National Forest and Tree Resources Assessment 2005-2007

Bangladesh

Funding through
Ministry of Environment and Forest (MoEF), Bangladesh
Food and Agriculture Organization of the United Nations (FAO)

Implementing Agencies
Bangladesh Forest Department, MoEF
Bangladesh Space Research and Remote Sensing Organization, Ministry of Defence

Advisory and Technical supervision
FAO Forest Resources Development Service (FOMR)

Editing
Dan.Altrell, Mohamed.Saket, Leif Lyckebäck, Marco Piazza

Photo credits
Dan Altrell

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ANNEXES

List of Acronyms

Abbreviations	Details
ACF	Assistant Conservator of Forests
ADB	Asian Development Bank
AGB	Above Ground Biomass
BBS	Bangladesh Bureau of Statistics
BEF	Biomass Expansion Factor
BFRI	Bangladesh Forest Research Institute
BUA	Built Up Area
CBD	Convention of Biological Diversity
CCF	Chief Conservator of Forests
CF	Conservator of Forests
Cft	Cubic Feet
CHT	Chittagong Hill Tracts
Cu M	Cubic Meter
DBH	Diameter Breast Height
DCCF	Deputy Chief Conservator of Forests
DCF	Deputy Conservator of Forests
DFO	Divisional Forest Officer
FAO	Food and Agriculture Organization of United Nations
FB	Bamboo Forest
FD	Forest Department
FF	Form Factor
FH	Hill Forest
FM	Mangrove Forest
Fo	Forest
FOMR	Forest Resources Development Service, FAO Rome
FRA	Forest Resources Assessment program of FAO
FRMP	Forest Resource Management Project
FSa	Sal Forest
GEZ	Global Ecological Zones
GI	Galvanized Iron
GIS	Geographic Information System
GLU	Global Land Use class
GOB	Government of Bangladesh
GPS	Global Positioning System
Ha	Hectare
IC	International Consultant
IW	Inland Water
LTU	Lead Technical Unit at FAO (=FOMR)
LU	Land Use
MIS	Management Information System
MOEF	Ministry of Environment and Forest
NFA	National Forest Assessment / FAO's support programme for national forest assessments
NFAU	National Forest Assessment Unit
NIC	National Information System Consultant
NPC	National Project Coordinator
NPD	National Project Director
NWFP-AP	Non Wood Forest Product – Animal Products
NWFP-PP	Non Wood Forest Product – Plant Products
ODA	Overseas Development Administration
OL	Other Land
OWL	Other Wooded Land
PL	Long Rotation Plantation
PM	Mangrove Plantation
PR	Rubber Plantation
PS	Short Rotation Plantation
RIMS	Resource Information Management System
SLU	Swedish Agricultural University

Abbreviations	Details
SOB	Survey of Bangladesh
SPARRSO	Space Research and Remote Sensing Organization
TAPP	Technical Assistance Project Proposal
TCDC	Technical Cooperation between Developing Countries
TOC	Table of Contents
TOF	Trees Outside Forest
TOR	Terms of Reference
UNCED	United Nations Conference on Environment and Development
VOB	Volume Over Bark
WD	Wood Density

Executive Summary

The National Forest and Tree Resources Assessment 2005-2007 is the first of its kind in Bangladesh. The initiative for the assessment originated from the signing of the Rio convention in 1992, which states that *"timely, reliable and accurate information on forests and forest ecosystems is essential for public understanding and informed decision-making"*. In Bangladesh, a broad knowledge on the forest and tree resources is needed for redefining the policy and strategy of Bangladesh Forest Department as well as for developing a comprehensive National Forestry Action Plan (NFAP) which is considered a high priority after the work on the current inventory was concluded.

Bangladesh Forest Department (BFD), lead institution and responsible for the implementation of this first national forest and tree resources assessment (NFA), carried out the field data collection during 2005 - 2006 while the Bangladesh Space Research and Remote Sensing Organization (SPARRSO), responsible for the remote sensing survey, employed Landsat TM data from 2005 for mapping the land uses and forest types. The overall technical supervision of the NFA implementation has been provided by FAO Forestry department in Rome (FOMR), who also provided technical assistance to the GoB to strengthen the capacities of BFD in the area of planning and implementing NFAs, including methodology development, sampling design, harmonization of land use classifications, mapping, field survey, data management and reporting.

The long-term objective of NFA is to promote sustainable management of the forests and tree resources in Bangladesh founded on policy that integrates and balances relevant environmental and social aspects of forestry. Sustainable management aims at enhancing the social, economic and environmental functions of forests and trees on the basis of better knowledge and at improving the contribution of these resources in the national economy. Furthermore, the NFA should be used for the development of forest policies, forestry programs, over all forest management, sustainable development, conservation of the resources, and may be used by various institutions also from other sectors to develop integrated national policies. The direct objectives are to develop and strengthen the national capacities to collect, compile process and disseminate reliable and up-to-date information on forestry to national policy makers as well as to international organisations.

The NFA process initiated with a series of consultations with a broad representation of national stakeholders to deliberate the national information requests and how the NFA could answer to these needs and, at the same time, be harmonised with international reporting systems. The inventory covered a wide range of biophysical and socio-economic variables with emphasis on the management and use of the resources and was conducted through a systematic sampling with sampling units laid at a regular interval of 10 minute longitude and 15 minute latitude. Each sampling unit is designated as a "Tract" measuring one square kilometre and a total of 296 Tracts have been inventoried. The NFA data have been entered into an Access Data Base application and the findings from the analyses of these data are the main input to this report.

The NFA findings are mainly presented by major National Land Use Class (LUC): "Forest", "Cultivated land", "Villages", "Built up areas" and "Inland water". Findings related to "Forest" are also presented by forest type: "Hill forest", "Mangrove forest", "Mixed Broad-leaved/Bamboo forest", "Sal forest", "Long rotation plantations", "Short rotation plantations" and "Mangrove plantations". The NFA findings comprise statistics on Areas, Wood volumes, Biodiversity & Regeneration, Social and Economic aspects, Biomass and Carbon. The land use area statistics were generated using a combination of findings from the remote sensing survey and the field survey, following a harmonised land use/forest type classification system.

It is suggested that the NFA be carried out on a continuous basis to enable maintenance and development of competences with limited annual needs of resources. The NFA cycle should be around five years to optimise the ratio of information value/cost, and a mix of both permanent and temporary plots is recommended. The value of the NFA data will increase with every NFA cycle in order to capture information on trends. To ensure the continuity of the NFA it is important that it be institutionalised to maintain and strengthen the capacities of the NFA team, maintain the NFA database and the network of permanent sample plots.

The NFA findings help identify priority areas and will be of great use for the development of the forestry sector (national forest programme) and to evaluate forestry policy/strategies in order to ensure a coherent legislation. The NFA is part of a continual process and not the end product in itself.

1. Introduction

1.1. General

The United Nations Conference on Environment and Development (UNCED) was held at Rio de Janeiro, Brazil in 1992. Government of Bangladesh signed this Rio convention in 1992 and ratified the convention on May 03, 1994. The Rio convention explicitly has a provision stating that 'timely, reliable and accurate information on forests and forest ecosystems is essential for public understanding and informed decision-making' should be made available by the participating countries. As a signatory of CBD the Government of Bangladesh has the obligation to accomplish the required. Though the state owned forest areas, especially the 'Reserved Forests', have been inventoried from time to time, inventory of 'Forest Ecosystems' outside the Government owned forest have hardly been done. To secure information of all the possible land uses of the country as a whole with especial emphasis on "Forest Land Use", an inventory like that of National Forest Assessment (NFA) has been identified by FAO to be a better one.

The present NFA has adopted a set of globally harmonized terms and definitions to provide information. These may be used for the development of forest policies, forestry programs, over all forest management, sustainable development, conservation of the resources, etc. The definition of forest used by the Government of Bangladesh is not the same as the global definition of forest used by the NFA.

Since inception of FAO in 1948, it has been reporting on the worldwide status and trends of forest resources, their management aspects and uses. All countries are reflected in the process. The required data are collected and collated to prepare such report. The data may or may not be based on systematic inventory however. FAO, in an attempt to enhance the reliability of such data, launched this program of support to NFAs including the support to the present NFA of Bangladesh.

1.2. TAPP & FAO Support

Under this context a Technical Assistance Project Proposal (TAPP) was submitted in April 2004 by FD and in November 2004 it was endorsed by the Government of Bangladesh (GoB), (TAPP of MOEF, November 30, 2004.). The total cost estimate of the project was 27.054 million Taka (59 Taka = 1 US$), out of which FAO-contribution was 20.768 million taka (equivalent to 352 thousand US dollar). The GOB contribution was 2.773 million Taka in cash and 3.513 million Taka in kind. The project was designated as "Strengthening Capacity to Generate Quality Information on Forest Resources", and initial planning activities started in July 2004. Several training activities were held from June 2005 to March 2006. Field data collection was carried out between November 2005 and May 2006 and the processing and analysis of collected field data was conducted during 2006 and the first half of 2007. Mapping activities undertaken by SPARRSO started in June 2006 and were completed in August 2007.

Table 1: The total cost break up of the NFA activities

FD Contribution in Kind	59,542 US$
FD Contribution in Cash	47,000 US$
FAO Contribution	352,000 US$
Total	**458,542 US$**

The long-term objective and approach is to build the national capacity, so that the national NFA program in Bangladesh continues in future with little or no external technical support, to generate the desired information. The core consideration of this program is to contribute towards the sustainable management of forests and trees, including those outside the areas designated as forest, by providing decision makers and stakeholders with the best possible and most relevant information. At the same time it is expected that this sort of inventory will generate the required data base that may be of good use at local, national and international levels. This NFA survey is thus a part of FAO's pilot program wherein Bangladesh has also been included.

Photo 1: Local food market in Dhaka, where also non-wood forestry products are put up for sale

2. Background

2.1. General History and Geography of Bangladesh

2.1.1. Historical context

Bangladesh came into existence only in 1971. This tract of land was under British rule from 1757 till August 14, 1947. This tract emerged as a wing of Pakistan, in 1947 as an independent country for the Muslims, and was designated as East Pakistan. It was liberated as Bangladesh in 1971 as an independent sovereign country. Forest management was however, initiated in Bangladesh during the British rule. The British crown for the first time promulgated Act VII in 1865 in connection with the Forests and Forestry and established a rule of law in this sector. This was the first forestry related 'Act' for this part of the world, the greater India which included the existing territory of Bangladesh. Many forest tracts were declared as "Reserved Forests" under this 'Forest Act' and were placed under the control of Forest Department for management.

2.1.2. Geographical context

Bangladesh lies in the north-eastern part of South Asia between 20°34′ and 26°38′ north latitude and 88°01 and 92°41′ east longitude. The country is bounded by India on the west, the north and the northeast and Myanmar on the southeast and the Bay of Bengal on the south. The area of the country is 147.57 thousand km^2 and the population was in 2003 135 million (BBS, 2004), with a growth rate 1.43%.

Bangladesh has a sub-tropical monsoon climate with three prominent seasons in a year; winter, summer and monsoon. During winter (November to February) temperature ranges from 7° -13°C to 24°-31°C. Maximum temperature in summer up to more than 40°C or more. Monsoon (July-October) accounts for 80% of the total rainfall, 1,400-4,300mm. Except the hilly regions in the northeast and the southeast, some areas of high lands in the north and north-western part, the country consists of low, flat and fertile land. A network of rivers and their tributaries numbering about 23 with a total length of about 24,000 km covering the country flow down to the Bay of Bengal.

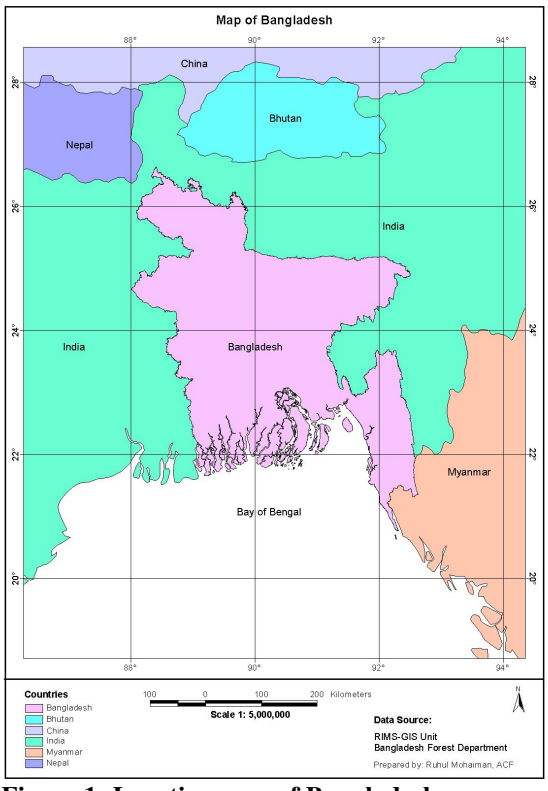

Figure 1: Location map of Bangladesh

2.2. Expressed need for the NFA

During the last decades a rapidly increasing population in Bangladesh with increased demand for resources and livelihoods, leading to a badly degraded environmental and natural resource base under serious treat from causing factors such as agricultural expansion, overexploitation of forest and tree resources, urban sprawl, overgrazing, quarrying etc.

Timely, easily available and accurate information on forest and tree resources and their utilization is a precondition for sustainable management of these resources based on an environmentally, socially and economically balanced forest policy.

The Government of Bangladesh (GoB) therefore requested the technical assistance of FAO under the Technical Cooperation Programme to assist the Bangladesh Forest Department to develop capacities to assess the country's forest and tree resources and to monitor trends and changes, to describe their nature and localities and to advise on adequate measures.

A broad knowledge on the forest and tree resources is critically needed for redefining the policy and strategy of the Forest Department as well as for developing a comprehensive National Forestry Action Plan (NFAP). The Government considers the formulation of its NFAP as a high priority after the work on the current inventory is concluded.

2.3. FAO support to the NFA

FAO has through the technical Cooperation Program (TCP) financed FAO technical assistance to the GoB. FAO LTU have had the overall technical supervision of project implementation and provided technical assistance to the GoB through national capacity building in the following main areas:

- Forest and tree inventory methodology development including sampling design, classification system harmonization and variables.
- Forest and land use mapping.
- Field survey
- Data processing, information system development and reporting
- Information management

The capacity building has been carried out through workshops, training events, on-the-job guidance, and through communication and feed-back.

The *FAO representation of Bangladesh* has as FAO project budget holder provided administrative assistance throughout the implementation of the various phases of the project. All Steering Committee Meetings were held at the FAO Representation

Till the launching of this NFA program, no inventory was carried out at a time all over the whole country with the same methodological approach to capture data on all the various land use patterns. The NFA approach is basically tagged with the land use aspects, with special emphasis to collect information on forests and tree resources, their uses and users, irrespective of its ownership, public or private. Thus for the foresters in Bangladesh this is a new approach.

2.4. Existing information on forests and ToF

Most of the existing Sundarbans was notified and declared as "Reserved Forest" during 1875-76. The existing 'Reserved Forests' in the greater district of Sylhet were declared as such under a similar Act, "Assam Forest Regulation" during the British Rule. Till 1914 there was neither any forest policy nor any Reserved Forest in this area of Sylhet. The policy of reservation of the Forest Area was first formulated on the basis of the note dated May 10, 1914 of Mr. G.C. Sankey an I.C.S. officer of the than British Government of India (Choudhury 1986). All most all of the existing "Reserved Forests" in the greater district of Sylhet were declared as such under Assam Forest Regulations. The forests of Chittagong and Chittagong Hill Tracts were declared 'Reserved Forests' in early 20th century during the British rule. Forest management followed such process of reservation.

Detailed inventories of various forests (notified forest land, mostly as 'Reserved Forests') under the control of the FD, Government of Bangladesh were under taken at various times especially for the preparation of Forest Management Plans. Since the major forest tracts are located in Sundarbans, Chittagong & Chittagong Hill Tracts, Sylhet. Dhaka-Tangail-Mymensingh, etc. forest inventories were under taken in these locations at different times.

2.4.1. The Sundarbans

The legal boundary of Sundarban forest (Bangladesh portion) covers an area of 577,000 hectares, out of which 401,600 hectares is land and the remaining 175,600 hectares is water bodies, as creeks, canals, rivers, etc. (Hossain & Acharya, 1994). F. Trafford wrote the first management plan for Sundarbans for the period 1912-13 to 1931-32. It is not known exactly how he carried out the inventory. The second management plan for Sundarbans was written by Mr. S. J. Curtis. It is learnt that he conducted the inventory and prepared the map by physical survey. His maps and inventory were milestones on this issue and were found to corroborate very closely with the high-tech inventories conducted at later ages. Curtis' plan came into operation in April 1931. Forestal Forestry and Engineering International Limited of Vancouver, Canada carried out the first detailed inventory of Sundarbans in 1960. The second detailed inventory of Sundarban was done by Overseas Development Administration (ODA) of U.K. during 1980 to 85. The report was published in 1985. The Forestal and ODA inventories of the Sundarbans used blocks. Forestal divided the forest into 8 blocks which were also used by the ODA. The last inventory of Sundarbans was carried out in 1996 by FD, Government of Bangladesh. Of all the inventories so far carried out in Sundarbans, the three inventories namely that of Forestal, ODA and FRMP seem to be quite comprehensive.

Photo 2: Water transportation in the mangroves in the Sunderbans.

2.4.2. Sylhet Forests

Under a similar historical context, the forests in greater Sylhet were declared 'Reserved Forest' gradually since 1914 following the note initiated by Mr. G. C. Sankey, I.C.S. assistant commissioner to the then Government of Assam. As far as the records reveal, Mr. C. Purkayastha prepared a plantation scheme for the period from 1935 to 1938 for Sylhet area for the first time. Since then, the forests of Sylhet have been worked under one scheme or the other. The first working plan was prepared in 1938 by N.N. Das for the period 1938-1947. He conducted the inventory of the Forests in Sylhet by partial physical enumerations. He reported to have used the Topo-Sheets that were produced in 1930s. The maps that he generated during that inventory were based on those Topo-Sheets. The second management plan was written by M. U. Choudhury for the period 1963-64 to 1982-83. The next forest management plan for Sylhet was written by Dr. J.H. Choudhury for the period 1992-2001, using the FAO forest inventory data of 1984. That was a comprehensive forest inventory especially focused for managing the forests.

2.4.3. Forestal Forestry Engineering Inventory in Chittagong

Forestal Forestry and Engineering International Limited. Vancouver, Canada. (May 1964, Project No F334 under Colombo Plan, Pakistan, Canada) conducted the inventory in CHT and prepared the report, Chittagong Hill Tracts Forest Inventory Survey 1961-1963, Kassalong and Rankhiang Reserved Forests, Vol. 1, 2, 3 and 4.

This inventory was carried out using aerial photography with 8,500 sample plots checks on the ground. The main purpose of this inventory was to get a proper estimate of the timber and bamboo in the two main reserved forests of CHT namely Kassalong RF and Rankhiang RF.

2.4.4. Village Forest Inventory

The first village forest inventory in this part of the world was conducted by Mr. Hammer Master, under a FAO assignment. That report was published in October 1981. This report

reflected the timber volumes in the village area of Bangladesh and is based on sample survey.

2.4.5. Forestry Master Plan

Asian Development Bank (ADB) assisted the Government of Bangladesh to prepare a "Forestry master Plan" during 1991-93 for the period 1993-2013. FAO (UNDP), Sandwell Inc and Reid Collins Ltd. extended some support to this activity. The 20-year plan provides the framework to optimize the forestry sector's contribution in stabilizing environmental conditions and assisting economic and social development.

3. Objectives of the study

The TAPP (Project Document) has identified two sets of objectives as Development Objectives and Immediate Objectives.

The development objective or the long term objective is as under :

> The project aims at promoting sustainable management of the forests and trees resources in Bangladesh founded on policy that integrates and balance relevant environmental and social aspects of forestry. Sustainable management aims at enhancing the social, economic and environmental functions of forests and trees on the basis of better knowledge and at improving the contribution of these resources in the national economy.

The purpose of the TAPP is to enhance the capacity of BFD and contribute to achieve the development objectives through implementation of activities of the following specific objectives:

- Assist the Forest Department (FD) of the Ministry of Environment and Forest (MOEF) in developing and strengthening its capacity to collect, compile, process and disseminate reliable and up-to-date information on forestry, to policy makers.
- Assist the FD to plan ands carry out national forest and tree resources inventory, develop up-to-date and sound base-line information and set up a long term resources monitoring system. The inventory will cover a large array of biophysical and socio-economic variables with emphasis on the management and use of the resources.
- Assist the FD in evaluating the findings, defining the sector priorities and outlining the national forest program.
- Advice and assist the Government to establish a long term monitoring of the national forest resources, take the necessary measures to maintain and support the National Forest Assessment Unit (NFAU), enable it to carry out continuous resource assessments in future and convert the project into a permanent program for long tern monitoring and support to decision making.

4. Resources for the implementation of the NFA

4.1. General

This NFA was initiated with a number of consultation workshops and discussion meetings; wherein departmental as well as expatriate experts participated. The design of the methodology aims at harmonizing the reporting systems between countries, while satisfying the national information needs. The designing of the project outline, formulation of its implementation procedures, reformulation and development of the field manuals, finalization of the field forms, orientation and training of the FD personnel, etc. were the initial tasks to start the project. A remote sensing component for mapping was included by involving the Space Research and Remote Sensing Organization (SPARRSO) Dhaka, Bangladesh.

The project was designed for implementation in three phases as follows.

Phase I: Preparation, Training and Mapping

Phase II: Field Survey and Remote Sensing analysis

Phase III: Data Processing, Analysis and Reporting

With these ground work the Inception Workshop of this project was organized by the FD during April 02 to 04, 2005 at Dhaka. The Inception workshop was facilitated by an NFA expert from FAO. In addition to that many experts and scientists from the following organizations attended and actively participated in that 'Inception Workshop' :

1. Ministry of Environment and Forests (MoEF), Government of Bangladesh.
2. Ministry of Planning, Government of Bangladesh.
3. Internal Monitoring and Evaluation Division (IMED), Government of Bangladesh.
4. Directorate of Environment (DoE), Government of Bangladesh.
5. Export Promotion Bureau, Government of Bangladesh.
6. Local Government Engineering Directorate (LGED)
7. Bangladesh Forest Research Institute (BFRI)
8. Space Research and Remote Sensing Organization (SPARRSO)
9. Bangladesh Bureau of Statistics (BBS), Government of Bangladesh.
10. Bangladesh National Herbarium, Government of Bangladesh.
11. Bangladesh Shongbad Shongstha (BSS) (The Press)
12. Bangladesh Agricultural Research Council (BARC)
13. Representative from Khulna University, Khulna.
14. Representative from Chittagong University, Chittagong.
15. Representative from Shajalal University, Sylhet.
16. Forest Department, Government of Bangladesh.
17. FAO Dhaka Bangladesh

Photo 3: Participants at the Workshop on "Needs and Requirements for the Strengthening of the Forest Department"

4.2. Analysis of the Remote Sensing Data

FAO Bangladesh established a Contract Agreement with the Space Research and Remote Sensing Organization (SPARRSO), Dhaka, Bangladesh in February 2006. The objectives of engaging SPARRSO was to generate statistics on the land use areas and also to provide FD with land use maps for the whole country, using the remote sensing data depicting all the land use classes that were identified and agreed upon for the purpose of the NFA. It was decided to procure the Landsat TM imageries (Band 3, 4 and 5) for the given purpose. FAO Bangladesh office facilitated the procurement of these imageries and in June 2006 SPARRSO received these imageries. In view of the real difficulties in identifying all the 27 land use types in the maps to be produced by SPARRSO, it was later agreed between the concerned parties that the following 14 land use classes should be identified and delineated in the land use maps (Inception report of SPARRSO, August 2006) to be produced by SPARRSO.

4.3. Setup of NFAU

According to the TAPP the Forest Department, Government of Bangladesh should setup a NFAU within the FD. The Chief Conservator of Forest vide his office order number 688/P dated 01-08-05 constituted a 15 member core team for this project and ordered them to function as member of NFAU. Thus the following members are expected to function as members of NFAU of FD.

Table 2 : Members of NFAU of FD

No.	Name	Designation and Position
1.	Mr. Ishtiaque Uddin Ahmed	DCF, DFO, Cox's Bazar, South.
2.	Mr. Zahir Hossain Khondaker	DFO, Management Plan Division, Dhaka
3.	Mr. Haradhan Banik	DFO, Management Plan Division, Chittagong
4.	Mr. Raihana Siddiqi	DCF, RIMS Unit, Dhaka
5.	Mr. Md. Tariqul Islam	ACCF, Management Plan Unit, Dhaka
6.	Md. Khayrul Alam Bhuiyan	ACF, Dhaka Forest Division, Dhaka
7.	Mr. Md. Sajjaduzzaman	ACF, Planning Wing, Ban Bhaban, Dhaka
8.	Mr. Mohammed Abdullah Abraham.	ACF, Development Planning, FD, Dhaka.
9.	Mr. Ruhul Mohaiman Choudhury	ACF, RIMS Unit, Ban Bhaban, Dhaka
10.	Ms. Shamima Begum Shiuli	RIMS, FD, Dhaka.
11.	Ms. Asma Islam	RIMS, FD, Dhaka.
12.	Mr. Sirajul Islam Gazi.	Management Plan Division, Dhaka.
13.	Mr. Mohammed Rafiqul Islam.	Estiblishment Unit, FD, Dhaka.
14.	Mr. Sushovan Anwar	Rims, FD, Dhaka
15.	Ms. Moni Adhikari	Development Planning, FD, Dhaka.

In addition to the above stated 15 personnel the following FD personnel have actively been involved with the process of data collection under the NFA activities (see Table 3).

Table 3 : List of Other Members of FD Closely involved with the NFA Activities

No.	Name	Designation and Position
1.	Mr. Uttam Kumar Shaha	DFO, WM & NC Division, Khulna
2.	Mr. Ratan Kumar Majumder	DFO, Management Plan Division, Khulna
3.	Mr. Quazi Md. Nurul Karim	ACF, Cox's Bazar South Forest Division, Cox's Bazar
4.	Mr. Modinul Ahsan	ACF, WM and NC Division, Sylhet
5.	Mr. Sheik Abu Tawhid	ACF, Social Forestry Division, Rangpur
6.	Mr. Md. Zahirul Haque	ACF, Tangail Forest Division, Tangail
7.	Mr. Md. Abdur Rahman	ACF, Dhaka Forest Division, Dhaka
8.	Mr. G. M. Rafique Ahmed	ACF, Social Forestry Division, Dinajpur
9.	Mr. Rajesh Chakma	ACF, Bandarban Forest Division, Bandarban
10.	Mr. Saleh Md. Shoyaib Khan	ACF, Sundarban East Forest Division, Bagerhat
11.	Mr. Shorf Uddin Ahmed	ACF, Social Forestry Division, Feni
12.	Mr. Manjurul Haque	ACF, Coastal Afforestation Division, Patuakhali

4.4. Study Tour

Mr. Md. Tariqul Islam, DFO, Management Plan Division, Khulna and Mr. Shorof Uddin Ahmed Chowdhury, ACF of Social Forestry Division, Feni, attended a study tour in the Philippines from August 8 to 20, 2005, to learn from the experiences gained during the NFA in the Philippines (2003-2005).

5. Field Survey Preparations

Survey of Bangladesh under the Ministry of Defense is the designated Government authority for Maps and Mapping. This organization produces topographic maps of 1:250,000 and 1:50,000 scale. The national territory of the country has been mapped in 267 numbers of Topo-Sheets at the scale of 1:50,000. In absence of Nation-Wide GIS data layered based maps for the whole of the country, Top-Sheets of 1:50,000 scale maps produced by the Survey of Bangladesh were used for this given work. The "Lat-Long" of the sample tracts were read form these Topo-Sheets. These Topo-Sheets were used for locating the tracts as well. These Topo-Sheets had the locations of the Thanas (/Upazilla, the lowest unit of Government administrative units) as well as the road net works. These features facilitated the physical location of the tracts during the field work. The sighting of the 'Lat-Long' Grid on these Topo-Sheets, along with all the other relevant physical features, facilitated with the use of hand held GPS and reading of the stored Lat-Long data from the GPS were used to reach and identify the desired location (especially the starting points of Tracts and Plots).

The systematically laid 299 tracts all over the country were identified to be within the 10 zones as indicated in Table 4. It has been aspired that these 299 tracts or samples will be revisited by reaching exactly the same locations using the GPS, maps, metal-detector (by locating the GI pipe already pegged below the ground level during the field survey) and personal knowledge.

Photo 4 : Team "F" in the Sunderban mangroves

Table 4 : Zone and Region wise numbers of Tracts used in NFA Survey

Zones	Area/Region	No. of Tracts
A	Dinajpur	37
B	Rajshahi	41
C	Mymensingh	35
D	Dhaka	30
E	Sylhet	26
F	Comilla	25
G	Chittagong	25
H	Hill Tracts	17
I	Khulna	33
J	Barisal	30
	Total Tracts	299

Out of the original 299 tracts, two tracts (Tract number 61 and 294) were inaccessible and were therefore not inventoried, and one tract (Tract number 7) was excluded when it was found out that it was in the sea (outside the country's land territory). Thus data from 296 tracts were collected ultimately.

6. Organisation and Management of NFA activities

A National Forest Assessment Unit (NFAU) was set within the FD for project implementation under the overall guidance of a National Project Coordinator (NPC). The requirements of local and expatriate assistance for the project were identified. The field data collecting was conducted by teams lead by FD professionals. The composition of the field crews is shown in Table 5.

Table 5 : Constitution of each NFA Survey Team

Field team member	Designation	Number
Team leader	Assistant Conservator of Forests, Forest Department	1
Investigator	Senior/junior field investigator, temporarily recruited as project personnel	1
Field crew	Temporarily recruited as project personnel	1
Labor	Locally hired	2

Based on the agreed land use classes at national level for the purpose of NFA and the FRA templates of FAO, 6 field forms were developed for recording the field survey data (see Annex II). The members of the field teams were appropriately trained and a thorough orientation was given, so that they can collect the data correctly and record them in a correct manner. During the field works the field work the field teams were properly supervised on a routine basis regularly to ensure the correct recording of the data and to ensure the quality of the data recorded.

Photo 5: Team "G" in Barisal.

7. Methodology

During phase I all the preliminary arrangements and preparatory works of the project was carried out. The major activities under this phase were :

- Development of a national Land Use classification system that corroborates with the Global Land Use classes (GLU) identified by FAO.
- Fine tuning of forest and tree assessment methodologies for field data collection.
- Identification and training of team leaders and field crews for the field data collection.
- Collection of maps to be used in the field during the field data collection.
- Identification and recruitment of the local as well international experts required for the implementation of the NFA.

7.1. Sampling design

The sampling design followed a global approach for systematic sampling used by FAO. The basic approach was to go for a systematic sampling. Each sampling unit was designated as a "Tract". To decide the intensity for field sampling several meetings were arranged, where most of the national stakeholders were present to thoroughly discuss what density was most appropriate for the NFA field survey. The cost involved for field data collection was a major limiting factor for deciding upon the sampling intensity.

Based on these discussions and availability of funds, an agreed principle of systematic sampling was finalized in this inception workshop. It was agreed that sample sites should be distributed systematically throughout the country at an interval of 15 minutes latitude and 10 minutes longitude, where the sample coordinates represent the **South-West corner** of the tracts, resulting in 299 Tracts (or samples site) for the whole of Bangladesh (see Annex IV).

7.2. Tract, Plot and Subplot design

FAO's standard layout fot Tracts, Plots and Subplots was adopted (see Figure 2), where the Tract represents a square of 1 km x 1 km (à 1km^2) in which the general context for field data collection is recorded. Each Tract comprises 4 Plots with the dimension 20m x 250m (à 0,5 ha) and it is within the Plots that the actual field measurements are carried out. The coordinates of the Plot starting point were noted on maps and also recorded in GPS receiver to orient to the tracts and the plots during the field work. The orientation (or the approach or direction for collecting data from the plot) of the plots are:

Plot # 1	North-ward
Plot # 2	East-ward
Plot # 3	South-ward
Plot # 4	West-ward

When the Land Use Class is "Forest", circular subplots are established to collect data on tree regeneration. The Subplots have a diameter of 3.99m (à 50m^2) and are placed with their centre at 5m, 125m and 245m from the Plot starting point along the Plot central axis (see Figure 2).

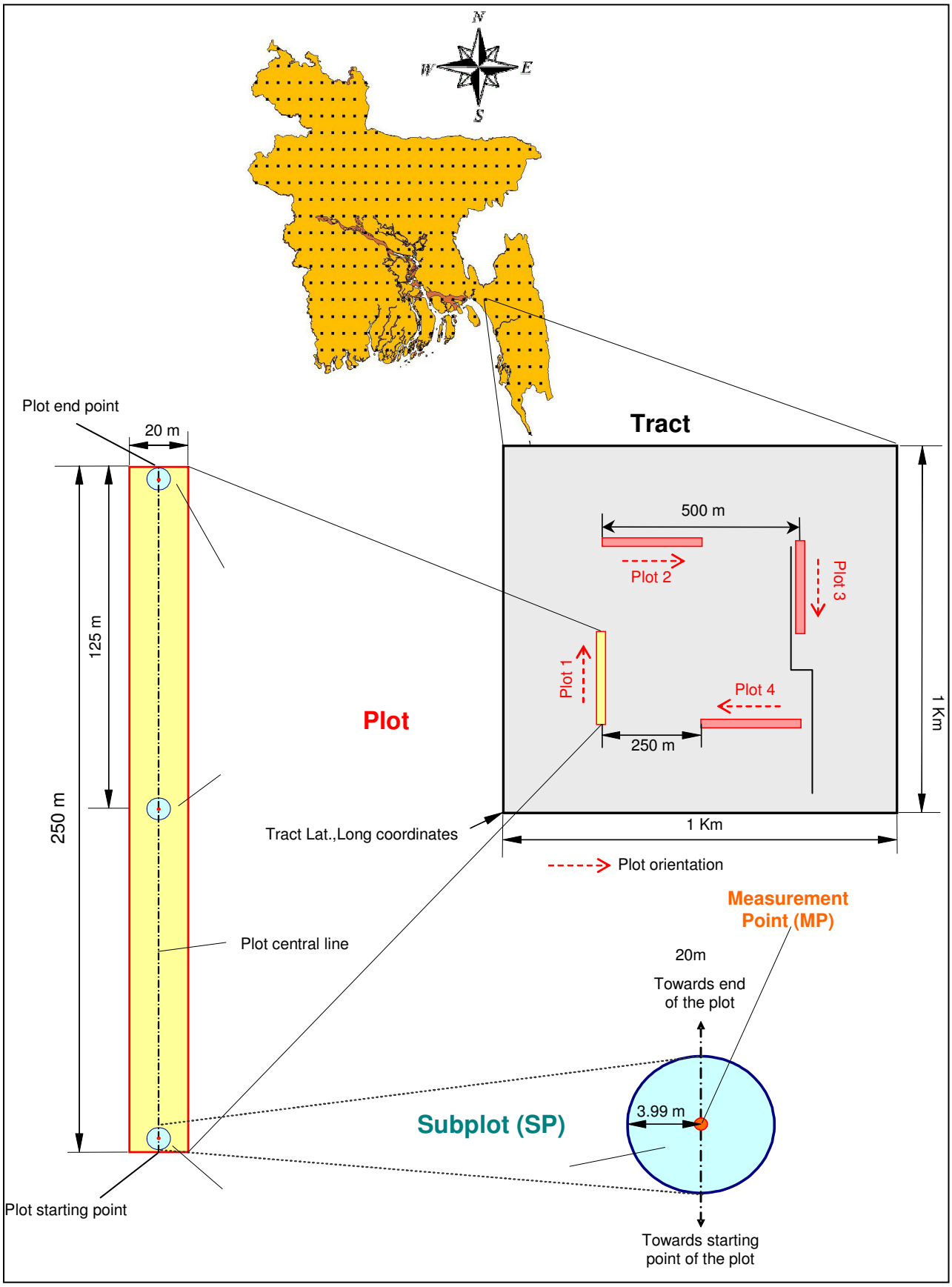

Figure 2: Tract, plot and subplot design

7.3. Classification system

FAO's support to National Forest Assessment (NFA) aims at building national capacities in long term monitoring of the national forest and tree resources. The globally harmonized major land use classes identified and detailed under the FRA program of FAO were studied in details and based on that given frame work the national land use classes were identified and firmed up, so that these while corroborating with the global criteria do not fail to record the possible national land use classes. This task was accomplished through a series of discussions and meetings. This was one of the most vital tasks of phase I of the project.

With the inputs from the Inception Workshop and following the recommendations of experts in this field especially of the LTU experts and the NFAU members 29 land use classes were finally identified for use during the collection of the field data (see Table 6)

Table 6 : National Land Use Classification system and national/international grouping

GFRA	National Land Use Classification				
	L1	L2	L3		Code
Forest (F)	**Forest (F)**	Natural Forest (FN)	Hill forest	(FH)	111000
			Sal forest	(FSa)	111002
			Swamp forest (freshwater)	(FSw)	111150
			Mangrove forest (saltwater)	(FM)	111160
			Bamboo or mixed Bamboo/broad-leaved forest	(FB)	114000
		Forest Plantations (FP)	Long rotation forest plantation	(PL)	121010
			Short/medium rotation forest plantation	(PS)	121020
			Mangrove Plantation	(PM)	121160
			Rubber Plantation	(PR)	121170
Other Wooded Land (OWL)	**Cultivated Land (Cult.)**	Shrubs (S)	Shrubs	(Sh)	210000
			Swamps with shrubs	(Sw)	210010
Other Land (OL)		Barren/Grass Land		(BG)	312000
		Annual Crops (CA)	Annual Crops Without trees	(CA0)	321001
			Annual Crops With trees 0,1 – 0,5 ha	(CA1)	321002
			Annual Crops With trees >0,5 ha	(CA2)	321003
		Perennial Crops (CP)	Perennial Crops Without trees	(CP0)	322001
			Perennial Crops With trees 0,1 – 0,5 ha	(CP1)	322002
			Perennial Crops With trees > 0,5 ha	(CP2)	322003
		Range Land/Pasture		(RL)	323000
		Wooded land with shifting cultivation (Fallow)		(Fa)	324000
	Villages (Vill.)	Rural settlement without trees		(SR0)	332001
		Rural settlement With trees 0,1 – 0,5 ha		(SR1)	332002
		Rural settlement With trees > 0,5 ha		(SR2)	332003
	Built-Up Areas (BUA)	Urban settlements		(SU)	331000
		Highways and other artificial areas		(HA)	333000
Inland Water (W)	**Inland Water (W)**	Lake		(WL)	400010
		River		(WR)	400020
		Pond		(WP)	400030
		Haor & Baor		(WHB)	400040
-nk-	Not Known (not visited in the field)			(nk)	900000
-OUT-	Outside land area			(OUT)	500000

7.4. Variables

The FAO developed NFA approach comprises the collection of data on the multiple functions of forests and trees, covering their Socio economic, Environmental as well as Productive functions, and the field data collection is therefore associated with a wide range of variables and different methods for data collections.

Please refer to List of Variables and related attributes in Annex III and the Field manual in Annex XII for a detailed description of the variables and their options covered in the field data collection.

7.5. Training of field crews

The NFAU team members as well as the Field Team members were trained at several occasions to strengthen their capacities and to ensure quality and proper collection and analysis of NFA data. The following training workshops were held for this purpose:

- From June 13 to 20, 2005:
  Training workshop was held for 14 FD officials including NFAU team on NFA Design on LU class definition.

- From October 4 to 11, 2005:
  Field Training of the NFAU team members and of the Field Crews were conducted by SLU expatriates and project consultants on familiarization of field equipments to be used during field survey and data collection.

- From October 23 to 27, 2005:
  Further Field training of the Team Leaders of the field survey teams and Senior/Junior Field Investigators were held.

- From November 29, 2005 to December 9, 2005:
  The technical back stopping personnel from FAO-FOMR installed the 'NFA-Bangladesh v.1.0 database' and trained the concerned FD personnel on data encoding.

- From February 28, 2006 to March 16, 2006:
  The FAO-FOMR team installed the NFA-Bangladesh v.1.2e data base system and trained the concerned personnel form the FD, Government of Bangladesh.

- From March 5 to 15, 2006:
  The FAO-FOMR team appraised the national consultants about the data processing. At the same time the same team trained the FD personnel on data processing.

7.6. Field Data Collection – Measurements, Observations and Interviews

The field data collection was started from the 2nd week of November 2005 by 10 teams in the predefined 10 inventory zone all over the country. The field work ended on May 15, 2006, except the data from tract 5. For some of the unavoidable law and order problem the data from tract 5 could not be collected in time. However, the data from tract 5 was gathered and sent to Dhaka by the end of August 2006. These have been entered into the data base in first week of October 2006.

It was expected that both the analysis results of the field inventory data and remote sensing analysis shall be used hand in hand for the compilation and preparation of the report. Though field survey, initiated in November 2005 was completed by May 2006, the classification of the remote sensing data could not be started until the arrival of the imageries in June 2006. During December 2005 to July 2006 data encoding of the sample tract was done by FD. This work was constantly supervised by NFISC and TCDC, while the technical back stopping was provided by FOMR, FAO, Rome. A total of 296 Tract reports were finally encoded by using the application (NFA Bangladesh v.1.2g) and database (NFA-Data_Bangladesh). The encoded sample tract data were examined and validated by TCDC, National Consultant (Analysis) and NFISC based on MS Access queries and MS Excel. Analysis of the findings from field inventory is done in line with the report layout provided by the FOMR, FAO along with the national requirements.

The field survey teams identified the plot-starting points with GPS receivers and placed a galvanized metal pole as a permanent marker at each starting point. Three reference features at suitable locations were noted with respect to the starting point for future location of the plot-starting point. Within the 250 meter long and 20 meter wide Plots, the field teams measured and registered related attributes for all trees ≥10cm D_{bh}, all stumps ≥10cm D_{sh} and all bamboo culms/clumps. The land uses (see Table 6) in the Plots were identified and delineated with their dimensions and attributes related to these land uses were noted accordingly.

Data on the status of forests and trees were measured by the field teams using forest inventory equipment, such as; diameter tape, altimeter, GPS receiver, compass, laser range finder, etc., while some variables can not be measured the field teams made adequate observations to determine the status, and interviews with key informants and user groups were conducted to assess information related to forest and tree resources management, uses and users.

Focus group discussions (FGDs) were conducted to collect information with respect to the products and services that the people generally harvest, collect and obtain form these land-use classes were recorded during the survey. During the focus group discussions the local key informants were interviewed to collect the required data especially with respect to the 'products and services'. All data collected from the tracts are entered and recorded in six field forms. The forms that were used for the purpose are given in Annex II.

7.7. Data entry, processing and analysis

7.7.1. Data entry

The team leaders were responsible for submitting the completed field forms to the NFAC/TCDC expert for review. After both the NFAC and the TCDC expert had cleared the submitted field forms for entry, data encoders at FD headquarters in Dhaka were responsible for the data entry in the NFA database application. Information on the NFA database is presented in chapter 8 and in Annex V.

Before a set of field forms was cleared for data entry the data needed to be checked and cleared by the NFAC or the TCDC expert. Field forms that were found to be incomplete was returned to the responsible team leader with instructions on what was missing or incorrectly registered and how to complete the form.

After the entry of the field data into the NFA database application the data was ready for processing and analysis.

7.7.2. Data processing

To ensure high quality data processing and statistical analysis several FD staff was trained by FAO experts at several occasions. For detailed information on the procedures for data processing please refer to Annex VI.

7.7.3. Data analysis

After data were processed they were analysed by the national consultant for data analysis together with the NISC and the TCDC expert. Most of the measured variables depend on the size of the area over which it is measured. For these variables Ratio estimates are used. All statistical functions employed during the study are illustrated in Annex VII.

Photo 6 and 7 : Training session on data processing and analysis at FD. Lecturer Mr Dan Altrell from FAO Rome and participants from FD.

7.8. Remote sensing

Table 7 shows the land use classification system that was prepared for the remote sensing survey. The classification system was based on the land use classification system employed by the field survey, but had to be slightly less detailed, due to the limitations in the spectral as well as spatial resolution of the remote sensing data. SPARRSO received the 14 Landsat TM imageries from 2005 that cover the whole of Bangladesh in June 2006. The mosaic constructed by using the 14 imageries procured, covering the whole country is presented in Annex IX. SPARRSO has initially downloaded the **" *.tiff "** format imageries to their local PCs and imported these from **" geotiff "** to image (***.img**) format. The three layers form the 3 bands were staked to generate "XS" imageries. Due to poor geometric accuracy of the "geotiff" files of the data (imageries) procured, SPARRSO conducted a geo-rectification of the data (imageries) procured by using the Landsat TM mosaic of 1997 which was available at SPARRSO's archive. Thus geo-rectification of the procured imageries was completed and is expected to be up to the mark for the given purpose.

Table 7 : Land Use and Forest Type Legend for Land Use mapping

Sl. #	Forest/Land Cover Type	Legend
1	Hill Forest	**FH**
2	Sal Forest	**FSa**
3	Mangrove Forest	**FM**
4	Hill Forest with Mixed Bamboo	**FB**
5	Mangrove Plantation	**PM**
6	Rubber Plantation	**PR**
7	Shrub	**Sh**
8	Agriculture & Rural Settlements with Tree Cover	**ASRT**
9	Urban Settlement	**SU**
10	Haor & Baor	**WHB**
11	Lake	**WL**
12	Rivers	**WR**
13	Large Ponds	**WP**
14	Highway	**Hw**

Source: Inception Report SPARRSO, Aug/2006

SPARRSO team along with 4 officials from RIMS Unit of Forest Department processed the remote sensing data at SPARRSO laboratories. Preliminary land use maps were prepared for field verification (ground-truthing) undertaken December 2006 and the final land use maps were generated in August 2007. The outputs from SPARRSO have been integrated into the RIMS at BFD.

The SPARRSO has supplied land use maps in two different scales, namely 1:1,000,000 (one sheet will cover the whole of Bangladesh) and 1:100,000 (67 sheets will cover the whole of Bangladesh)

8. NFA Data base application

Thus data base became ready for query and extraction of data for desired analysis. The National Consultant Result Analysis (NCRA) was hired from July 18, 2006.

The required data was retrieved from the access database by using queries. The query output was exported to MS Excel sheets and the statistical analysis was carried out following the guidelines given by FOMR, FAO, Rome. The details of the guidelines for the statistical analysis are given in Annex VII.

To store and manage the collected NFA data a database application was developed by FAO/FRA in collaboration with the country national team. The database application, based on the MS Access software (2000/2002), comprises two database files; one "data" database (NFI-data_<*COUNTRY*>.mdb) and one "application" database (NFI-<*COUNTRY*> v.*x.x*.mdb). All collected field data (dynamic data) are stored in inter-related tables in the "data" database, while the "application" database contains code tables (static data), forms and queries and macros. The users of the NFA database manage the data through the application database. To open the database application the users double-click on the *NFI-<COUNTRY> v.x.x.mdb* file. The data are managed through forms and the user navigates in the database by selecting different forms according to required operation.

The efforts in developing the NFA database application have initially been focused on wise data storage and on facilitating the input of primary data, why until now the only activated section in the database application is the section on "*Field Data*".

The design of the forms for adding/editing field data in the database application follows the same as the field forms employed for the data collection in the field inventory. The idea with this coherence is to facilitate the entering of field data into the database application since the instructions on how to register field data are given in the field manual (please refer to Annex XII).

8.1. Tables

All data in the NFA is stored in tables. All tables with collected inventory data (primary data) is kept in the "data" database (NFI-data_<*COUNTRY*>.mdb), while all static data like codes, expansion factors, etc. are kept in the "application" database (NFI-<*COUNTRY*> v.*x.x*.mdb) (refer to Figure 4).

8.1.1. Code tables

For each variable with attribute options there is a corresponding code table with defined options. The names of code tables all begin with "C-" and they contain internationally harmonized terminology and nationally adapted options to the variables, where every option has a unique code.

8.1.2. Data tables

For each level of data collection there is a corresponding data table with defined variables. The variables are internationally harmonized and nationally adapted terminology, and may have unbound values or may be bound to predefined attribute options according to code tables. The names of data tables begin with "F-", "P-", "Ph-" or "H-"(refer to Figure 5). The *F-tables* contain the values of all the variables that are collected at corresponding inventory level; Tract data is stored in the *F1-Tract* table, Plot data is stored in the *F1-Plot*, LUS data is stored in the *F5-LUS* table, etc. The *P-table* contains data on informants or other persons involved in the inventory, the *Ph-table* contains data on photos taken during the NFA, and the

H-tables are help-tables that relate the data from two data tables to each other, for example the *H-Person-Function-Tract* relates the information of persons to tracts and indicates what function the person had in that tract.

8.1.3. Relation database

The NFA database application is developed in MS Access, which is a relation database. A relation database allows that data can be collected at different inventory levels (Tract, Plot, LUS, Tree, etc.) and still relate to each other. In practice this is accomplished by creating separate data tables for each inventory level. To relate (link) the data in on table to another the tables must have at least one common field. In this way the tract attributes can be related to the attributes in all plots in the tract through the "ID-TRACT" field, and the Plot attributes can be related to the attributes in all LUS in the plot through the "ID-PLOT" field, and the LUS attributes can be related to all product/service attributes in the LUS through the ID-LUS field and further to the attributes of all trees through the two common fields ID-PLOT and ID-LUS, etc (see Figure 3).

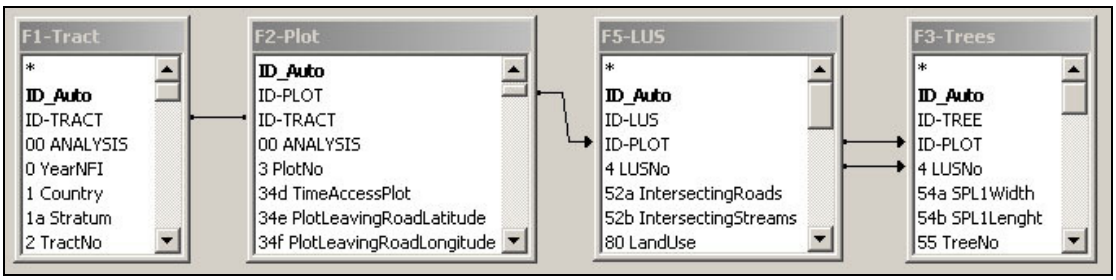

Figure 3: Illustration of the relationship between different data tables

Tables can be linked to each other even though they are not physically in the same database file. A fixed location of the database files is necessary as the database application has linked to the dynamic tables in the "data" database and therefore need to know where the "data" database is located. The NFA database application consists of the two database files "*NFI-data_<COUNTRY>.mdb*" and "*NFI-<COUNTRY> v.x.x.mdb*" and the location of the "data" database is set to the C:\NFA\ folder (see Figure 4).

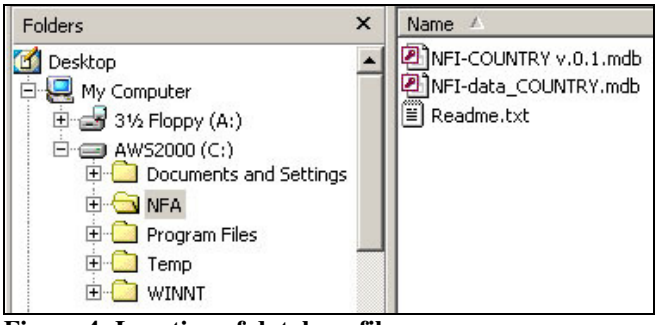

Figure 4: Location of database files

In Figure 5 the database window from the application database (*NFI-<COUNTRY> v.x.x.mdb*) is displaying some of the tables in the database application. The tables displayed with only a table symbol next to the table name are tables stored in the same application database, while the tables with an arrow symbol next to the table symbol are the tables with dynamic data (primary field data) and they are linked from the data database (*NFI-data_<COUNTRY>.mdb*).

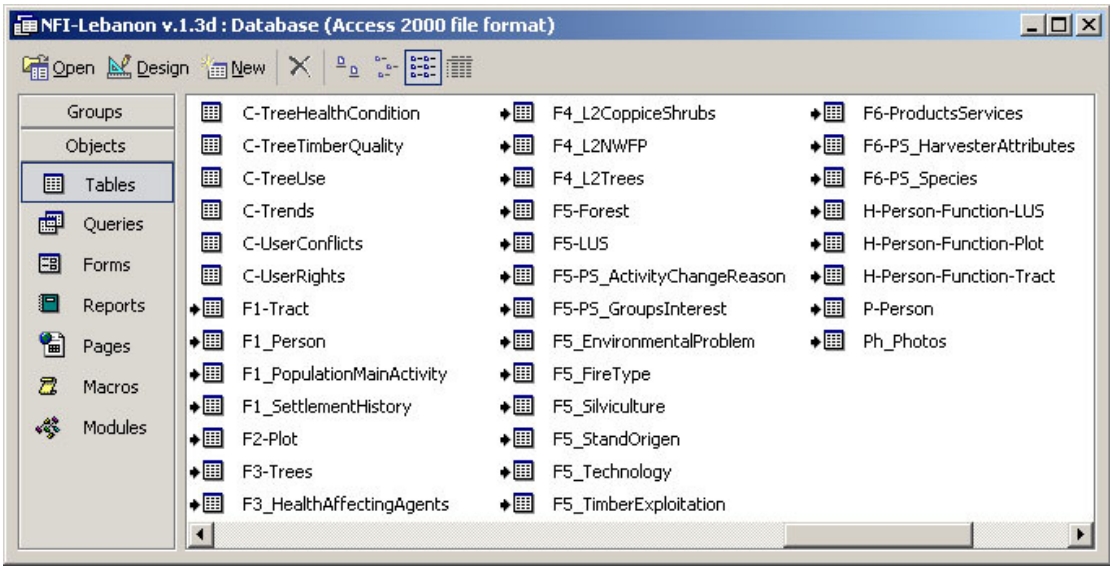

Figure 5: Database window in the NFA application database ("NFI-<COUNTRY> v.x.x.mdb") showing some of the code tables in the database (beginning with "C-") and some of the linked data tables (with an arrow symbol next to the table symbol).

The purpose of separating the dynamic field data from the rest of the database application is to allow users to work with the database application from different computers in a network and only have one main database with the inventory data. The NFA application database can be installed on computers in the network and they are all related to one database where the inventory data are stored. In this way only one version of the inventory data exist. Another benefit with separating the dynamic data from the rest of the database is to allow a smoother actualisation of the features in the database application without altering the primary data. A database specialist can in this way develop new versions of the NFA database application, with improved functionality, while other users continue to enter/edit data through an older version of the database application. When the new version of the application database ("*NFI-<COUNTRY> v.x.x.mdb*") is ready it will substitute the older version, but the primary data remains unaltered in the data database (*NFI-data_<COUNTRY>.mdb*).

8.2. Forms

The users of the NFA database manage the data through forms. There is a form corresponding to every field form for field data collection, and further sub-forms within these forms (see Figure 6). The users add and edit the NFA field data through these forms. A validation of the field data built-in in the forms. Criteria for acceptable values and reasonable values are defined for most of the variables, so when the users enter the field data through the forms they automatically go through a general validation. For more information on the forms and on how to navigate in the NFA database application please refer to Annex V.

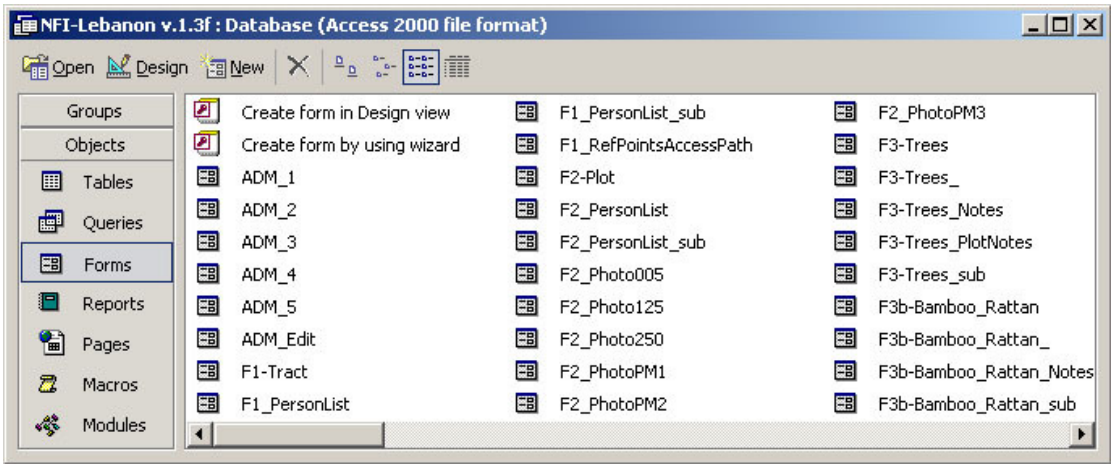

Figure 6: Database window in the NFA application database ("*NFI-<COUNTRY> v.x.x.mdb*") showing some of the forms that are employed in the database application.

8.3. Queries

Queries can be used for processing and analysing data that are stored in tables. However it is not recommended to process or analyse the NFA data in any of the two database application files, *NFI-data_<COUNTRY>.mdb* and *NFI-<COUNTRY> v.x.x.mdb*, as it would cause the application to become very "heavy". Instead the data processing and analysis should be carried out in a separate database that is linked to the two database application files.

In the NFA database application the Queries are only employed to filter the data in Tables or in other Queries. The information displayed through forms is filtered through Queries or through Tables with applied filters. For each form there can be one or more Queries employed depending on the structure and functionality of the form. For example the data source for every sub-form in a form could be based on a separate Query. Some of the Queries that are used as data sources for the forms in the NFA database application are displayed in Figure 7.

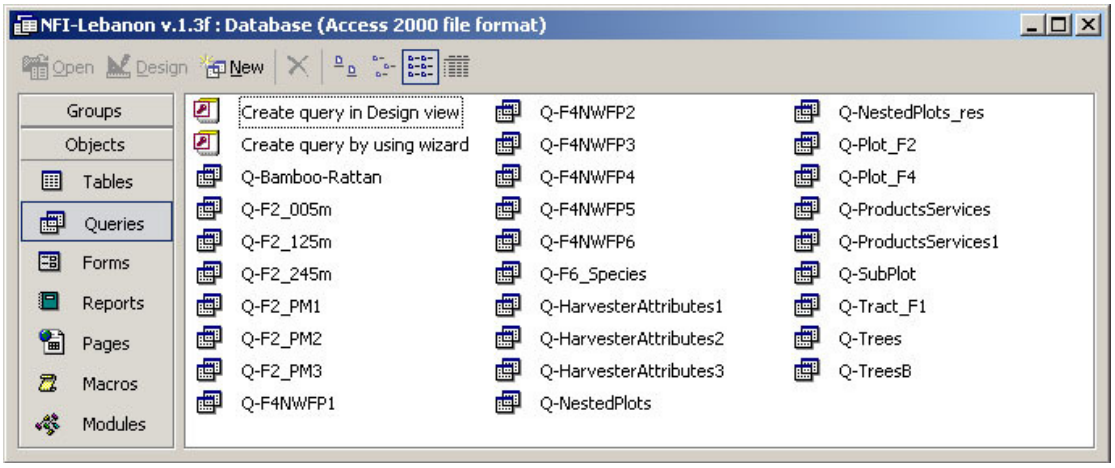

Figure 7: Database window in the NFA application database ("*NFI-<COUNTRY> v.x.x.mdb*") showing the queries in the database application.

9. Results

The Results chapter is composed by five sections, each one focusing on a specific aspect of the NFA of Bangladesh: Area, Volume, Biodiversity, Social and Economic, Biomass and Carbon. In each section the variables of interest are presented in relation to the Major National Land Use Classes (LUCs) and, in the case of "Forest", the variables are compared among different forest types.

The land area of Bangladesh is described by NFA data according to characteristics such as tree cover, protection level, ownership status, environmental problems and species diversity among others. Information on total and commercial volume is presented over a range of comparative classes. Population characteristics and dynamic is also presented in relation to various forest characteristics, in terms of resource availability and utilization. The contribution of forests of Bangladesh in terms of Biomass and Carbon is also presented.

NFA results with descriptive statistics are presented Annex XI while Results for international reporting (FRA2010) can be found in Annex XIII.

The NFA is not able to present estimates for all variables in all land use classes, as the field data collection did not cover all of the land use classes defined for Bangladesh and in some cases only limited data has been recorded.

9.1. Area

Total area of Bangladesh is classified into 28 national land uses (see Table 9) which can be grouped into five Major National LUCs: "Forest", "Cultivated land", "Villages", "Built up areas" and "Inland water". Detailed definitions of the LUCs are presented in Annex I. With regard to "Forest", the definition adopted in this study is the one used by FAO for FRA2005 (FAO 2006):

"Land spanning more than 0.5 hectares with trees higher than 5 metres and a canopy cover of more than 10 percent, or trees able to reach these thresholds in situ. It does not include land that is predominantly under agricultural or urban land use. Forest is determined both by the presence of trees and the absence of other predominant land uses. The trees should be able to reach a minimum height of 5 metres (m) in situ. Areas under reforestation that have not yet reached but are expected to reach a canopy cover of 10 percent and a tree height of 5 m are included, as are temporarily unstocked areas, resulting from human intervention or natural causes, which are expected to regenerate. Includes: areas with bamboo and palms provided that height and canopy cover criteria are met; forest roads, firebreaks and other small open areas; forest in national parks, nature reserves and other protected areas such as those of specific scientific, historical, cultural or spiritual interest; windbreaks, shelterbelts and corridors of trees with an area of more than 0.5 ha and width of more than 20 m; plantations primarily used for forestry or protective purposes, such as rubber-wood plantations and cork oak stands. Excludes: tree stands in agricultural production systems, for example in fruit plantations and agroforestry systems. The term also excludes trees in urban parks and gardens."

Photo 8: Cattle grazing on an agricultural field in the Madhupur Forest Reserve

9.1.1. The area of Bangladesh by Land Use Classes

The land use area statistics have been generated using a combination of findings from the remote sensing survey and the field survey, following a harmonised land use/forest type classification system. The total area of Bangladesh is 14.757 million hectares (Stat. Year Book 2004). In this current NFA, 56% of the area has been classified as "Cultivated land", almost 20% as "Villages", 14% as "Inland water", close to 10% as "Forest" and less than 1% as "Built up areas" as shown in Table 8 and Figure 8. A further subdivision of land classes and respective area contribution to the total is presented in Table 9.

Table 8: Area of major National LUCs (1000 ha)

Forest	Cultivated land	Villages	Built up area	Inland water
1,442	8,327	2,862	104	2,022

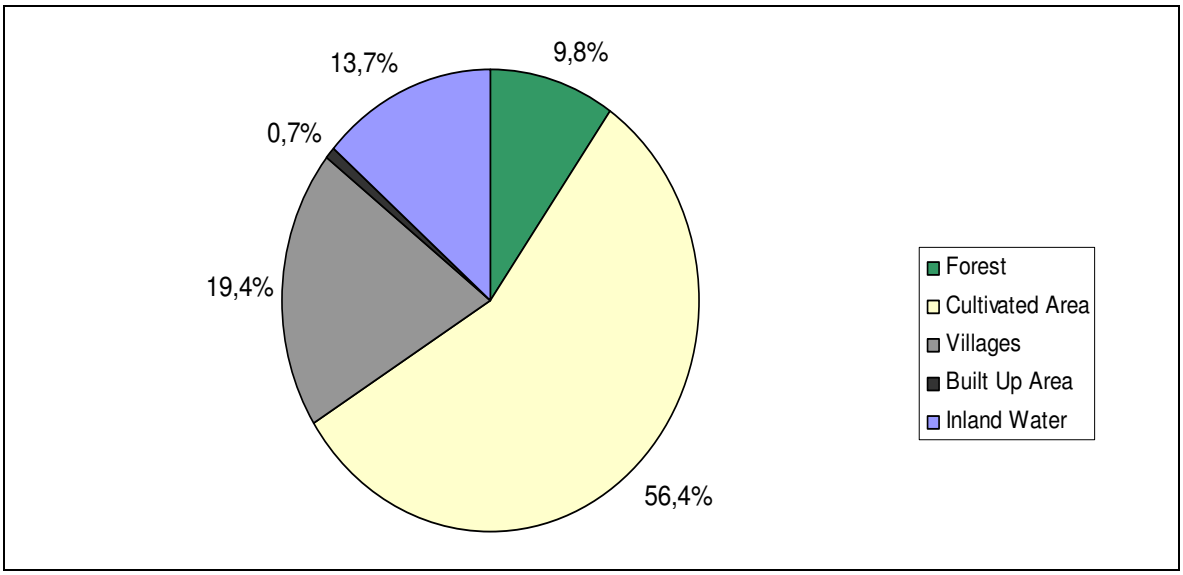

Figure 8: Total area of Bangladesh divided into major National LUCs
Table 9: Total area of Bangladesh by National Land Use Classes

International LUCs	National Land Use Classes				Area
	Level 1	Level 2	Level 3		1000 ha
Forest (F) 1 442	**Forest (F) 1 442**	Natural Forest (FN) 1 204	Hill forest	(FH)	551[1]
			Sal forest	(FSa)	34[1]
			Mangrove forest (saltwater)	(FM)	436[1]
			Bamboo or mixed Bamboo/broad-leaved forest	(FB)	184[2]
		Forest Plantations (FP) 237	Long rotation forest plantation	(PL)	131[2]
			Short/medium rotation forest plantation	(PS)	54[2]
			Mangrove Plantation	(PM)	45[1]
			Rubber Plantation	(PR)	8[1]
Other Wooded Land (OWL) 289	**Cultivated Land (Cult.) 8 327**	Shrubs (S) 289	Shrubs	(Sh)	266[6]
			Swamps with shrubs	(Sw)	23[1]
Other Land (OL) 11 005		Barren/Grass Land		(BG)	89[4]
		Annual Crops (CA) 7 492	Annual Crops Without trees	(CA0)	6,583[4]
			Annual Crops With trees 0,1 – 0,5 ha	(CA1)	784[4]
			Annual Crops With trees >0,5 ha	(CA2)	126[4]
		Perennial Crops (CP) 106	Perennial Crops Without trees	(CP0)	19[4]
			Perennial Crops With trees 0,1 – 0,5 ha	(CP1)	8[4]
			Perennial Crops With trees > 0,5 ha	(CP2)	79[5]
		Range Land/Pasture		(RL)	25[4]
		Wooded land with shifting cultivation (Fallow)		(Fa)	327[2]
	Villages (Vill.) 2 862	Rural settlement without trees		(SR0)	95[4]
		Rural settlement With trees 0,1 – 0,5 ha		(SR1)	1,090[4]
		Rural settlement With trees > 0,5 ha		(SR2)	1,677[4]
	Built-Up Areas (BUA) 104	Urban settlements		(SU)	85[1]
		Highways and other artificial areas		(HA)	19[1]
Inland Water (W) 2 022	**Inland Water (W) 2 022**	Lake		(WL)	43[1]
		River		(WR)	1,070[1]
		Pond		(WP)	286[4]
		Haor & Baor		(WHB)	622[1]
Total country area of Bangladesh					**14,757[0]**

[0] Data calibrated to official land area of Bangladesh : 13,021,452 ha, and official inland water (WL+WR+WHB) area of Bangladesh : 1,735,548 ha (source SPARRSO)

[1] Data source: National Forest Field Inventory, NFI (BFD, 2007)

[2] Data source: Remote Sensing Study, RS (SPARRSO, 2007)

[3] Data source: RS adjusted by NFI data

[4] Data source: NFI calibrated by RS: NFI (BG+CAP+RL+SRT+WP+$PS^{plainland}$) = RS (CAP+SRT+WP)

[5] Data source: Remote Sensing Study, RS (SPARRSO, 2007). Data correspond to RS (Tea and Mango plantations)

[6] Data source: RS adjusted by NFI data. Data correspond to RS(Sh+FB+Fa) - NFI(FB+PL+$PS^{hilltracts}$+Fa)

9.1.2. Forest area divided into natural and plantation forest

Of the total Forest area, 84% has been classified as natural forest and 16% as plantation forest as shown in Figure 9.

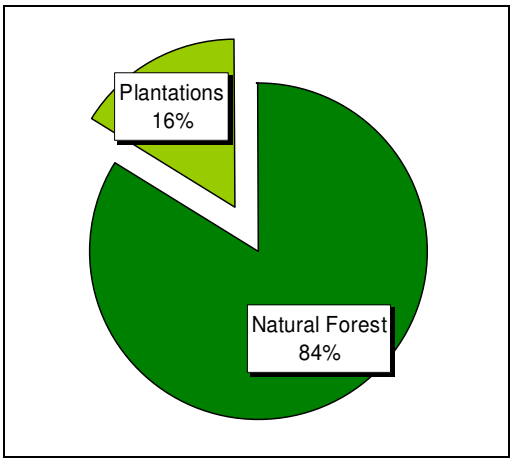

Figure 9: Proportion of Plantation and Natural forest over Total Forest area

9.1.3. Forest area by Forest Types

The two most common forest types – Hill Forest and Mangrove Forest – cover more than 2/3 of the total forest area. Bamboo Forest covers almost 13% and Long Rotation Plantations almost 10% of the total forest area.

Table 10: Forest area by forest types (1000 ha)

Hill Forest	Sal Forest	Mangrove Forest	Bamboo Forest	Long Rotation Plantation	Short Rotation Plantation	Mangrove Plantation	Rubber Plantation
551	34	436	184	131	54	45	8

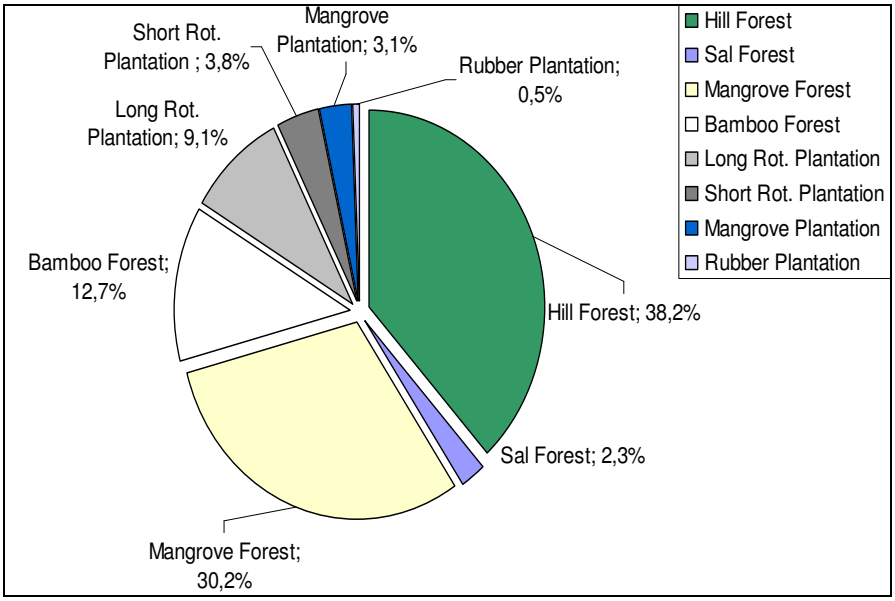

Figure 10: Forest area by forest types

9.1.4. The area of Bangladesh by Tree Cover Classes

Almost 50% of the area of Bangladesh has some kind of tree cover. Only 2,3% of the area has a very high tree cover (>70%) and roughly 20% has low tree cover (<5%).

Table 11: Total area of Bangladesh by tree cover classes (1000 ha)

No Tree Cover	Tree Cover <5%	Tree Cover 5-10%	Tree Cover 10-30%	Tree Cover 30-70%	Tree Cover >70%
7,605	2,886	1,431	1,276	1,225	334

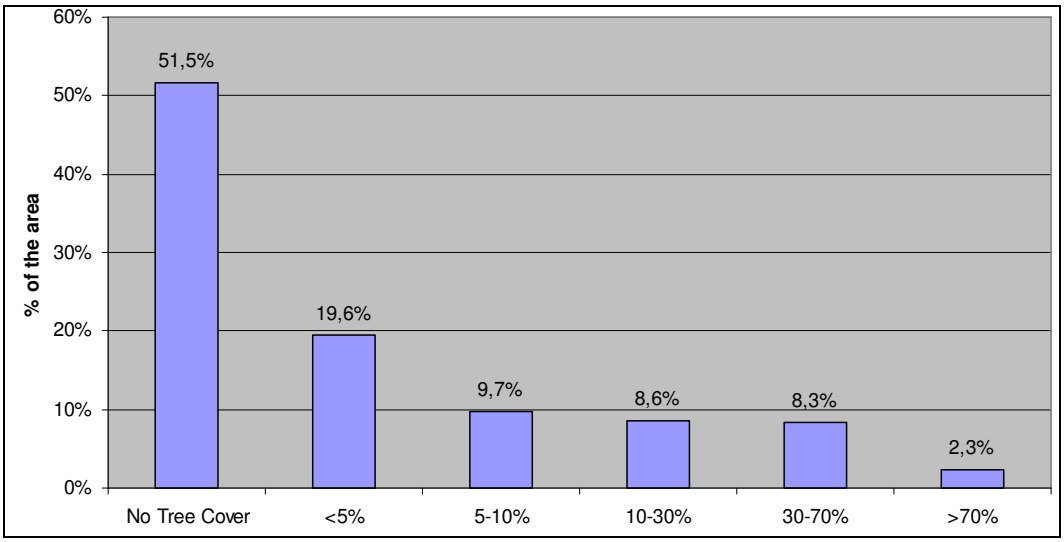

Figure 11: Total area of Bangladesh by tree cover classes

9.1.5. Forest area by Tree Cover Classes

Less than 25% of the "Forest" area has a very high tree cover (>70%), almost 40% has a tree cover of 30 to 70%, and almost 40% has less than 30% tree cover.

Table 12: Forest area by tree cover classes

No Tree Cover	Tree Cover <5%	Tree Cover 5-10%	Tree Cover 10-30%	Tree Cover 30-70%	Tree Cover >70%
-	68	30	440	574	330

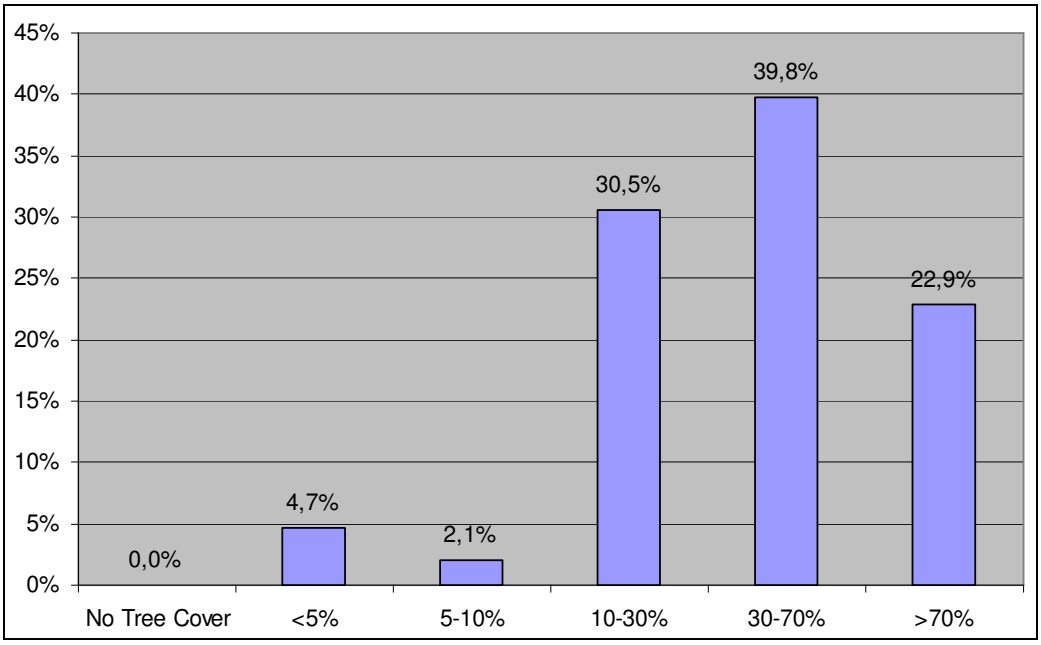

Figure 12: Forest area by tree cover classes

9.1.6. Cultivated land area by Tree Cover Classes

More than 30% of the Cultivated land area has tree cover, however it is generally low in terms of percentage of cover, with 20% having a cover of less then 5%.

Table 13: Cultivated land area by tree cover classes (1000 ha)

No Tree Cover	Tree Cover <5%	Tree Cover 5-10%	Tree Cover 10-30%	Tree Cover 30-70%	Tree Cover >70%
5,553	1,866	460	197	227	25

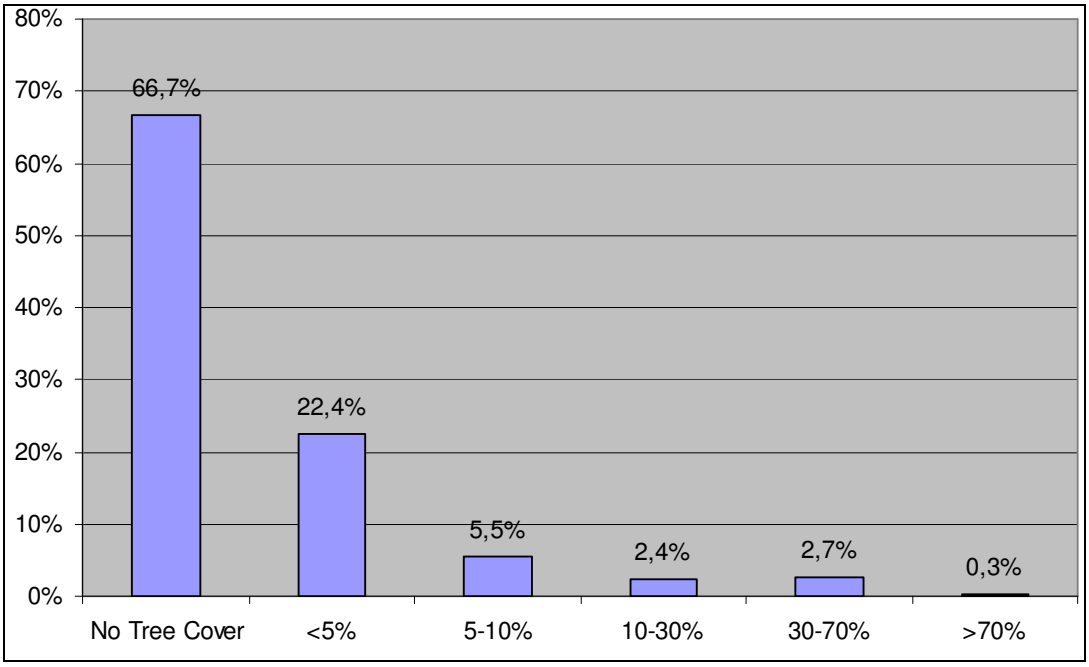

Figure 13: Cultivated land area by tree cover classes

9.1.7. Village area by Tree Cover Classes

Almost all of the Village area is covered by trees however, only a very small fraction of the Village area has a very high tree cover. Also, a very small area has no tree cover at all.

Table 14: Village area by tree cover classes (1000 ha)

No Tree Cover	Tree Cover <5%	Tree Cover 5-10%	Tree Cover 10-30%	Tree Cover 30-70%	Tree Cover >70%
40	752	873	675	491	31

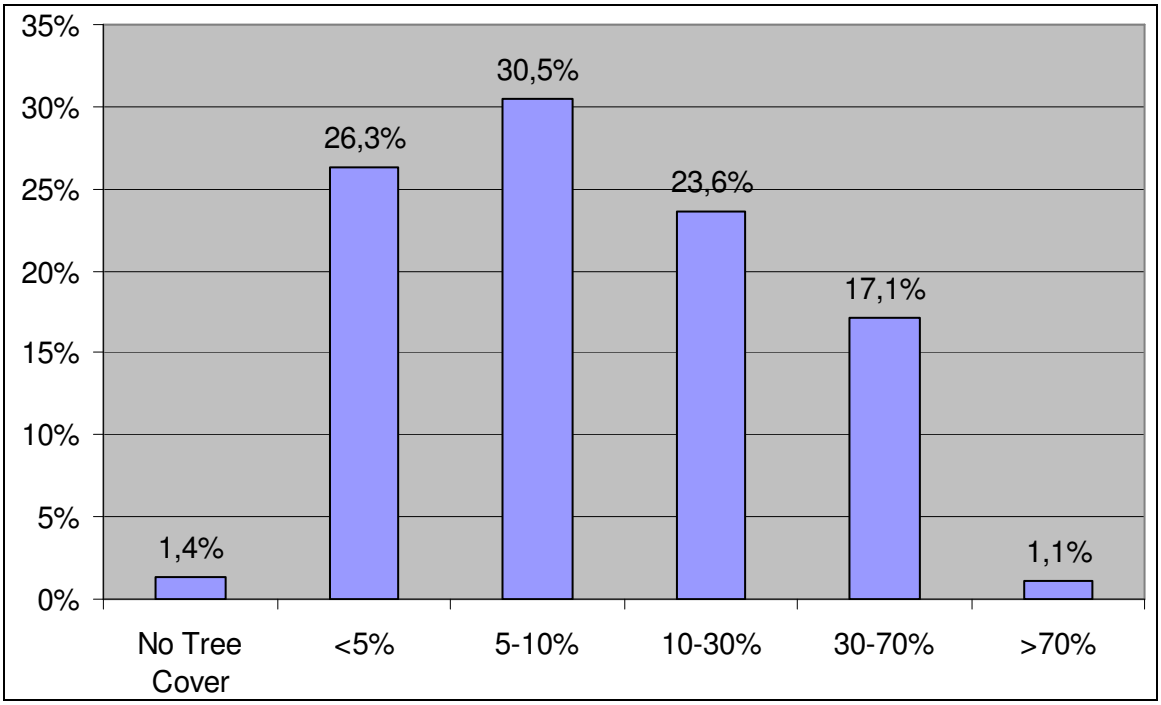

Figure 14: Village area by tree cover classes (%)

9.1.8. Built-up areas by Tree Cover Classes

The majority of the Built-up area has a low tree cover. Almost 70% has a tree cover of less then 5% while 11% has no tree cover at all.

Table 15: Built-up area by tree cover classes (1000 ha)

No Tree Cover	Tree Cover <5%	Tree Cover 5-10%	Tree Cover 10-30%	Tree Cover 30-70%	Tree Cover >70%
12	72	19	0	0	0

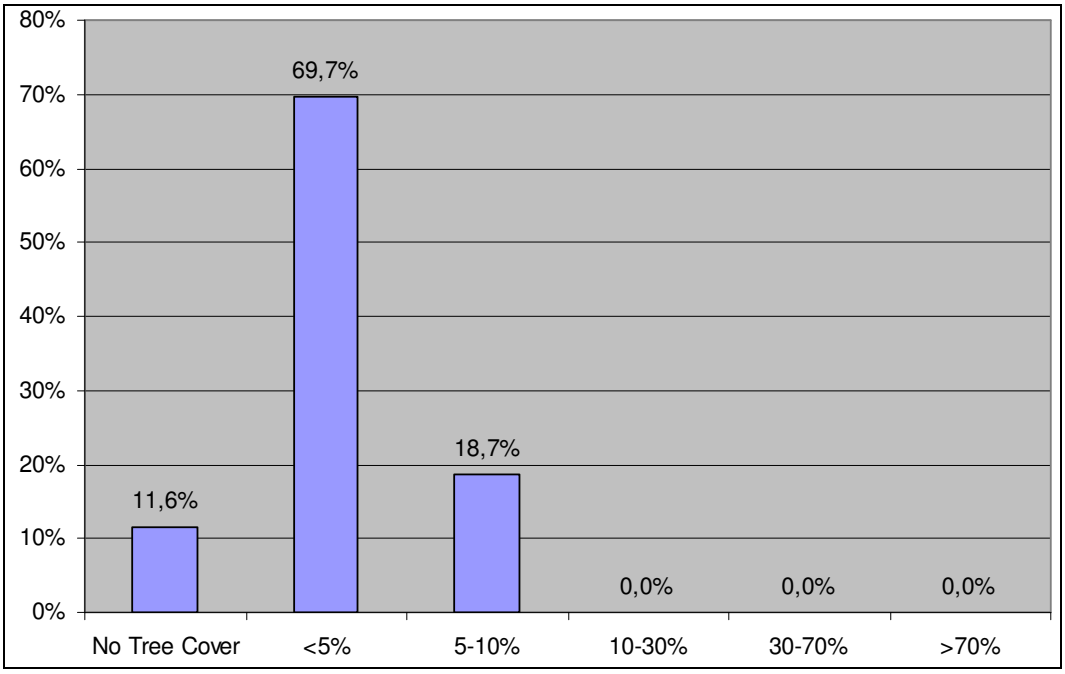

Figure 15: Built-up area by tree cover classes

9.1.9. Inland water by Tree Cover Classes

Almost 95% of the Inland water area has no tree cover. Only 5% has tree cover of < 5%.

Table 16: Inland water area by tree cover classes (1000 ha)

No Tree Cover	Tree Cover <5%	Tree Cover 5-10%	Tree Cover 10-30%	Tree Cover 30-70%	Tree Cover >70%
1,910	100	12	0	0	0

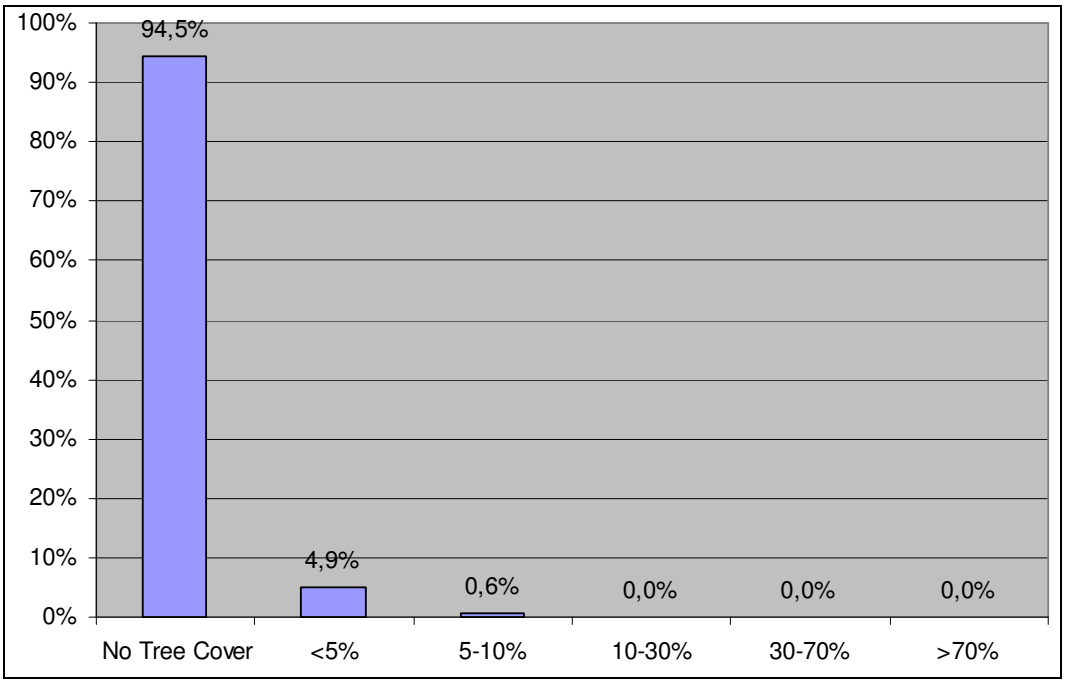

Figure 16: Inland water area by tree cover classes

9.1.10. Forest types area by Tree Cover Classes

The Hill Forest and Bamboo Forest in general have a tree cover of 10-70%. All the Mangrove forest area has a very high tree cover. The plantations in general have a low tree cover.

Table 17: Forest types area by tree cover classes (1000 ha)

Forest Type	Tree Cover <5%	Tree Cover 5-10%	Tree Cover 10-30%	Tree Cover 30-70%	Tree Cover >70%
Hill Forest	0	3	247	297	4
Mangrove Forest	0	0	0	0	436
Bamboo Forest	5	3	39	131	6
Long Rotation Pltn.	39	16	18	31	27
Short Rotation Pltn.	0	3	48	3	0
Mangrove Pltn.	45	0	0	0	0

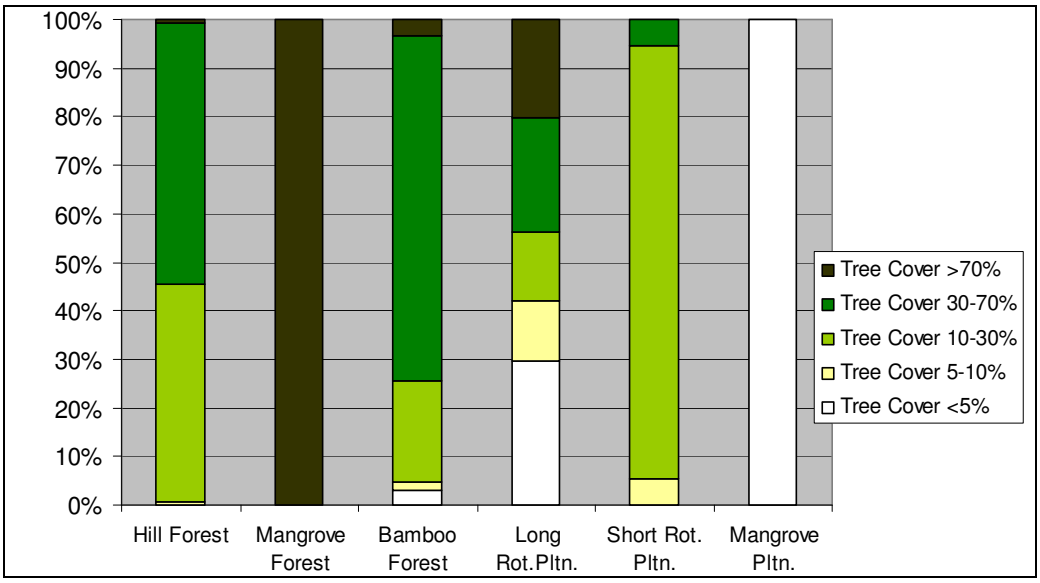

Figure 17: Forest types area by tree cover classes (%)

9.1.11. Bangladesh total area by classes of protection level

Of the Major Land Use classes (LUCs) “Cultivated land”, “Villages” and “Built up areas” have a low level of protection. Almost 10% of the “Inland water” is protected. For “Forest”, 30% of the area is protected as Strict Nature Reserve or National Park.

Table 18: Major LUCs by classes of protection level (1000 ha)

Forest Type	Strict Nature Reserve	National Park	National Monument	HM Area	Protected Landscape	Multiple Purposes	Production	Others/ Not known
Forest	390	43	0	12	0	0	996	0
Cultivated land	3	1	0	14	97	0	8,212	0
Villages	0	0	6	0	0	18	2,827	10
Built up area	0	0	0	0	0	2	98	3
Inland water	0	0	0	20	130	6	1,746	120

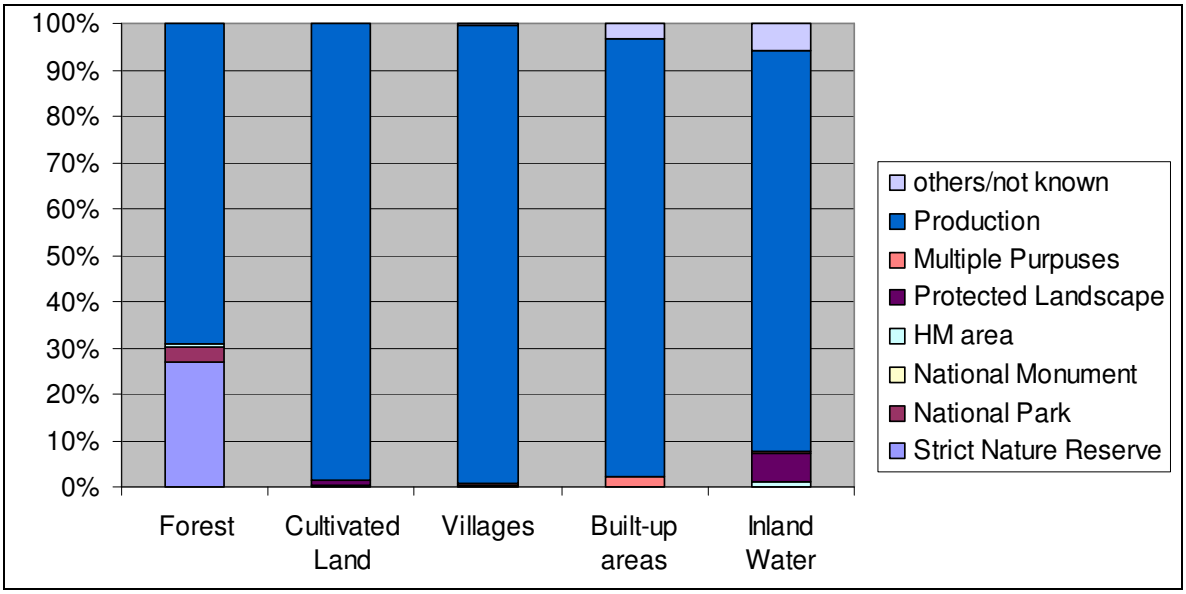

Figure 18: Major LUCs by classes of protection level (%)

9.1.12. Forest types by classes of protection level

Close to 100% of the Mangrove forest is considered as Strict Nature Reserve. In Hill Forest and Bamboo Forest about 20% of the area is considered Strict Nature Reserve or National Park. The Plantation areas have a very low level of protection.

Table 19: Forest types by classes of protection level (1000 ha)

Forest Type	Strict Nature Reserve	National Park	HM Area	Production
Hill Forest	93	4	1	453
Mangrove Forest	414	0	0	22
Bamboo Forest	0	30	9	145
Long Rot. Pltn.	0	2	0	128
Short Rot. Pltn.	0	0	0	54
Mangrove Pltn.	0	0	0	45

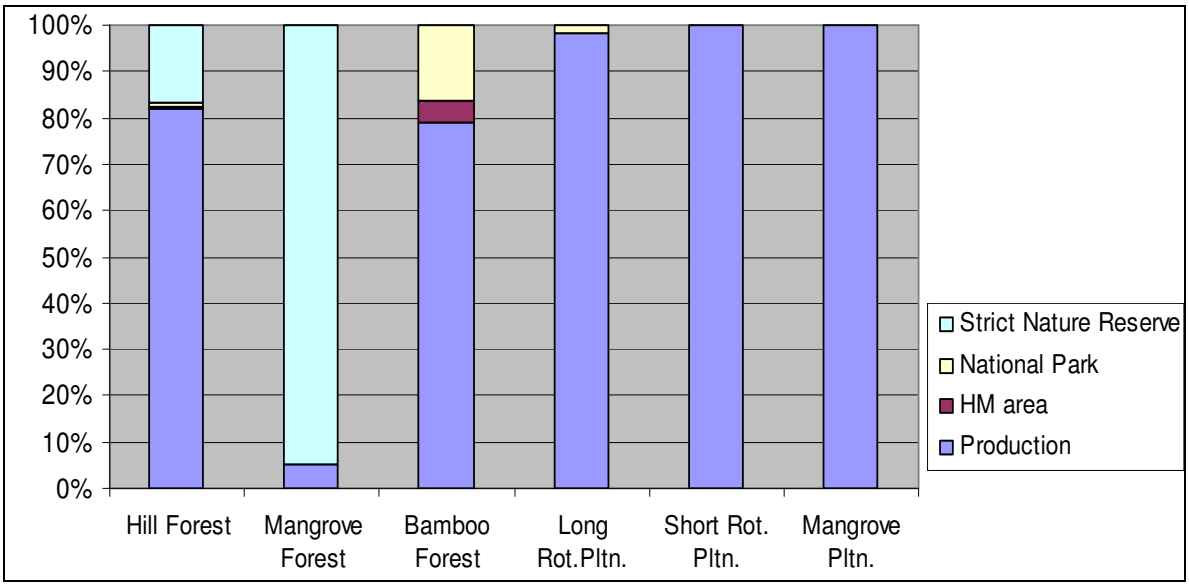

Figure 19: Forest types by classes of protection level (%)

9.1.13. The area of Bangladesh by type of ownership

More than 95% of the area of Bangladesh is owned by individuals (81%) or by the state (14%). Indigenous ownership constitutes 2,5%. In "Cultivated land" and "Villages" almost 100% of the area is individually owned. In "Forest" and "Inland water" about 50% of the area is state-owned. Approximately 20% of the "Forest" area is owned by indigenous groups.

Table 20: Major National LUCs by ownership class (1000 ha)

Land Use	Individual ownership	Industrial ownership	State ownership	Public ownership Regional	Community ownership	Indigenous ownership	Other/ unknown ownership
Forest	177	0	860	27	0	344	33
Cultivated land	8,002	25	213	2	6	28	51
Village	2,828	12	3	0	15	0	4
Built up area	91	0	13	0	0	0	0
Inland water	892	0	1,026	29	22	0	53
TOTAL	**11,990**	**37**	**2,115**	**58**	**43**	**372**	**141**
TOTAL (%)	81,3%	0,2%	14,3%	0,4%	0,3%	2,5%	1,0%

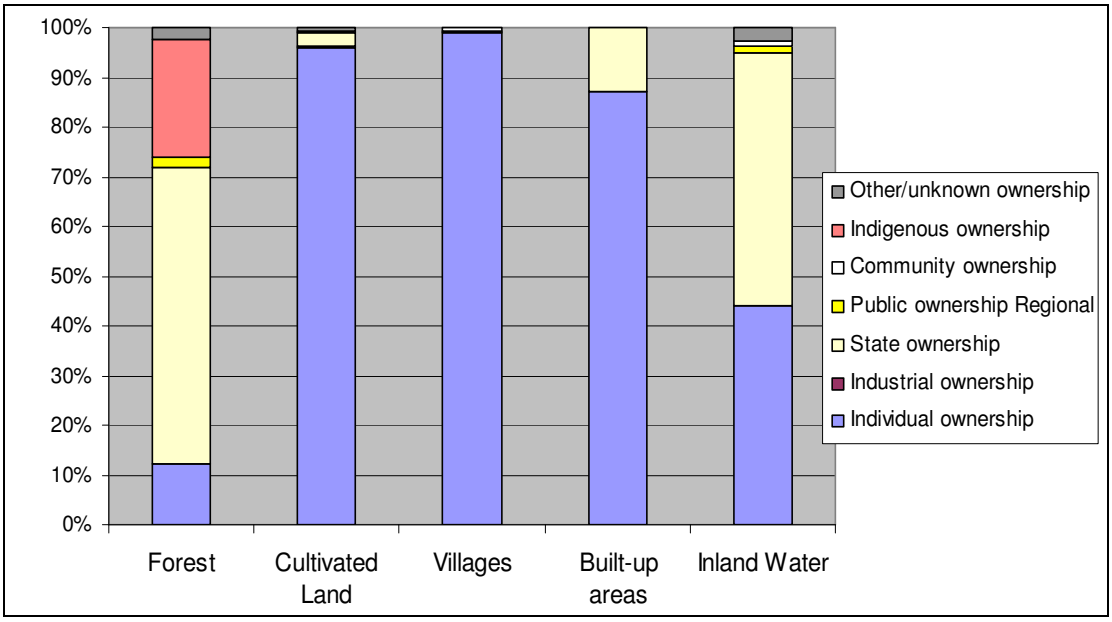

Figure 20: Major National LUCs by ownership class (%)

9.1.14. The area of state owned and individually owned land by major National LUC

The state owns 860 thousand hectares classified as "Forest", slightly more than 200 thousand hectares of "Cultivated land" and more than 1,000 thousand hectares of "Inland water". Altogether the state owns an area of more than 2,100 thousand hectares. Individuals own 12,500 thousand hectares. This area mainly consists of "Cultivated land" and "Villages".

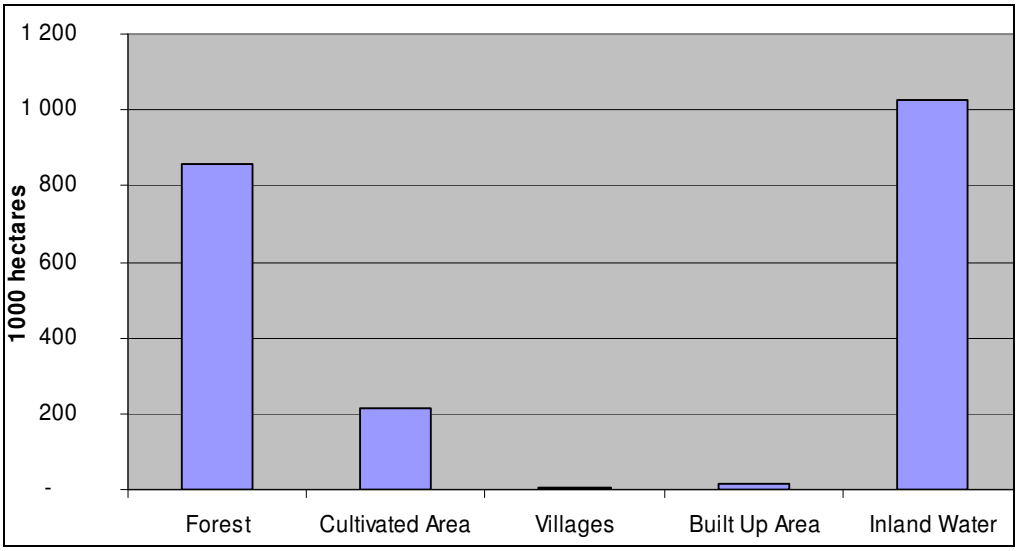

Figure 21: State owned land by major national LUC (1000 ha)

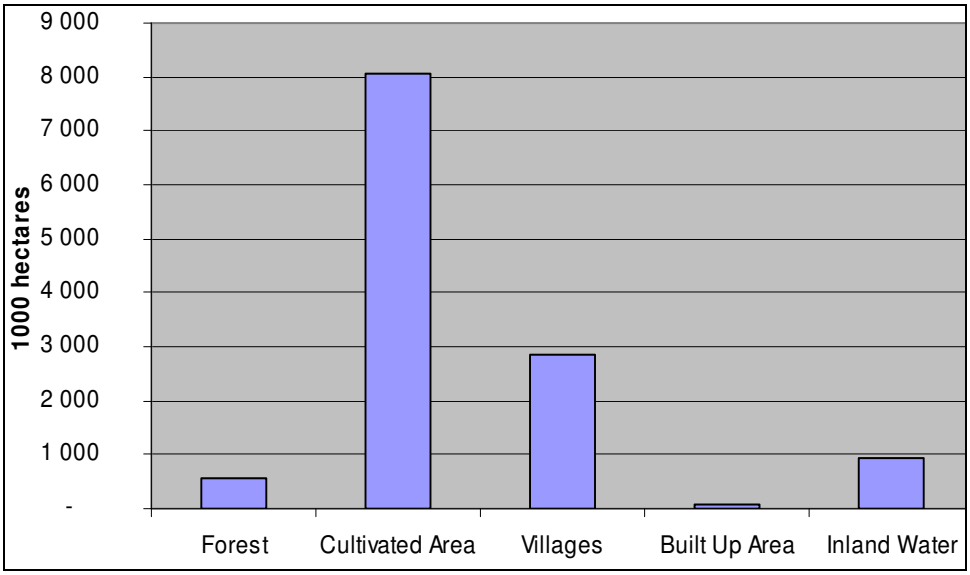

Figure 22: Individually owned land by major national LUC (1000 ha)

9.1.15. The area of Bangladesh by Global Ecological Zones (GEZ)

The world is divided into 5 Global Ecological Domains (Figure 23) and 20 Global Ecological Zones (Figure 24 and Table 21) (FAO 2001). Two of these zones are present in Bangladesh: Tropical rain forest (TAr) and Tropical moist deciduous forest (TAwa) (Figure 25). The area of Bangladesh and major LUCs belonging to the two GEZ classes is indicated in Table 22.

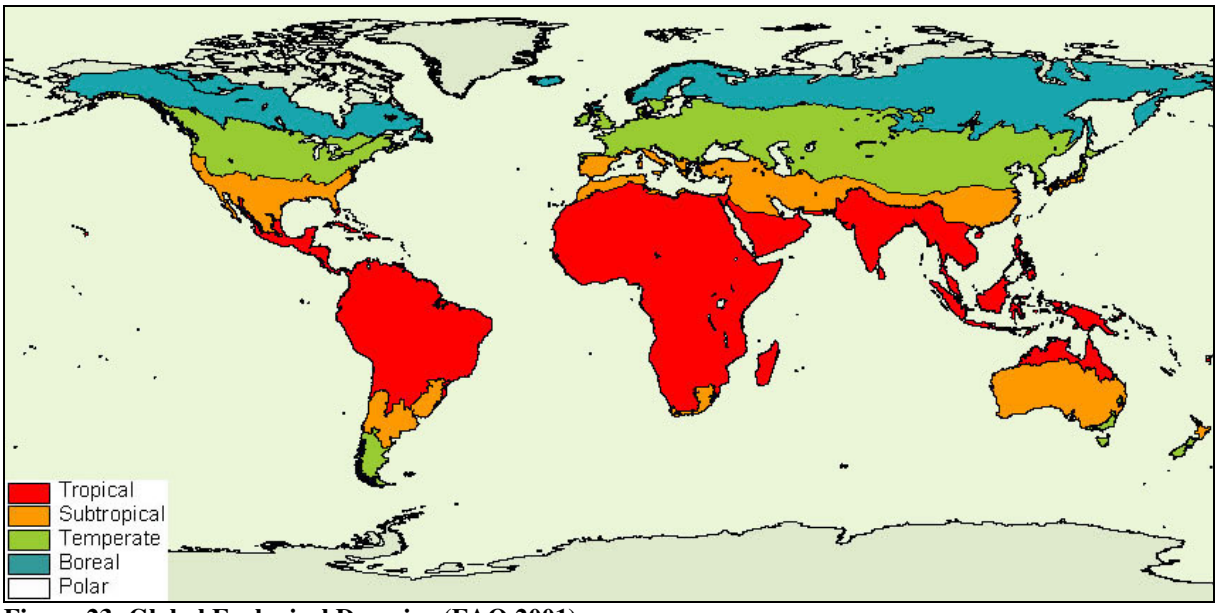

Figure 23: Global Ecological Domains (FAO 2001)

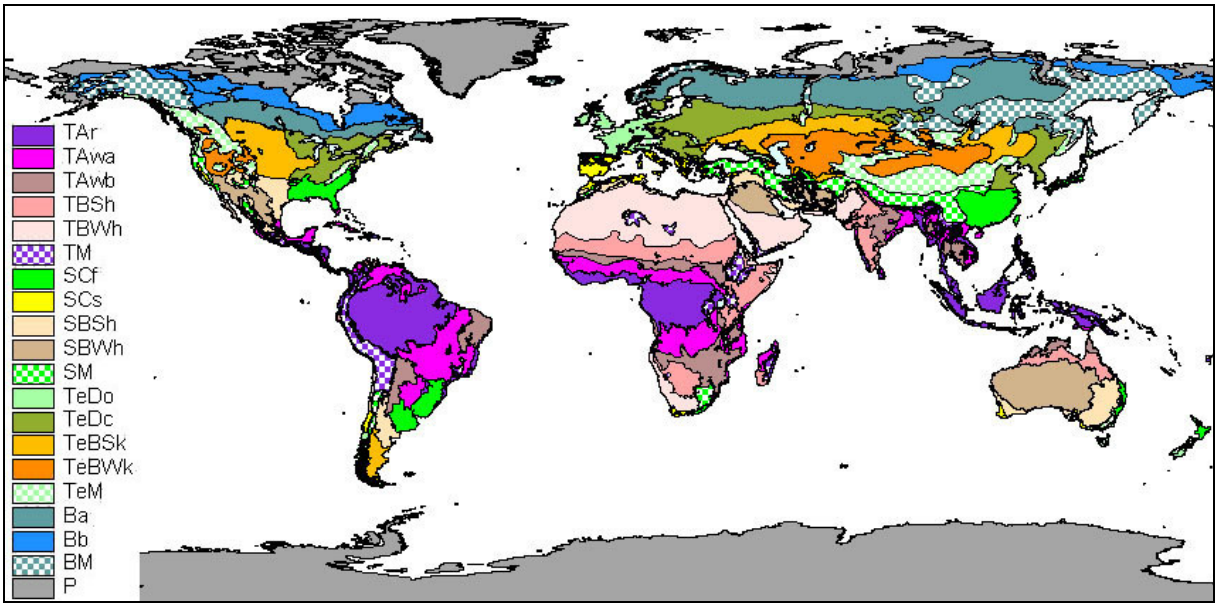

Figure 24: Global Ecological Zones (FAO 2001)

Table 21: Global Ecological Zones (FAO 2001)

Tropical rain forest	TAr
Tropical moist deciduous forest	TAwa
Tropical dry forest	TAwb
Tropical shrubland	TBSh
Tropical desert	TBWh
Tropical mountain systems	TM
Subtropical humid forest	SCf
Subtropical dry forest	SCs
Subtropical steppe	SBSh
Subtropical desert	SBWh
Subtropical mountain systems	SM
Temperate oceanic forest	TeDo
Temperate continental forest	TeDc
Temperate steppe	TeBSk
Temperate desert	TeBWk
Temperate mountain systems	TeM
Boreal coniferous forest	Ba
Boreal tundra woodland	Bb
Boreal mountain systems	BM
Polar	P

Table 22: Total area of Bangladesh and major LUCs by GEZ classes (1000 ha)

Land Use	TAR	Tawa
Forest	1,014	428
Cultivated land	2,311	6,017
Village	604	2,258
Built up area	7	97
Inland water	899	1,123
Total	**4,835**	**9,922**
Total (%)	32,8%	67,2%

The geo-ecological zone tropical moist Forest (Tawa) constitutes more than 2/3 of Bangladesh. Less than 1/3 of the area belongs to the Geo-zone Tropical Rain Forest (TAR), see Figure 26. The "Forest" area is mainly situated in the "TAR" zone. One exception is the Mangrove Forest which is found primarily in the "Tawa" zone (see Table 22).

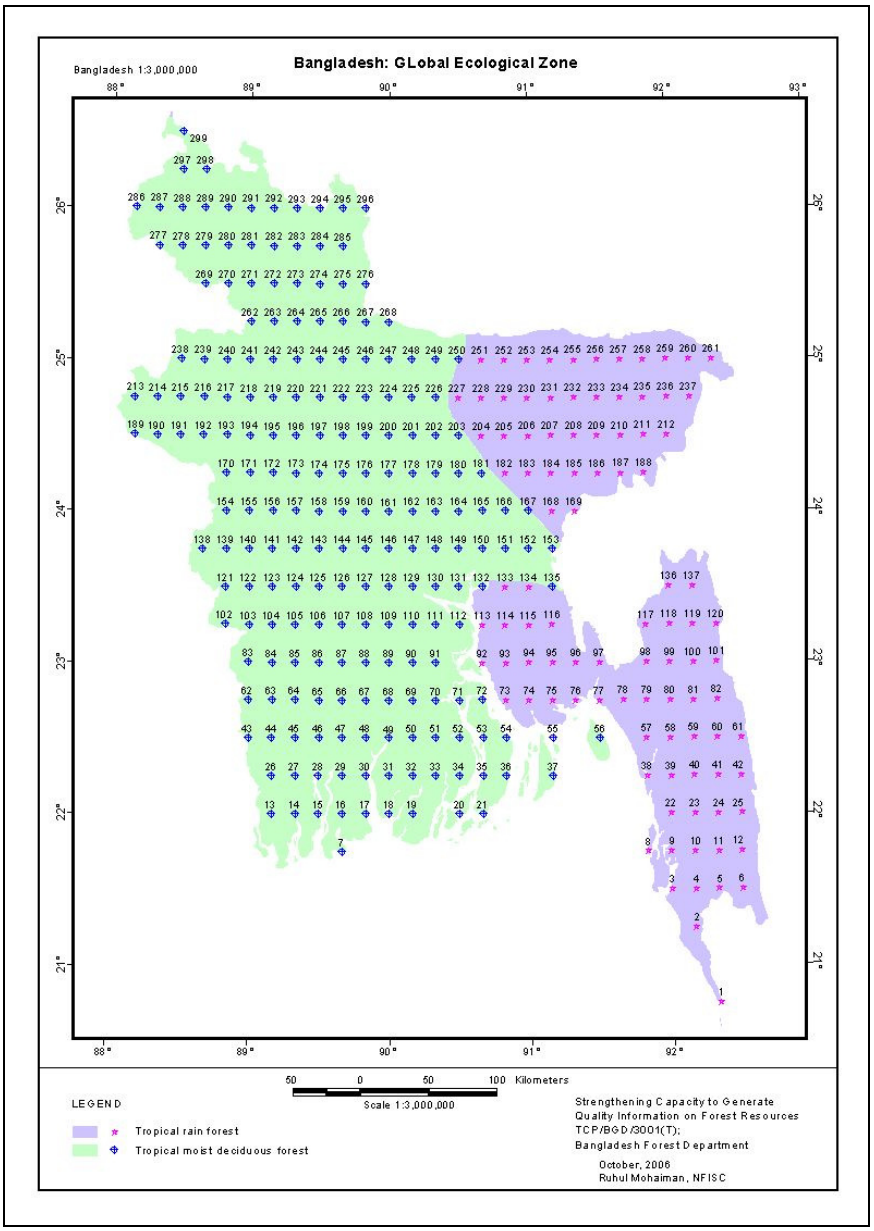

Figure 25: Global Ecological Zones of Bangladesh (including NFA tracts)

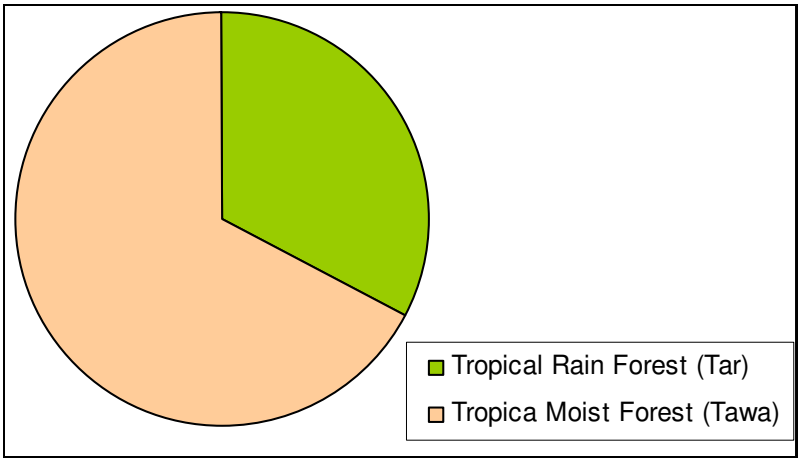

Figure 26: Area proportions of Global Ecological Zones in Bangladesh

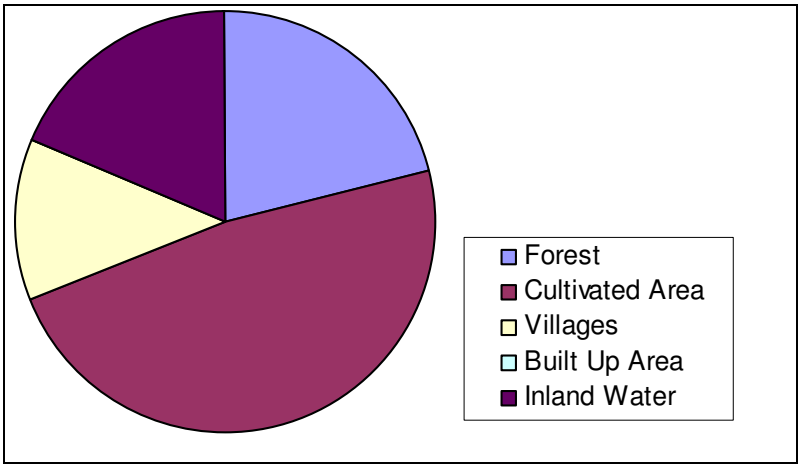

Figure 27: Distribution of major land uses in the Tropical Rainforest zone

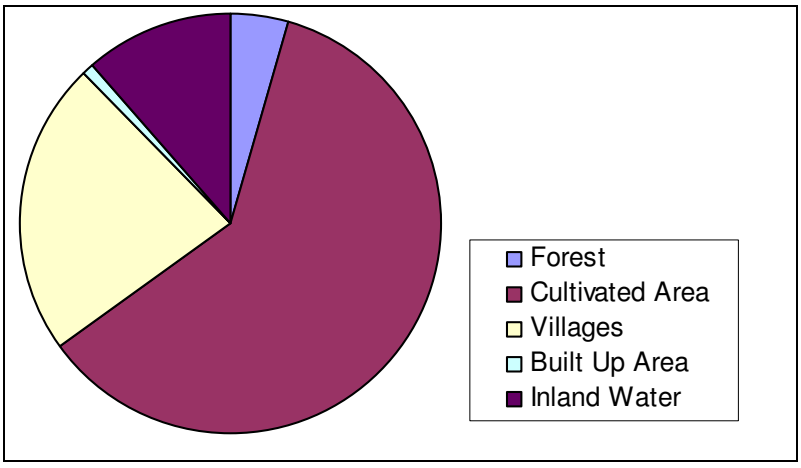

Figure 28: Distribution of major land uses in the Tropical Moist Forest zone

9.1.16. The area of Bangladesh by Environmental problems

In the NFA-methodology the same area can have several environmental problems. Environmental problems in the major National Land Use Classes are presented below in Table 23.

Table 23: Environmental problems in major National LUCs (%)

	Forest	Cultivated land	Village	Built up area	Inland water	Total
Not existing	9%	44%	40%	55%	40%	**39%**
Loss of water	-	2%	2%	-	2%	**2%**
Drought	-	9%	9%	1%	2%	**7%**
Flooding	-	18%	17%	5%	16%	**16%**
Poor water	9%	5%	11%	-	16%	**8%**
Pests	10%	7%	2%	-	-	**5%**
Erosion	60%	8%	2%	-	20%	**14%**
Loss of soil fertility	24%	20%	17%	14%	11%	**19%**
Burning	5%	3%	2%	-	-	**3%**
Landslide	5%	4%	-	-	2%	**3%**
Wind throw	2%	-	-	-	-	**-**
Over exploitation	28%	4%	-	1%	-	**5%**
Over grazing	2%	-	-	-	-	**-**

The most common environmental problems in Bangladesh are loss of soil fertility, erosion and flooding, but also poor water and drought. In “Forest”, the most common environmental problems are erosion, over exploitation and loss of soil fertility. In “Cultivated land” and “Villages” the most common problems are loss of soil fertility, flooding, poor water and drought. In “Inland water” erosion, flooding, poor water and loss of soil fertility are the most common environmental problems.

9.1.17. Environmental problems in the different forest types

In Hill Forest the most common environmental problems are erosion, over exploitation and loss of soil fertility. In Mangrove Forest the most common environmental problems are poor water and pests and in the Bamboo Forest erosion and over exploitation. In the plantations the environmental problems are loss of soil fertility, erosion and over grazing.

Table 24: Environmental problems in different Forest types (%)

	Hill Forest	Mangrove Forest	Bamboo Forest	Long rotation plantation	Short rotation plantation
Not existing	2%	10%	-	50%	-
Loss of water	-	-	-	-	-
Drought	-	-	-	-	-
Flooding	-	-	-	-	-
Poor water	-	44%	-	-	-
Pests	2%	47%	-	-	-
Erosion	87%	-	83%	39%	-
Loss of soil fertility	35%	-	11%	34%	46%
Burning	8%	-	7%	-	-
Landslide	11%	-	-	-	-
Wind throw	-	10%	-	-	-
Over exploitation	47%	-	31%	-	-
Over grazing	-	-	-	-	46%

9.1.18. Expected change in tree cover by major National LUC

Roughly 5,000 hectares of cultivated land is expected to increase its tree cover. To a lesser extent also areas in Villages, Forest and Inland water are expected to register an increase in its tree cover. A decrease in tree cover is expected in Forest area (about 50%) and in a small portion of cultivated area. The rest is expected to maintain current tree cover level.

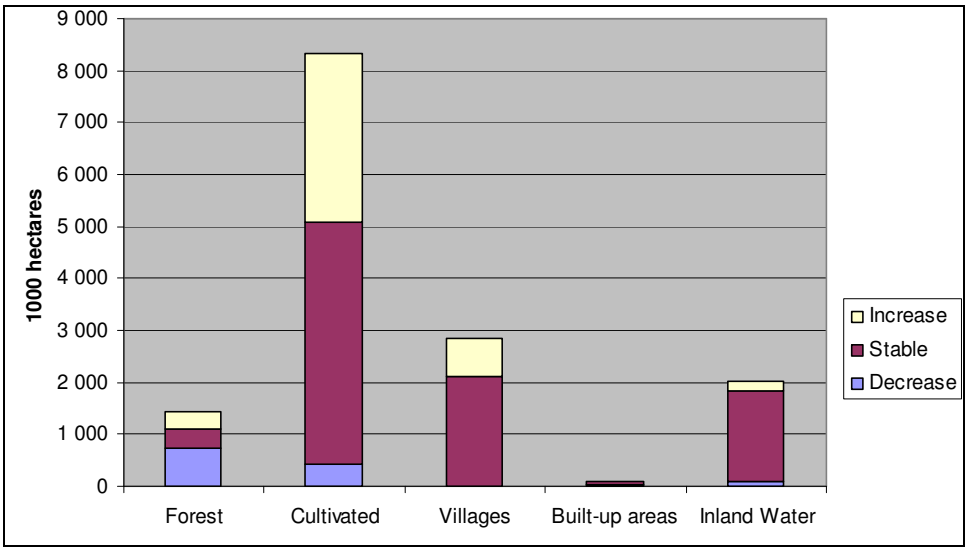

Figure 29: Expected change in tree cover by major National LUC (1000 ha)

9.1.19. Expected future trees in the different forest types

The most significant decrease in tree cover is expected to occur in Hill Forest and, less significantly, in Mangrove and Bamboo forests. Plantation areas are expected to either maintain their current cover or increase.

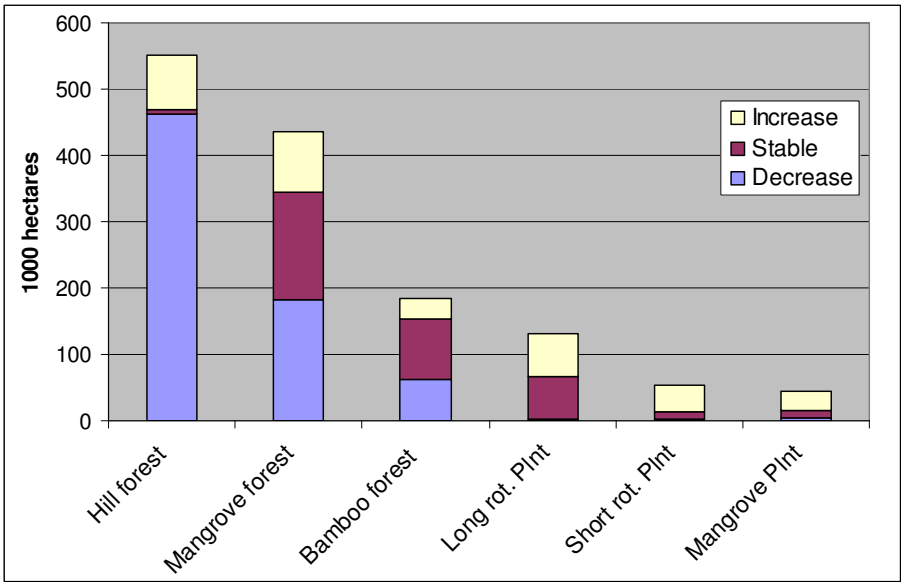

Figure 30: Expected change in tree cover by forest type (1000 ha)

9.1.20. Forest area – management agreements and management plans

In the NFA Project, the management plan is categorized into "Formal" and "Traditional". An area is said to be managed under "Formal management plan" when a "formal management plan was formulated and implemented". On the other hand, an area is said to be under "Traditional management plan" when "no formal management plan was formulated or when a formal management plan was formulated but not implemented".

For all the different forest types, where the management agreement is known, the forest is exclusively managed by the owner. Thus, in some of the Hill forest the management agreement is unknown.

Based on the results of the forest assessment 46% of the country's total "Forest" are under "Formal management plan" and 50% are under "Traditional management plan". Of the different forest types, only "Mangrove Forest" is totally covered by a "Formal management plan". Most of the areas in "Hill Forest" and "Bamboo or mixed Bamboo/Broad-leaved Forest" are under "Traditional management plan".

Table 25: Forest area by type of Management and by forest types (1000 ha)

Forest Type	Formal	Traditional	Not Known	Total
Hill Forest	63	453	35	551
Mangrove Forest	436	0	0	436
Bamboo Forest	7	162	14	184
Long Rotation Pltn.	104	27	0	131
Short Rotation Pltn.	37	14	3	54
Mangrove Plantation	0	45	0	45
Forest*	**648**	**700**	**52**	**1,400**
Forest* (%)	46%	50%	4%	100%

* Total Forest area only inclusive of inventoried forest types

9.1.21. Forest area – stand origin

Stand origin refers to the apparent source of the vegetation on the area. Stand origin can vary from one stand to another, even though the stands are of the same forest type. It may either be natural, plantation or coppice. "Natural stand" refers to natural regeneration of stand by seed; "Plantation stand" refers to the artificial regeneration of stand by seeding or planting; and "Coppice stand" refers to regeneration by shoots from stumps or roots.

82% of the total "Forest" area consists of natural stands and 18% are man-made forests. The results also show that there are patches of established plantations within the "Hill Forest" and "Bamboo or mixed Bamboo/Broad-leaved Forest".

Table 26: Forest area by forest type and stand origin (1000 ha)

	Natural	Plantation
Hill Forest	528	23
Mangrove Forest	436	0
Bamboo Forest	180	4
Long Rotation Pltn.	0	131
Short Rotation Pltn.	0	54
Mangrove Pltn.	0	45
Forest*	**1,143**	**257**
Forest* (%)	82%	18%

* Total Forest area only inclusive of inventoried forest types

9.1.22. Forest area – stand structure

Tree canopies can be categorized into single layer, two-layer, three-layer, or more than three-layer. "Single layer vegetation" refers to a stand with only one well-defined layer formed by the tree canopies; "two-layer vegetation" refers to a stand with two distinct canopy layers: an upper layer (a dominant canopy layer with two thirds above the lower layer, forming a clearly defined layer with at least 20% canopy cover), and a lower layer; "three-layer vegetation" refers to a stand with three distinct canopy layers, each with at least 20% canopy cover; and "more than three-layer" refers to a stand with more than three distinct layers of tree canopies. Out of the total "Forest" area in Bangladesh 33% of the tree canopies have single layer, 25% two-layers and 42% three-layers. Hill forest and Bamboo forest have tree canopies ranging from single layer to three layers, whereas the tree canopy of "Mangrove Forest" is completely in three layers. Plantations generally have one layer.

Table 27: Forest and forest type by classes of stand structure (1000 ha)

Forest Type	1-Layer	2-Layer	3-Layer
Hill Forest	234	237	78
Mangrove Forest	-	-	435
Bamboo Forest	9	107	68
Long Rotation Pltn.	124	7	-
Short Rotation Pltn.	53	1	-
Mangrove Pltn.	45	-	-
Forest	**465**	**352**	**581**
Forest (%)	33%	25%	42%

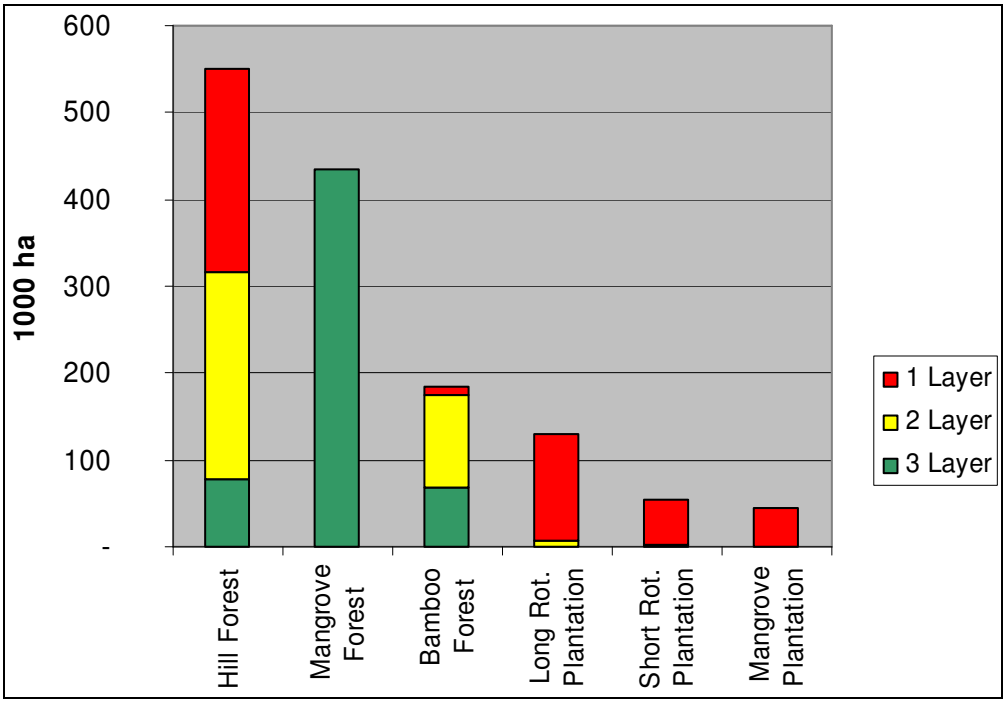

Figure 31: Forest types by classes of stand structure (1000 ha)

9.1.23. Forest area – shrub coverage

Shrubs are multi-stemmed, woody perennial plants of more than 0.5 meters and less than 5 meters in height at maturity and without a definite crown. Shrubs dominate most of the forest understory and are generally found where the trees are more widely spaced and along the forest edges. The opening of a "light gap" in the forest canopy in general stimulates the growth of pioneer tree species including shrubby plants that colonize clearings.

Mangrove forests have less than 10% shrub coverage. This may imply that mangrove areas are not suitable site for the growth of shrubs because these areas are under water most of the time or the forest stands have closed tree canopy that help suppress understory growth.

On the other hand almost 60% of the Hill forest and almost 70% of the Long rotation plantations have more than 40% shrub coverage. This may be an indication that the forest stands in these forest types have experienced either moderate or heavy ecological disturbances. Less than 25% of the Bamboo forest has shrub coverage of more than 40%.

Table 28: Forest and forest types by classes of shrub coverage (1000 ha)

Forest Type	<10%	10-40%	40-70%	>70%
Hill Forest	44	184	136	186
Mangrove Forest	435	-	-	-
Bamboo Forest	9	132	32	10
Long Rotation Pltn.	22	19	12	77
Short Rotation Pltn.	50	-	4	-
Mangrove Pltn.	45	-	-	-
Forest	**605**	**335**	**184**	**273**
Forest (%)	43%	24%	13%	20%

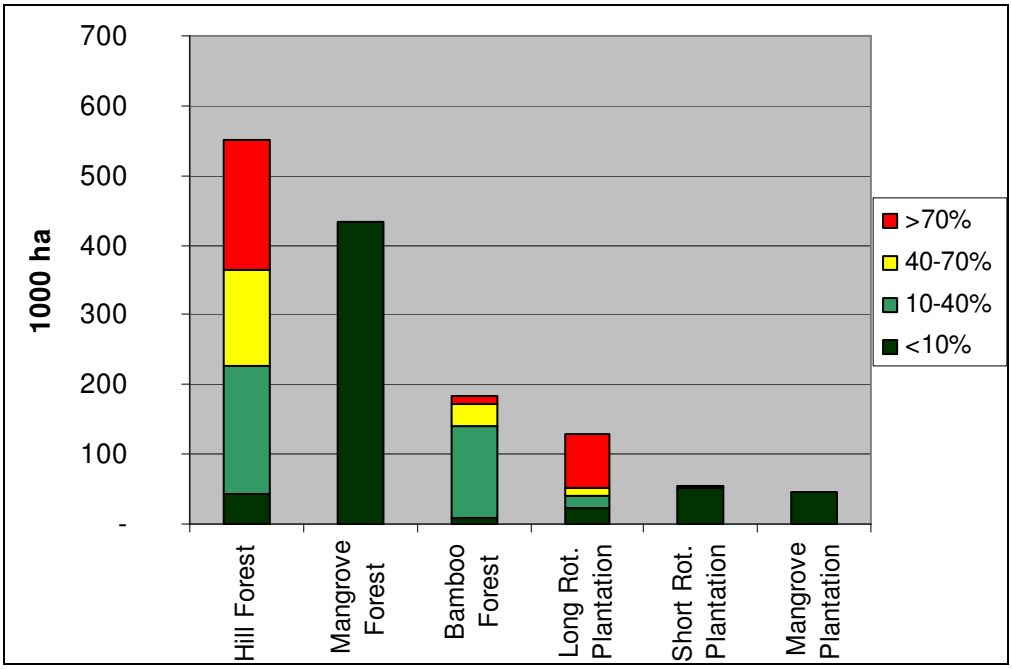

Figure 32: Forest types by classes of shrub coverage (1000 ha)

9.1.24. Forest area – degree of disturbance

In NFA, "forest disturbance" refers to the "impact level of human activity in the forest". A forest stand is categorized as "slightly disturbed" when the exploitation of goods and services is carried out according to management plans; "moderately disturbed" when many products are collected without conforming to management plans, and the notion of sustainability is not respected; and "heavily disturbed" when the rate of removal of products is higher than the Mean Annual Increment (MAI), additionally, biodiversity degradation is caused by high pressure on selected species and encroachment of agriculture leads to high rate of deforestation.

Table 29 and Figure 33 show the degree of distubance in "Forest" and in the different forest types. It can be noticed that 78% of the total Forest area is disturbed. More than 1/3 of the "Forest" area is moderately or heavily disturbed. Only slightly more than 1/5 of the "Forest" area is classified as not disturbed. Almost 60% of the Hill Forest is heavily or moderately disturbed. None of the Mangrove forest is moderately or heavily disturbed, but the major part of is slightly disturbed. Less than 40% of the Bamboo forest is moderately or heavily disturbed.

Table 29: Forest and forest types by degree of disturbance (1000 ha)

Forest Type	Not Disturbed	Slightly Disturbed	Moderately Disturbed	Heavily Disturbed
Hill Forest	130	101	268	51
Mangrove Forest	62	373	0	0
Bamboo Forest	82	34	64	3
Long Rotation Pltn.	23	37	70	0
Short Rotation Pltn.	9	43	0	1
Mangrove Pltn.	0	0	0	45
Forest	**307**	**588**	**402**	**100**
Forest (%)	22%	42%	29%	7%

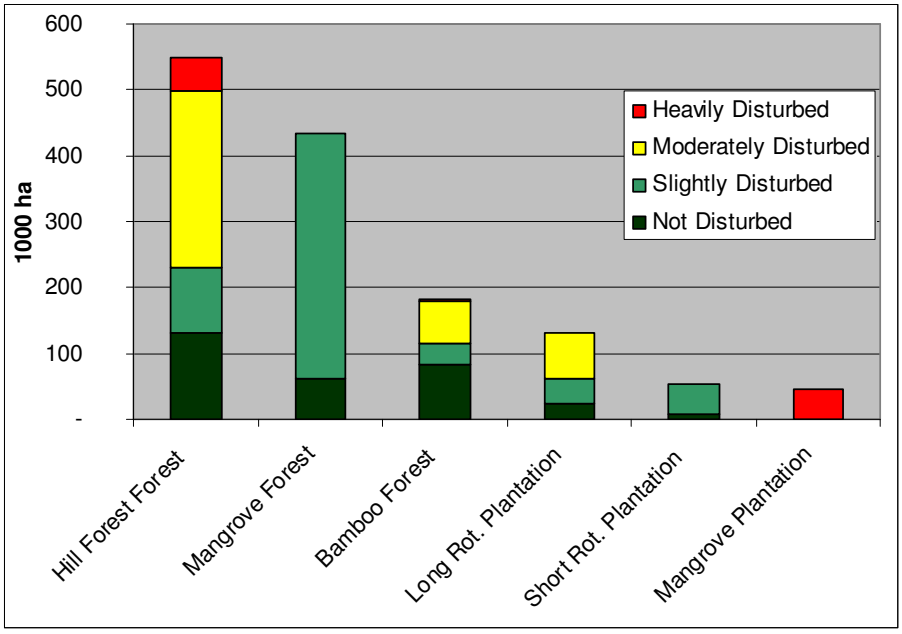

Figure 33: Forest types by degree of disturbance (1000 ha)

9.1.25. Forest area – fire occurrence

In NFA, fire occurrence is categorized as "recent fire" when the evidence of fire shows that it occurred during the current season/year; "old fire" when the evidence of fire shows that it occurred during the previous years but not during the current season. Table 30 indicates that in most of the forest area in Bangladesh there is no evidence of burning. Only 6% of the total "Forest" area has experienced burning. The major part of the burned area can be found in the Hill forest.

Table 30: Forest and forest types by classes of fire occurrence (1000 ha)

Forest Type	No Evidence of Fire	Recent Fire	Old Fire
Hill Forest	468	56	28
Mangrove Forest	436	0	0
Bamboo Forest	181	0	3
Long Rotation Pltn.	131	0	0
Short Rotation Pltn.	54	0	0
Mangrove Pltn.	45	0	0
Forest*	**1,314**	**56**	**31**
Forest* (%)	94%	4%	2%

* Total Forest area only inclusive of inventoried forest types

9.1.26. Forest area – timber exploitation

In Bangladesh, selective felling is practiced in natural forest stands and clear felling in plantation forest. NFA defines "selective felling" as extracting only trees of certain species, dimensions, value, etc., not taking into account silvicultural needs; and "clear cutting" refers to the felling of most commercial-sized trees in a stand.

Table 31 shows that timber exploitation was carried out in 63% of the total "Forest" area. Out of the exploited area, 82% was selectivelt felled (Table 32). The clear felling was carried out mainly in the "Hill Forest", which may imply that these are either clear-cut plantations or potential areas for shifting cultivation.

Table 31: Timber exploitation area by forest types (1000 ha)

Forest Type	No Felling	With Timber exploitation
Hill Forest	161	390
Mangrove Forest	182	254
Bamboo Forest	30	154
Long Rotation Pltn.	97	33
Short Rotation Pltn.	50	4
Mangrove Pltn.	0	45
Forest*	**520**	**880**
Forest* (%)	37%	63%

* Total Forest area only inclusive of inventoried forest types

Table 32: Area by forest types and type of timber exploitation technique (1000 ha)

Forest Type	Clear Felling	Selective Felling	Total area with Timber exploitation
Hill Forest	111	279	390
Mangrove Forest	0	254	254
Bamboo Forest	0	154	154
Long Rotation Pltn.	0	33	33
Short Rotation Pltn.	0	4	4
Mangrove Pltn.	45	0	45
Forest*	**155**	**724**	**880**
Forest* (%)	18%	82%	100%

* Total Forest area only inclusive of inventoried forest types

9.1.27. Forest area – silviculture

Table 33 shows that 35% of the total "Forest" area has been subjected to different silvicultural practices. In

Table 34 it is indicated that Enrichment planting has been the most commonly practiced treatment, covering 72% of the total area treated.

Analyses also show that two or more silvicultural practices have been applied in some forest types. This explains why in some forest types the data under "Any practice" is not equal to the sum of the different silvicultural practices.

Table 33: Area with silviculture practices by forest types (1000 ha)

Forest Type	No Practice	With Practice	Total
Hill Forest	384	167	551
Mangrove Forest	325	111	436
Bamboo Forest	90	93	184
Long Rotation Pltn.	15	116	131
Short Rotation Pltn.	45	9	54
Mangrove Pltn.	45	0	45
Forest*	**904**	**496**	**1,400**
Forest* (%)	65%	35%	100%

* Represented by inventoried forest types

Table 34: Area by forest types and type of silviculture (1000 ha)

Forest Type	Improvement	Release of desirable trees	Removal of undesirable vegetation layer	Enrichment	Total area with Practice
Hill Forest	0	9	1	163	167
Mangrove Forest	111	0	0	0	111
Bamboo Forest	0	35	35	69	93
Long Rotation Pltn.	0	0	3	116	116
Short Rotation Pltn.	0	0	0	9	9
Mangrove Pltn.					0
Forest*	**111**	**44**	**39**	**358**	**496**
Forest* (%)	22%	9%	8%	72%	>100%

* Represented by inventoried forest types

9.1.28. Forest area – technology for tree exploitation

Technology for tree exploitation refers broadly to the equipment and techniques employed in the felling of trees and the extraction of their stems or other usable parts for subsequent processing into industrial products.

Table 35 indicates that tree exploitation was exclusively carried out with the aid of non-motorized hand tools, such as axes and manual saws.

Table 35: Area by forest type and type of technology used (1000 ha)

Forest Type	Manual	Chainsaw	Mechanized	Total
Hill Forest	390	0	0	390
Mangrove Forest	254	0	0	254
Bamboo Forest	154	0	0	154
Long Rotation Pltn.	33	0	0	33
Short Rotation Pltn.	4	0	0	4
Mangrove Pltn.	45	0	0	45
Forest*	**880**	**-**	**-**	880
Forest* (%)	100%	-	-	100%

* Represented by inventoried forest types

Photo 9: Local timber market close to the Madhupur Forest Reserve

9.2. Volume

The tree volumes have been divided into "Commercial volume" and "Gross volume" according to measured commercial height and total height of the trees (see Annex XII). However, since the pressure on the natural resources in Bangladesh is very high, it is plausible that not only the "commercial volume", but also the total gross volume will be of significant value to the people of Bangladesh.

The Gross Tree stem Volume has been calculated as : $D_{bh}^2 / 4 * \pi * H_{tot} * \pi * f_{gross}$

Where

D_{bh} = Tree Diameter at breast height
H_{tot} = Tree Total Heigth
π = 3.1416
f_{gross} = 0.5

The Commercial Tree stem Volume has been calculated as : $D_{bh}^2 / 4 * \pi * H_{comm} * f_{comm}$

Where

D_{bh} = Tree Diameter at breast height
H_{comm} = Tree Commercial Heigth
π = 3.1416
f_{gross} = 0.7

The Bamboo Culm Woody Volume has been calculated as : $D_{bh}^2 - (D_{bh}*0.7)^2 / 4 * \pi * H_{length} * f_{bamboo}$

Where

D_{bh} = Bamboo Culm Diameter at breast height
$D_{bh}*0.7$ = Bamboo Culm inner hollow Diameter at breast height
H_{lenght} = Bamboo Culm Total Length
π = 3.1416
f_{bamboo} = 0.8

9.2.1. Tree volumes by major National Land Use Class

In Bangladesh the average gross volume per hectare is 14 m^3 per ha and the average commercial volume is 10 m^3 per ha. "Forest" is the LUC with the highest gross volume per ha, followed by "Villages". However, the commercial volume per ha is about the same for "Forest" and "Villages". "Cultivated land" and "Inland water" have low volumes per ha.

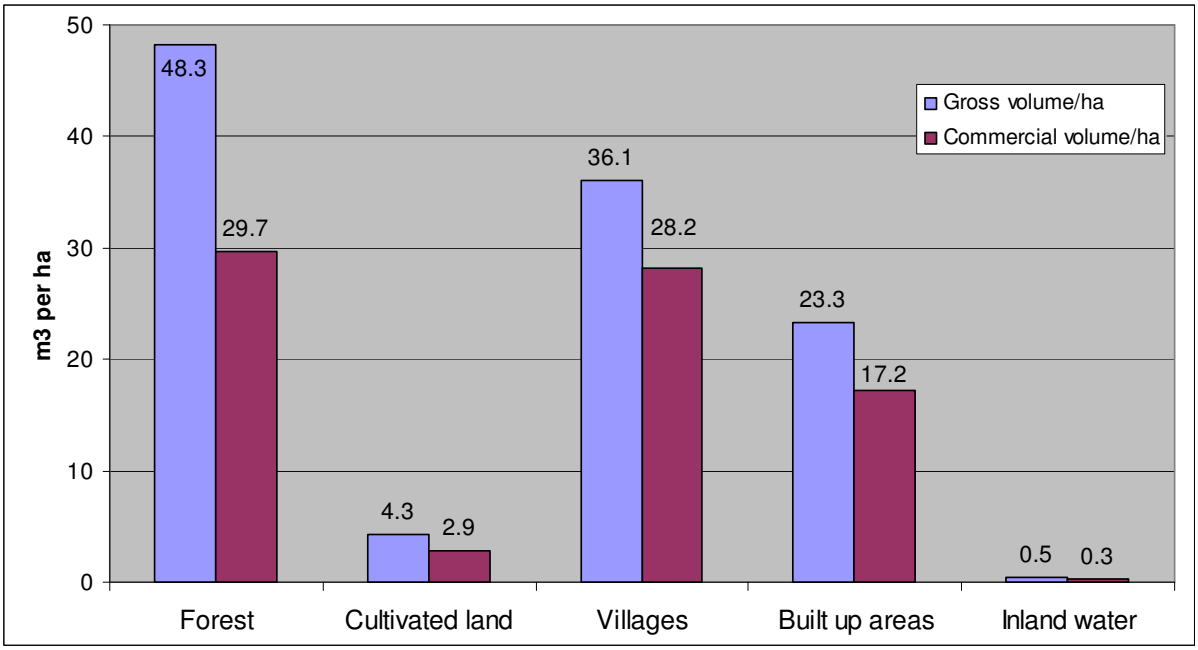

Figure 34: Average gross and commercial volume per hectare for major National LUCs

9.2.2. The total gross and commercial volume for the major National LUCs

In Bangladesh the total gross volume is 212 million m^3 and the total commercial volume is 150 million m^3 as shown in Table 36. Almost 50% of the total gross volume, and more than 50% of the total commercial volume, can be found in "Villages" (Figure 35 and Figure 36). Approximately 1/3 of the gross volume, and less than 30% of the commercial volume, is found in "Forest". "Cultivated land" contains about 17% of the total gross and 16% of the total commercial volume. "Built up areas" and "Inland water" contain low volumes.

Table 36: Total gross and commercial value for major National LUCs (million m^3)

	Forest	Cultivated land	Villages	Built up area	Inland water	Total
Gross volume	70	36	103	2.4	1.0	**212**
Commercial volume	43	24	81	1.8	0.6	**150**

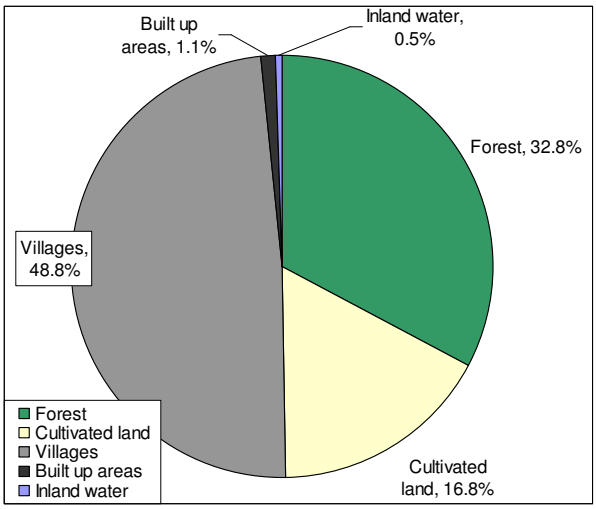

Figure 35: Percentage of total gross volume by major National LUC

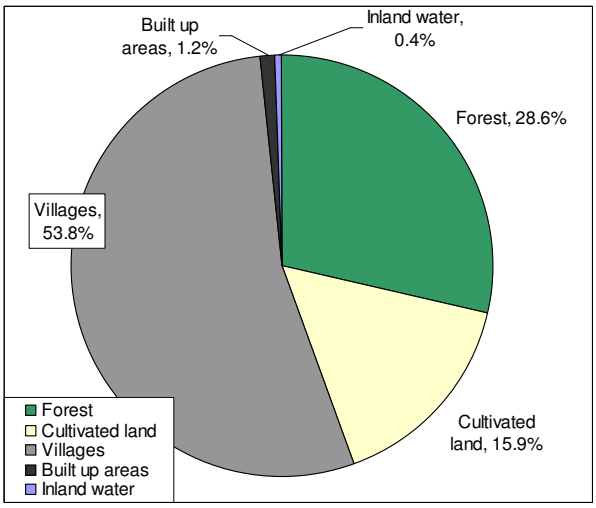

Figure 36: Percentage of total commercial volume by major National LUC

9.2.3. The total gross and commercial volume for the different forest types

Out of the total gross volume in "Forest" about 1/3 can be found in the Hill forest, 1/3 in the Bamboo forest and almost 1/3 in the Mangrove forest. The volume in plantations is representing less than 3% of the total gross volume in "Forest".

Out of the commercial volume almost 30% will be found in Hill forest, almost 30% on Bamboo forest and almost 40% in Mangrove forest. The volume in plantations constitutes less than 3% of the total commercial volume in "Forest".

Table 37: Total gross and commercial volume by forest type (million m3)

	Hill Forest	Mangrove Forest	Bamboo Forest	Long Rot. Plantation	Short Rot. Plantation
Gross volume	23	21	23	1.4	0.5
Commercial volume	12	16	13	0.8	0.3

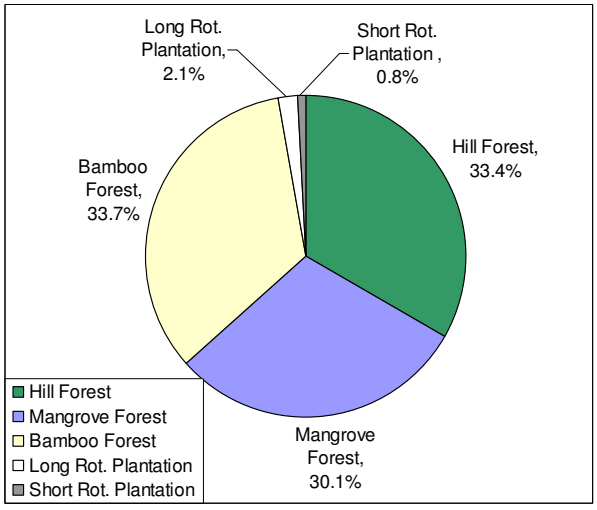

Figure 37: Total gross volume by forest type (%)

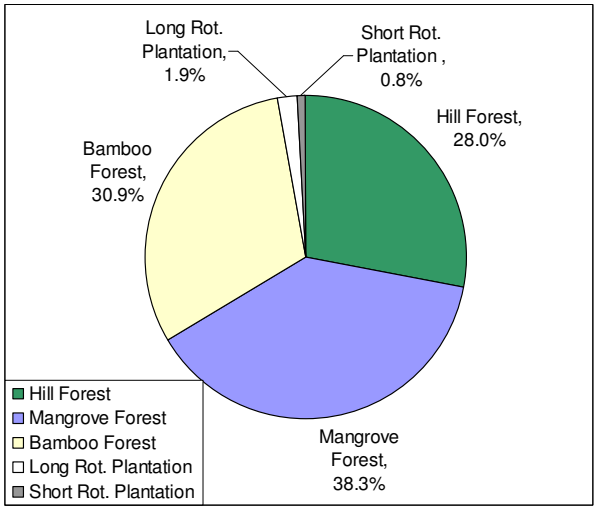

Figure 38: Total commercial volume by forest type (%)

9.2.4. The gross and commercial volume per hectare for the different forest types

Bamboo forest has the highest gross and commercial volumes per hectare. Mangrove forest and Hill forest have significantly lower gross and commercial volumes per hectare. The plantations in general have low tree volumes.

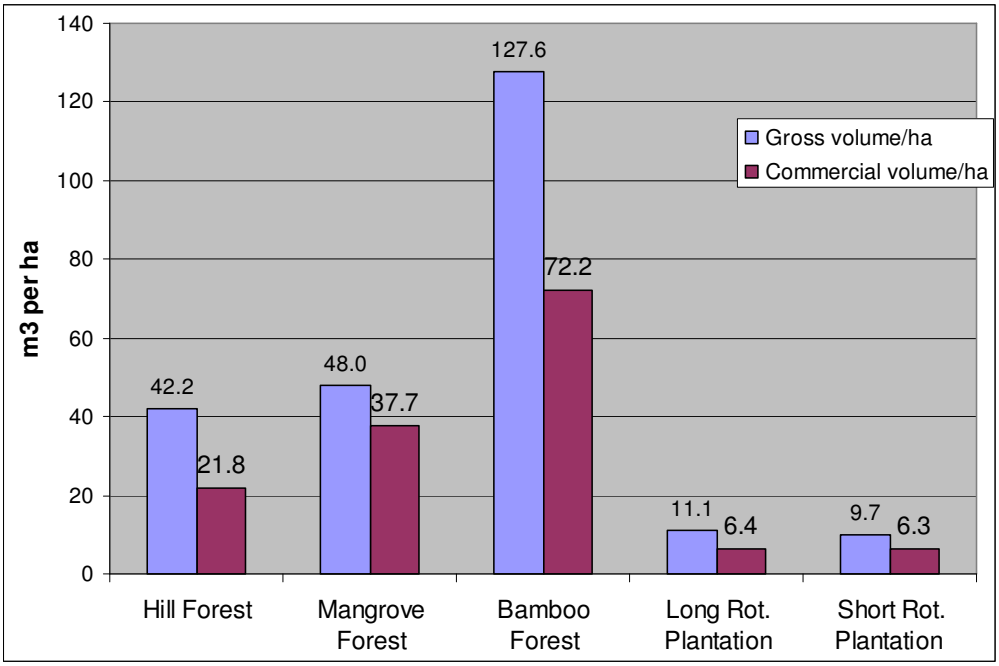

Figure 39: Average gross and commercial volume per hectare by forest type

9.2.5. The total gross volume of Bamboo in the major National LUCs

The total gross volume of bamboo in Bangladesh is 22,8 million m3. From this volume about 66% can be found in “Villages”, 16% in “Forest” and 17% in “Cultivated land”. The average number of culms per clump is 41.

Table 38: Bamboo Culm Volume ('000 m^3) in Major Land Use Class

	Forest	Cultivated Area	Villages	Built-up Area	Inland Water	Total
Number of culms (M)	2,043	2,215	3,074	2	22	7,200
Volume per hectare	1,417	266	1,074	22	11	488
Volume* ('000m^3)	**3,716**	**3,831**	**15,125**	**2**	**156**	**22,829**
% of Total Volume	16%	17%	66%	0.01%	0.7%	100%

*Total Bamboo Culm Volume = $(D_{bh}^2-D_{bh}*(d/D)^2)*pi*H_{avg}*f_{form}*n_{culms}/4000$

9.2.6. Tree volumes for the most common tree species

The 20 tree species presented in Figure 40 represent more than 75% of the total gross volume in Bangladesh. The most common species (according to volume) are *Cocos nucifera*, *Samanea saman* and *Mangifera indica*.

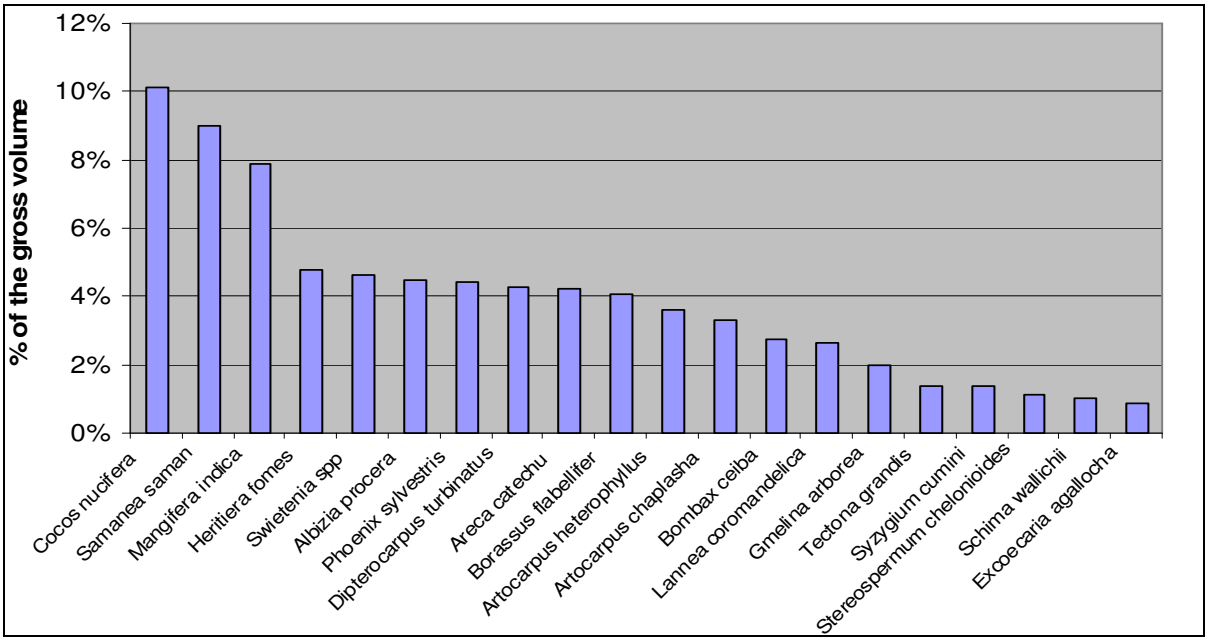

Figure 40: Percentage of total gross volume per species

9.2.7. Volume proportions of the total gross volume by tree species in "Forest"

The 15 species listed in Figure 41 represent 70% of the total tree volume in "Forest". The most common species in "Forest" are *Heritiera fomes* and *Dipterocarpus turbinatus*, representing together 25% of the total gross volume in Forest. Other important species are *Gmelina arborea, Albizia procera* and *Lannea coromandelica.*

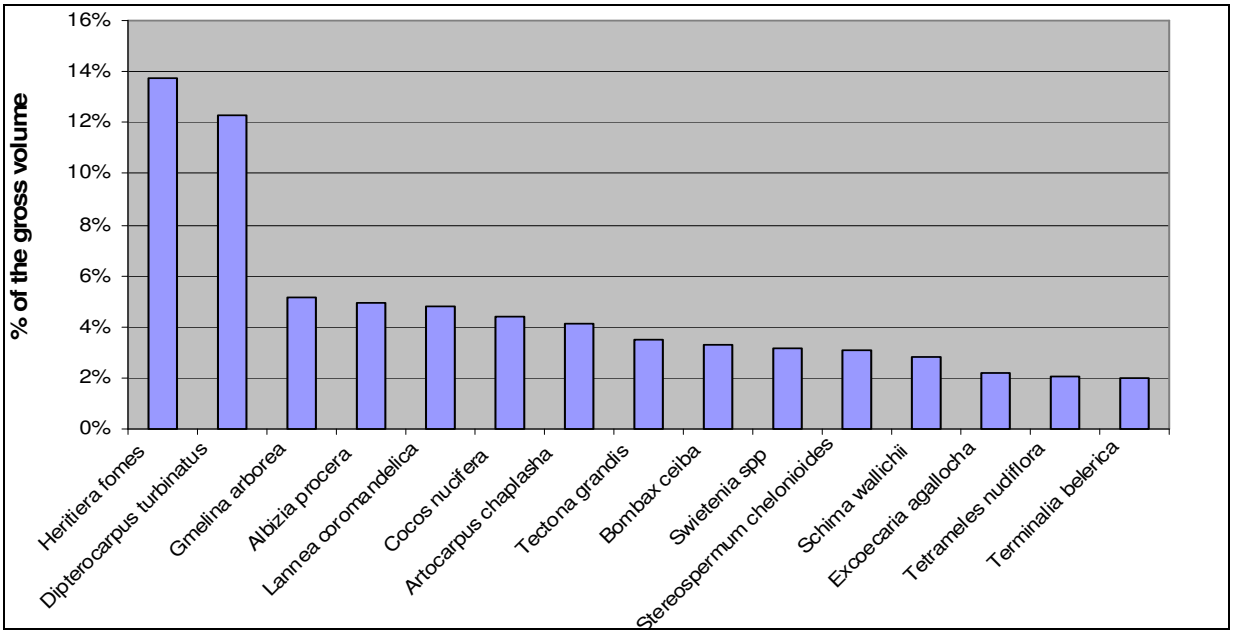

Figure 41: Percentage of total gross volume in "Forest" per species

9.2.8. Volume proportions of the total gross volume by tree species in "Cultivated land"

The 15 species listed in Figure 42 represent over 80% of the total tree volume in "Cultivated land". The four most common species (*Phoenix sylvestris, Samanea saman, Borassus flabellifer* and *Mangifera indica*) represent 50% of the gross volume in the "Cultivated land".

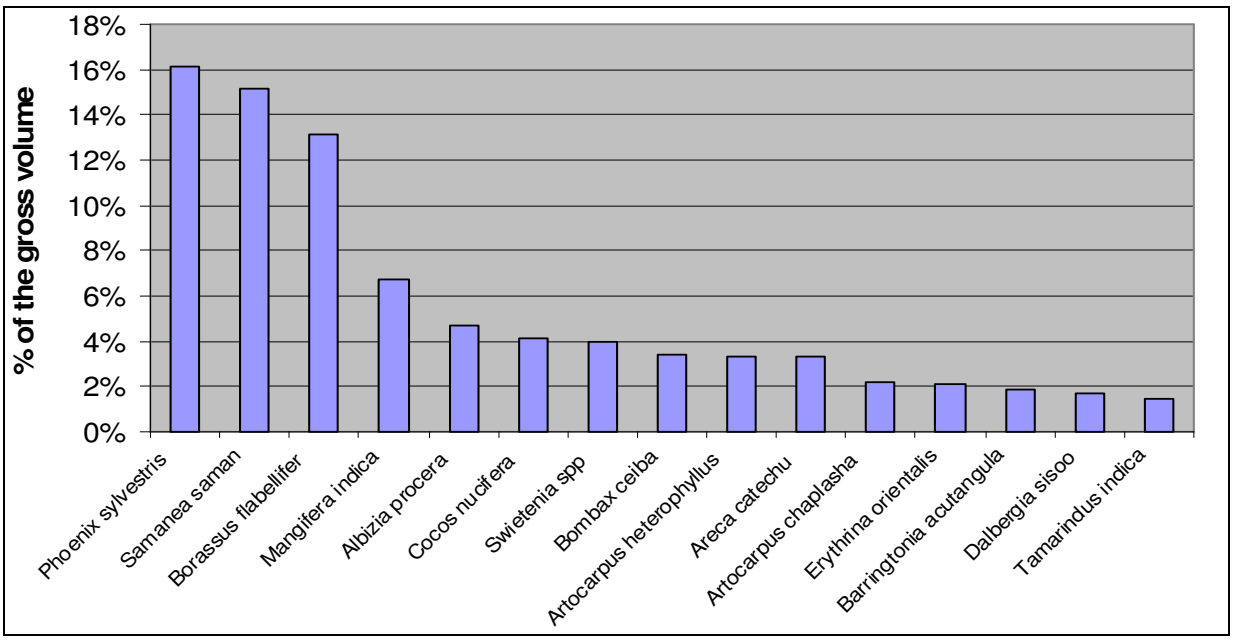

Figure 42: Percentage of total gross volume in "Cultivated land" per species

9.2.9. Volume proportions of the total gross volume by tree species in "Villages"

The 15 species listed in Figure 43 represent over 80% of the total tree volume in "Villages". The 4 most common species (*Cocos nucifera, Samanea saman, Mangifera indica* and *Areca catechu*) represent almost 50% of the gross volume in "Villages".

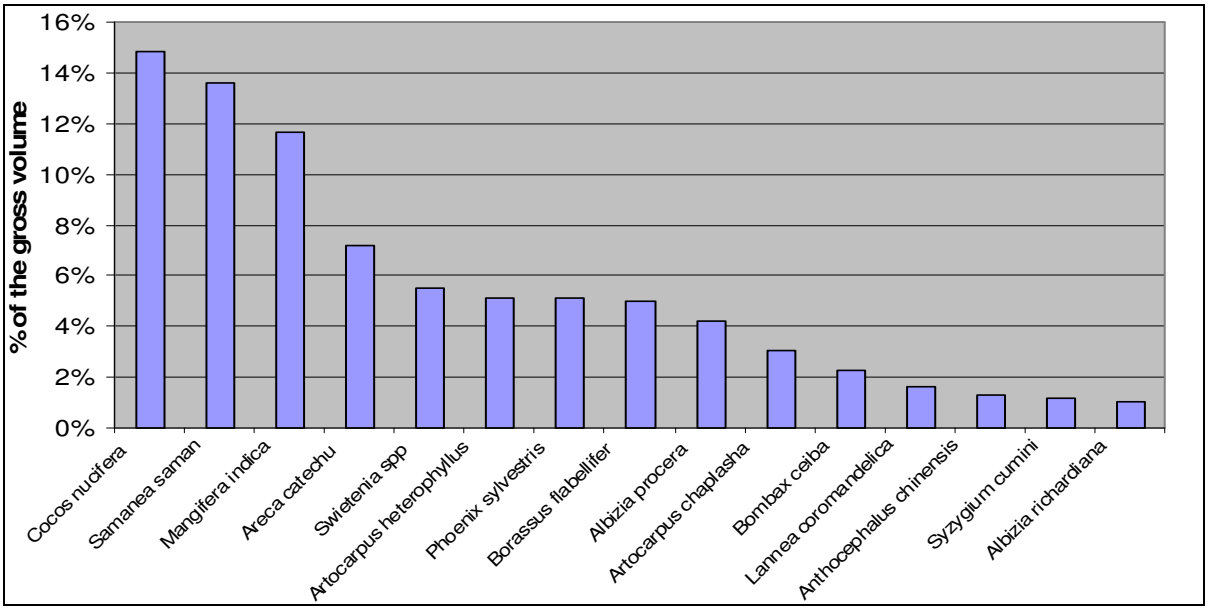

Figure 43: Percentage of total gross volume in "Villages" per species

9.2.10. Volume proportions of the total gross volume by tree species in "Built up areas"

The most common tree in "Built up areas" is *Swietenia spp*. with almost 25% of total volume. Other species contributing to total volume in "Built up areas" area are *Cocos nucifera* and Mangifera indica).

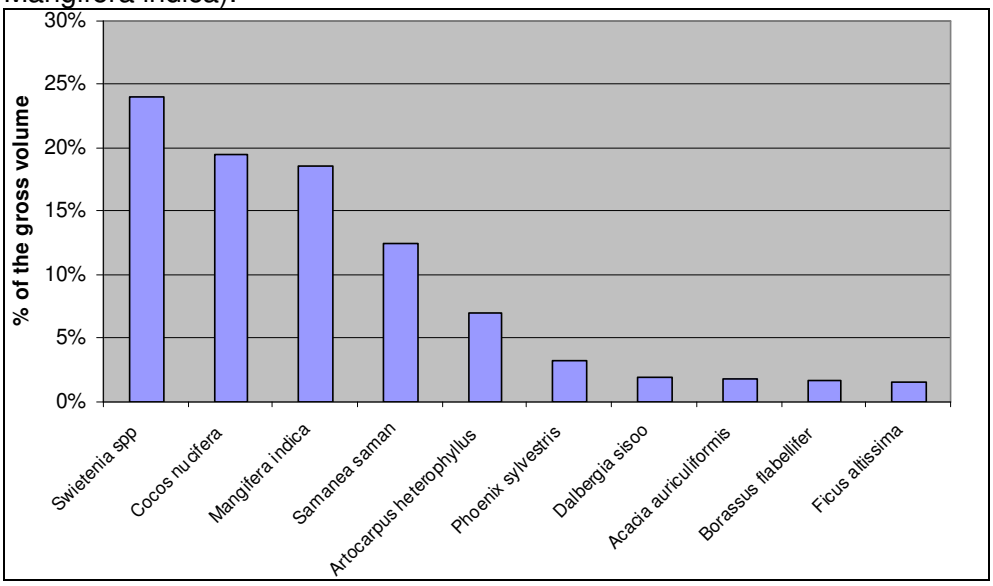

Figure 44: Percentage of total gross volume in "Built up areas" per species

9.2.11. Volume proportions of the total gross volume by tree species in "Inland water"

The most common species in "Inland water" is *Mangifera indica* representing over 18% of total volume in Inland water area.

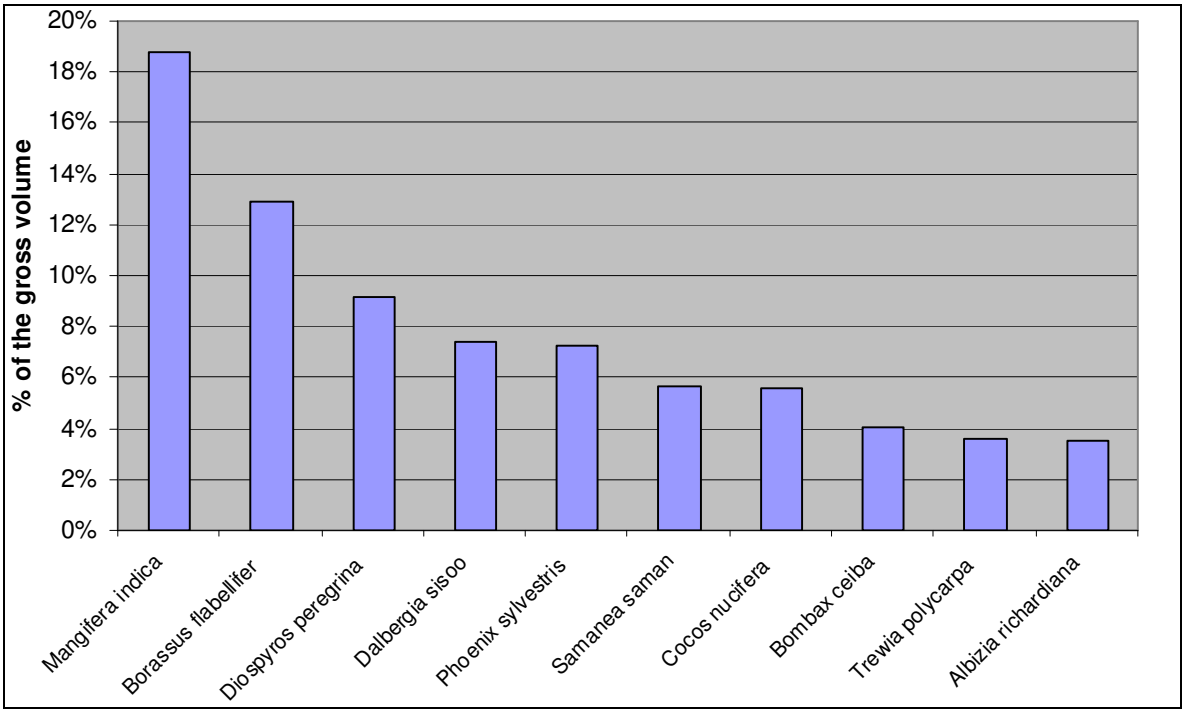

Figure 45: Percentage of total gross volume in "Inland water" per species

9.2.12. Tree volumes per Global-ecological zones (GEZs)

The volume per hectare in Tar is higher for all the different major National Land Use Classes (except "Inland water"). The average gross volume for the geo-ecological zone TAR is almost 20 m^3 per hectare. For Tawa the average volume is less than 12 m^3 per hectare.

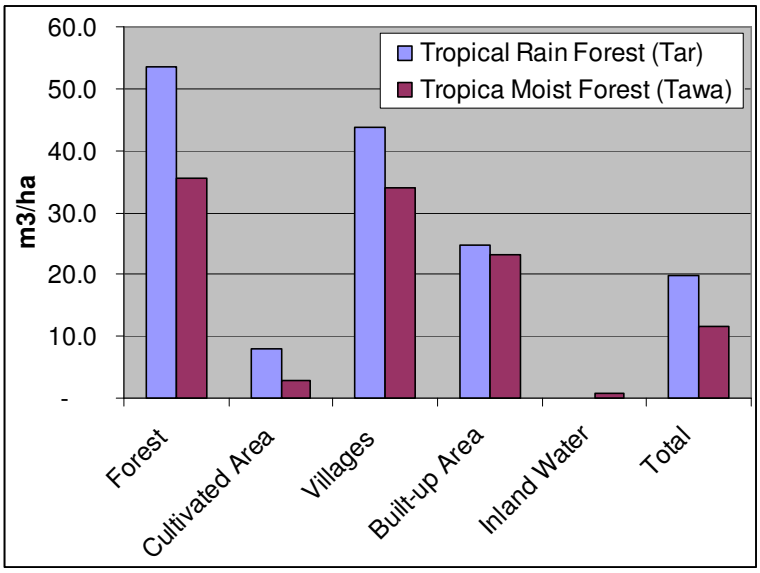

Figure 46: Gross volume per hectare for the Geo-ecological zones by major National LUC

9.2.13. Volume and stems per hectare by Dbh-class

For the total area of Bangladesh the average tree volume per hectare is 14 m^3. More than 75% of this volume can be found in trees with a Dbh smaller than 50 cm, and almost 50% of the tree volume in trees with a Dbh 20-40 cm.

The total area of Bangladesh has on average 68 stems per hectare (>10 cm). 85% of these stems have a Dbh 10-30 cm and only 5% of these stems have a Dbh >40 cm.

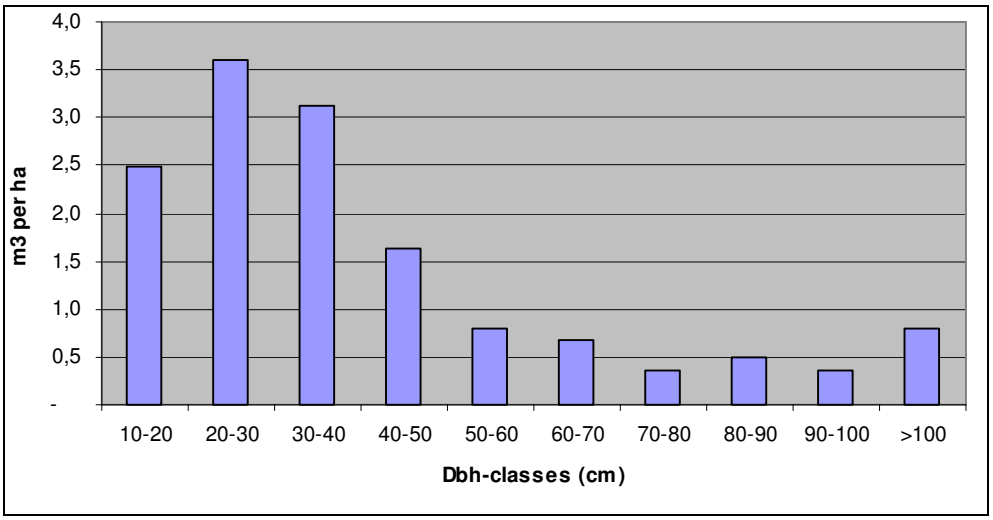

Figure 47: Gross volume per hectare by Dbh class over total area of Bangladesh

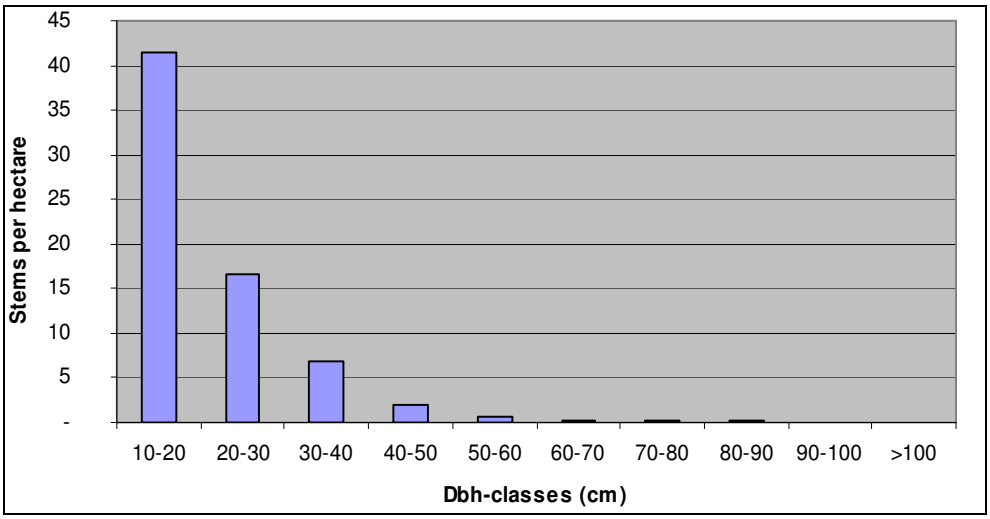

Figure 48: Stems per hectare by Dbh class over total area of Bangladesh

9.2.14. Gross volume and stems per hectare per Dbh-class for the major National Land Use Classes

The tree volume in “Villages” is concentrated to the lower Dbh-classes and more than 50 percent of the volume is found in the Dbh-classes10-30 cm. In “Cultivated land” and “Forest” the volume is more evenly distributed in relation to Dbh-class. The same applies to “Built-up areas” and “Inland Water” but in these land uses the higher Dbh-classes (>80 cm) do not contain significant tree volumes.

The average number of stems per hectare in "Forest" is 184 and almost 90% of these stems have a Dbh 10-30 cm. In "Villages" the average number of stems per hectare is over 210 and over 90% of these stems have a Dbh 10-30 cm. In "Cultivated land" the average number of stems per hectare is only 15. In "Built up areas" the average number of stems per hectare is 130 and almost entirely concentrated in the Dbh-classes 10-40 cm. In "Inland water" the average number of stems per hectare is less than 3.

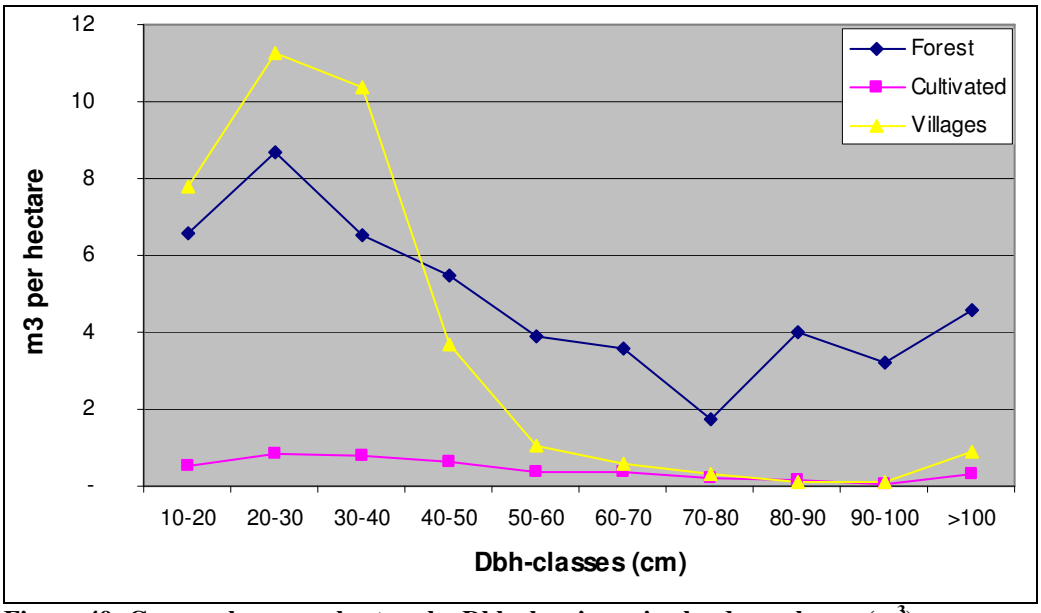

Figure 49: Gross volume per hectare by Dbh class in major land use classes (m^3)

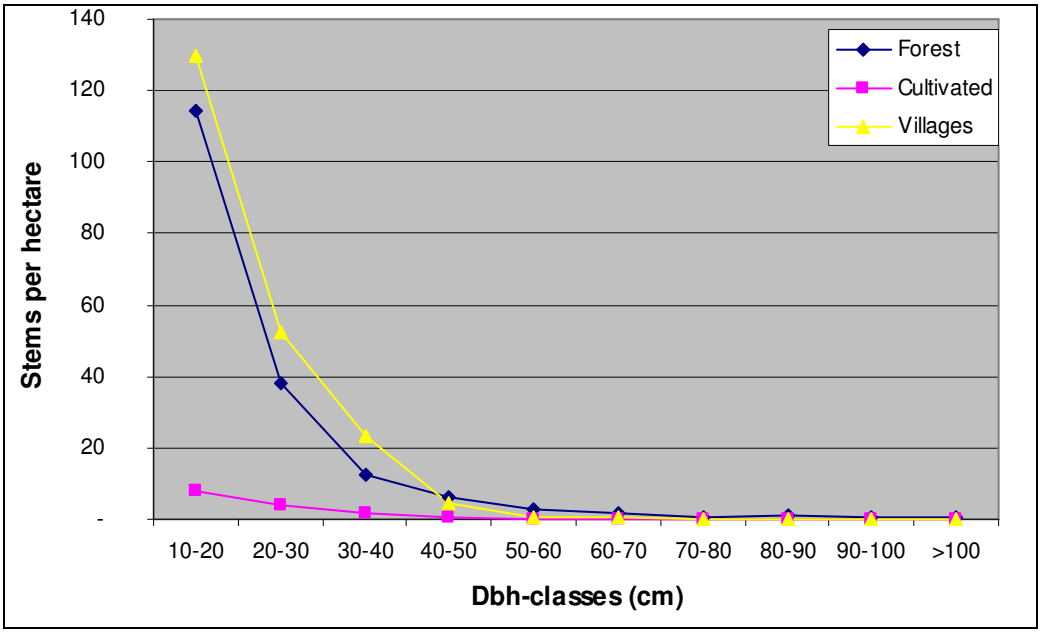

Figure 50: Stems per hectare by Dbh class in major land use classes

9.2.15. Gross volume and stems per hectare per Dbh-class for the different forest types

In Mangrove forest the volume is concentrated to the Dbh-classes 10-40 cm. In Hill forest the volume is more evenly distributed among the Dbh-classes. However, the Dbh-classes 20-50 cm have the highest volume per hectare. For Broad-leaved/Bamboo forest the tree volume

per hectare is primarily concentrated in the lower Dbh classes and tends to decrease with increasing Dbh. The same applies to Plantations, with hardly any volume in the high Dbh classes.

Mangrove forest have nearly 400 stems per hectare with a Dbh >10 cm. Almost all the stems can be found in the Dbh-classes 10-30 cm. Mixed Broadleaved/Bamboo forest have slightly over 100 tree stems per hectare and Hill Forest less than 100 stems per hectare. For Mixed Broadleaved/Bamboo forest more than 75 percent of the tree stems have a Dbh smaller than 40 cm, however it is the forest type with most even tree distribution among the diameter classes. In Hill forest 73% of the trees have a Dbh of <30 cm. In the plantations the majority of the stems can be found in the lower Dbh-classes.

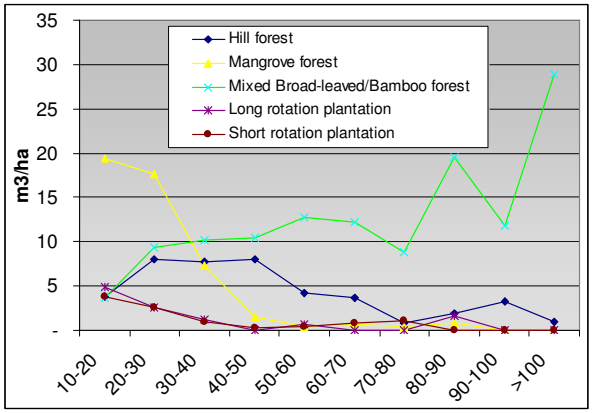

Figure 51: Gross tree volume per hectare by Diameter class in different forest types

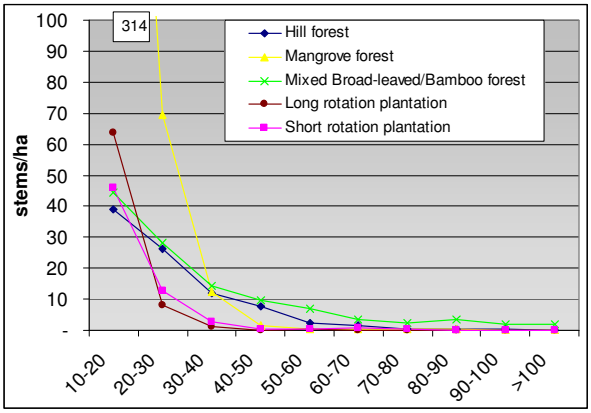

Figure 52: Stems per hectare by Diameter class in different forest types

9.2.16. Volume by stem quality class by major LUC

For all LUCs the majority (over 90%) of the Gross volume belongs to the High stem quality class as indicated in Table 39.

Table 39: Gross volume (1000 m^3) by stem quality class and major National LUC

Land Use	Stem Quality class			
	Total vol.	Low	Medium	High
Forest	69,563	1,026	2,478	66,060
Cultivated land	35,611	717	671	34,224
Villages	103,390	1,092	2,100	100,197
Built-up area	2,417	-	132	2,285
Inland water	1,038	71	64	903
Tot	***212,019***	***2,905***	***5,445***	***203,669***

* Represented by inventoried land uses

9.2.17. Gross volume by stem quality class per forest type

In all forest types, the majority of the volume belongs to the high stem quality class with percentages over 90%. For Mangroves the percentage of high stem quality volume is 80%.

Table 40: Gross volume (1000 m^3) by stem quality class and Forest Type

Land Use	Stem Quality class			
	Total vol.	Low	Medium	High
Hill forests	**23,232**	15	298	22,920
Sal forest	**-**	-	-	-
Mangrove forests	**20,911**	618	3,511	16,783
Bamboo forests	**23,447**	741	164	22,542
Long rotation	**1,445**	4	71	1,371
Short rotation	***527***	*2*	*26*	*499*

9.2.18. Commercial volume for the most important timber species for the major National Land Use Classes in Bangladesh

The commercial tree volume for the 25 most common species in each major land use class is presented in the following five tables beginning with Table 41.

In the whole of Bangladesh ten species make up almost 50 percent of the total commercial tree stem volume. Ordered by volume contribution they are: *Cocos nucifera, Samanea saman, Mangifera indica, Dipterocarpus turbinatus, Swietenia spp, Albizia procera, Areca catechu, Heritiera fomes*.

Between 8 and 15 species make up more than 50 percent of the commercial volume in each major land use class. In villages, Built-up areas and Inland water LUCs more than 25 percent of the commercial volume is made up by 2 to 3 tree species, while in Forest and Cultivated areas 4 to 6 tree species make up more than 25 percent of the commercial volume.

For more detailed and complete information on commercial tree volume by tree species and major land use class, please refer to Annex VIII.

Table 41, 42 and 43: Commercial volume of the 25 most important species in the LUC Forest, Cultivated land and Villages

Forests			
Species	**Total (1000 m^3)**	**(m^3/ha)**	**% of tot. comm. vol.**
Heritiera fomes	8,296	5.8	19.2
Dipterocarpus turbinatus	4,895	3.4	11.3
Gmelina arborea	2,432	1.7	5.6
Albizia procera	2,074	1.4	4.8
Lannea coromandelica	2,047	1.4	4.7
Cocos nucifera	1,961	1.4	4.5
Bombax ceiba	1,751	1.2	4.0
Tectona grandis	1,671	1.2	3.9
Artocarpus chaplasha	1,657	1.1	3.8
Swietenia spp	1,331	0.9	3.1
Excoecaria agallocha	1,270	0.9	2.9
Stereospermum chelonioides	1,227	0.9	2.8
Schima wallichii	1,216	0.8	2.8
Tetrameles nudiflora	952	0.7	2.2
Mangifera indica	846	0.6	2.0
Terminalia belerica	710	0.5	1.6
Duabanga grandiflora	658	0.5	1.5
Avicennia officinalis	655	0.5	1.5
Syzygium cumini	624	0.4	1.4
Xylocarpus mekengensis	483	0.3	1.1
Syzygium grandis	470	0.3	1.1
Amaranthus tricolor	448	0.3	1.0
Artocarpus heterophyllus	428	0.3	1.0
Lagerstroemia speciosa	425	0.3	1.0
Michelia champca	352	0.2	0.8

Cultivated land			
Species	**Total (1000 m^3)**	**(m^3/ha)**	**% of tot. comm. vol.**
Borassus flabellifer	2,316	0.3	10.1
Samanea saman	2,063	0.2	9.0
Dipterocarpus turbinatus	2,046	0.2	9.0
Phoenix sylvestris	1,897	0.2	8.3
Artocarpus chaplasha	1,234	0.1	5.4
Albizia procera	1,082	0.1	4.7
Cocos nucifera	771	0.1	3.4
Areca catechu	733	0.1	3.2
Swietenia spp	687	0.1	3.0
Gomphrena globosa	646	0.1	2.8
Mangifera indica	577	0.1	2.5
Bombax ceiba	524	0.1	2.3
Barringtonia acutangula	439	0.1	1.9
Syzygium cumini	410	0.05	1.8
Others	402	0.05	1.8
Lannea coromandelica	398	0.05	1.7
Artocarpus heterophyllus	349	0.04	1.5
Gmelina arborea	319	0.04	1.4
Dalbergia sisoo	258	0.03	1.1
Bouea oppositifolia	254	0.03	1.1
Terminalia belerica	253	0.03	1.1
Erythrina orientalis	234	0.03	1.0
Drimycarpus racemosus	233	0.03	1.0
Tectona grandis	219	0.03	1.0
Lagerstroemia speciosa	205	0.02	0.9

Villages			
Species	**Total (1000 m^3)**	**(m^3/ha)**	**% of tot. comm. vol**
Cocos nucifera	14,700	5.1	18.2
Samanea saman	9,961	3.5	12.4
Areca catechu	8,144	2.8	10.1
Mangifera indica	7,026	2.5	8.7
Borassus flabellifer	5,104	1.8	6.3
Phoenix sylvestris	4,898	1.7	6.1
Swietenia spp	4,059	1.4	5.0
Artocarpus heterophyllus	3,180	1.1	3.9
Albizia procera	2,502	0.9	3.1
Artocarpus chaplasha	2,380	0.8	3.0
Bombax ceiba	2,045	0.7	2.5
Anthocephalus chinensis	1,207	0.4	1.5
Lannea coromandelica	1,162	0.4	1.4
Albizia richardiana	903	0.3	1.1
Syzygium cumini	839	0.3	1.0
Eucalyptus camaldulensis	622	0.2	0.8
Terminalia catappa	604	0.2	0.7
Diospyros peregrina	540	0.2	0.7
Zizyphus mauritiana	539	0.2	0.7
Trewia polycarpa	531	0.2	0.7
Ficus benjamin	530	0.2	0.7
Dalbergia sisoo	478	0.2	0.6
Erythrina orientalis	453	0.2	0.6
Tamarindus indica	436	0.2	0.5
Azadirachta indica	383	0.1	0.5

Table 44 and 45: Commercial volume of the 25 most important species in the LUC Built up areas and Inland water

Built-up			
Species	**Total (1000 m^3)**	**(m^3/ha)**	**% of tot. comm. vol.**
Cocos nucifera	435	4.2	24.0
Swietenia spp	412	4.0	22.7
Mangifera indica	352	3.4	19.4
Samanea saman	183	1.8	10.1
Artocarpus heterophyllus	104	1.0	5.8
Phoenix sylvestris	79.4	0.8	4.4
Borassus flabellifer	47.3	0.5	2.6
Dalbergia sisoo	32.8	0.3	1.8
Acacia auriculiformis	31.1	0.3	1.7
Zizyphus mauritiana	29.3	0.3	1.6
Syzygium cumini	21.2	0.2	1.2
Acacia nilotica	15.2	0.1	0.8
Trewia polycarpa	13.9	0.1	0.8
Moringa oleifera	9.9	0.1	0.5
Ficus altissima	7.5	0.1	0.4
Erythrina orientalis	6.5	0.1	0.4
Annona squamosa	6.2	0.1	0.3
Gmelina arborea	4.9	0.05	0.3
Syzygium samarangense	3.5	0.03	0.2
Psidium guajava	3.1	0.03	0.2
Eucalyptus camaldulensis	3.1	0.03	0.2
Diospyros peregrina	2.8	0.03	0.2
Ficus hispida	2.3	0.02	0.1
Melia sempervirens	2.0	0.02	0.1
Azadirachta indica	1.5	0.01	0.1

Inland Water			
Species	**Total (1000 m^3)**	**(m^3/ha)**	**% of tot. comm. vol.**
Mangifera indica	99.0	0.05	15.1
Borassus flabellifer	96.3	0.05	14.7
Phoenix sylvestris	58.1	0.03	8.9
Cocos nucifera	57.2	0.03	8.7
Diospyros peregrina	53.4	0.03	8.2
Dalbergia sisoo	51.5	0.03	7.9
Samanea saman	42.8	0.02	6.5
Albizia richardiana	23.9	0.01	3.6
Bombax ceiba	23.3	0.01	3.6
Trewia polycarpa	21.8	0.01	3.3
Tectona grandis	19.8	0.01	3.0
Albizia procera	18.3	0.01	2.8
Artocarpus heterophyllus	14.7	0.01	2.3
Ochna squarrosa	10.5	0.01	1.6
Swietenia spp	8.9	0.004	1.4
Moringa oleifera	7.0	0.003	1.1
Syzygium cumini	6.2	0.003	1.0
Acacia nilotica	5.9	0.003	0.9
Zizyphus mauritiana	5.8	0.003	0.9
Lannea coromandelica	5.4	0.003	0.8
Azadirachta indica	4.9	0.002	0.8
Others	4.2	0.002	0.6
Tamarindus indica	3.4	0.002	0.5
Erythrina orientalis	3.2	0.002	0.5
Alstonia scholaris	2.3	0.001	0.3

9.2.19. Commercial volume per Dbh-class for the most important timber species for the total area of Bangladesh

Table 46: Commercial volume per diameter class in Bangladesh (1000 m^3)

Tree species	Total	DBH 15	DBH 25	DBH 35	DBH 45	DBH 55	DBH 65	DBH 75	DBH 85	DBH 95	DBH ≥100
Cocos nucifera	17,925	165	6,312	8,973	827	400	331	162	254	360	143
Samanea saman	12,276	1,205	3,406	3,782	2,253	773	414	65	-	-	378
Mangifera indica	8,899	1,209	2,724	2,535	1,131	509	548	172	72	-	-
Areca catechu	8,882	8,558	177	136	11	-	-	-	-	-	-
Heritiera fomes	8,301	2,910	3,760	1,528	103	-	-	-	-	-	-
Borassus flabellifer	7,571	19	253	2,738	3,734	805	23	-	-	-	-
Dipterocarpus turbinatus	6,978	17	63	106	219	546	1,081	686	1,172	757	2,330
Phoenix sylvestris	6,942	124	3,002	3,167	337	221	25	65	-	-	-
Swietenia spp	6,498	1,784	2,232	1,094	421	245	62	41	163	353	102
Albizia procera	5,676	589	1,905	1,479	583	419	317	285	98	-	-
Artocarpus chaplasha	5,272	330	1,611	1,116	246	198	247	394	383	191	556
Bombax ceiba	4,343	332	764	939	568	384	356	25	264	119	593
Artocarpus heterophyllus	4,077	1,010	1,536	1,030	367	84	19	-	30	-	-
Lannea coromandelica	3,612	813	828	434	417	216	41	199	115	300	250
Gmelina arborea	2,969	352	605	411	72	95	115	106	249	-	963
Tectona grandis	2,078	457	494	229	206	178	146	115	254	-	-
Syzygium cumini	1,901	326	535	367	500	162	10	-	-	-	-
Anthocephalus chinensis	1,453	388	631	197	69	16	86	66	-	-	-
Stereospermum chelonioides	1,442	83	319	300	216	294	159	-	71	-	-
Excoecaria agallocha	1,383	1,096	178	76	33	-	-	-	-	-	-
Schima wallichii	1,242	110	276	283	322	17	-	234	-	-	-
Albizia richardiana	1,131	225	363	443	80	21	-	-	-	-	-
Trewia polycarpa	987	98	192	315	167	104	-	-	-	-	111
Terminalia belerica	977	30	31	133	13	100	223	-	355	-	93
Tetrameles nudiflora	959	3	3	10	153	182	326	40	153	88	-

9.2.20. Commercial volume per stem quality class for the most important timber species for the total area of Bangladesh

Table 47: Commercial volume per stem quality class in Bangladesh (1000 m^3)

Tree species	Total	Low	Medium	High
Cocos nucifera	17,925	63	114	17,747
Samanea saman	12,276	7	68	12,201
Mangifera indica	8,899	19	148	8,732
Areca catechu	8,882	13	26	8,843
Heritiera fomes	8,301	110	1,335	6,855
Borassus flabellifer	7,571	4	85	7,482
Dipterocarpus turbinatus	6,978	181	-	6,797
Phoenix sylvestris	6,942	34	94	6,815
Swietenia spp	6,498	7	29	6,462
Albizia procera	5,676	12	41	5,623
Artocarpus chaplasha	5,272	9	11	5,252
Bombax ceiba	4,343	2	17	4,324
Artocarpus heterophyllus	4,077	27	120	3,930
Lannea coromandelica	3,612	28	45	3,539
Gmelina arborea	2,969	3	5	2,960
Tectona grandis	2,078	0	31	2,048
Syzygium cumini	1,901	4	14	1,882
Anthocephalus chinensis	1,453	-	2	1,451
Stereospermum chelonioides	1,442	-	6	1,436
Excoecaria agallocha	1,383	19	63	1,301
Schima wallichii	1,242	2	2	1,237
Albizia richardiana	1,131	3	16	1,112
Trewia polycarpa	987	10	18	959
Terminalia belerica	977	1	-	977
Tetrameles nudiflora	959	40	-	919

9.2.21. Gross volume in Major LUCs by health class

As shown in Table 48, 95 % of total gross volume is healthy in all LUCs. Forest and Villages contain patches of slightly affected trees in small percentages of the total as shown also in Figure 53 on a per hectare basis.

Table 48: Gross volume in major LUCs by health class (1000 m^3)

Land Use	Healthy	Slightly affected	Severely affected	Dead standing	Dead lying	Total
Total	**203,296**	**6,355**	**1,089**	**1,202**	**78**	**212,019**
Forest	65,185	3,036	411	875	56	**69,563**
Cultivated	34,698	743	37	132	1	**35,611**
Villages	100,173	2,428	576	193	21	**103,390**
Built-up areas	2,280	133	4	-	-	**2,417**
Inland Water	960	15	62	2	-	**1,038**

* Represented by inventoried land uses

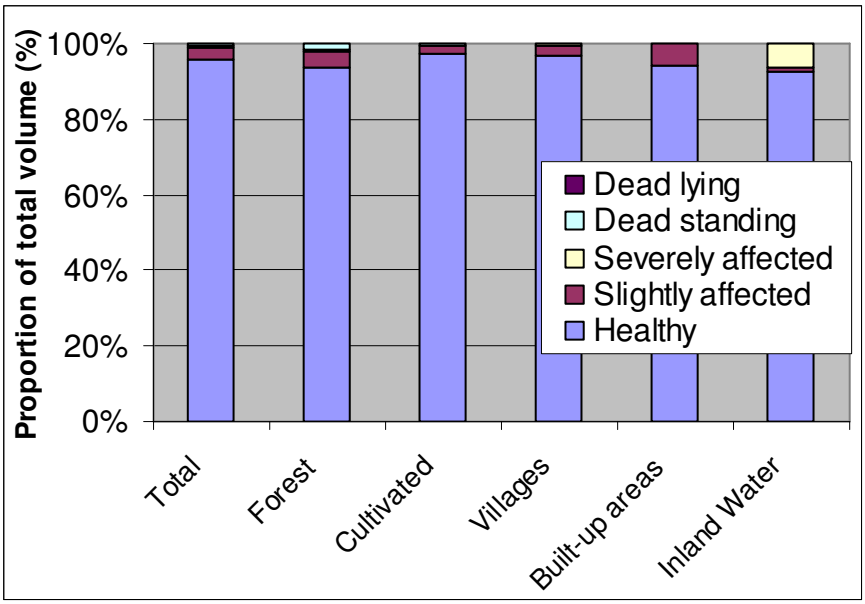

Figure 53: Gross volume per hectare in major LUCs by health class

9.2.22. Gross volume in major LUCs by Health affecting agents

Over all LUCs, about 30% of the total affected volume is due to disease and fungi. Insects, Climate and Humans are the causative agents of slightly over 20% each. Proportions are shown in Figure 54 while total volume in Table 49: Gross volume (1000 m^3) in Major LUCs by health affecting agent.

Table 49: Gross volume (1000 m^3) in Major LUCs by health affecting agent

Land Use	Insects	Disease/ Fungi	Fire	Animals	Climate	Humans	Total
Total	**2,016**	**3,545**	**769**	**44**	**1,052**	**1,065**	**8,491**
Forest	1,157	2,333	688	-	49	37	**4,264**
Cultivated	55	478	50	-	195	58	**836**
Villages	804	659	32	35	778	904	**3,211**
Built-up areas	-	67	-	10	23	-	**100**
Inland Water	-	7	-	-	8	66	**80**

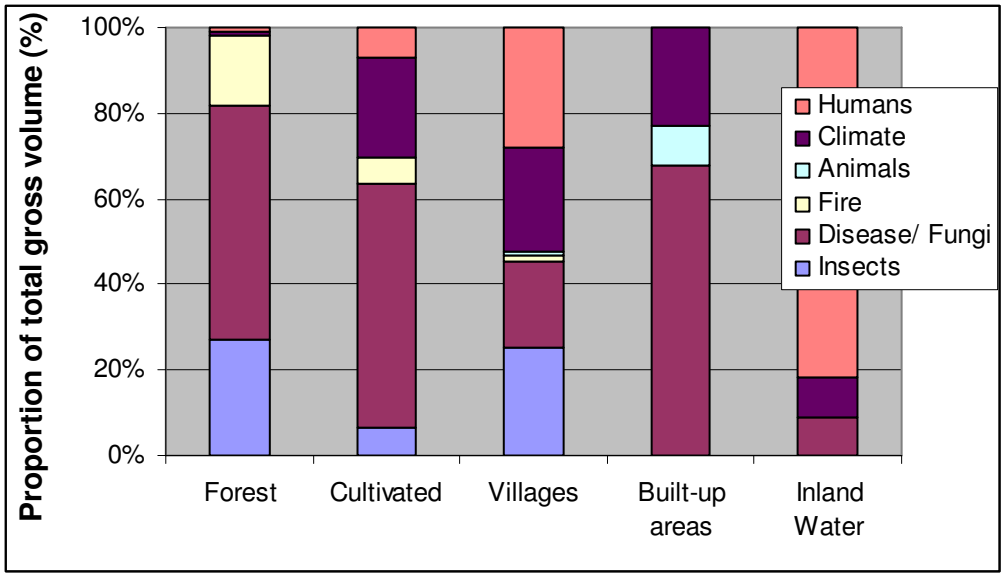

Figure 54: Proportion of gross volume in major LUCs by Health affecting agents (%)

9.2.23. Gross volume in each forest type by health class

Among all forest types, about 94% of total volume is healthy and only 4% is slightly affected. About 2/3 of the 'slightly affected' volume is within Mangrove forests which is also the only forest type with severely affected volume. Bamboo is the only class containing dead standing volume. Total volumes and proportions are presented in Table 50 and Figure 55.

Table 50: Gross volume (1000 m^3) in Forest types by health class

Forest Type	Healthy	Slightly affected	Severely affected	Dead standing	Dead lying	Total
FH	23,133	99	0	0	0	**23,232**
FM	17,634	2,681	399	141	56	**20,911**
FB	22,548	164	11	724	0	**23,447**
PL	1,371	67	0	8	0	**1,445**
PS	499	26	0	2	0	**527**
PM	0	0	0	0	0	**0**
Sum	**65,185**	**3,036**	**411**	**875**	**56**	69,563

* Represented by inventoried forest types

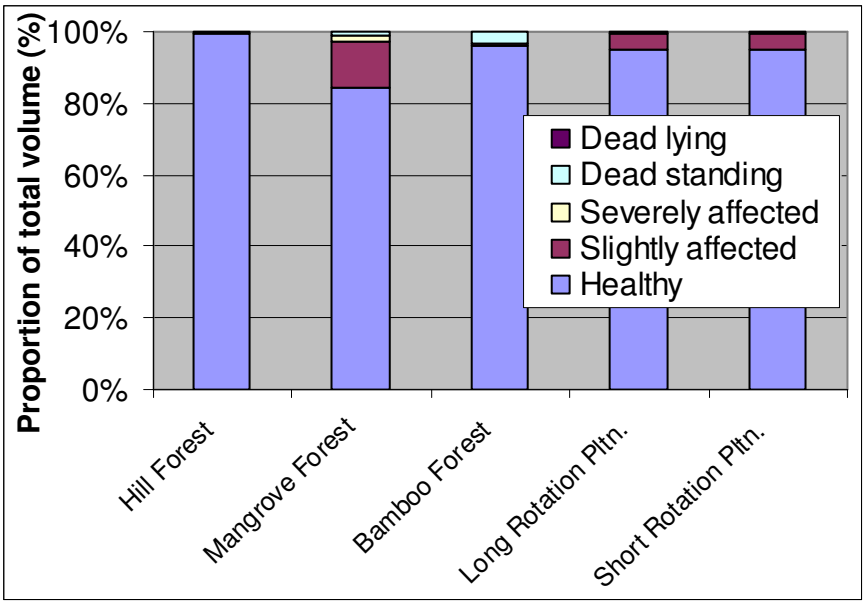

Figure 55: Gross volume per hectare in forest types by health class

9.2.24. Gross volume in major forest types by Health affecting agents

Diseases and fungi constitute 55% of the causing agents affecting tree health over the total forest volume. Insects (27%) and Fire (16%) are the other most relevant affecting agents. Mangrove forest in particular, but also bamboo appear as the forest type most affected by insects and disease / fungi, while animals do not seem to play any role as health affecting agent.

Table 51: Gross volume (1000 m^3) in forest types by health affecting agent

Forest Type	Insects	Disease/ Fungi	Fire	Animals	Climate	Humans	Total
FH	-	82	-	-	17	-	**99**
FM	1,096	1,986	24	-	21	37	**3,164**
FB	62	172	664	-	1	-	**899**
PL	-	67	-	-	8	-	**75**
PS	-	26	-	-	2	-	**28**
Sum	**1,157**	**2,333**	**688**	**-**	**49**	**37**	**4,264**

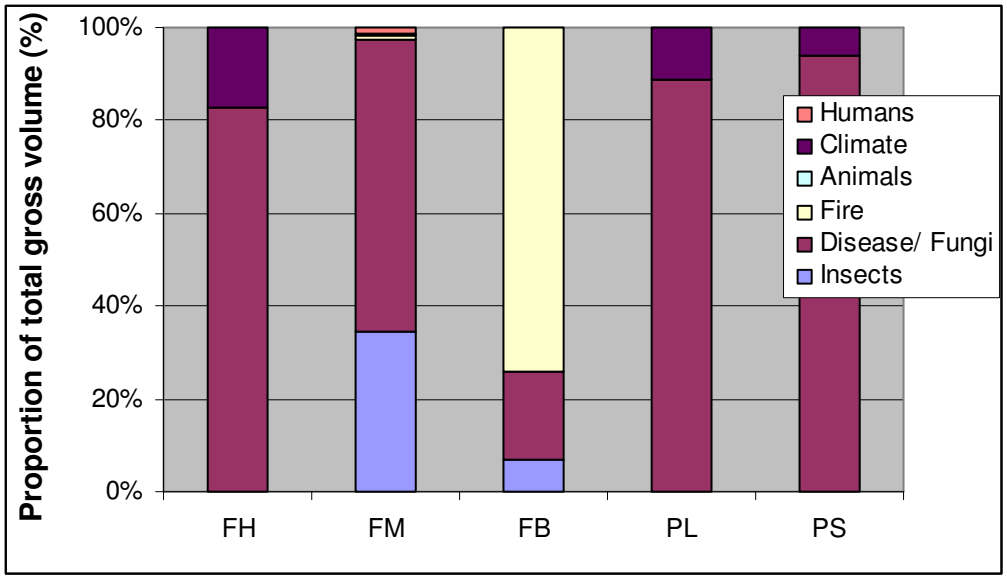

Figure 56: Proportion of gross volume in forest types by Health affecting agents

9.2.25. Number of stumps per hectare by Diameter class and stump age per major National LUC

Table 52: Total number of Stumps (1000) in Major Land Use Class, by DBH

Land Use	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100	>100	Total
Total	**4,298**	**4,336**	**2,396**	**1,823**	**981**	**478**	**143**	**309**	**141**	**190**	**15,095**
<1 year	1,559	1,988	1,081	685	310	122	25	25	-	-	5,794
1-5 years	2,616	2,251	1,143	1,113	647	356	118	260	141	190	8,836
5-10 years	98	72	48	-	23	-	-	-	-	-	242
>10 years	25	25	49	25	-	-	-	25	-	-	148
Forest	**3,450**	**3,588**	**1,742**	**1,285**	**687**	**332**	**93**	**212**	**117**	**165**	**11,670**
<1 year	1,026	1,407	572	266	139	23	-	-	-	-	3,434
1-5 years	2,325	2,107	1,022	993	525	308	93	187	117	165	7,843
5-10 years	98	48	48	-	23	-	-	-	-	-	218
>10 years	-	25	25	25	-	-	-	25	-	-	100
Cultivated	**468**	**320**	**369**	**443**	**246**	**98**	**49**	**74**	**25**	**25**	**2,116**
<1 year	271	271	295	418	148	98	25	25	-	-	1,550
1-5 years	172	49	74	25	98	-	25	49	25	25	541
5-10 years	-	-	-	-	-	-	-	-	-	-	-
>10 years	25	-	-	-	-	-	-	-	-	-	25
Villages	**381**	**428**	**286**	**95**	**48**	**48**	**-**	**24**	**-**	**-**	**1,309**
<1 year	262	309	214	-	24	-	-	-	-	-	809
1-5 years	119	95	48	95	24	48	-	24	-	-	452
5-10 years	-	24	-	-	-	-	-	-	-	-	24
>10 years	-	-	24	-	-	-	-	-	-	-	24

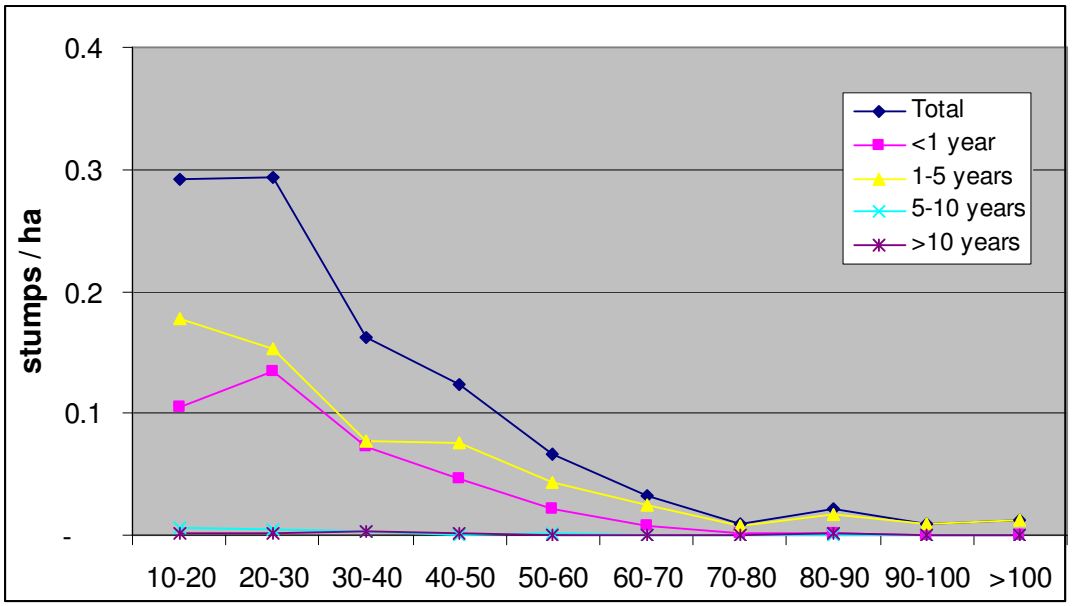

Figure 57: total number of stumps / ha in Bangladesh

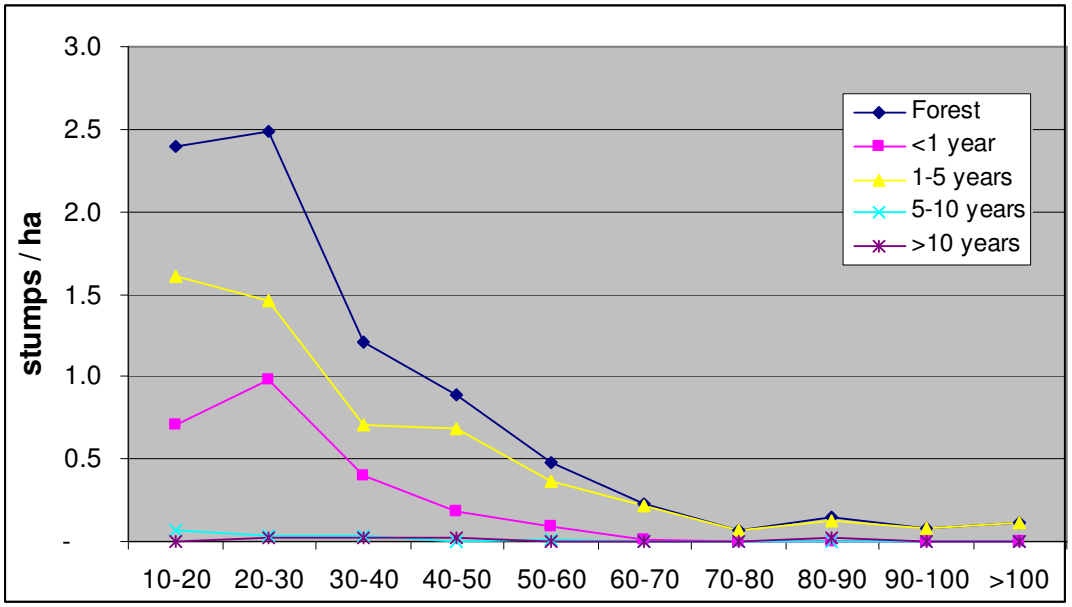

Figure 58: total number of stumps / ha in Forest

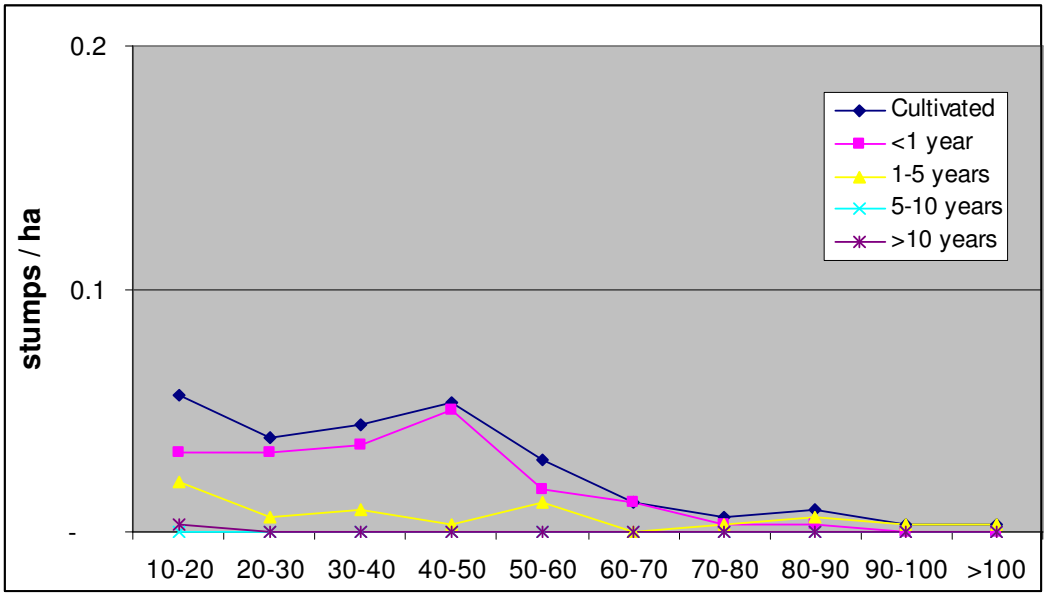

Figure 59: total number of stumps / ha in Cultivated land

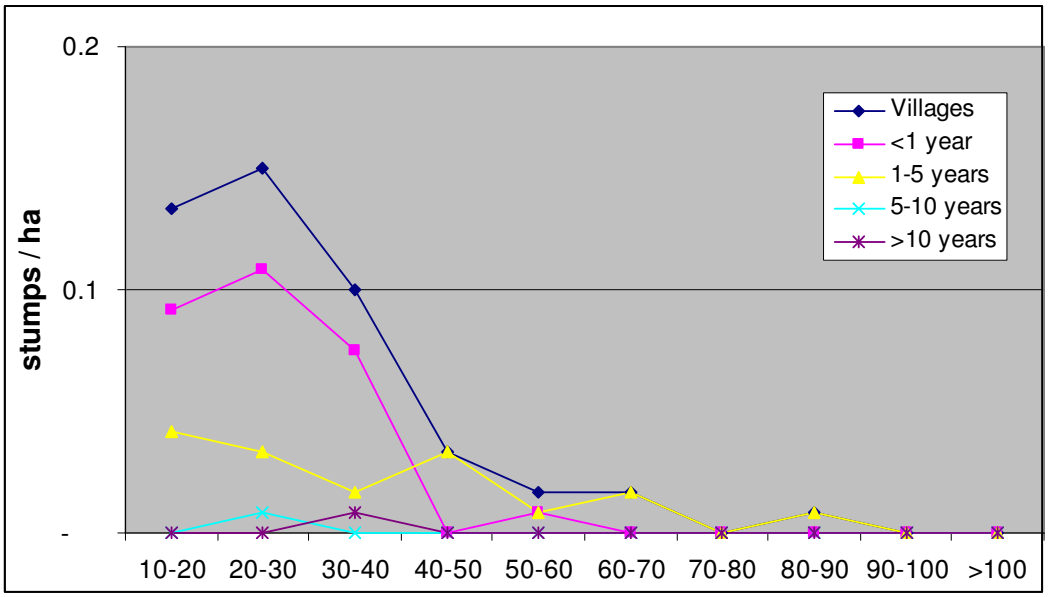

Figure 60: total number of stumps / ha in Villages

9.3. Biodiversity and regeneration

The total number of tree species (or genus) that were measured and identified in Bangladesh was 258 (see Table 53 and Annex VIII). Of these, 198 species are found in Villages, 129 species are found in Forest, 137 species are found in Cultivated Land, 33 species are found in Inland water and 28 species are found in Urban areas.

The species representing the highest volume in general are *Cocos nucifiera*, *Samanea Saman* and *Mangifera indica* (as shown previously in Table 41 through Table 47). These three species are also the most common in the major National LUC Villages. In Forest the two species with highest volume are *Dipterocarpus turbinatus* and *Heritiera fomes*, followed by *Albizia procera*, *Gmelina arborea* and *Lannea coromandelica*. The total list of tree species in the different major National LUC:s and their volumes can be viewed in Annex VII.

9.3.1. Biodiversity

Biodiversity index is a mathematical measure of species diversity in a community. It provides information on the number of species present in the community (species richness) and also the relative abundance of the different species.

To characterize the species diversity in the major land use classes, the *Shannon's Diversity Index* was employed. The *Shannon index* accounts for both abundance and evenness of the species present. The Shannon Index ranges from 0.0 to approximately 4.6. A value near 0.0 means that every tree in the sample is of the same species and a value near 4.6 would indicate that the numbers of individuals are evenly distributed among the different species.

9.3.2. Biodiversity index for the major National LUC

It can be seen in Table 53 that diversity and equitability are higher in Cultivated Land and Inland Water than in Forest. Although there are more tree species in Forest (129 species) as compared to Cultivated Land (137 species) and Inland Water (33 species), about 46% of the total number of individuals in Forest belong to only two tree species: *Heritiera fomes* and *Excoecaria agallocha*.

Table 53: Diversity Index and Equitability

	Total	Forest	Cultivated Land	Villages	Urban Areas	Inland Water
No. of species	258	129	137	198	28	33
Diversity	3.57	3.03	3.31	3.23	2.22	3.08
Equitability	0.64	0.61	0.72	0.61	0.67	0.87

9.3.3. Regeneration

In the Forest LUC, tree regeneration is of 2,361 stems per hectare on average. This is almost 20 times the average number of stems per hectare for all trees with D_{bh} >10 cm, which is 127 stems per hectare.

Results show 121 species identified as tree regeneration in the Forest. Of these, *Ceriops roxburghiana, Excoecaria agallocha and Heritiera fomes* are the most abundant tree species; their relative proportion to the total number of individuals within the Forest is approximately 49%. Table 54 shows the top 15 most abundant tree regeneration species in Forest.

Table 54: Number of regeneration stems,(Dbh <10 cm) per hectare of the most important species in major National LUC "Forest"

No.	Scientific Species Name	Total Count (NPL2)	Proportion to the total number of species(pi)	Average No. of stems per ha
1	Ceriops roxburghiana	785	18%	420
2	Excoecaria agallocha	742	17%	397
3	Heritiera fomes	635	14%	340
4	Ficus hispida	292	7%	156
5	Amoora cucullata	162	4%	87
6	Malocanna baccifera	126	3%	67
7	Tectona grandis	113	3%	60
8	Macaranga denticulate	101	2%	54
9	Grewia microcosm	83	2%	44
10	Callicarpa arborea	73	2%	39
11	Others	70	2%	37
12	Schima wallichii	68	2%	36
13	Stereospermum chelonioides	65	1%	35
14	Lannea coromandelica	59	1%	32
15	Albizia procera	57	1%	30

9.3.4. Number of stems per hectare of Dbh 1-10 cm (regeneration) in the different forest types

The number of regeneration stems per hectare in Forest is on average 2,361 stems/ha. Figure 61 shows that the Mangrove forest has more than 8,000 regeneration stems per hectare. Hill forest, Bamboo forest and Long rotation plantations have slightly over 1,000 regeneration stems per hectare and Short rotation and Mangrove plantations have around 500 such stems per hectare.

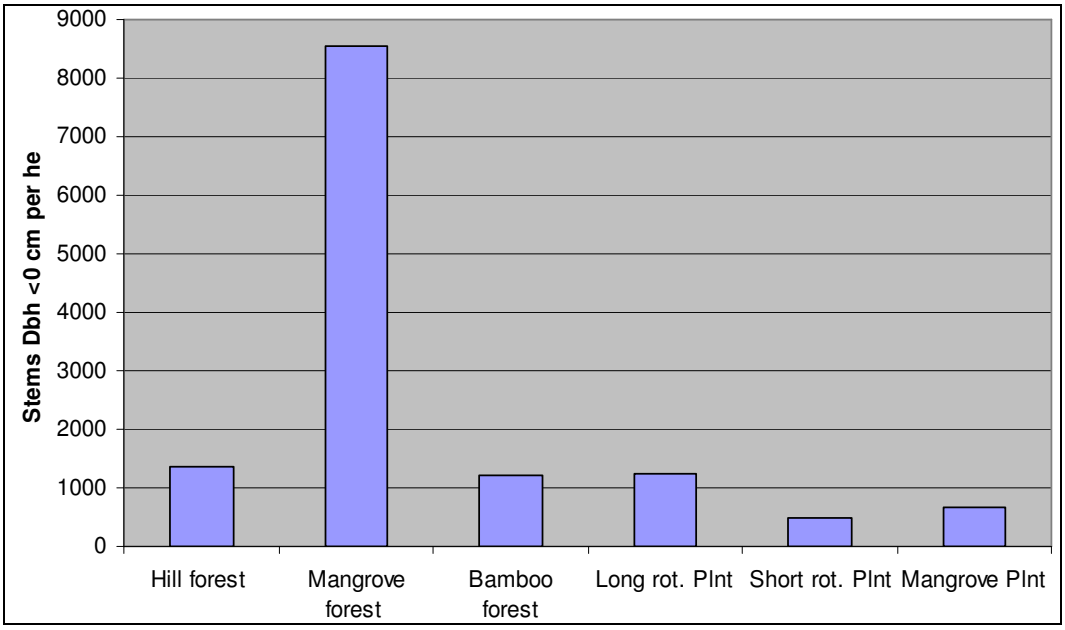

Figure 61: Number of regeneration stems (Dbh < 10 cm) per hectare for different forest types

9.4. Social and economical

The products/services for the LUCs "Built up" area and "Inland Water" will not be presented in the following (although data has been collected). This is due to low utilization of products/services in these LUCs.

9.4.1. Estimated population for tracts with high forest content and for tracts without (or low) forest content

The average population density of Bangladesh is about 1,000 persons per km^2. For tracts with low forest content (<25%) the density is slightly higher than 1,000 persons per km^2. For tracts with high forest content (>25%) the population density is significantly lower: 235 persons per km^2, as shown in Figure 62.

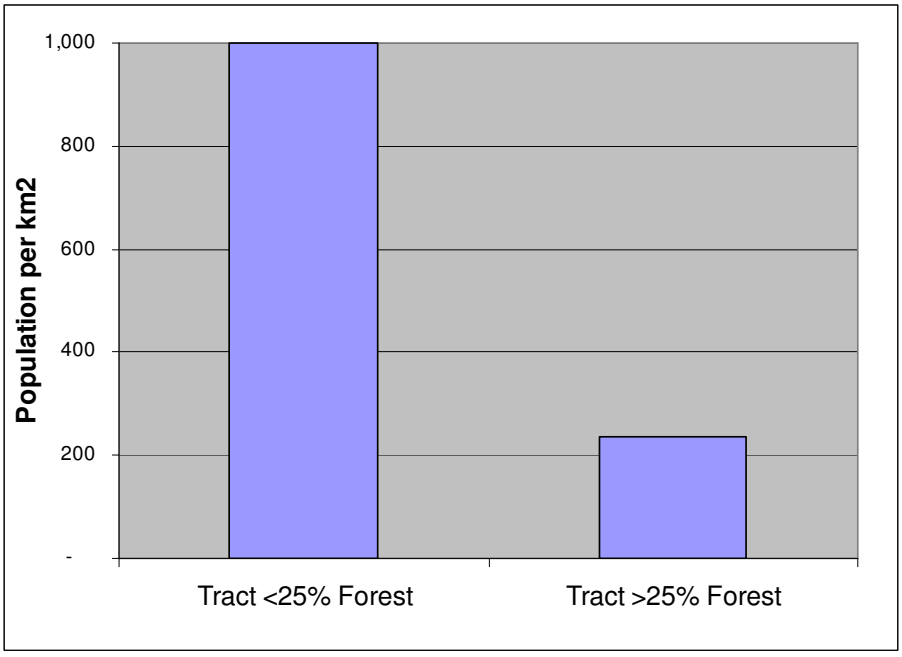

Figure 62: Estimated population per Km^2 for areas with high (>25%) and low (<25%) forest content

9.4.2. Number of years since populated for tracts with high forest content and for tracts without (or low) forest content

Almost 1/5 of the areas with high forest content were populated less than 25 years ago. In areas with low forest content only 3% were populated during the last 25 years. More then 80% of the area, both in high and low forest content, were populated more then 25 years ago.

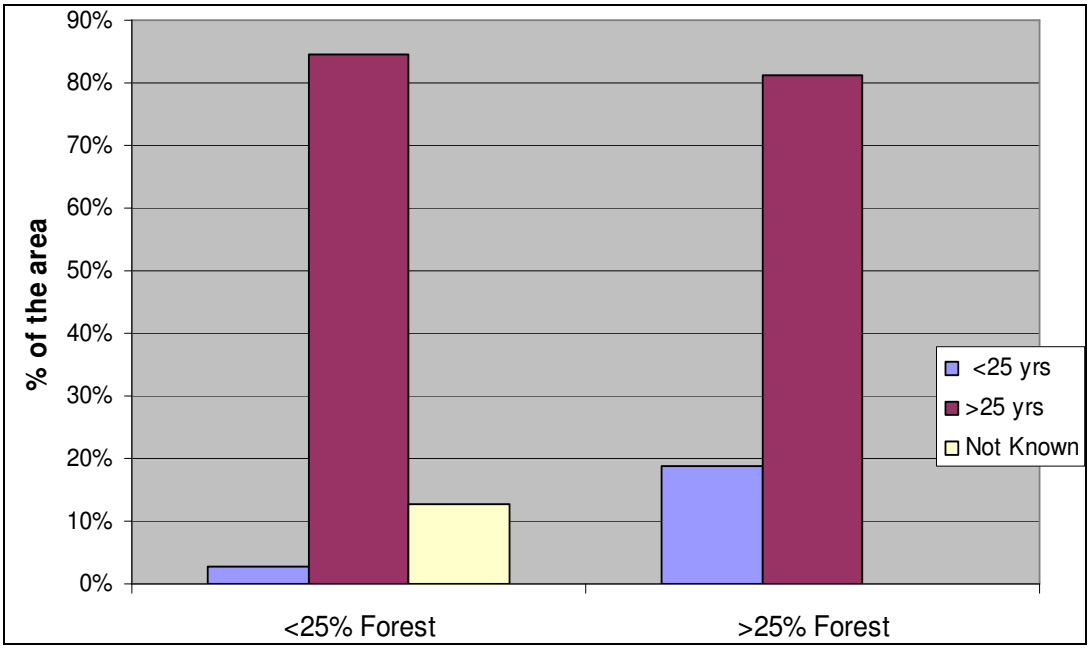

Figure 63: Number of years since populated by area with high and low forest content

9.4.3. Trend of population for tracts with high forest content and for tracts without (or low) forest content

Figure 64 shows that the population is increasing in over 85% of the areas, both in areas with high and with low forest content.

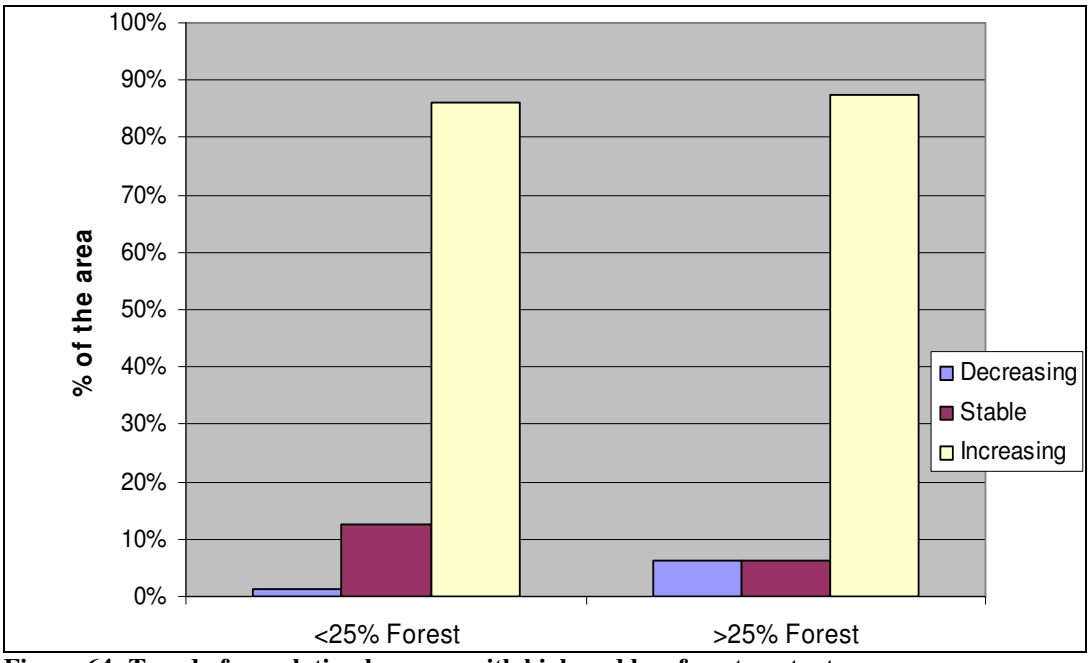

Figure 64: Trend of population by areas with high and low forest content

9.4.4. Main activity of the permanent population for tracts with high forest content and for tracts without (or low) forest content

The most important activity of the permanent population is crop production. However, in areas with high forest approximately ¼ of the population has forestry as main activity.

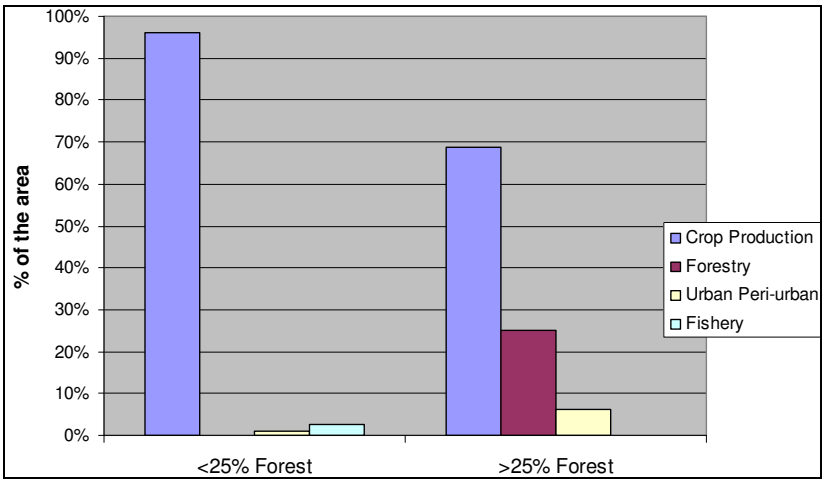

Figure 65: Main activity of permanent population by areas with high and low forest content

9.4.5. Products and services - general

The range of Forestry Products and Services included in the NFA is presented in Table 55. The findings on forestry products and services that are harvested/used are presented as area in which they are harvested/used.

Table 55 : Area in which forestry products and services are harvested/used (1000 ha)

Product/service type	TOT area
Timber	6,237
Fuelwood	6,354
Charcoal	25
Wood carvings	335
Poles	1,085
Plant Food	4,910
Fodder	148
Plant medicines	220
Soap/cosmetics	38
Dying/tannins	51
Herbs & spices	3
Exudates	79
Utensils/Handicrafts	92
Construction materials	2,472
Ornamentals	27
Other plant products	434
Living animals	7
Employment	57
Protection	295
Windbreaks	12
Shade	27

9.4.6. The area where each of product/service is used, in three classes of importance – for the total area of Bangladesh

Figure 66 shows the area where each product and service is used/harvested (based on the total area of Bangladesh). It is confirmed that the most important products are: timber, fuelwood, poles, plant food and construction material. Below, these products will be analyzed in more detail.

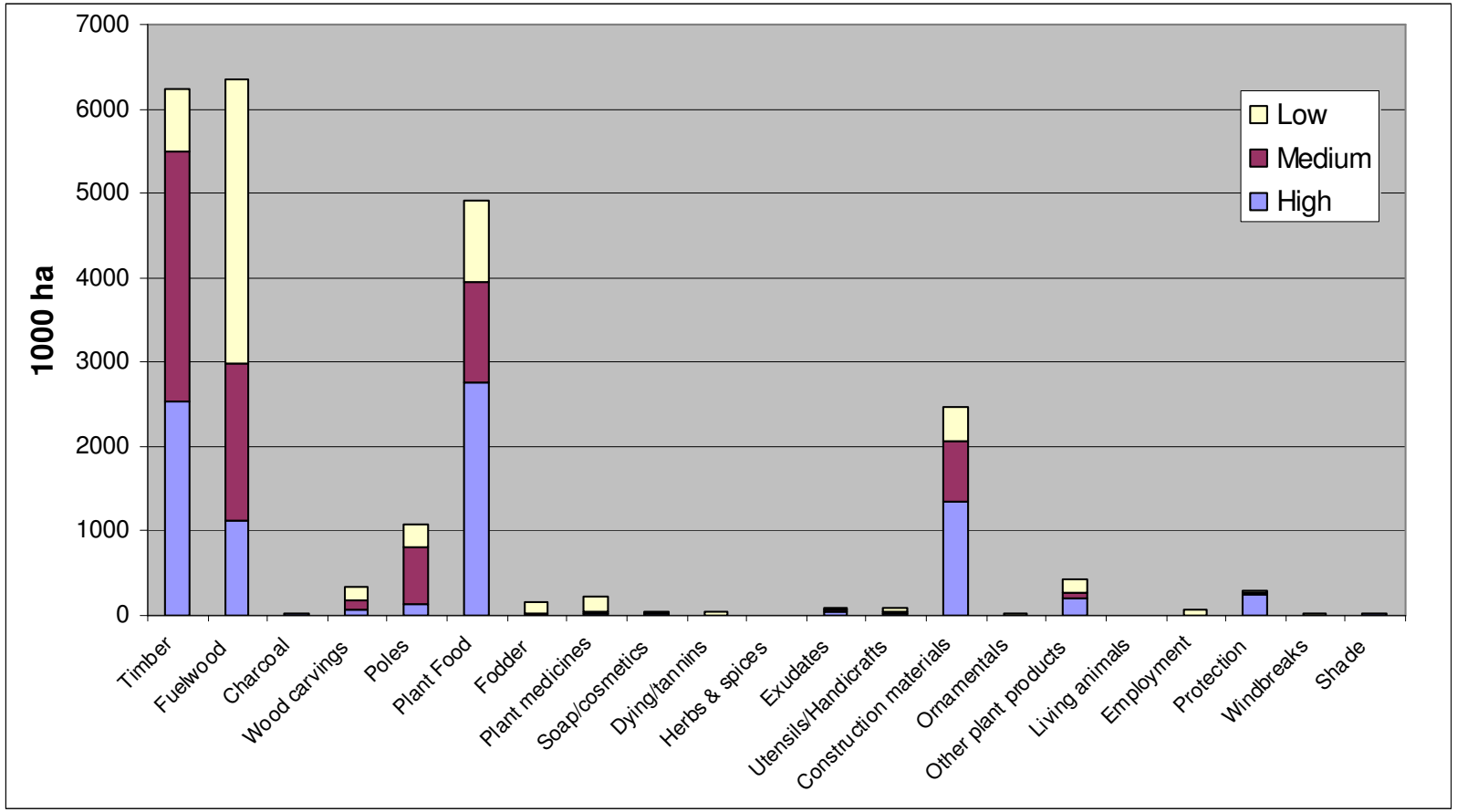

Figure 66: Importance (low/medium/high) of forestry products/services that are harvested/used in Bangladesh, presented as area in which the they are harvested/used

9.4.7. Products and services - conflicts

From Figure 67 to Figure 69 it can be seen that user conflicts are most common in the LUC "Forest". The products/services with most conflicts are timber, fuelwood and poles.

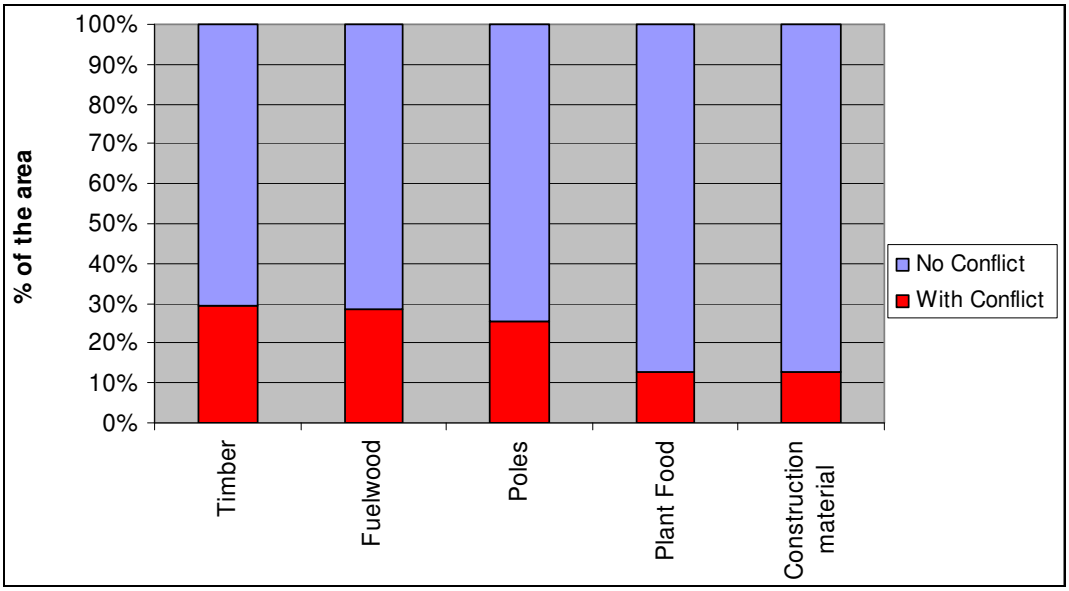

Figure 67: Proportion of forest area with user conflicts by product type

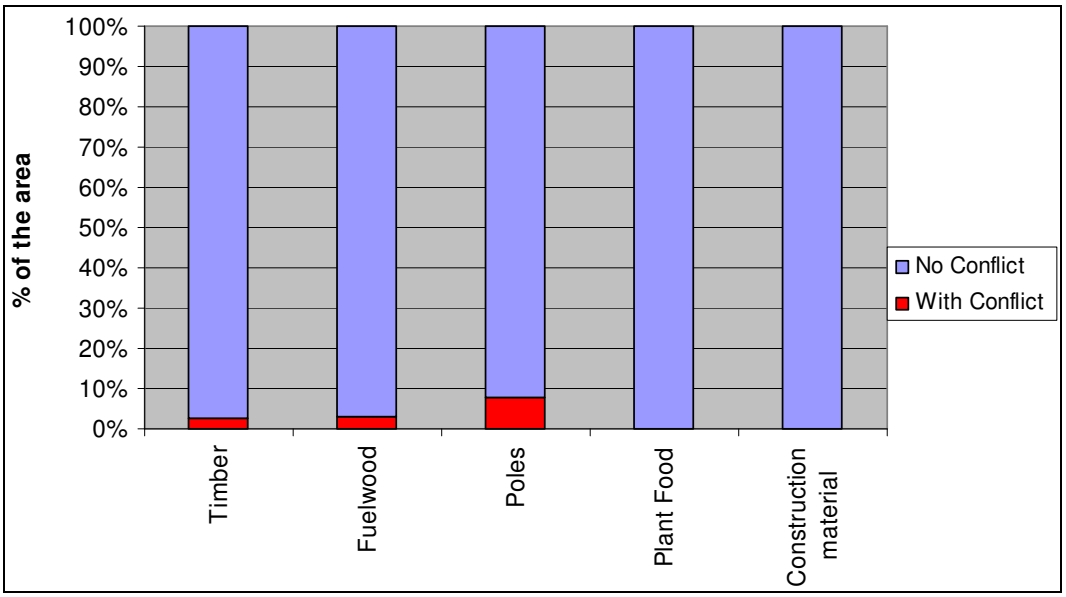

Figure 68: Proportion of cultivated land area with user conflicts by product type

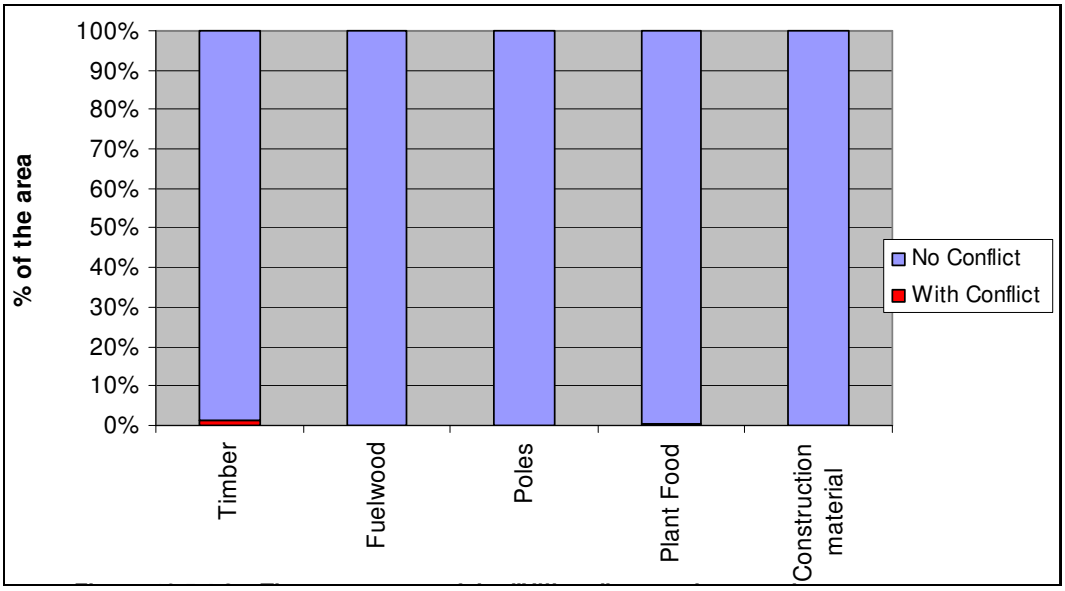

Figure 69: Proportion of village area with user conflicts by product type

9.4.8. Products and services – demand and supply

Figure 70 to Figure 72 show that the demand for timber, fuelwood, poles, construction material and plant food is increasing in all LUC:s, which creates a general shortage of the mentioned products/services.

In Forest the supply trend of fuelwood, poles and construction material is decreasing, creating a strong shortage of these products. For plant food the supply is increasing in the majority of the area, which altogether gives a nearly balanced situation. In Cultivated land the supply trend for timber, fuelwood, poles, construction material and plant food services is neutral, but the increasing demand gives altogether a shortage. In Villages the supply trend is increasing for all the mentioned products and services. But a very strongly increasing demand gives us altogether a situation of shortage.

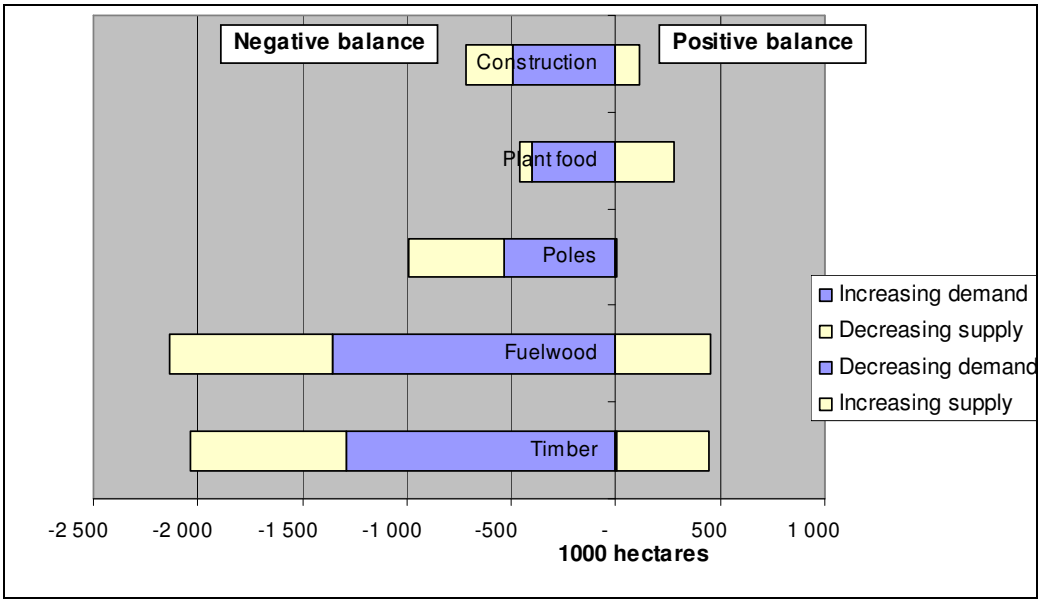

Figure 70: Supply / Demand balance for products and services in "Forest" area

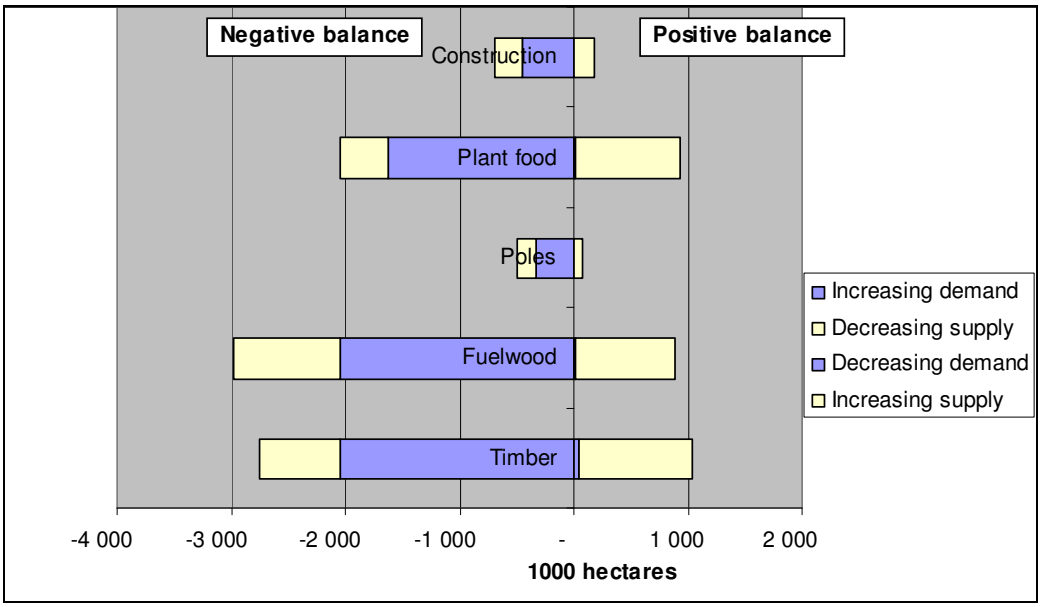

Figure 71: Supply / Demand balance for products and services in "Cultivated land" area

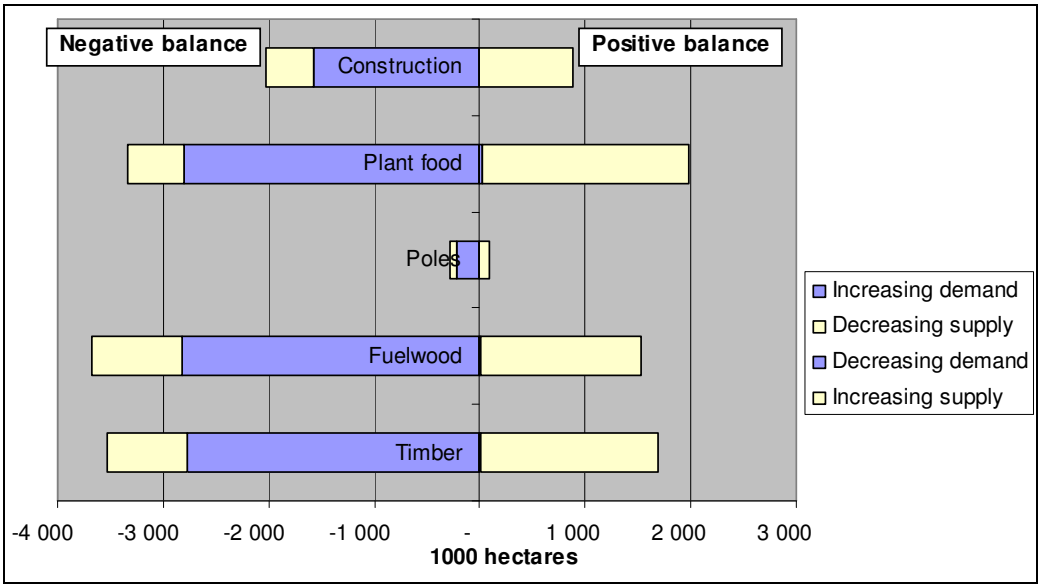

Figure 72: Supply / Demand balance for products and services in "Village" area

9.4.9. Products and services – important species

Table 56: The most important tree species for products and services in "Forest" (tree count in the NFA)

ScientificName	**Wood products**	Timber	Fuelwood	Poles	ScientificName	**NWFP-PP**	Plant Food	Constr. mtrl
Ochna squarrosa	**49**	1	34	14	Terminalia belerica	**9**	5	0
Stereospermum chelonioides	**20**	2	13	5	Syzygium cumini	**7**	7	0
Ficus hispida	**18**	1	17	0	Dillenia indica	**5**	5	0
Gmelina arborea	**17**	11	5	1	Ficus hispida	**4**	4	0
Syzygium cumini	**17**	12	4	1	Artocarpus lacucha	**2**	2	0
Lannea coromandelica	**15**	6	4	5	Swietenia spp	**2**	0	1
Albizia procera	**12**	8	3	1	Protium serratum	**1**	1	0
Toona ciliata	**12**	5	3	4	Bouea oppositifolia	**1**	0	0
Castanopsis indica	**11**	8	2	0	Bombax ceiba	**1**	0	0
Mitragyna parvifolia	**10**	3	7	0	Ficus bengalensis	**1**	0	0
Protium serratum	**10**	6	4	0	Artocarpus heterophyllus	**1**	1	0
Vitex glabrata	**10**	2	5	1	Oroxylum indicum	**1**	0	0
Microcos paniculata	**9**	0	9	0	Phoenix sylvestris	**1**	1	0
Artocarpus chaplasha	**8**	8	0	0	Xylocarpus mekengensis	**1**	1	0
Cassia fistula	**8**	1	7	0	Ceriops roxburghiana	**1**	0	1
Tectona grandis	**7**	5	1	1	Terminalia chebula	**1**	0	0
Dipterocarpus turbinatus	**6**	6	0	0				
Macaranga denticulata	**6**	3	3	0				
Schima wallichii	**6**	1	4	1				

Table 57: The most important tree species for products and services in "Cultivated land" (tree count in the NFA)

ScientificName	**Wood products**	Timber	Fuelwood	Poles	ScientificName	**NWFP-PP**	Plant Food	Constr. mtrl
Samanea saman	**47**	21	26	0	Phoenix sylvestris	**31**	24	0
Mangifera indica	**45**	20	25	0	Mangifera indica	**29**	28	1
Phoenix sylvestris	**24**	6	17	1	Borassus flabellifer	**17**	17	0
Albizia procera	**23**	11	9	2	Artocarpus heterophyllus	**8**	7	0
Lannea coromandelica	**21**	6	14	1	Cocos nucifera	**8**	8	0
Bombax ceiba	**18**	8	9	0	Syzygium cumini	**8**	8	0
Acacia nilotica	**15**	6	4	1	Moringa oleifera	**7**	7	0
Syzygium cumini	**14**	9	5	0	Areca catechu	**6**	6	0
Borassus flabellifer	**11**	4	4	3	Diospyros peregrina	**4**	4	0
Cassia fistula	**11**	4	6	1	Spondias pinnata	**4**	4	0
Azadirachta indica	**10**	8	1	0	Zizyphus mauritiana	**4**	4	0
Erythrina orientalis	**9**	1	8	0	Swietenia spp	**3**	0	3
Melia sempervirens	**9**	4	5	0	Azadirachta indica	**2**	0	2
Aphanamixis polystachya	**8**	3	4	1	Bombax ceiba	**2**	0	1
Artocarpus heterophyllus	**8**	5	3	0	Citrus grandis	**2**	2	0

Table 58: The most important tree species for products and services in "Villages" (tree count in the NFA)

ScientificName	**Wood products**	Timber	Fuelwood	Poles	ScientificName	NWFP-PP	Plant Food	Constr. mtrl
Samanea saman	**92**	48	44	0	Mangifera indica	**102**	101	0
Mangifera indica	**80**	39	41	0	Syzygium cumini	**35**	34	0
Albizia procera	**65**	40	21	2	Spondias pinnata	**33**	33	0
Lannea coromandelica	**50**	17	31	2	Zizyphus mauritiana	**32**	32	0
Syzygium cumini	**43**	34	7	2	Borassus flabellifer	**31**	30	0
Bombax ceiba	**37**	12	25	0	Phoenix sylvestris	**31**	31	0
Artocarpus heterophyllus	**32**	24	8	0	Cocos nucifera	**30**	30	0
Cassia fistula	**32**	16	14	2	Areca catechu	**28**	28	0
Phoenix sylvestris	**32**	6	25	0	Artocarpus heterophyllus	**20**	19	0
Azadirachta indica	**26**	23	3	0	Moringa oleifera	**14**	14	0
Borassus flabellifer	**26**	14	11	1	Artocarpus lacucha	**10**	10	0
Acacia auriculiformis	**22**	8	14	0	Citrus grandis	**10**	10	0
Albizia richardiana	**21**	13	7	1	Psidium guajava	**10**	10	0
Aphanamixis polystachya	**18**	11	6	1	Ficus hispida	**9**	8	0
Cocos nucifera	**18**	7	11	0	Tamarindus indica	**9**	9	0

9.4.10. Products and services – users of forestry products/services

Figure 73 to Figure 75 show that most of the important products and services are harvested or used by individuals. The only exception is construction material in the Forest area, which to 50% is harvested by companies.

In the Forest area 20-35% of these products and services are used without any rights. In the villages and in the Cultivated land almost non of the products or services is used without rights.

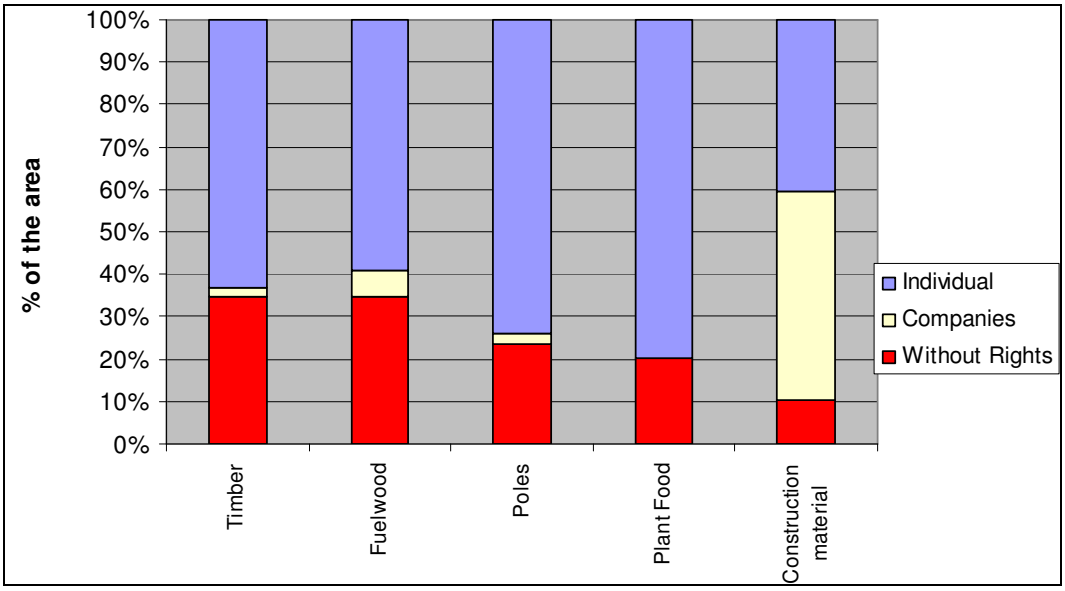

Figure 73: Users of most important products and services in "Forest" area

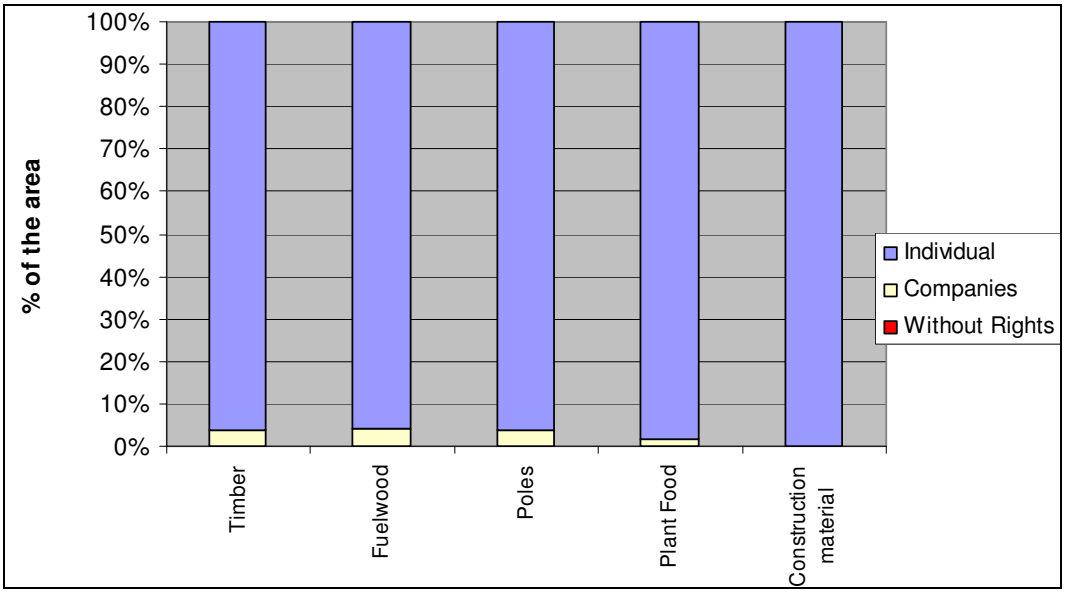

Figure 74: Users of most important products and services in "Cultivated land" area

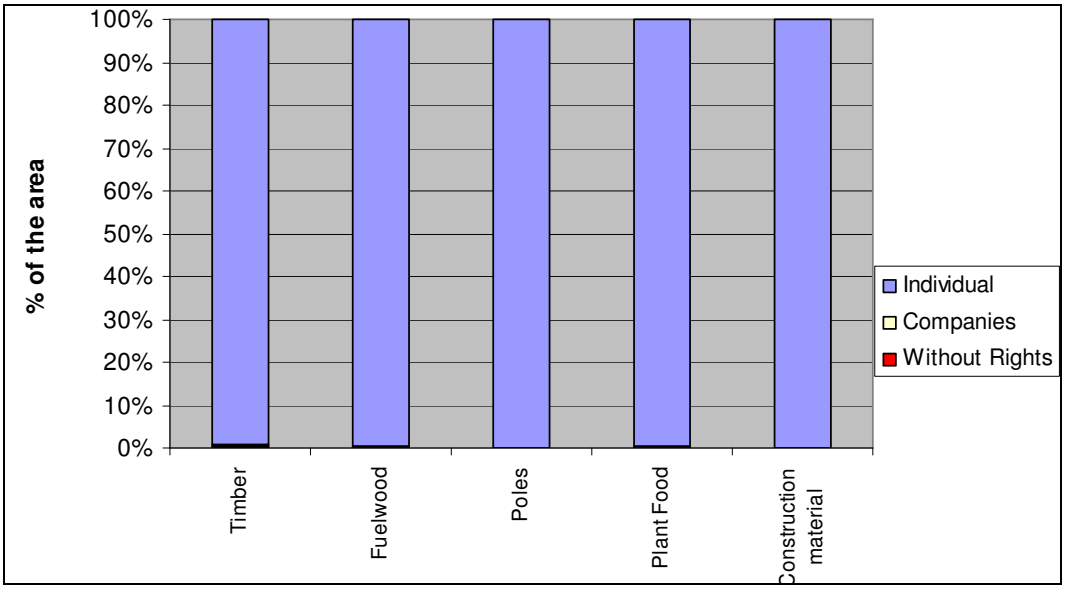

Figure 75: Users of most important products and services in "Inland water" area

9.4.11. Products and services – User rights to forestry products / services

In the Villages and in the Cultivated land the use of products and services is based on property rights. In the Forest about 50% of the use is based on property rights but approximately 30% of the use is not based on any rights at all. Some of the use in Forest is also based on customary rights or open access.

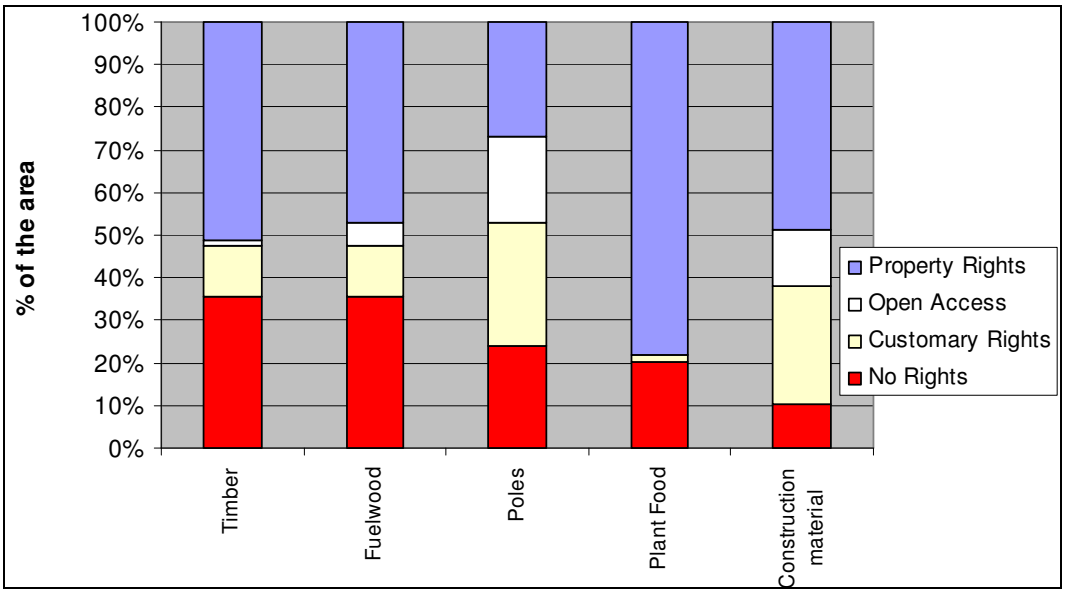

Figure 76: User right for the most important products / services in "Forest" area

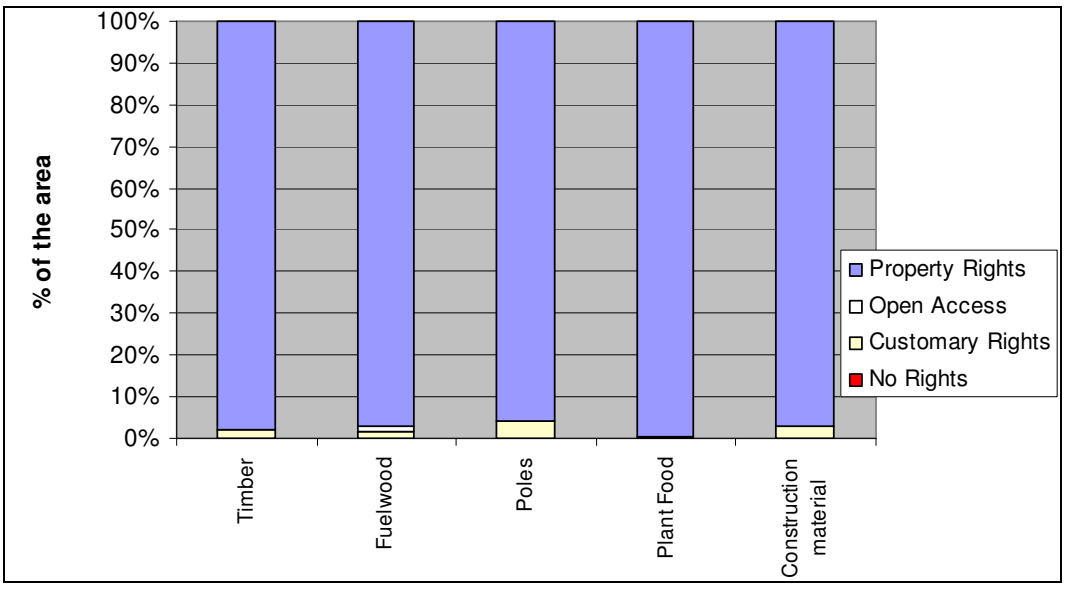

Figure 77: User right for the most important products / services in "Cultivated land" area

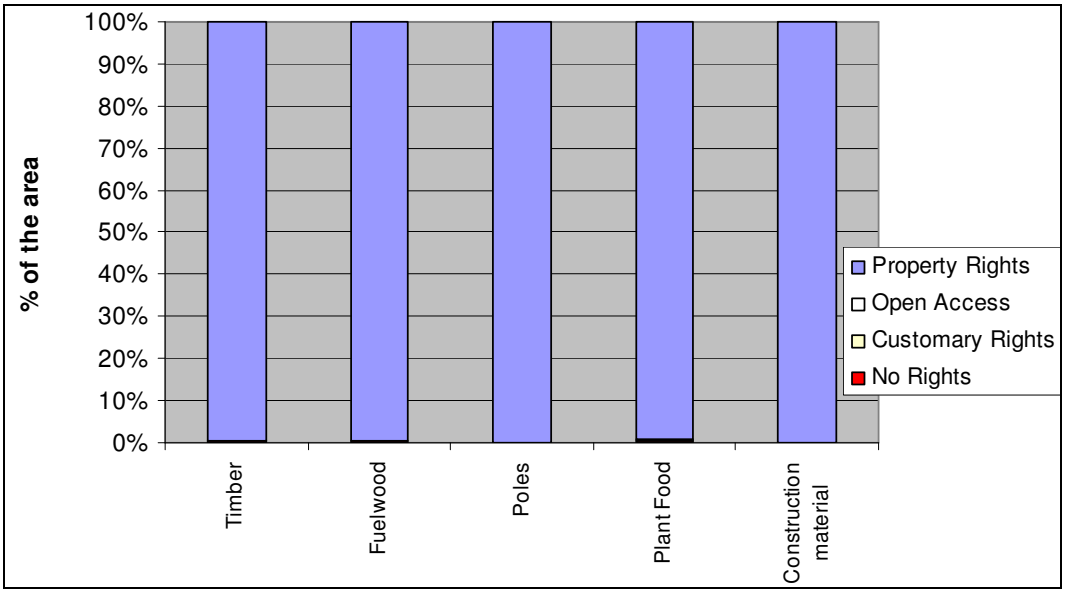

Figure 78: User right for the most important products / services in "Village" area

9.4.12. Products and services – organizational level and gender balance

Figure 79 to Figure 81 show that the harvest or use of the most important products and services in general is spontaneous. In the Villages and in the cultivated area the use is slightly more organized than in the Forest.

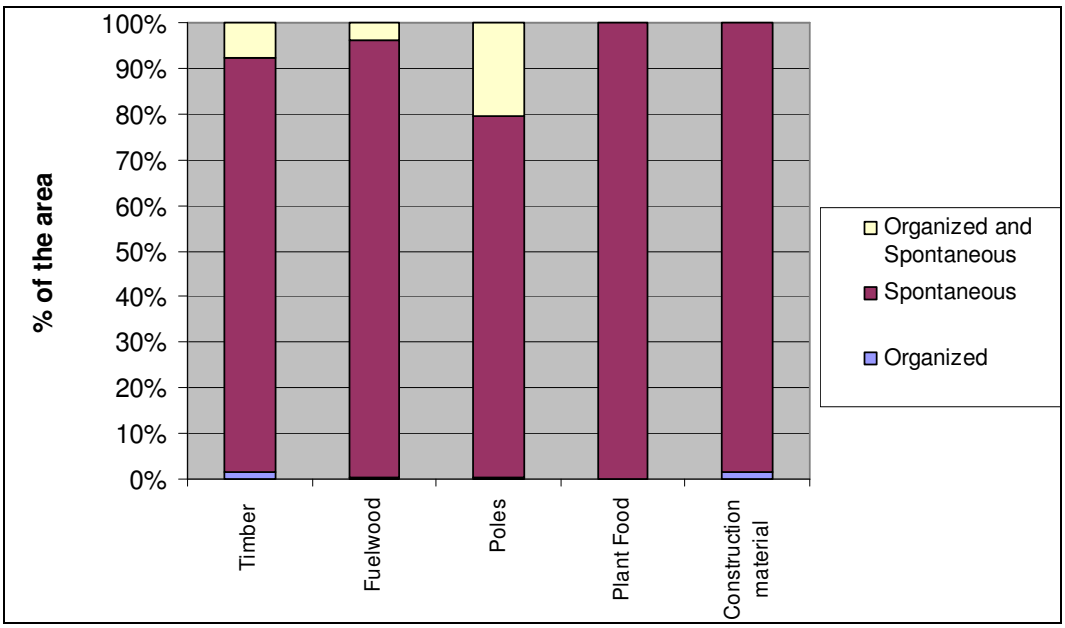

Figure 79: Organization level for the most important products/services in "Forest" area

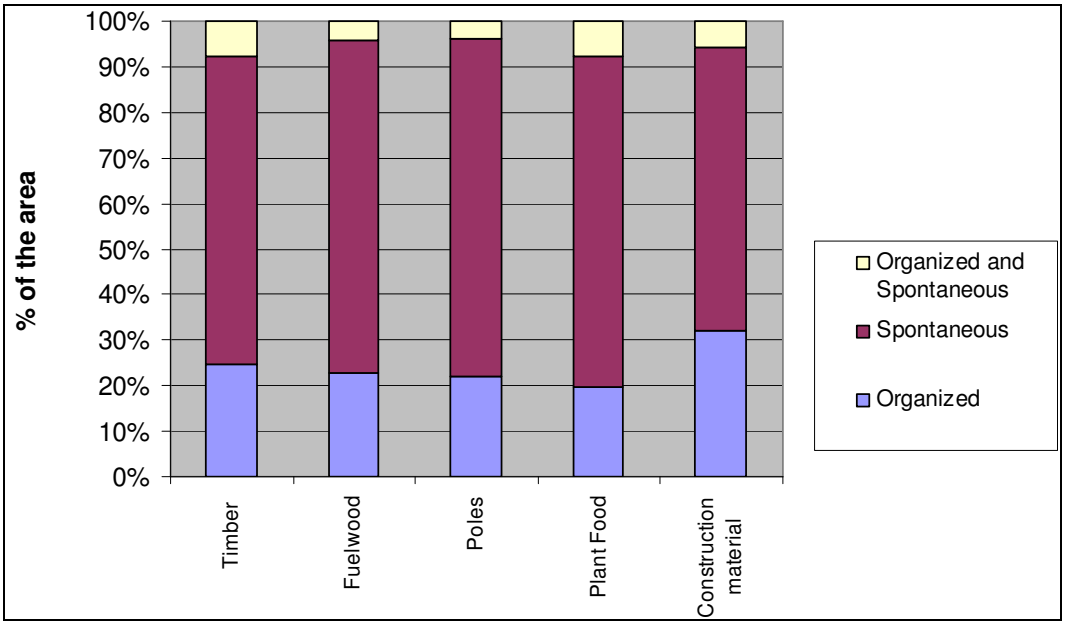

Figure 80: Organization level for the most important products/services in "Cultivated land" area

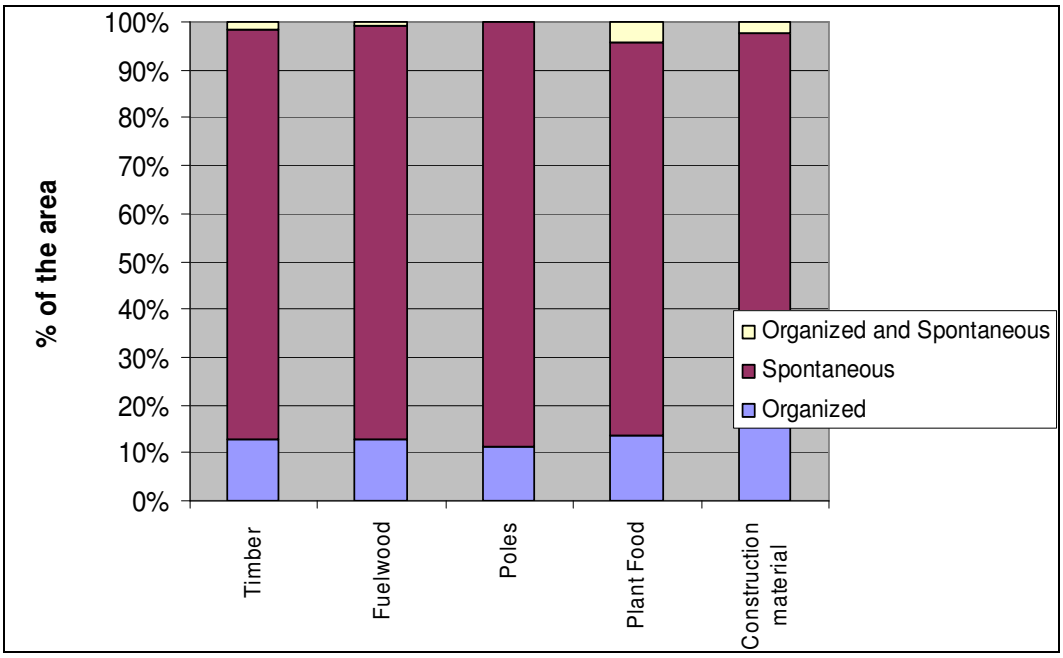

Figure 81: Organization level for the most important products/services in "Village" area

9.4.13. Products and services – Gender balance among harvesters/users of forestry products/services

Figure 85 to Figure 87 show that all the products – timber, fuelwood, poles, construction material and plant food - are mainly harvested by men.

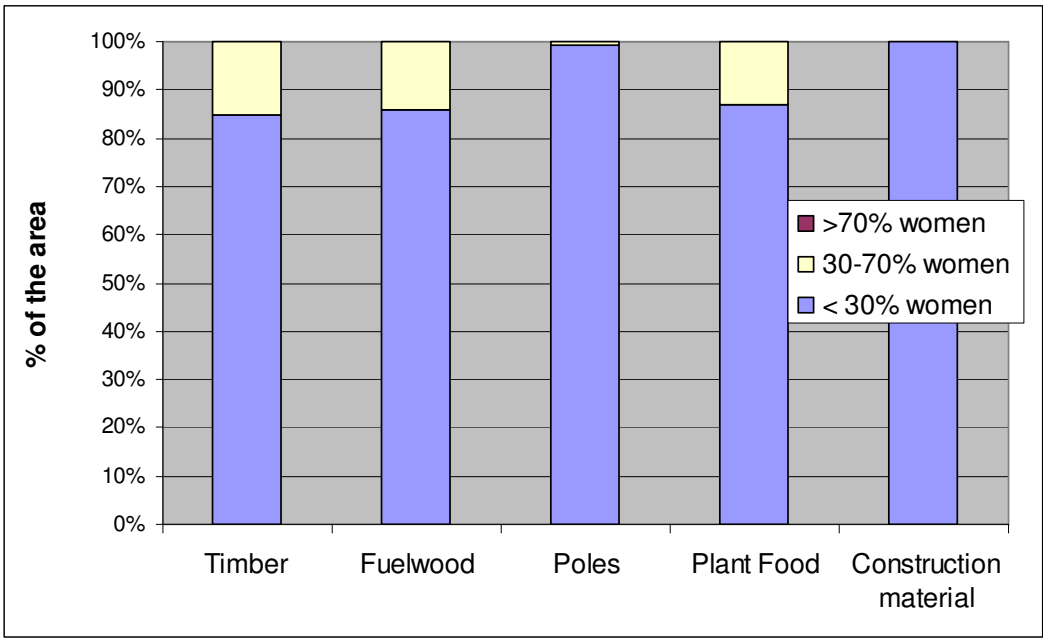

Figure 82: Gender balance among harvesters/users of products / services in "Forest" area

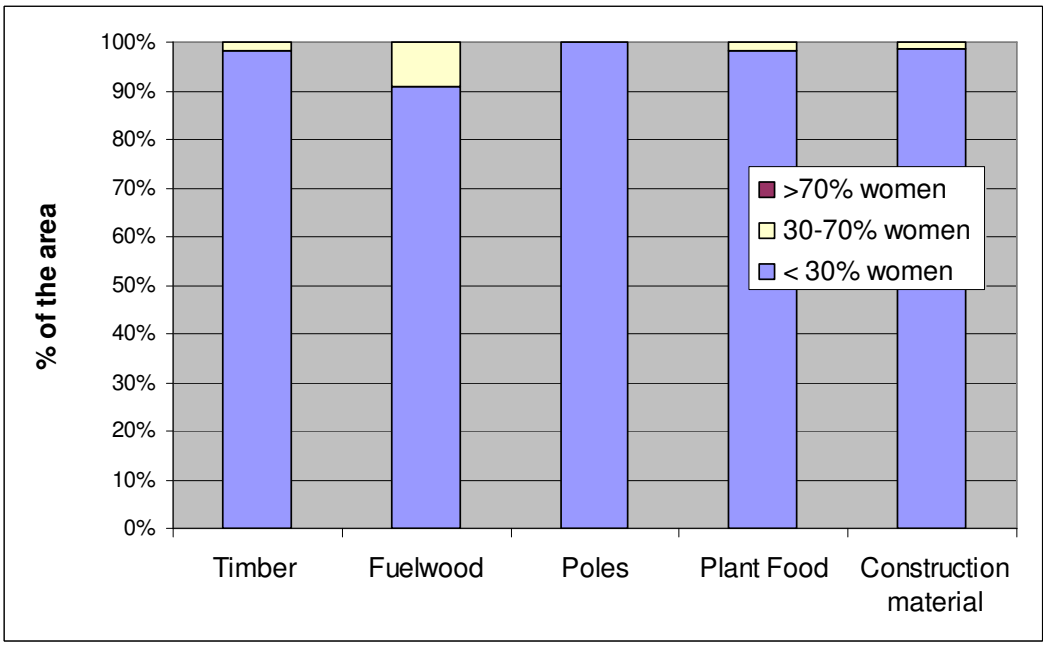

Figure 83: Gender balance among harvesters/users of products / services in "Cultivated area"

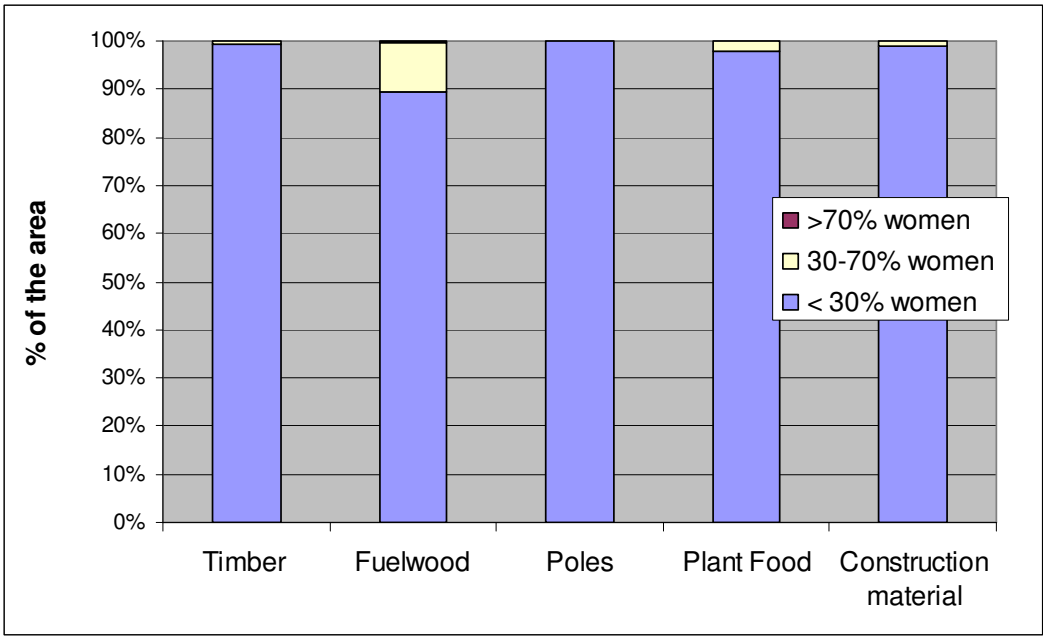

Figure 84: Gender balance among harvesters/users of products / services in "Villages"

Photo 10 : Wood locally transported on a rickshaw in the Madhupur Forest Reserve area

9.4.14. Products and services – end-use

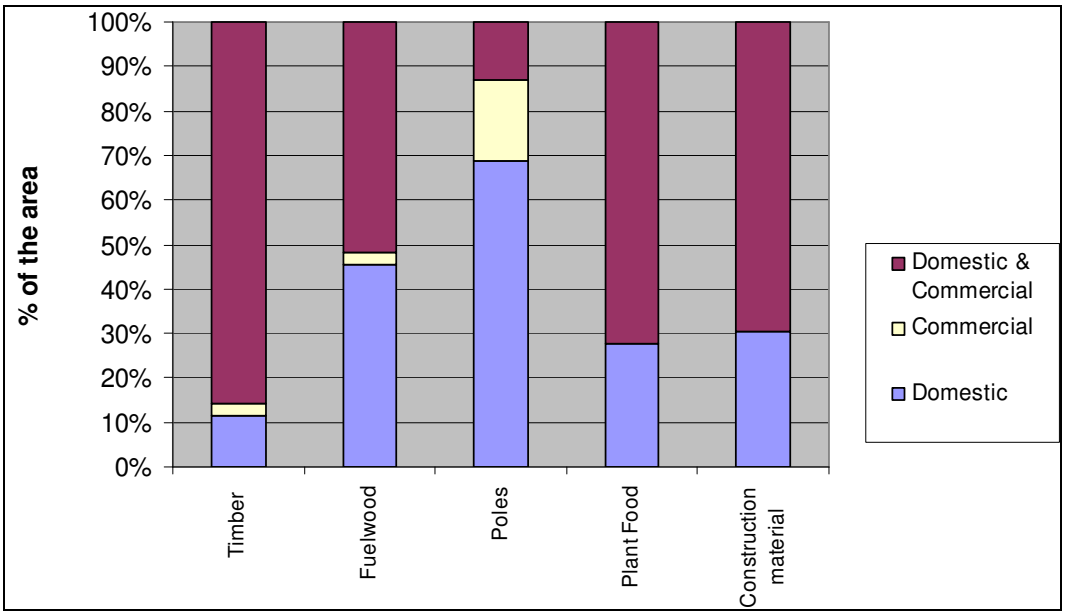

Figure 85: End use of most important products / services in "Forest" area

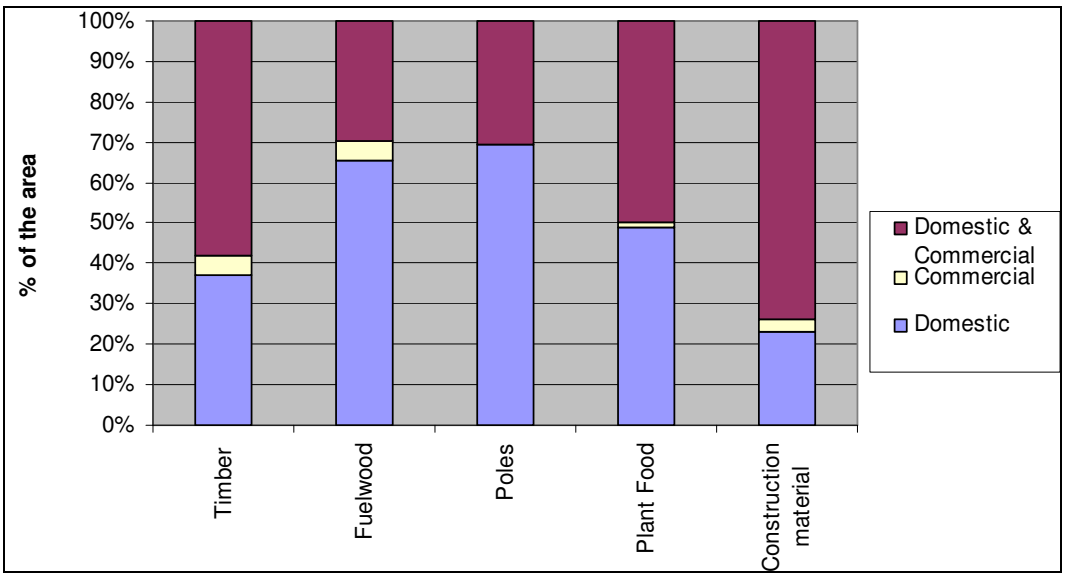

Figure 86: Organization level for the most important products/services in "Cultivated land" area

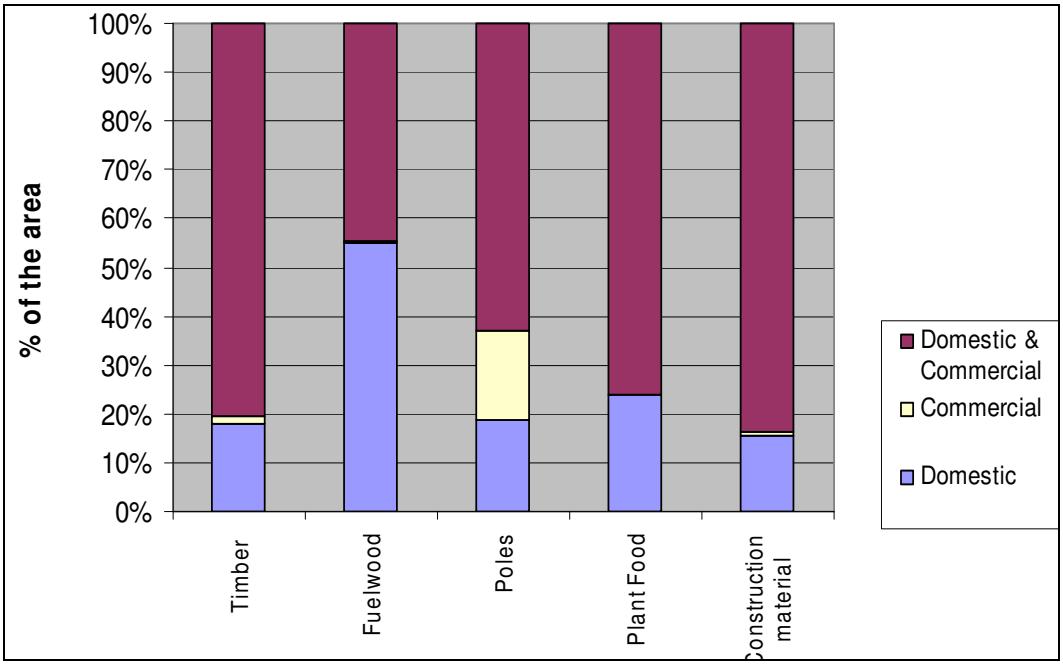

Figure 87: Organization level for the most important products/services in "Village" area

9.4.15. Products and services – frequency of harvesting/usage

Figure 88 to Figure 90 show that the frequency of harvesting/use of the different products/services is almost the same in the Forest, in the Villages and in the Cultivated land. Timber and poles are mainly harvested in intervals >1 year or seasonally. Fuelwood is mainly harvested seasonally or weekly/daily. Construction materials and also plant food are mainly harvested seasonally.

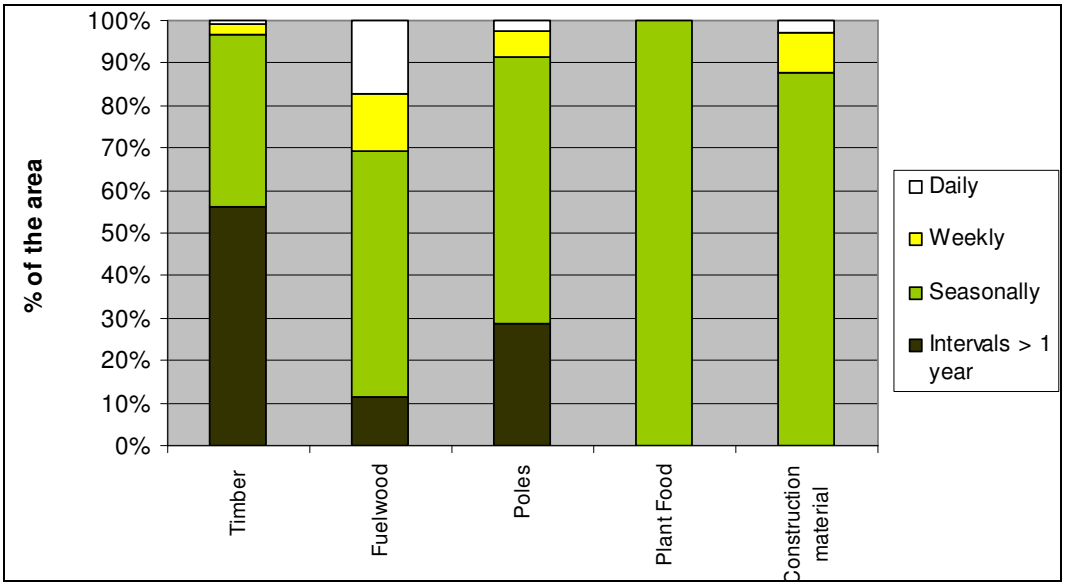

Figure 88: Frequency of harvest / use of most important products and services in "Forest" area

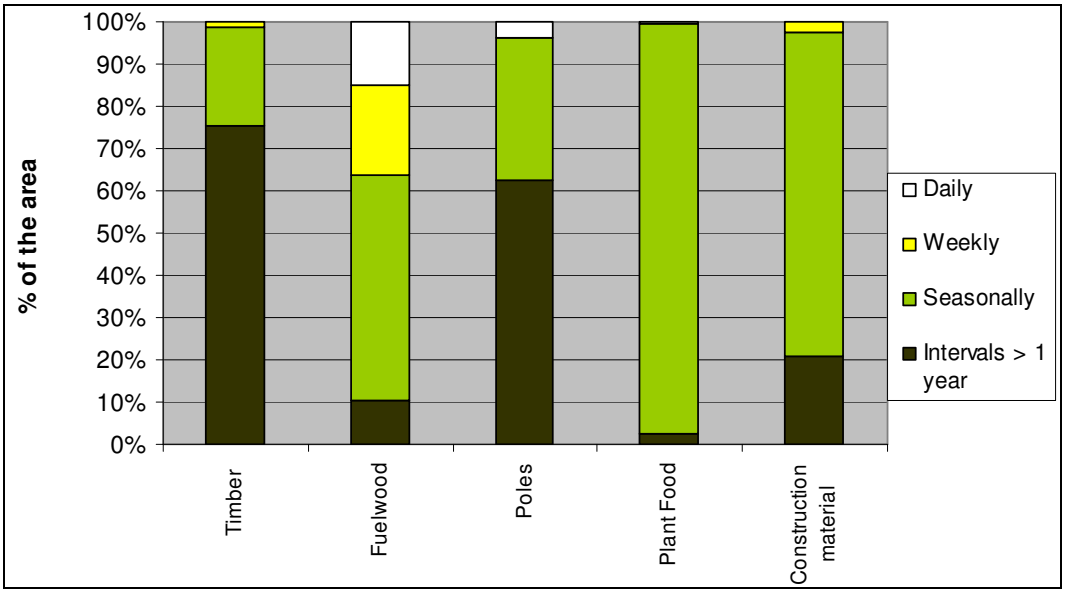

Figure 89: Frequency of harvest / use of most important products and services in "Cultivated land" area

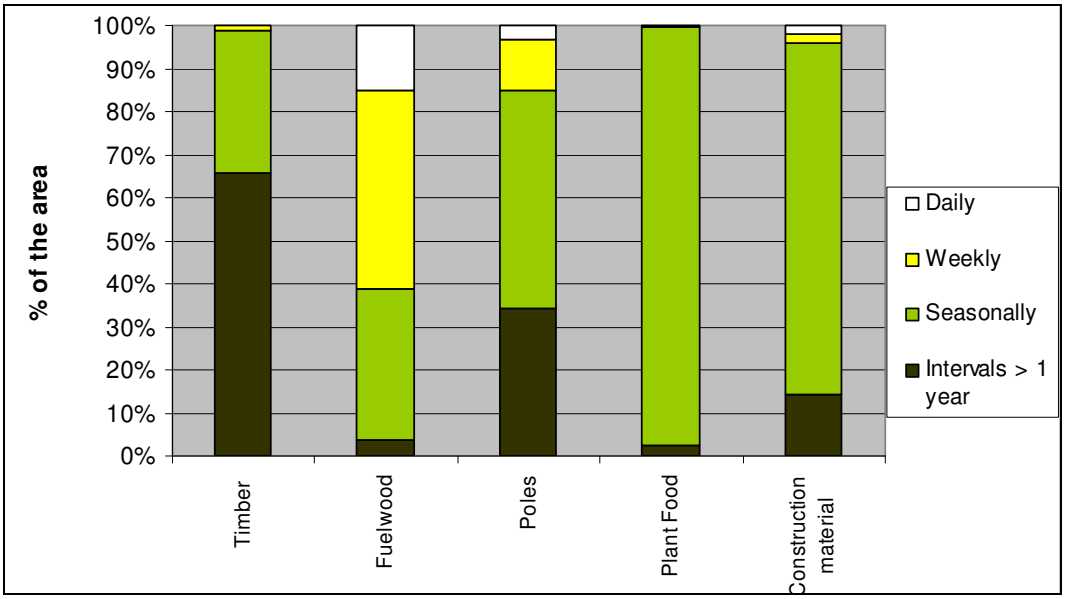

Figure 90: Frequency of harvest / use of most important products and services in "Village" area

9.4.16. Products and services – trend of harvesting/usage

Figure 91 to Figure 93 show that in the Villages the harvesting of timber, fuelwood, poles, construction materials (and also plant food) shows strongly increasing trends. In the Forest the harvesting of timber and fuelwood is increasing in the majority of the areas, but in about 30% of the area it is decreasing. Poles and construction materials are increasing in some areas, but decreasing in other areas. In the Forest, Plant food shows a strongly increasing trend. In the Cultivated land timber, fuelwood, plant food and construction materials shows weakly increasing trends, while the harvest trend for poles is stable.

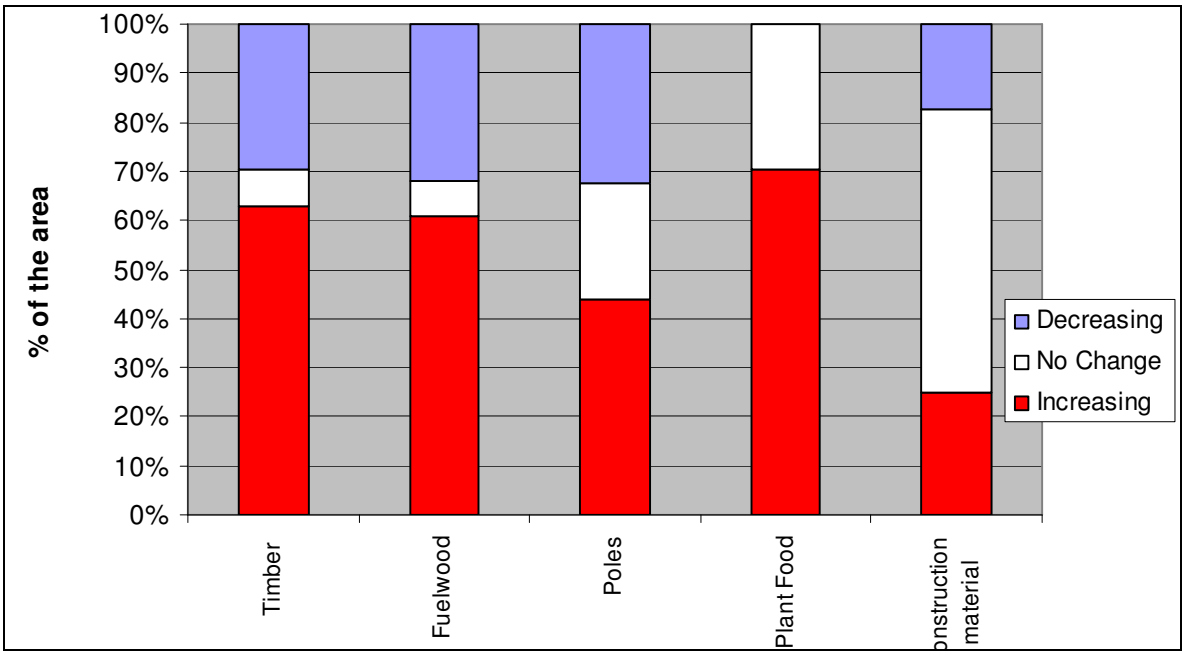

Figure 91: Trend of harvest/usage of the most common/important products/services in the "Forest" area

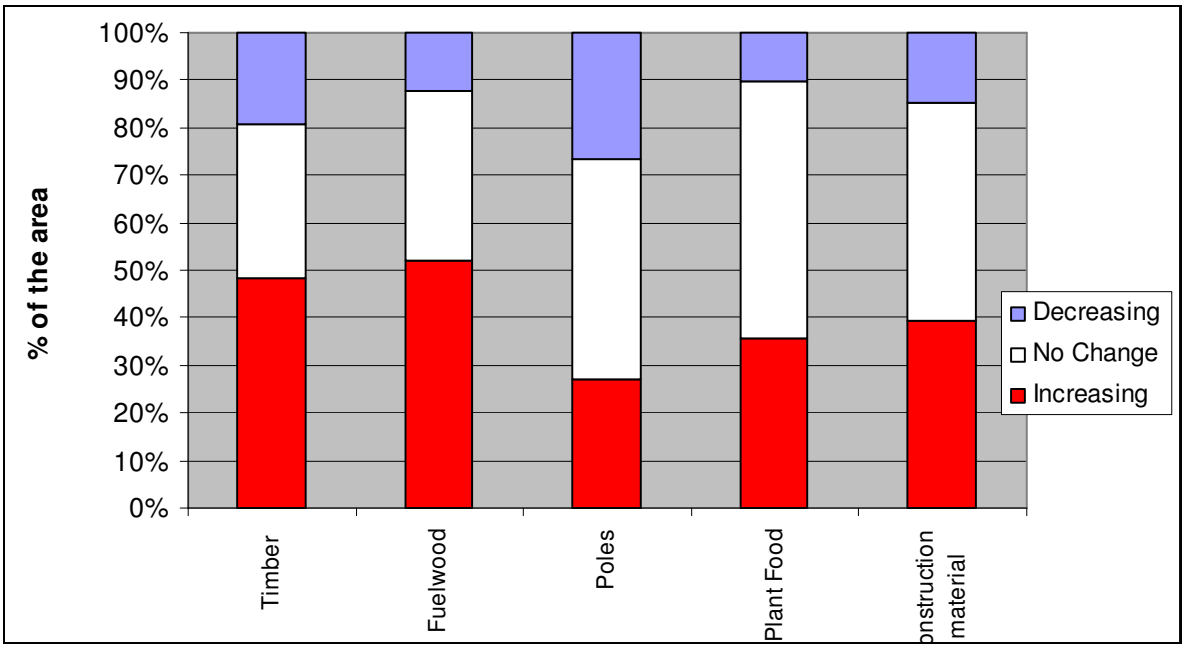

Figure 92: Trend of harvest/usage of the most common/important products/services in the "Cultivated land" area

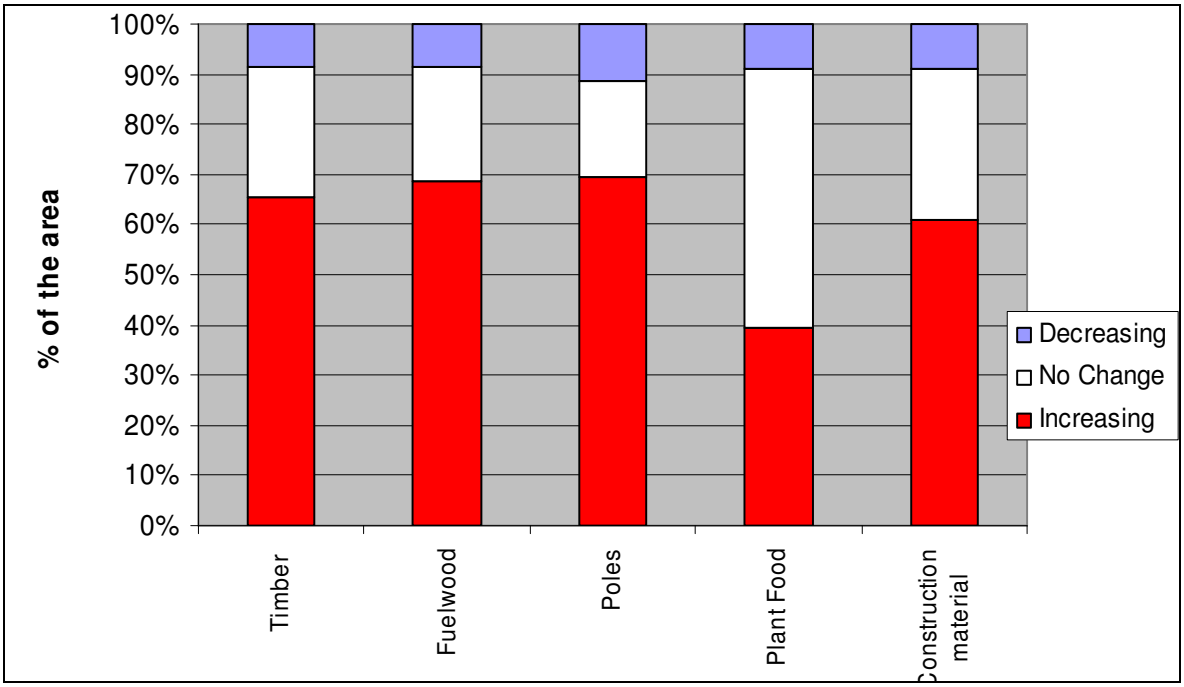

Figure 93: Trend of harvest/usage of the most common/important products/services in the "Village" area

9.5. Biomass and carbon

The primary data used to calculate the biomass and carbon is the inventoried volume over bark (VOB) of all trees with DBH/DAB 10 cm and larger. The inventoried volume is measured from stump to top of bole and excludes branches (FRA 2000).

In the case of NFA-Bangladesh, the inventoried volume refers to the total volume, which is based on the total height of the tree. The total height of a tree is the linear distance along the axis of the bole from the base of the tree to the tip of the crown.

The biomass density for each major land use class was calculated from the inventoried volume over bark per hectare (VOB/ha) by first estimating the biomass of the inventoried volume and then "expanding" this value to take into account the biomass of the other aboveground components, calculating the “aboveground biomass” (Brown and Lugo 1992):

Aboveground biomass (tons) = VOB * WD * BEF

where:

WOB = volume over bark
WD = volume-weighted average wood density (oven-dry biomass per green volume)
BEF = biomass expansion factor

The arithmetic mean and most common wood density value (tons/m^3) for tropical tree species in tropical Asia is 0.57 tons/m^3 with a common range within 0.40 – 0.69 tons/m^3 (FAO 2001). The wood density of 0.57 tons/m^3 is therefore applied in the biomass calculations.

The arithmetic mean and most common biomass expansion factor (BEF) to convert growing stock into above ground biomass is 3.4 for tropical broad-leaved forests in Asia, ranging from 2.0 – 9.0, where the higher values are related to lower biomass densities. In Bangladesh the average biomass density (tons/ha) is relatively low and the value of 6 is therefore applied to the BEF.

9.5.1. The total biomass and the biomass per hectare for the total area of Bangladesh and for the major National LUC

Table 59 shows the (aboveground) biomass per hectare and the total (aboveground) biomass in each major land use class. It can be seen that "Forest" and "Villages" have the highest aboveground biomass density whereas "Inland Water" had the lowest. In terms of the total aboveground biomass, "Villages" has a higher aboveground biomass than "Cultivated Land" despite the fact that the size of "Villages" is only approximately 34% of the area of "Cultivated Land".

Table 59: Total above ground biomass and biomass density in the major land use classes

Land use	Biomass density (tons/ha)	Total Above Ground Biomass (1000 tons)
Forest	193	278,000
Cultivated Land	17	142,000
Villages	144	413,000
Urban Areas	93	10,000
Inland Water	2	4,000
Total	**57**	**846,000**

9.5.2. The total (above ground) carbon and the (above ground) carbon per hectare for the total area of Bangladesh and for the major National LUCs

The result on total carbon and carbon per hectare was derived from the conversion of the aboveground biomass to carbon, based on the assumption that 50% of the tree biomass is comprised of carbon (Gifford 2000).

Table 60 shows the carbon per hectare and the total carbon in each major land use class. Inasmuch as the data used in calculating carbon was based on the aboveground biomass, the results are similar, whereby "Forest" and "Villages" have the highest carbon per hectare and "Inland Water" had the lowest.

Table 60: Total carbon and carbon per hectare in the major land use classes

Land use	Carbon (tons/ha)	Total Carbon (1000 tons)
Forest	96	139,000
Cultivated Land	9	71,000
Villages	72	206,000
Urban Areas	46	5,000
Inland Water	1	2,000
Total	**29**	**423,000**

10. Comparison of NFA-results earlier national statistics

10.1. Area comparisons

The following will give a comparison of area obtained through NFA and that reported by Bangladesh Bureau of Statistics (BSS) 2004.

Table 61 : Comparison of Nfa Findings with BBS 2004 Reported Data on Areas

Land Use Category	Area in Million Hectares			
	NFA 2005-2006	BSS 2004	Bangladpedia	BFD
Forest	**1.44**	2.19**	1.96	2.52
Cultivated Land	**8.33**	8.03		
Village	**2.86**			
Built-Up Area	**0.10**	0.09		
Inland Water	**2.02***			

* NFA estimate for inland water area comprises Rivers, Lakes, Haor & Baor and Ponds

** BSS statistics for forest area comprises WAPDA & Khashland, Reserve-, Acquired-, Vested-, Protected- and Unclassified State Forest, as well as nurseries and garden areas

The finding of the NFA for **'Cultivated land'** coincides well with that of the BSS 2004 (see Table 61). In case of "Forest" Bureau of Statistics (BSS 2004) reported that in 1992 the area was 1.9 Million Hectares while it was reported to be 2.6 Million Hectares in 2000. In 2004 their reported number for 'Forest' is 2.5 Million Hectares. In all the cases their reported number is higher than that what has been obtained in NFA. The area shown in BSS report is mostly legal forest area, while the legal forest area may or may not be forested and it also comprises garden areas. It is therefore logical that forest area of 1.44 Million hectares assessed by the NFA represent the most reliable estimate for the land use **'Forest'**.

BSS 2004 has reported that the urban area in Bangladesh is 0.08 Million Hectares. According to this report the total road length of various types of roads is 20,800 Km, whereof 9,200 are major roads (GIS data BFD). Using an average width of 20m for major roads and 5 m for minor roads we have found that the area under road will be about 0.02 Million Hectares. Since our major land use category **'Built-up areas'** (BUA) includes roads also this manipulation was done to have better comparable number. Thus according to the BSS 2004 the BUA equivalent area is 0.10 Million Hectares which corresponds very well with the figure presented by the NFA, 0.10 Million Hectares.

The NFA estimate of **'Inland Water'** is adopting SPARRSO's official area estimate of inland water 1.74 Million Hectares, which includes water bodies of lakes Rivers and Haor & Baor, and adding to that the 0.29 Million Hectares of Ponds assessed through the NFA field sample survey.

Discussion

According to earlier estimates of Bangladesh Forest Department a total of 2.52 million hectares, nearly 17.4% of Bangladesh, was regarded as forest, of which:

- 1.52 Million Hectares was under the direct control of Forest Department (FD), Government of Bangladesh

- 0.73 Million Hectares was Unclassed State Forest (USF) under the control of district administration and
- 0.27 Million Hectares was privately owned Village Forest (VF).

Banglapedia presents the area of forest land as 1.96 Million Hectares.

BSS 2004 presents the forest area in Bangladesh as follows.

State Forest	1.64 Million Hectares
USF	0.55 Million Hectares
Total	**2.19 Million Hectares.**

The NFA data analyses show that the total area of the land use 'Forest' in Bangladesh is 1.44 Million Hectares. No estimates of the errors for of these statistics are available, except for that of NFA. The sampling error for the estimated forest area as 1.44 Million Hectares by NFA 2005 is 18% and it was reduced further through the employment of full cover mapping.

10.2. Volume comparisons

10.2.1. Comparison of Village Forest Inventory: Gross Tree Volume with NFA Gross Volume

In 1981 a village forest inventory was conducted (Hammermaster 1981). This inventory divided the whole of Bangladesh, excluding Chittagong Hill Tracts, into six strata. This inventory focused on per capita wood volume. However, this report has the stratum wise volume of wood on pages 12 to 17 of the report. This inventory estimated volume for trees with breast height diameter (D_{bh}) 8 inches and above and did not present the volumes by the strata that were used for the purpose.

From this report, using their map and a GIS program the area of each of the stratum that were used in the said village forest inventory was computed and converted the gross volume given in thousand ft^3 (cubic feet) to m^3. (cubic meter) and calculated the gross volume per hectare.

A map was generated (By superimposing the NFA tract locations, on this map of village forest inventory we identified stratum wise NFA tracts (tract numbers). Since the village forest inventory computed the volume of trees that were 8 inches and above at their D_{bh}, the gross volumes from trees with D_{bh} ≥20cm were calculated for the land use classes presented in Table 62.

Table 62 : Land use classes, with corresponding alphanumeric and numeric codes, for which gross volume including trees with D_{bh} ≥20cm was calculated

Land Use Class	Abbreviation	DB Code
Barren/Grass Land	BG	312000
Annual Crops Without trees	CA0	321001
Annual Crops With trees 0,1 – 0,5 ha	CA1	321002
Annual Crops With trees >0,5 ha	CA2	321003
Perennial Crops Without trees	CP0	322001
Perennial Crops With trees 0,1 – 0,5 ha	CP1	322002
Perennial Crops With trees > 0,5 ha	CP2	322003
Range Land/Pasture	RL	323000
Wooded land with shifting cultivation	Fa	324000
Rural settlement without trees	SR0	332001
Rural settlement With trees 0,1 – 0,5 ha	SR1	332002
Rural settlement With trees > 0,5 ha	SR2	332003
Urban settlements	SU	331000
Highways and other artificial areas	HA	333000
Lake	WL	400010
River	WR	400020
Pond	WP	400030
Haor & Baor	WHB	400040

Only the above said land use categories were considered, as the 'Village Forest Inventory' collected only from the village and not from the Forest. It needs to be mentioned herein that our D_{bh} measurements in the NFA data are in 10cm diameter classes and not in inches. The gross volume of trees with D_{bh} ≥20cm was generated stratum (of village forest inventory)

wise. Since we have already calculated the area of each of these strata we use those and generated the following table.

Table 63 and Figure 94 give a comparison of the gross volume per hectare estimated through Village Forest Inventory 1981 with the estimated average gross volume (in Other Land & Inland Water LU) per hectare of NFA 2006, stratum (used in the Village Forest Inventory) wise. This clearly conveys that the wood (gross) volume has increased in every stratum.

Table 63 : Comparison of Gross Volume as per VFI 1981 with average Gross Volume in grouped "Other Land & Inland Water" as per NFA 2005-2006

Village Forest Inventory 1981					NFA Inventory 2005-2006	Percent Increase
Strata	Gross Volume (OB) $D_{bh} \geq 8cm$		Area	Gross Volume per hectare	Gross Volume per hectare	
	('000 ft^3)	(Mm^3)	(Mha)	(Mm^3/ha)	(Mm^3/ha)	
1 (Rajshahi)	463	13.1	3.40	3.85	**5.93**	**54%**
2 (Dhaka)	300	8.5	2.26	3.76	**6.48**	**72%**
3 (Jesore)	356	10.1	2.09	4.82	**17.03**	**252%**
4 (Barisal)	321	9.1	1.64	5.55	**24.03**	**333%**
5 (Chittagong)	372	10.5	1.50	7.00	**16.14**	**131%**
6 (Sylhet)	124	3.5	1.72	2.04	**4.90**	**141%**

In the above analysis the gross volume was computed including volumes from all Land Use categories except "Forest". It was decided to undertake another analysis to compare the gross volume of 'Rural Area' only and compare that with the Village Forest Inventory data since the Village Forest Inventory concentrated in Village Area only. Thus the gross volume in Rural Settlement i.e. in SR0, SR1 and SR2 was computed (see Table 64 and Figure 95). This is probably more realistic since the Village Forest Inventory looked for trees only in the village areas which is more or less the 'Rural Settlement' areas of NFA.

Table 64 : Comparison of Volume per hectare in VFI 1981 with Volume per hectare in SR0, SR1 and SR2 of NFA 2005-2006

Village Forest Inventory 1981					NFA Inventory 2005-2006	Percent Increase
Strata	Gross Volume (OB) $D_{bh} \geq 8cm$		Area	Gross Volume per hectare	Gross Volume per hectare	
	('000 ft^3)	(Mm^3)	(Mha)	(Mm^3/ha)	(Mm^3/ha)	
1 (Rajshahi)	463	13.1	3.40	3.85	**4.36**	**13%**
2 (Dhaka)	300	8.5	2.26	3.76	**4.43**	**18%**
3 (Jesore)	356	10.1	2.09	4.82	**12.24**	**153%**
4 (Barisal)	321	9.1	1.64	5.55	**17.26**	**211%**
5 (Chittagong)	372	10.5	1.50	7.00	**12.03**	**72%**
6 (Sylhet)	124	3.5	1.72	2.04	**3.86**	**89%**

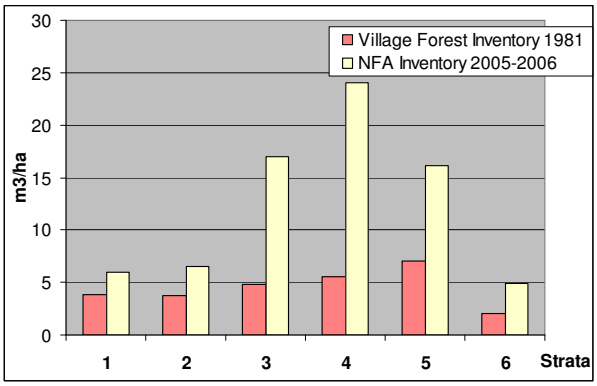

Figure 94 : Volume per hectare in VFI 1981 and average volume per hectare in grouped "Other Land & Inland Water" as per NFA 2005-2006, presented by VFI 1981 strata

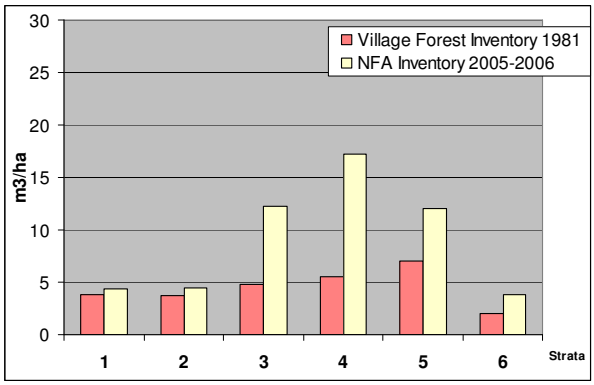

Figure 95 : Volume per hectare in VFI 1981 and average volume per hectare in "Villages" as per NFA 2005-2006, presented by VFI 1981 strata

Both analyses clearly indicate that in each stratum there has been a definite increase in the wood volume per hectare. In 1981 the total population in Bangladesh was 87.1 Million and in 2006 the estimated population was slightly more than 140 Million. Thus the population increase has been more than 60%. Under such a population growth it is likely that the forestry resources will be under heavy pressure, and therefore the rural communities need to plant more trees to sustain their increasing consumption. The increase in tree volume in village areas presented above shows the positive impact of the Community Oriented Forestry Programs launched by the Forest Department Government of Bangladesh.

The increase in tree wood volume however varies in different areas (strata). The maximum increase is seen in Barisal area. The second highest growth is in Jessore area. Barisal and Jessore are the two areas in Bangladesh that produce most of the seedlings that are planted in the country focusing on the species that are preferred by the rural communities. Good accessibility to seedlings and the promotion program of FD, Government of Bangladesh have probably lead to this increase of the wood volumes at these two given sites.

11. Conclusions

The National Forest and Tree Resources Assessment 2005-2007 is the first exercise of its kind in Bangladesh. The assessment was supported by FAO technical assistance and implemented under the entire managerial responsibility of Bangladesh Forest Department. Such model of implementation gave national ownership and responsibility to ensure the long term sustainability of the NFA findings.

Biophysical and socio-economic data about forests and trees outside forest were collected from a national grid of systematic field sampling and wall-to-wall land use mapping. The field data and maps were based on harmonised land use classification system and forest related terms and definition. Current resources assessment has covered a wide range of forest and tree attributes including the productive, social, economic and environmental functions of forests and trees, resulting in the assessment richest in information compared to any other inventory work carried out in Bangladesh.

Beside the rich baseline information developed in Bangladesh, the NFA process contributed largely to build the capacity within the Forestry Department and SPARRSO: -information framework harmonisation, -national forest and tree inventory and monitoring, -data collection for systematic field sampling, -mapping using remote sensing techniques, -database development, -data processing and reporting.

The statistics on land use areas were generated using two main sources: from the mapping on Landsat TM imagery and from the field sampling following a harmonised land use/forest type classification system. Each of these two approaches has different level of spatial resolution. The visual interpretation of 30x30m Landsat images does not recognise the small size (<25mm^2 at interpretation scale) features on the ground such small patches of forests or small land use units as defined in the classification system. This leads to mapping results generally coarse and of lower accuracy compared to field sampling when done at national level with an adequate sampling intensity. In the case of the NFA of Bangladesh, the mapping and field sampling results are used to generate the estimates of forest types and land use classes. The project findings of area and related parameters are based more on the field sampling with limited adjustment using the mapping results.

The NFA process has set up a monitoring system for future assessments of the forest and tree resources. A network of permanent sample plots has been materialised on the ground and well referenced in the records of Bangladesh Forest Department for easy re-localisation in future opportunities. This project should therefore be seen as the foundation of long term monitoring. But this remains dependent of the priorities and willingness of Bangladesh Forest Department to maintain the built capacity, the developed database, and the set up network of permanent sample plots. It will depend on the action of Bangladesh Forest Department to institutionalise the NFA and ensure continuous financing from the Government budget. Moreover, it will depend on how the results will be disseminated and used by the decision makers and these decision makers will value the NFA results.

The NFA has followed a harmonised approach to forestry resources monitoring and assessment putting Bangladesh at same level in scope, quality and format of information as other countries collaborating with FAO. The NFA followed a cost-effective approach designed and promoted by FAO for long term forestry resources and land use change monitoring. With repeated measurements, the NFA will capture information related to the change in the extent, the state and use of forest and trees outside forest resources. Additional parameters can be included in future measurements if deemed relevant. The value of the NFA will therefore increase with every re-measurement.

12. Recommendations

12.1. Future monitoring

The Forestry Department of Bangladesh collaborated with FAO in setting up a long term monitoring system of the country's forest and tree resources. The NFA and the monitoring system were a Government request that reflected the country's need for updated and sound information to feed into the national decision making process when needed. It is of utmost importance that the results of the project are valued and the monitoring system becomes a lasting activity of the Forestry Department. To guarantee continuity of the monitoring system, it is recommended that Bangladesh Forest Department:

- Institutionalise the NFA, improve the managerial capacity of the NFA team, continue strengthening the NFA unit by additional training of the national personnel, maintain the personnel assigned to the project in their position and allocate means and resources for implementation of the forestry resources monitoring related activities.
- Maintain the NFA database, introduce new technologies of information management and continue updating the baseline information to increase its relevance to the national policy processes and the international reporting.
- The NFA should be carried out on a continuous basis to enable maintenance and development of competence and limit the annual needs of resources.
- The cycle for re-measurement in the NFA permanent plots should be around 5 years. A shorter cycle would not be cost efficient and a longer cycle would not meet the needs of updated information.
- A mix of permanent and temporary plots is recommended. Information from new temporary plots during year 1-2 of the NFA could be used to increase the precision in some specific area.
- Maintain the network of the permanent sample plots by safeguarding the records and undertaking periodic visits to the plot location.
- Develop an advisory board involving experts from stakeholders e.g. FD, the regional offices of forests, Survey of Bangladesh, SPARRSO, Agriculture, Environment, etc. to provide guidance on the forestry monitoring system, facilitate inter-institutional collaboration and ensure generalised benefit of it.
- Recognise that Forest Management Inventories and the National Forest Assessment have totally different objectives and that they should not be integrated.

12.2. Additional information needs

Decision-makers have continuous changing demand of information. It is recommended that:

- the NFA and the monitoring system be continually adapted to the shifting needs of information by timely identification and inclusion of the new variables.
- the information framework be widened to cover issues of management and uses of the resources, biodiversity, climate change (biomass and carbon accounting), livelihoods and in relation with the national poverty reduction strategy.
- Bangladesh Forest Department work to count on its own technical capacity to plan and implement future surveys based on the new identified information needs and generate the required knowledge.

- Bangladesh Forest Department work to assign dedicated personnel who ensure that the interest of the forestry sector and interest of Bangladesh in general prevail by optimising the available resources and ensuring high quality delivery.

12.3. Actions for resources development

- The country-wide presence of Bangladesh Forest Department consist a great potential for undertaking future systematic monitoring of the resources. Technical personnel in the Districts require a close follow-up and training to ensure enhanced quality of data collection and timely implementation of the entire NFA process.

- The value of the NFA data will increase with every re-measurement of the permanent sample sites in order to capture information on changes. The data and the permanent sampling grid is potentially useful to many other institutions. Collaboration concerning the fieldwork and the sharing of data between relevant institutional stakeholders should therefore be promoted. It could also help spreading the workload related to conducting periodic fieldwork.

- The NFA findings will help identify priority areas and will be of use for the development of the forestry sector (national forest programme) and an evaluation of forestry policy/strategies in order to ensure a coherent legislation. The NFA is part of a continual process and not the end product in itself.

- The diversity of ownership of the forestry resources in Bangladesh and the high density of population lead to the recommendation of developing wise policies and management plans for forests and TOF to include a participatory approach with the private stakeholders.

12.4. International reporting

The NFA will facilitate International Reporting as it produces information required by a number of international processes according to international standards. However, the driving force behind the NFA is the extent to which data is of use at national level e.g. for policy development or for resources management.

Data related to the composition of forests, their state and the uses of forestry resources will always come from field inventories through on-the-ground measurements, being the only way to capture reliable information on the majority of the many functions of forest and trees.

The FAO support to the national forest and tree resources assessment of Bangladesh is a two-way process, building national capacity in NFA and providing continuous feedback on methodological issues to FAO. It is recommendable

- To continue improve the compatibility between the different classification systems and forest/land use related terms and definition employed nationally and in relation with the international reporting requirements.
- To add new scope of information on global benefits such as biodiversity, climate change, trends (deforestation, improvement or degradation of natural forests.
- To include any new parameters that can be of importance to the international processes.

12.5. Capacity building

To ensure the continuity of forestry resources monitoring it is necessary to build and maintain national capacities related to sampling design, field data collection, data processing and analysis, remote sensing and reporting. FD needs to formulate a “Plan of Action” to secure that the experiences gained from the NFA will be followed-up and implemented in such a way that the capacity to carry out long term NFAs is guarantied. The RIMS-unit (central tasks) and the Management Plan Divisions (field work) both need to be strengthened in order to take on the NFA task.

The RIMS-unit and the three Management Plan Divisions must maintain staff and their competences through continuous capacity building related to NFA activities. Bangladesh Forest Department must work to improve the field and map data processing and analytical capacity within the NFA team. Without such capacity and improved outcomes of the NFA and the resources monitoring process, Bangladesh Forest Department might find it difficult to justify maintaining and financing NFA Unit.

13. Bibliography and reference literature

Avery, T.U. 1967. *Natural Resource Measurements*. McGraw-Hills, Inc. pp 339.

Bangladesh Bureau of Statistics (BBS) 2005. *Statistical Year Book of Bangladesh 2004, 24th edition*. Ministry of Planning, Government of Bangladesh, December 2005. pp 28.

Banglapedia. http://banglapedia.org/

Baten, S.A. 1969. *Revised Working Plan for the Forests of the Chittagong Division for the period from 1968-69 to 1977-78*. Forest Department Government of Bangladesh. pp 153.

Brown, S. and A. E. Lugo. 1992. *Above ground biomass estimates for tropical moist forests of the Brazilian Amazon.* Interciencia 17:8-18.

Chaffy, D.R.; Miller, F.R. and J.H Sandom. 1985. *A Forest Inventory of the Sundarbans, Bangladesh*. Overseas Development Administration; Land Resources Development Centre; Tolworth Tower, Surbiton, Surrey, England KT6 7DY. pp 196.

Choudhury, M.U. 1973. *Working Plan for Chittagong Hill Tracts South Forest Division for the period 1969-70 to 1988-89, Vol I and II*. Forest Department Government of Bangladesh. pp 145.

Choudhury, J.K. 1986. *Sylhet Forest Division at a Glance*. pp 54

Choudhury, J.H. 2001. *Forest management plan for Sylhet for the period 1992-2001.*

Choudhury, J.K. 2002. *An Introduction to Forest Management for the Students of Environmental Science*. pp 115.

Curtis, S. J. 1924. *Management plan for Sundarbans*.

FAO 2001. *Global Ecological Zoning for the Global Forest Resources Assessment 2000*. FRA Working Paper 56. FAO Rome.

FAO 2006. *Global forest resources assessment 2005*. FAO Forestry Paper No. 147. FAO Rome (also available at http://www.fao.org/forestry/site/41555/en/).

Forest Department 1996. *Inventory of Sundarbans.* FD, Government of Bangladesh

Forest Department 2004. *Strengthening Capacity to Generate Quality Information on Forest Resources*. Ministry of Environment and Forests, Government of Bangladesh November 30, 2004 (Ref Planning Commission's letter No. PoKo/Krishi/BoPoMo (Ban)-199/2004/478 Dated November 30, 2004) pp 39.

Forest Department 2006. *Social Forestry in Bangladesh, Bulletin No 5*. Government of Bangladesh. June 2006.

Forestal, 1960. *First detailed inventory of Sundarbans in 1960.* Forestry and Engineering International Limited of Vancouver, Canada.

Forestal 1964. *Chittagong Hill Tracts Forest Inventory Survey 1961-1963, Kassalong and Rankhiang Reserved Forests*. Forestry and Engineering International Limited. Vancouver, Canada. May 1964. (Project No F334 under Colombo Plan, Pakistan, Canada).

Gifford, R. 2000. *Carbon Content of Woody Roots: Revised Analysis and a Comparison with Woody Shoot Components*. National Carbon Accounting System Technical Report No. 7 (Revision 1). Australian Greenhouse Office, Canberra.

Hammermaster, E.T. 1981. *Village Forest Inventory of Bangladesh: Inventory Results. Field Document No 5*. FAO of United Nations. UNDP/FAO Project BGD/78/020. pp 59.

Haroun Er Rashid 1991. *Geography of Bangladesh*, University Press Ltd, Dhaka.

Hussain, Z. and G. Acharya. 1994. Mangroves of the Sundarbans Volume two: Bangladesh. IUCN.

Ministry of Environment and Forests (MoEF) 2004. *Technical Assistance Project Proposal (TAPP).* Project document of MOEF. November 30, 2004.

Nishat, A. et. al. 2005. *Restoration of Degraded Coastal Ecosystem by Participatory Approach: A Pilot Initiative. Rehabilitation of Critical Coastal Ecosystem: Chokoria Sundarbans*. IUCN, Bangladesh. (Awaiting publication).

ODA 1985. *Second detailed inventory of Sundarban 1980-198* . Overseas Development Administration (ODA) U.K.

Purkayastha, C. 1938. *Plantation scheme for the period from 1935 to 1938 for Sylhet Working plan*. Prepared in 1938 by N.N. Das for the period 1938-1947.

ANNEXES