *Dipterocarpus turbinatus*, *Swintonia floribunda*, *Swintonia floribunda*, *Hopea odorata*, *Syzygium grande*, *Tectona grandis*, *Artocarpaus chaplasha*, *Lagerstromia speciosa*, *Albizia procera*, *Swintonia floribunda*, *Quercus speciata*, and *Microcos paniculata* will also be used, and in some cases, as in MNP and TWS, fodder plantations for flagship fauna species will be implemented utilizing species such as *Elaeocarpus floribundus*, *Zizipus mauritiana*, *Phyllanthus emblica*, *Syzygium cuminii*, *Artocarpaus chaplasha*, *Musa spp.*, and *Artocarpus heterophyllus*.

6.2.1 Reforestation through Enrichment Plantations

No block plantations (per ha 2500 seedlings planted at a spacing of 2 x 2 m usually) will be taken up in the project forest reserves due mainly to take advantage of natural regeneration that comes well in these high rainfall PAs. Existing vegetation will be enhanced by enrichment plantations (on an average 1000 seedlings planted per ha in identified gaps) of indigenous species which will be established in identified gaps of the core zone to supplement and complement natural regeneration through the project activities listed below. As appropriate, assistance from the co-management committees will be sought for putting in place suitable preventative and monitoring measures to control illicit activities such as felling of logs and extractive harvesting.

- Identification of suitable areas/gaps for enrichment planting.
- Advance closure (suitable protection measures against hacking, cultivation, forest land encroachment, grazing and forest fires) of identified areas.
- Collection and treatment of seeds, and development and maintenance of nursery of indigenous species.
- Cutting of unwanted bushes, climbers and tall weeds. Bushes not hindering natural regeneration will be retained for biodiversity, as well as for their creation of moist local conditions.
- Dead and hollow trees suitable for wildlife will not be removed.
- Half-moon trenches around the planted seedlings are suggested in the slopes as a means to conserve and trap soil, and retain soil moisture locally in the identified micro-watersheds.
- Weeding, beating up, and cleaning will be taken up as and when required. Normally weeding is carried out thrice during the second financial year and twice in the third financial year. The filling of vacancies, if required, will be done along with weeding.
- Coppice shoots will be singled, leaving two to three shoots per stool, during the second year for the regenerating coppice stumps that are to be dressed during the first year.

- Suitable species for enrichment plantations are mainly indigenous species that (in mixed planting) may include *Swintonia floribunda*, *Artocarpaus chaplasha*, *Swintonia floribunda*, *Syzygium grande*, *Dipterocarpus turbinatus*, *Lagerstromia speciosa*, *Shoria robusta*, and *Hopea odorata*.
- Monoculture will not be allowed, and cane will not be under-planted by clearing ground vegetation.
- Exotic species such as *Acacia auriculiformis*, *Eucalyptus camaldulensis,* and *Acacia mangium* will not be planted inside the project areas.
- Plantation of shrubs and herbs may be taken up around waterbodies (e.g. charas, ponds) by involving local stakeholders.
- Subsidiary silvicultural operations such as cleaning of weeds, climber cutting and freeing of natural regeneration from suppression will be taken up for encouraging natural regeneration. In coppicing species, stump dressing and stool thinning (retaining two to three shoots per stool) will be carried out. Existing bamboo and cane clumps will be decongested and managed.

Two main methods for species selection will be used for identifying suitable plant species for enrichment plantations. Framework species method involves the planting of a few species of pioneer and mid successional species along with a mixture of mature forest species. Framework species are those that establish and grow well in disturbed areas, which produce flower and fruits that attract animals quickly, and also have robust germination and vigorous production of branches and litter. Key stone species such as *Ficus* species attract many frugivorous animals to their fruits. This method is best suited for sites that are close to other seeds sources or habitats with populations of mammals and birds that can colonize and bring seeds into the restoration site. Maximum diversity method involves the re-establishment of as many of the original pre-disturbance species as possible. In sites with few adjoining seed sources or plant species that are locally extinct or have poor dispersal, this may be the only means to bring back plant populations in a restoration site.

6.2.3 Revegetation through Restoration and Assisted Natural Regeneration

Main factors responsible for deforestation and habitat degradation will be identified through stakeholder consultations. Mitigation measures against the identified contributors to forests degradation, including illicit felling, forest fires, grazing, encroachment, and poaching, will be implemented by collaborating with local stakeholders for the ecosystem restoration. Restoration in the 6 PAs will involve adopting a the process of returning degraded forests ecosystems to relatively undisturbed condition which they might have prior to biotic impacts. Here the emphasis of project interventions would be on returning the original assemblage of flora and fauna species and forests structure to the site by assisting the recovery (e.g. multi-layer vegetation, tree canopy cover, seed dispersal, decomposition and nutrient cycling, native species assemblages and diversity) of forests ecosystems of the six PAs that have been deforested and/or degraded. Forests protection as discussed above will be part of revegetation, though a number of other restoration interventions are simultaneously necessary to assist the recovery of the degraded forests ecosystems in the six PAs.

The following revegetation and restoration practices will be implemented for enriching the existing growing stock in and around the project areas:

- Reintegration of fragmented ecosystems and landscapes, rather than focusing on just a single ecosystem or landscape.
- Dead, dying and diseased trees will be salvaged, ensuring that some dead trees suitable for wildlife nesting remain. The collected forest produce will be equitably distributed among the members of local CPGs.
- Silvicultural operations including cleaning, coppicing, stump cutting and dressing, and stool thinning will be carried out, preferably along with the establishment of enrichment plantations.
- Bamboo clumps will be thinned to facilitate wildlife movement and promote elephant corridors.
- Habitat improvement works including rehabilitation of degraded forest areas, planting of fruit bearing shrubs and trees, development of palatable grasses in open space, thinning of existing plantations, maintenance of glades and waterholes, replacement of exotics by gradual canopy opening, eradication of weeds from glades and wetlands, soil and water conservation, waterbodies rehabilitation and development, and micro-watershed development will be conducted.
- Gradual opening of the top canopy in the existing exotic plantations will be taken up primarily to encourage natural regeneration of indigenous species. Removal of herbaceous understorey weeds and enrichment planting of a diversity of native species will be taken up in such areas.
- Targeted control of exotics, particularly invasive species, which pose ecological threat at landscape level. Targeted suppression practices may include cutting or uprooting of rootstock, hand weeding and pressing down of grasses with boards. Care should be taken in such weeding operations not to disturb soil or native vegetation as disturbances can lead to further proliferation of weeds.
- Waterbodies such as streams/*charas* and ponds in the project areas will be maintained for the use of both wildlife and local communities, whose participation will be ensured in their restoration and maintenance.
- Eco-restoration encourages and is dependent upon gainful participation of local people, particularly indigenous community dependent on nearby forests for their livelihoods.

6.2.4 Revegetation through Bamboo Clump Management

Bamboo forests in the six PAs have developed in some areas as part of plant succession in the degraded sites affected by illicit felling and forest fires. The CMCs will play key role in facilitating their growth as well as in managing mature clumps to ensure their decongestion and to prevent the hampering of natural and artificial regeneration of indigenous species. Participating households of CPGs will be allowed intermittent yields obtained through decongestion of mature bamboo clumps. Depending upon site conditions, the harvest of mature clumps will be done with a cutting cycle of three years that may be followed until the bamboo clumps flower or die. Old culms will be removed first from the centre of a clump, and not from the periphery, and enrichment plantations in bamboo areas will be taken up in identified gaps.

In addition to enhancing forests' productivity, managed bamboo groves whose canopy is manipulated appropriately will afford protection to young seedlings. Over a period of time bamboo will form as a middle-storey in the reserve forests and will provide good soil cover, enhancing the moisture retention capacity of forest soils. Natural regeneration would benefit from a protective umbrella, enabling young seedlings to flourish, free from danger of being trampled, grazed and browsed.

6.2.5 Revegetation through Grass Management

Grasslands have evolved in some parts of the 6 protected areas under an unplanned system of forest fires, forest grazing, and site deterioration caused by deforestation and forests degradation. Existing grasslands continue to be promoted by heavy biotic pressure. The grasses have short maturity and long life cycles, as they sprout back almost instantaneously after being cut. They can support a rich diversity of fauna including elephants in open grass patches, and are efficient in absorbing rain water. Protection, development and sustainable use of the grasslands (*sunkholas*) patches in the six protected areas are important as a large number of poor people depend on them for their livelihood by selling it in local markets as thatch roof material. In addition, sporadic patches of grasslands are good for elephants, which regularly use them as their movement corridors, and grassland patches interspersed with enrichment plantations, will attract bird species and other fauna.

Excessive exploitation of the sunkholas have made them unsustainable, and immediate interventions are required for restoring the degraded sites. A controlled use of grasslands through rotational harvesting will help to prevent unsustainable exploitation, and special groups of grass users may be formed and linked with the CMCs. The CMCs will employ the existing CPGs in controlling forest fire, forest grazing and illicit felling of both trees and grasses.

6.2.6 Nursery Development and Planting

As almost all the recommended tree species are slow growing indigenous species, nursery preparations should be started at least one year in advance of planting season. Seed collection from the identified trees will be initiated in order to develop nurseries for producing one year old seedlings for planting. The co-management plans for the six protected areas as prepared by the CMCs will be referred to for following management precriptions. Possible sources of mother trees, seed collection methods and calendar, storage and treatment of seeds, seed testing, seed sowing, potting media, filling and staking of polybags, watering of seedlings, grading and hardening of seedlings, and record keeping will be ensured. Suitable guidelines on appropriate planting practices, including site preparation, planting of potted seedlings, weeding, casualty replacement, and maintenance of plantations will be followed as per the standard practices of FD.

6.3 Project Organizational Structure, Governance and Community Participation

Due to differences in the capacity of the CMCs from site to site, the organizational and management structures of project activities may vary slightly depending on the protected area. However, the following will be integral aspects of the management structures in all the 6 protected areas:

- As important platforms for local community participation, recognized by the Ministry of Environment and Forests, the project will be implemented through the relevant CMCs; and
- As owners of the forest land in the protected areas, the FD will be responsible for the management of the forest lands under the project and the protection of forests as per the provisions of relevant Acts.

It is envisioned that in most protected areas, the organizational and management arrangements will be similar to what is laid out in this section. However, modifications may be made depending on the capacity of a particular CMC as well as of the availability of local organizations that may be enlisted as partners for various project activities. While the CMCs will largely be responsible for the implementation, management, and monitoring of project activities, including approving the selection and contracting of the necessary staff, they will be supported by the FD, who will lead and/or guide the technical aspects of implementation of forestry related activities as well as provide necessary training to members of the CMCs and CPGs, forest villages, and other local communities involved in project activities. Other relevant organizations may also be involved in discrete implementation and monitoring activities, as needed. Assistance may include receipt and allocation of funding received from investors; monitoring of carbon prices; and financial transaction reporting. However, identification and selection of the beneficiaries would be done by the CMCs.

Several layers of monitoring will take place under the project. While the CMCs, with support from the FD, will be responsible for regular monitoring of project activities, including those in place to minimize leakage and the drivers of forest degradation, partner organizations will periodically assess impact, administration, and management as well as provide monitoring reports as per agreement with the FD and the CMCs, and based on approval from investor(s)/donor(s). In terms of financial management, there will be strict adherence to the transparency guidelines as required by the investor(s)/donor(s), and the Committees accounts will be audited as per the regulations of the Government Gazette establishing them.

6.4 Project Financial Structure

The following estimated costs for reforestation through enrichment planting, revegetation through assisted natural regeneration and eco-restoration, and forests protection through joint community patrolling were collected directly from the FD field offices. As per the FD's approved planting cost norms, a Tk. 23 is the total cost for establishing one seedling and this includes seedling cost, planting and two years maintenance costs. The total cost of Tk. 23,000 will therefore be incurred in enrichment planting of on an average 1,000 seedlings per ha. An enhanced rate of Tk. 25,000 per ha is taken as the cost for reforestation through enrichment plantations, considering inflation. For revegatation and eco-restoration, a total cost of Tk. 15,000/ha on an average is estimated for the six PAs. Total cost of Tk. 10,000/ha is provided for forests protection activities jointly by the CMCs and FD field staff. The total cost for the integrated forests protection, reforestation and revegetation thus works out to be Tk. 50,000/ per ha. The total cost for the integrated forests protection and revegetation works out to be Tk. 25,000/ per ha. The total project costs are approximated to be Tk 1030 million, and are broken down by the three main activities (integrated forests protection, reforestation and revegetation; integrated forests protection and revegetation; and forests protection) for each of the six protected areas in Table 6.1 as below:

Table 6.1: Physical and Financial Targets of Project Activities

Protected Area	Forests Protection, Revegetation and reforestation (ha in project area)	Forests Protection and Revegetation (ha in project area)	Forest Protection (ha in reference region)	Total costs (Tk. million)
DDWS	2,500	1,904	6,465	237.25
FWS	800	268	675	43.45
INP	2,500	3,432	2,728	238.08
MKNP	250	-	1,011	22.61
SKRF	5,000	2,237	12,696	432.92
TWS	5,000	4,618	2,089	386.34
Total	**16,050**	**12,459**	**25,664**	**1,360.65**

A revolving fund will be set up at the CMC level by depositing an initial seed money of Tk. 60 million and the amount accrued through the fifteen percent overhead (15% of Tk. 1030 million) which will be charged by the CMCs when implementing project activities. The CMCs, who will implement the project over the period of 40 years, will use these funds to set up a revolving fund to support livelihood activities, through the extension of microcredit (with 5 percent service charge), for the members of the CPGs responsible for forests protection and project monitoring. An amount of USD 1 million is earmarked for the monitoring of project outputs and capacity building of FD field staff and the members of CMCs and CPGs. A provision of USD 2 million is kept for carrying out demarcation of PA boundaries and pillars posting and for developing FD facilities for forests protection. So the total project cost works out to be as USD 17.73 million (includes Tk. 1030 million and Tk. 60 million, and USD 3 million).

The following table provides illustrative financing plans for the project implementation

Table 6.2: Illustrative Physical and Financing Plans for Project Implementation

PA	Project Intervention	Physical Targets (in ha)						Financial Targets (in Tk. million)					
		Y1	**Y2**	**Y3**	**Y4**	**Y5**	**Total**	**Y1**	**Y2**	**Y3**	**Y4**	**Y5**	**Total**
DDWS	Forests Protection, Reforestation, Revegetation	600	700	700	300	200	2500	30	35	35	15	10	125
	Forests Protection, Revegetation	600	700	400	150	54	1904	15	17.50	10	3.75	1.35	47.6
	Forests Protection	2,000	2,500	1,300	400	265	6,465	20	25	13	4	2.65	64.65
	Total	**3,200**	**3,900**	**2,400**	**850**	**519**	**10,869**	**65**	**77.50**	**58**	**22.75**	**14**	**237.25**
FWS	Forests Protection, Reforestation, Revegetation	250	350	100	50	50	800	12.50	17.5	5	2.50	2.50	40
	Forests Protection, Revegetation	75	125	50	18	-	268	1.88	3.13	1.25	0.45	-	6.71
	Forests Protection	300	400	100	75	-	675	2	3	17.25	0.75	-	6.75
	Total	**625**	**875**	**250**	**143**	**50**	**1,743**	**16.38**	**23.63**	**23.50**	**3.70**	**2.50**	**53.46**
INP	Forests Protection, Reforestation, Revegetation	600	700	700	300	200	2,500	30	35	35	15	10	125
	Forests Protection,	750	850	800	632	400	3,432	18.75	21.25	20	15.80	10	85.80

	Revegetation												
	Forests Protection	700	1000	800	150	78	2728	7	10	8	1.50	0.78	27.28
	Total	**2,050**	**2,550**	**2,300**	**1,082**	**678**	**8,660**	**55.75**	**66.25**	**53**	**32.30**	**20.78**	**238.08**
MKNP	Forests Protection, Reforestation, Revegetation	100	150	-	-	-	250	5	7.50	-	-	-	12.50
	Forests Protection, Revegetation	-	-	-	-	-	-	-	-	-	-	-	-
	Forests Protection	400	500	111	-	-	1011	4	5	1.11	-	-	10.11
	Total	**500**	**650**	**111**	**-**	**-**	**1,261**	**9**	**12.50**	**1.11**	**-**	**-**	**22.61**
SKRF	Forests Protection, Reforestation, Revegetation	1,300	2,000	1,200	300	200	5,000	65	100	60	15	10	250
	Forests Protection, Revegetation	600	800	700	100	37	2237	15	20	17.50	2.50	-	55
	Forests Protection	3,500	4,000	3,000	1,500	696	12,696	35	40	30	15	6.96	126.96
	Total	**54,00**	**6,800**	**4,900**	**1,900**	**933**	**19,933**	**115**	**160**	**107.50**	**32.50**	**16.96**	**431.96**
TWS	Forests Protection, Reforestation, Revegetation	1300	2000	1200	300	200	5000	65	100	60	15	10	250
	Forests Protection, Revegetation	1500	2000	500	400	218	4618	37.50	50	12.50	10	5.45	115.45

	Forests Protection	500	1000	400	189	-	2089	5	10	4	1.89	-	20.89
	Total	**3,300**	**5,000**	**2,100**	**889**	**418**	**11,707**	**107.50**	**160**	**76.50**	**26.89**	**15.45**	**386.34**
TOTAL													

7 Estimating Additionality

Additionality is estimated for REDD and ARR separately, though these two mechanisms complement each other in the forests conservation. Two main approaches to estimating land-use emissions are the stock-change approach and the gain-loss approach. The stock-change approach estimates the difference in carbon stocks at two points in time, while the gain-loss approach estimates the net balance of additions to and removals from a carbon stock; this later approach is used is establishing additionality due to REDD and ARR separately as discussed below.

7.1 Additionality due to REDD

Annual rates of deforestation have been estimated for all 6 PAs in Section 3.2, whereas per ha carbon baselines are worked out in Sections 3.8 and 3.9. Based on these estimations, the annual forest carbon loss and the annual loss of soil carbon are presented for the 6 PAs in the following Table 7.1.

Table 7.1 : Carbon stock additionality due to REDD

Sl. No.	Protected Area	Forest Area (ha)	Annual Forest Carbon Loss (ton/ha)	Annual Soil Carbon Loss (ton/ha)	Total Annual Carbon Loss (ton/ha)	Total Annual Carbon Loss over the Forest Area (ton)
1	Dudpukria-Dhopachari	2,653	(-245.72)	62.14	(-183.58)	(-487,038)
2	Fashiakhali	301	1,113.72	278.13	1,391.85	418,947
3	Inani	2,249	2,977.41	3,185.91	6,163.32	13,861,307
4	Medhakachpia	112	41.31	6.12	47.43	5,312
5	Sitakunda	2,461	(-2,343.52)	2,521.51	177.99	438,033
6	Teknaf	1,794	4,872.78	2,914.84	7,787.62	13,970,990
7	TOTAL	9,570				28,207,551

Total carbon loss over the entire forest area (9570 ha) in 6 PAs works out to be as 28,207,551 ton annually. Over the project period of 40 years the total carbon loss in 6 PAs will be 1,128,302,040 ton. Through the project interventions focused on forests protection, this estimated loss of carbon will be saved and hence the additionality due to REDD.

7.2 Additionality due to ARR

In a neighboring similar tropical semi-evergreen hill forests of the Chunoti Wildlife Sanctuary, the above-ground mean annual increment (MAI) for *sal* forest patch and *garjan* forest patch have been estimated as 5.1 and 4.8 m^3/ha/year (FD, 2008) based on the field measurements for growing stock. This indicates that for reforestation of indigeneous species and revegetation we can expect an average MAI of 4.95 m^3/ha/year (or biomass of 4.95x0.67 t/ha/year). This compares closely with the MAI value (4.8 m^3/ha/year) as estimated by the BFRI based on the data regularly collected from the Sample Plots maintained by them in the hill forests of 6 PAs. In another study (Dmeldo and Ahmad, 1985), the values of MAI have been estimated as 4.8 and 5.4 m^3/ha/year in Chittagong for teak and dhakijam plantations respectively. These estimated MAI values compare well with the MAI value (4.66 m^3/ha/year) for similar reforestation efforts in India (Sharma and Pandey, 1989).

The above-ground forest carbon sequestration rate for bole will work out to be as 1.7 (=4.95x0.67x0.5) t/ha/year and by multiplying a conversion factor of 1.2 a total of 2.04 t/ha/year sequestration rate for bole and foliage is estimated. The below-ground forest carbon sequestration rate will, therefore, be as 0.53 (=2.04x0.26) t/ha/year. For estimating on-ground forest carbon sequestration rates, biomass sample plots were laid out in TWS and Chuloti Wildlife Sanctuary where some plantations raised earlier (12 years old plantations) have developed ground vegetation. After one week the harvested biomass samples were weighed both for green weight in field and air dry weight in project office. Based on field data, the air dry biomass is estimated as 34 t/ha and so total on-ground forest carbon works out to be as 17 t/ha. This, over a period of 12 years, gives an on-ground forest carbon sequestration rate of 1.42 t/ha/year. Total forest carbon sequestration rate is, therefore, worked out as average carbon tonnage of 3.99/ha/year (by adding above-ground, below-ground and on-ground carbon sequestration rates as estimated above). So for a medium term plan for 40 years (2011-2050) the total carbon sequestration would be 156.60 t/ha, which if multiplied by 3.67 works out as 574.72 t CO_2e per ha.

The BFRI, Chittagong has conducted soil organic carbon studies in the hill forests and the results have been published (BFRI, 1996). Based on these empirical estimates average soil carbon in the forests of indigenous species in 6 PAs is estimated by the Soil Science Division of BFRI as 32 t/ha.

Total carbon stocks for the 6 PAs are summarized as below in Table 7.2 for the proposed reforestation and revegetation activities:

Table 7.2 : Carbon stock assessment (in t/ha) in mitigation scenario (through reforestation and revegetation)

Sl. No.	Protected Area	Proposed Intervention Area	Forest Carbon	Soil Carbon	Total Carbon Stock
1	Dudpukria-Dhopachari	2,500	391,500	80,000	471,500
2	Fashiakhali	800	125,280	25,600	150,880
3	Inani	2,500	391,500	80,000	471,500
4	Medhakachpia	250	39,150	8,000	47,150
5	Sitakunda	5,000	783,000	160,000	943,000
6	Teknaf	5,000	783,000	160,000	943,000
7	**TOTAL**	**16,050**	**2,513,430**	**513,600**	**3,027,030**

The following summary Table 7.3 is presented (by using the above-discussed estimates) for discerning the carbon stock change patterns as a result of reforestation and revegetation activities.

Table 7.3 : Total carbon stock changes (in ton) over 40-years project period

Sl. No.	Protected Area	Proposed Area (in ha)	Carbon Stock under base-line scenario	Carbon Stock under mitigation scenario	Total Carbon Stock changes
1	Dudpukria-Dhopachari	2,500	276,975	471,500	194,525
2	Fashiakhali	800	91,776	150,880	59,104
3	Inani	2,500	75,450	471,500	396,050
4	Medhakachpia	250	47,195	47,150	(-45)
5	Sitakunda	5,000	151,450	943,000	791,550
6	Teknaf	5,000	246,550	943,000	696,450
7	**TOTAL**	**16,050**	**889,396**	**3,027,030**	**2,137,634**

The total carbon stock changes are estimated as 2,137,634 ton over the project period of 40 years. The annual carbon stock change, therefore, works out as 53,441 ton. By multiplying by 3.67 as conversion factor, the total carbon CO2e change for the project period of 40 years and the annual CO2e change due to reforestation and revegetation are estimated as7,845,117 ton and 196,128 ton respectively.

7.3 Total Carbon Stock Changes due to Project Interventions

By adding the total carbon stock changes due to REDD and ARR as estimated in Sections 7.1 and 7.2 as above, the total carbon stock change due to BRAPAP interventions are estimated as 28,260,992 (= 28,207,551 + 53,441) ton annually. By using the conversion factor of 3.67, the annual CO2e change is 103,717,841 ton.

8 Permanence and Leakage

8.1 Measures to Ensure Permanence

Identified project risks fall into the following categories:

- Project – Risk of unclear land tenure and user rights, and financial, technical, and/or management failure
- Economic – Risk of rising land opportunity costs
- Regulatory and social – Risk of political or social instability
- Natural disturbance – Risk of devastating fire, pest and disease attacks, extreme weather events, and geological occurrences

In terms of project risks related to land tenure and user rights, although the protected areas are officially owned by the FD on behalf of the GOB, as noted in our discussion of the causes of deforestation and degradation, some disputes exist over user rights, with local communities, including forest villagers, refugees, and other groups, exploiting forest resources to meet domestic needs or to serve as a source of income. By involving the CMCs to raise awareness amongst local communities regarding the importance of forest conservation, and leveraging existing co-management activities to help enforce protection of the forest reserves, this risk will largely be reduced. The project will also seek to mitigate this risk by involving local communities through the CMCs and CPGs in implementation (e.g., forests protection, enrichment planting, and tending including mulching, weeding, pruning, stump dressing, coppicing, cleaning and thinning) and monitoring activities, thereby offering alternative income streams. Furthermore, by increasing the attractiveness of these forest reserves to tourists and strengthening the eco-tourism industry, the project will offer alternative employment opportunities in ecotourism to members of local communities, diminishing the risks related to user rights.

There is little risk of technical failure, as the technologies proposed to be used by the project are ones with which the FD is familiar, and their knowledge and expertise will be further enhanced through appropriately targeted training in areas such as data collection, co-management, revegation technology, and monitoring during the course of the project. Relevant training will also be offered to community participants before undertaking any project activities. The risk of management failure is also minimal, as the FD has experience in carrying out and managing the type of activities proposed under this project. Moreover, NGOs such as CODEC familiar with the FD and the CMCs will be brought in to assist with administrative, operational, and financial management as needed. Financial risk poses the greatest barrier at this point in time, due to the fact that funding for the project has yet to be secured.

Regarding economic risk, the measures discussed under user rights risks will promote immediate, tangible benefits of retaining land as forests, and enhance the value of forest protection and sequestration, so that forests as a land use category are competitive to others such as agriculture. This will help to mitigate the risk that rising land opportunity costs will lead to a reversal of forest protection and sequestration. Political instability at the national level is a relatively minor risk in Bangladesh, as a parliamentary democracy is functional. Although elections are held every five years, most regimes recognize the importance of addressing climate change through mitigation and adaptation, and are committed to the protection of the environment and forests. At the local level, collaboration with local socio-political entities such as the CMCs serves as a means to reduce and manage the risk of instability. The factors affecting risks related to users rights noted above also have an impact on the risk of social instability; the measures implemented to reduce the former including the provision of alternative employment options will also advance social stability. Facilitating improvements in people's standard of living and alleviating poverty will further help to minimize both political and social instability at the local level.

In the category of natural disturbance risks, the probability of geological risks is low in most of the protected areas. The geological risk that has posed the greatest hazard in recent years has been landslides, and their occurrence has been low, with the exception of in TWS, which experienced landslides in 2007 and 2010. The risk of extreme weather events is variable, with the coastal forested areas bordering the Bay of Bengal most vulnerable due to their exposure to tropical storms. However, the planting activities in these areas will help to establish a buffer to enable both human populations and natural resources to better withstand such extreme events. Pest and disease outbreaks tend to be infrequent in the project areas. Risk of pest and disease outbreaks will be reduced through close monitoring and improved management of the protected areas. There is some risk of forest fires due to human actions such as the improper extinguishing of cigarettes in nearby areas or roads, and the burning of sungrass patches as part of their management by local communities. The probability of forest fires will be diminished by raising communities' awareness of the importance of proper disposal of cigarettes and by better monitoring of forest fire lines that will be created by employing CPGs under the supervision of concerned CMCs. Enhancing the value of forest conservation activities will also contribute to lowering this risk.

8.2 Measures to Address Leakage

Leakage is defined by the Inter-governmental Panel on Climate Change (IPCC) as the "indirect impact that a targeted land use, land-use change and forestry activity in a certain place at a certain time has on carbon storage at another place or time"[16], and the "unanticipated decrease or increase in GHG benefits outside of the project's accounting boundary…as a result of the project activities"[17]. Despite the fact that leakage can be either positive (i.e., result in greater sequestration and emissions removals) or negative (i.e., lead to less sequestration and fewer emissions removals), it is often characterized as the latter. As a result, and due to standards' explicit stipulation that accounting for positive leakage is impermissible[18], we will only focus on project management of negative leakage[19].

The two types of leakage that are likely to be relevant to the proposed project and that will be taken into consideration are activity-shifting and market-effect[20]. The former refers to the project-induced movement of deforestation and degradation activities from inside to outside project areas. Market-effect leakage takes place when project activities affect prices and the market, leading to an increase in the attractiveness of deforestation and degradation activities. For instance, reductions in illegal felling in the protected areas may lead to reductions in the supply of illegally logged wood, thereby pushing up prices and placing greater pressure on forests elsewhere. The project will prevent leakage by offering alternative sources of income to surrounding communities, thereby helping to address the greatest incentive for illegal harvest of forest resources and encroachment in nearby forested areas. Moreover, increased monitoring of forest activities in all protected areas will further minimize leakage.

At present, estimates of leakage can only be tentative at best at due to the still nascent nature of understanding of and methodologies for leakage assessment in both academic and policy arenas. Thus, it is not possible to provide a definitive, quantitative estimate of leakage. As a result, we will seek to ensure that an adequate risk buffer is established in order to be able to compensate for the anticipated risk posed by the two types of leakage discussed above. Continuous monitoring of leakage will be conducted in order to be able to adjust activities and the risk buffer as needed. This will include assessing rates of

[16] IPCC (2000: 71).
[17] IPCC (2000: 246).
[18] Voluntary Carbon Standard (VCS) *Tool for AFOLU Methodological Issues* (2008: 7).
[19] All further references to leakage will only be to negative leakage unless explicitly stated otherwise.
[20] Other types of leakage that may occur are life-cycle emissions shifting and ecological. The former refers to an increase in emissions in upstream or downstream activities (e.g., forest conservation may ensue in greater road traffic from tourists), while the latter occurs when ecosystem level changes are caused in surrounding areas by the project, which causes greater carbon release into the atmosphere. Ecological leakage will not be measured because its magnitude in comparison to other types of leakage and implications remain unstudied. Life-cycle emissions shifting leakage will not be included because project activities have yet to be confirmed with the CMCs.

deforestation and degradation in the forest reserves as well as in surrounding forested areas; potential means for accomplishing this include field monitoring and remote sensing. Potential leakage will be compensated for by holding a risk buffer of 20% percent of tons of carbon equivalent sequestered.

8.3 Adapting to climate change

Climate change may have an impact on the environment of the protected areas over the forty-year project period. Projections for Bangladesh suggest that the country will experience changes in rainfall patterns, with precipitation becoming heavier and more erratic during the monsoon season, and lesser and more erratic during the dry season21. Recent experience also indicates that the frequency of tropical storms may increase. These changes may have implications for the forest ecosystems that comprise the proposed project area. Changes in precipitation may affect the growth of certain species, and greater frequency of extreme events such as storms may cause damage to forests or result in flooding. The proposed project will seek to promote climate resilience of both the ecosystems and communities it works with through continuous monitoring and adjustment. For instance, it may become necessary to introduce indigenous species that are more drought- or flood-resistant, or to plant larger landscape zones in coastal areas to mitigate the impacts of tropical storms.

[21] GOB (2009).

9 Participatory Monitoring

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 establishment; forest management; carbon stock changes; and leakage. It is envisioned[22] that the CMCs, together with the FD, will play a central role in monitoring, with assistance from relevant NGOs in the areas of administrative, managerial, and financial monitoring.

9.1 Monitoring of Project Parameters

Several aspects of the project will be monitored to ensure that project activities are successfully carried out and adhere to conservation principles. Regarding the boundaries of the six protected areas encompassed by the proposed project, although they are defined in the field and on maps as per GOB notification[23], periodic monitoring of the boundaries of the project and reforested 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 groundtruthing in the field. Maps will be updated regularly to ensure that monitoring is based on the most current situation.

The development of the nurseries will be monitored on a monthly basis to ensure the quality of planting stock as well as avoidance of detrimental measures such as burning and clearing of existing vegetation that may contribute to decreases in biodiversity and increases in GHG emissions. The technical aspects of nursery and forest development will be overseen by the FD, while the CMCs will participate in monthly monitoring activities. Upon completion of planting, the survival of planted seedlings and other relevant information will be collected and recorded annually for the first three years by CPG members in accordance with the relevant field inventory methods. In terms of forest management activities such as tending, weeding, mulching, and cleaning, which will be undertaken by the CMCs through the CPGs, although the FD will be responsible for supervising their implementation, an NGO may be brought in to undertake regular

[22] A full monitoring plan for the project will be developed within six months of the project start date.
[23] DDWS was established in 2009, MNP in 2004, RKWS in 1996, SKEP in 1998, and TGR in 1983.

monitoring. 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.

9.2 Monitoring of Carbon Stocks

Measuring of below- and above-ground carbon and biomass will be carried out through permanent sample plots determined by systematic random sampling in each of the land cover categories developed during the initial field inventory. As land cover changes due to project planting activities, they will be reclassified, and this will inform any necessary changes in the monitoring of carbon stocks.

The dominant pools of biomass and carbon stock (i.e., trees) will be measured every five years, along with periodic independent verification of reforestation activities. 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 inform 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 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.

9.3 Monitoring, Reporting and Verification System

Main elements of a feasible monitoring, reporting and verification (MRV) system are discussed in this section. Hill forests form an important bio-geographical zone (the country's other such strata/zones include mangrove 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 six PAs, 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 in chapter 3 for establishing baseline is recommended for application. A two-five year cycle inventory will be carried out in the sample plots laid out as per the grid by marking them in the field. Hill forests of the 6 PAs will be categorized in the following 4 categories:

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

Carbon gain-loss method estimates net balance of additions to and removals from a carbon stock (based on annual growth rates), whereas the carbon stock change method estimates the difference in carbon stocks at two periods. Temporal inventories for the PAs providing time series data on growing stock, particularly for trees, will be conducted 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 as described in chapter 3. 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 at RIMS of FD and/or SPARRSO. 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 six PAs. Land-use changes in Bangladesh are happening rather fastly due to heavy biotic pressure. RIMS of FD requires being equipped with the latest equipments and technology, and manned with trained staff

9.4 Participatory Monitoring Plan

A participatory monitoring plan will be developed with active participation of the CMCs and other local stakeholders and will focus on : i) monitoring of project implementation, including purpose of monitoring; ii) monitoring of project boundaries; and iii) monitoring of forest management to ensure forests are managed according to the description in the forest management plan and are consistent with the approved methodology. The project proponent will commit to developing a full monitoring plan within 6 months of the start date, and will disseminate the plan and the results of monitoring, ensuring they are made publicly available on the internet, and are communicated to stakeholders. The plan would include data and parameters as in following table:

Table 9.1: Parameters for participatory monitoring

Data / Parameter	
Data unit	
Description	
Source of data to be used	
Value of data applied for the purpose of calculating expected emission reductions	
Description of measurement methods and procedures to be applied	
Recording frequency	
QA/QC procedures to be applied	
Any comment	

Sampling design and stratification would be based on :

1. Stratification of the project area

   a. Factors to be considered in *ex post* stratification – to reflect characteristics of proposed activity, stand type, age class, and planting year

2. Sampling frame

   a. Sample size

b. Plot size

c. Locating permanent sample plots

Monitoring of the baseline net GHG removals by sinks will be taken up as provided in Table 9.2.

Table 9.2 Parameters for baseline monitoring

ID number	Data variable		Measured (m), calculated (c), estimated (e) or default (d)	Recording frequency	Number of sample plots at which the data will be removed	Comment

Monitoring of the *ex post* baseline net GHG removals by sinks after the start of the project will be taken up as provided in Table 9.3 below:

Table 9.3 Parameters for ex post baseline monitoring

ID number	Data variable		Measured (m), calculated (c), estimated (e) or default (d)	Recording frequency	Number of sample plots at which the data will be removed	Comment

Monitoring of the actual net GHG removals by sinks will be taken up. Data to be collected in order to monitor the verifiable changes in carbon stock in the carbon pools within the project boundary resulting from the proposed project (including units of measurement and origin of the data) would include:

1. Monitoring the actual net GHG removals by sinks
2. Measuring and estimating carbon stock changes within the project activity boundary

3. Carbon stocks of the living biomass

Possible parameters for measurements along with sampling details for actual net GHG removals are indicated in Table 9.4 as below:

Table 9.4 Parameters for actual net GHG removals

ID number	Data variable	Data unit	Measured (m), calculated (c), estimated (e) or default (d)	Recording frequency	Number of sample plots at which the data will be removed	Comment
	Stratum ID					
	Sub-stratum ID					
	Confidence level					
	Accuracy					
	Standard deviation of each stratum					
	Number of sample plots					
	Sample plot ID					
	Plot location					
	Tree species					
	Age of plantation					
	Number of trees					
	Diameter at breast height (DBH)					
	Mean DBH					
	Tree height					
	Mean tree height					
	Merchantable (standing) volume					
	Wood density					
	Biomass expansion factor (BEF)					
	Carbon fraction					
	Root-shoot ratio					
	Carbon stock in above-ground biomass of plots					
	Carbon stock in					

	below-ground biomass of plots					
	Mean Carbon stock in aboveground biomass per unit area per compartment per species					
	Mean Carbon stock in belowground biomass per unit area per compartment per species					
	Area of Compartment					
	Carbon stock in aboveground biomass of compartment per species					
	Carbon stock in belowground biomass of r compartment per species					
	Carbon stock change in aboveground biomass of compartment per species					
	Carbon stock change in belowground biomass of compartment per species					
	Total carbon stock change					

Quality control and quality assurance procedures undertaken for data monitored will include uncertainty assessment as in Table 9.5.

Table 9.5: Uncertainty assessment

Data	Uncertainty level of data (High/Medium/Low)	Explain QA/QC procedures planned for these data, or why such procedures are unnecessary

Measures to reduce uncertainty would include:

i. Quality assurance of field monitoring

ii. Data collection

iii. Data entry and analysis

Description of the operational and management structure(s) (roles and responsibilities) to be implemented to monitor actual GHG removals by sinks by the proposed project will be provided. Monitoring times and periods, considering the intended users, will be included in the monitoring plan.

Name of person(s) implementing the monitoring plan will be recorded as in Table 9.6.

Table 9.6: Information about the implementers of monitoring plan

Name	Affiliation	Contact Information

Annex I – Local and Scientific Names of Flora Species

Scientific Name	Local Name	Scientific Name	Local Name
A. chaplasha roxb.	Cham	*Ficus hispida*	Dumur
Acacia auriculiformis	Akashmoni	*Firmiana colorata*	Udal
Acacia mangium	Mangium	*Flacourtia jangomas*	Painnagula
Acanthus illicifolius	Hargoza	*Garcinia cowa*	Kao
Achar gula	Jibili	*Glochidion multiloculare*	Kastoma
Adina cordifolia	Haldu, kelikadam	*Gmelina arborea*	Gamar, gamari
Aegle marmelos	Bel	*Heterophragma adenophyllum*	Dakrum
Albizia procera	Korai, koroi, Sil Koroi	*Hevea brasiliansis*	Rubber
Albizzia odoratissima	Tetuya Koroi	*Holarrhena antidysenterica*	Kurchi, kuruchi
Alostonia scolaris	Chatian, Chatim	*Hopea odorata*	Telsur
Anacardium occidentale	Kaju Badam	*Lagerstromia speciosa*	Jarul
Annona squamosa	Ata	*Lannea coromandelia*	Badi, bhadi
Anthocephalus chinensis	Kadam	*Leucaena leucocephala*	Epil-epil
Aphanamixis polystachya	Pitraj	*Litchi chinensis*	Lichu
Aporusa dioica	Kakra	*Macaranga denticulata*	Bura
Areca catechu	Supari	*Madhuca indica* G. Mell.	Mahua
Artocarpaus chaplasha	Chapalish	*Magnifera indica*	Am
Artocarpaus lakoocha	Dewa	*Mangifer sylvatica*	Uriam
Artocarpus heterophyllus	Kanthal, kathal	*Melia azedarach* L.	Bokain, Poma
Artocarpus lacucha	Borta	*Michelia champaca*	Champa

Averrhoa carambola	Kamranga, kamrangra	*Microcos paniculata*	Achar, asar
Avicenia officinalis	Baen	*Mitragyne parvifolia*	Kelikadam
Azadirachta indica	Neem	*Musa spp.*	Banana
Barringtonia acutangula	Hijal, hijol	*Palaquium polyanthum*	Dudya, tali
Bina orellana	Lotkon	*Phoenix sylvestris*	Khejur
Bombax ceiba	Shimul, simul, tula	*Phyllanthus emblica*	Amloki
Borassus flabellifer L.	Tal	*Propium serratum*	Gutguttya
Bridelia retusa	Kosoi	*Psydium grande*	Guava
Brownlowia elata	Much	*Pterospermum acerifolium* Willd.	Moos
Bursera serrata	Gutguitta	*Quercus speciata*	Batna
Cacia festula	Sonalu	*Randia dumetorum* Lamk.	Monkata
Cassia siamea Lamk.	Minjiri	*Samania saman*	Rain tree
Cedrela toona	Toon	*Schima wallichii*	Kanak
Chickrassia tabularis	Chikrassi	*Shoria robusta*	Sal
Cinnamomum cecidodaphne Meissn.	Tezbahal	*Sonneratia apetala*	Keora
Citrus spp.	Lebu	*Spondias pinita*	Amra
Cocos nucifera	Narkel	*Stereosperlum personatum*	Dharmara
Dalbergia sissoo	Sissoo	*Streblus asper*	Sheora
Delonix regia	Krishnachura	*Swietenia macrophylla*	Mehagoni
Dillenia indica	Chalta	*Swintonia floribunda*	Civit
Dillenia pentagyna	Hargaza, hargoja	*Syzygium cuminii*	Jam
Diospyros peregrina	Gab	*Syzygium fruticosum*	Putijam
Dipterocarpus turbinatus	Garjan	*Syzygium grande*	Dhakijam
Ekaeocarpus robustus	Jolpi	*Tectona grandis* L. f.	Segun
Elaeocarpus floribundus	Jalpai	*Terminal chebula*	Haritaki
Eleocarpus spp.	Olive	*Terminalia arjuna*	Arjun

Emblica officinalis	Amlaki	*Terminalia balerica*	Bahera, bohera
Eqularia agallocha	Agor	*Terminalia chebula*	Dakrum, Horitoki
Erythrina indica	Mander	*Tetrameles nudiflora*	Chundul
Erythrina variega	Mandar	*Trewia nudiflora*	Pitali
Eucalyptus camaldulensis	Eucalyptus	*Vitex spp.*	Goda
Ficus bengalensis	Bot	*Xylia dolabriformis*	Lohakath
Ficus bengalousis	Dumur	*Xylia kerii*	Lohakat
Ficus glomerata	Dumor	*Zizipus mauritiana*	Boroi

Annex 2 – Common Flora Species by Protected Area

Protected Area	Commonly found flora species
DDWS	*Magnifera indica, Microcos paniculata, Lannea coromandelia, Terminalia balerica, Castonopsis tribuloides, Zizipus mauritiana, artocarpus lacucha, Dillenia indica, Artocarpus chaplasha, Alostonia scolaris, Swintonia floribunda, Syzygium grande, Stereospermum personatum, Ficus hispida, Diospyros peregrine, Gmelina arborea, Dipterocarpus turbinatus, Vitex spp., Psydium grande, Bursera serrata, Acarthus illicifalius, Ekaeocarpus robustus, Garcinia cowa, Glochidion multiloculare, Artocarpus heterophylus, Holarrhena antidyseltrica, Litchi chinensis, Bina orellana, Erythrina variega, Acacia mangium, Aphanamixis polystachya, Areca catechu, Tectona grandis, Cinnamomum cecidodaphne, Bombex ceiba, Mangifer sylvatica*
FWS	*Acacia auriculiformis, Acacia mangium, Albizia procera, Annona squamosa, Anthocephalus chinensis, Bombax ceiba, Cassia siamea* Lamk., *Dalbergia sissoo, Dipterocarpus turbinatus, Eucalyptus camaldulensis, Firmiana colorata, Gmelina arborea, Hevea brasiliansis, Hopea odorata, Lagerstromia speciosa, Lannea coromandelia, Magnifera indica, Michelia champaca, Pterospermum acerifolium* Willd., *Quercus speciata, Shoria robusta, Syzygium grande, Tectona grandis* L. f., *Terminalia arjuna , Terminalia balerica, Zizipus mauritiana*
INP	*Acacia auriculiformis, Magnifera indica, Phyllanthus emblica, Spondias piñata, Terminalia arjuna, Microcos paniculata, Lannea coromandelia, Quercus speciata, Ficus bengalensis, Macaranga denticulate, Michelia champaca, Artocarpaus chaplasha, Alostonia scolaris, Tetrameles nudiflora, Swintonia floribunda, Heterophragma adenophyllum, Terminalia chebula, Syzygium grande, Stereosperlum personatum, Palaquium polyanthum, Ficus bengalousis, Ficus hispida, Diospyros peregrine, Gmelina arborea, Dipterocarpus turbinatus, Propium serratum, Adina cordifolia, Dillenia pentagyna, Acanthus illicifolius, Terminal chebula, Barringtonia acutangula, Elaeocarpus floribundus , Syzygium cuminii, Lagerstromia speciosa, Anthocephalus chinensis, Artocarpus heterophyllus, Phoenix sylvestris, Albizia procera, Erythrina indica, Pterospermum acerifolium* Willd., *Brownlowia elata, Azadirachta indica , Flacourtia jangomas, Aphanamixis polystachya, Melia azedarach* L.,

	Syzygium fruticosum, Shoria robusta, Tectona grandis L. f., *Streblus asper, Cacia festula , Areca catechu, Borassus flabellifer* L., *Hopea odorata, Cinnamomum cecidodaphne* Meissn, *Mangifer sylvatica*
MKNP	*Acacia auriculiformis, Achar gula, Aegle marmelos, Albizia procera, Alostonia scolaris, Artocarpus heterophyllus, Azadirachta indica, Bombax ceiba, Cacia festula , Areca catechu, Citrus spp. , Cocos nucifera, Dalbergia sissoo, Dipterocarpus turbinatus, Elaeocarpus floribundus, Eqularia agallocha, Eucalyptus camaldulensis, Ficus bengalensis, Gmelina arborea, Hopea odorata, Achar gula, Averrhoa carambola, Delonix regia, Lannea coromandelia, Litchi chinensis, Magnifera indica, Michelia champaca, Trewia nudiflora, Samania saman, Shoria robusta, Spondias pinita , Swietenia macrophylla, Syzygium cuminii, Tectona grandis* L. f., *Terminalia arjuna , Terminalia balerica, Zizipus mauritiana*
SKEP	*Acacia auriculiformis, Albizia procera, Albizzia odoratissima, Areca catechu, Artocarpaus chaplasha, Artocarpaus lakoocha, Artocarpus heterophyllus, Artocarpus lacucha, Bombax ceiba, Cedrela toona, Chickrassia tabularis, Eleocarpus spp., Emblica officinalis, Erythrina variega, Eucalyptus camaldulensis, Ficus bengalousis, Gmelina arborea, Heterophragma adenophyllum, Hevea brasiliansis, Holarrhena antidysenterica, Lannea coromandelia, Macaranga denticulate, Magnifera indica, Propium serratum, Psydium grande, Samania saman, Schima wallichii, Stereosperlum personatum, Streblus asper, Swietenia macrophylla, Syzygium cuminii, Tectona grandis* L. f., *Terminalia balerica, Vitex spp., Xylia kerii, Zizipus mauritiana*
TGR	*Acacia auriculiformis, Albizia procera, Alostonia scolaris, Anthocephalus chinensis, Artocarpaus chaplasha, Artocarpus heterophyllus, Avicenia officinalis, Bombax ceiba, Chickrassia tabularis, Cocos nucifera, Dalbergia sissoo, Dillenia indica, Dipterocarpus turbinatus, Ficus bengalensis, Ficus glomerata, Gmelina arborea, Hopea odorata, Lagerstromia speciosa, Leucaena leucocephala, Mangifer sylvatica, Phyllanthus emblica, Quercus speciata, Samania saman, Sonneratia apetala, Swintonia floribunda, Syzygium cuminii, Tectona grandis* L. f., *Terminal chebula, Terminalia arjuna, Terminalia balerica, Zizipus mauritiana*

Annex 3: Contact information of the proponents of the proposed project activity

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Bibliography

BFRI, 1996. *Bhumi O Mritikka Sampad Babohar Nirdeshika*, Bangladesh Forest Research Institute, Chittagong.

CEGIS, 2011. Land-use Change Trend Analysis in Seven Protected Areas in Bangladesh. Centre for Environment and Geographic Information Systems, Dhaka.

Dmeldo, R. and Ahmad, I.U., 1985. *Field Document No. 9*, FAO, UNDP, Dhaka.

FAO, 2005. *Global Forest Resources Assessment. Country Reports. Bangladesh*. Rome: Forest Resources Assessment Programme, FAO.

FAO, 2000. *Forest Resources of Bangladesh. A Country Report*. Rome: Forest Resources Assessment Programme, FAO.

FSP, 2001. *Guidelines for the Development of Conservation Area Facilities*. Forest Department, Dhaka.

GOB, 1973. *Bangladesh Wildlife Preservation Order*.

GOB, Forest Department, 2010. *Land and Forest Area.* <URL: http://www.bforest.gov.bd/land.php> [Accessed September 19, 2010]

GOB, Ministry of Environment and Forest, 2005. *Bangladesh Climate Change Strategy and Action Plan*. Dhaka: Ministry of Environment and Forests.

GOB, Ministry of Environment and Forest, 2005. *Bangladesh National Adaptation Program of Action*. Dhaka: Ministry of Environment and Forests.

International Disaster Database (EM-DAT), 2010. Cyclones in Bangladesh. <URL: http://www.emdat.be> [Accessed September 19, 2010]

IPAC, 2010. *Carbon Forest Inventory Manual.* Integrated Protected Area Co-management Project, Dhaka

IPCC, 2000. *Special Report. Land Use, Land-Use Change, and Forestry. Summary for Policymakers*.

NSP, 2007. *Illustrated Guide of Buildings Specifications for Conservation Area Facilities within the Protected Area System*. Nishorgo Support Project, Dhaka.

FD, 2008. *Chunoti CDM Reforestation Program : Mitigation of Greenhouse Gas Emissions through Co-Management of Chunoti Wildlife Sanctuary*. Forest Department, Dhaka.

Sharma, S.C. and Pandey, S.K., 1989. Patterns of litter nutrient concentration in some plantation ecosystems. *Forest Ecology and Management*, 29(3):151-163.

VCS, 2008. *Tool for AFOLU Methodological Issues*.