CHARM

CHARM Project Report 2

ASIA PRO ECO

EUROPEAID
CO-OPERATION OFFICE

CHITTAGONG HILL TRACTS IMPROVED NATURAL RESOURCES MANAGEMENT

Bangladesh






STATE OF THE ENVIRONMENT OF THE CHITTAGONG HILL TRACTS

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State of the Environment of the Chittagong Hill Tracts

Editors

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List of Acronyms

BCAS	Bangladesh Centre for Advanced Studies
BFRI	Bangladesh Forest Research Institute
BLRI	Bangladesh Livestock Research Institute
BMD	Bangladesh Meteorological Department
BWDB	Bangladesh Water Development Board
CBO	Community Based Organization
CEGIS	Center for Environmental & Geographic Information Services
CHARM	Chittagong Hill Tracts Improved Natural Resources Management
CHT	Chittagong Hill Tracts
CHTDF	Chittagong Hill Tracts Development Facility
CHTDB	Chittagong Hill Tracts Development Board, Bangladesh
DAE	Department of Agricultural Extension
DEM	Digital Elevation Model
DoF	Department of Fisheries
EU	European Union
FAO	United Nations Food and Agriculture Organization
GIS	Geographic Information System
GoB	Government of Bangladesh
GRAUS	Gram Unnayan Sanghaton- NGO based in the Chittagong Hill Tracts
HIMCAT	Himalaya Overview of Soil and Water Conservation Approaches and Technologies
HKH	Hindu-Kush-Himalaya
ICIMOD	International Centre for Integrated Mountain Development, Kathmandu, Nepal
IDRC	International Development Research Centre
ILO	International Labour Organization
ISRIC	International Soil Reference and Information Centre, Wageningen, the Netherlands
LGED	Local Government Enhineering Department
MoL	Ministry of Land
MENRIS	Mountain Environment and Natural Resources Information System
NRM	Natural Resources Management
NWMP	National Water Management Plan
RS	Remote Sensing
SRTM	Shuttle Radar Topography Mission (NASA Satellite)
UNDP	United Nations Development Programme, Dhaka
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNICEF	United Nations International Children's Emergency Fund
UNFPA	United Nations Population Fund
SDC	Swiss Agency for Development and Cooperation
SEMP	Sustainable Environment Management Programme (UNDP)
SRDI	Soil Resources Development Institute
WARPO	Water Resources Planning Organization, Dhaka
WFP	World Food Programme
WHO	World Health Organization
WOCAT	World Overview of Conservation Approaches and Technologies, CDE, Berne, Switzerland

Executive Summary

Chittagong Hill Tracts

The Chittagong Hill Tracts (CHT) differs in almost every aspect from the rest of Bangladesh. It is geographically part of the Hindu-Kush-Himalaya (HKH) region. Forest conversion, population increase and the creation of the Kaptai Lake that inundated good agricultural land, have led to environmental change, resulting in forest decline, soil degradation, biodiversity loss and production loss.

Historical statistics indicate a density of 10 people per square kilometre in 1901, increasing tenfold by 2001. Migration is the main source of the high population growth of 3.23 in the CHT, which is more than twice the country's rate (1.54).

Environment

The soils of the CHT are infertile compared to other parts of Bangladesh, as they were formed from rocks that generally contain few weatherable minerals. Additionally, the soils formed over unconsolidated sedimentary rocks (Dupi Tila formation) predominantly contain kaolinitic clay, which creates a low capacity for retaining nutrients. Most soils in the CHT are sensitive to erosion and soil fertility is declining rapidly due to unsustainable resources management practices. The soils over siltstones and mudstones are better as they have mainly illitic clays that have higher nutrient buffering capacities and are a mineral source of K and Mg. Except under natural forests or well-established tree crops, the content of organic matter is low. Due to the leaching effect during high monsoon rainfall, the nitrogen and potash are washed out.

The CHT has a tropical monsoon climate. A decrease in rainfall, although small in magnitude (max 8mm over 2 decades), was found in a regional study. The study was based on monthly grids of meteorological station-observed data, for the period 1901-2002, covering land surface at a 0.5-degree resolution. A moderate correlation was also found between biomass, precipitation and temperature (correlation coefficients of 0.74 and 0.49, respectively).

In the CHT as a whole, 74% people have no access to safe water. People suffer from different water-related diseases due to the scarcity of safe water and lack of knowledge about proper hygiene. Poor access to safe drinking water is a key problem for communities in the CHT and is a big problem in Bandarban, where less than 15% of the households have access to tube-well water. The steep topography and the hard bedrock underlying much of the region makes the installation of tube-wells difficult. As a result, wells are not drilled deep enough and so they dry up quickly. Different techniques of water harvesting provide opportunities for improving water availability, such as rainwater harvesting from roofs and the development of surface water systems using various types of collection devices. The installation and maintenance of existing tube-wells can potentially improve water availability.

Bangladesh is home to an estimated 13 species of mammals, 628 species of birds, 126 species of reptiles, 22 species of amphibians, 708 species of freshwater and marine fish, 400 species of mollusks and over 5,000 species of vascular plants. Many of these species are of international significance, such as the Asian Elephant, Royal Bengal Tiger, Gharial, Gangetic Dolphin and Hoolock Gibbon (IUCN, 2007). The CHT, as a large portion of Bangladesh's remaining natural environment, contains many of these important species. Biodiversity is declining in the CHT as a consequence of forest decline and population pressure increase.

The government has allocated protected areas for conservation of natural forests, and has identified game sanctuaries and national parks in order to preserve biodiversity. Policies, such as the National Environment Policy declared in 1992, for the preservation of biodiversity have been formulated, but are often not fully implemented.

Managing the natural resources

The traditional farming system of rotational slash and burn system, locally know as *jhum*, is sustainable if practiced with long enough fallows. But due to an increased population and scarcity of suitable land, the fallow periods have shortened from 15-20 years to 2-5 years. The *Jhum* system is commonly blamed for land and forest degradation. For centuries, the land of the CHT has sustained its people; but currently, migration and natural increases in population have amplified the impacts of a human population dependent on a fragile natural environment. People in poverty are forced to focus on the short-term survival strategies and lack the means to invest for the long term or for direct production or environmental benefit. *Jhum* cultivation will likely remain a fundamental land use system in the region because of the need for self-sufficiency, the difficulties that farmers have in reaching markets, the lack of infrastructure and the overall situation in the Chittagong Hill Tracts. Policies for improving the sustainable management of the natural resources in the CHT must therefore also consider sustainable alternatives *within jhum* farming. The use of "manipulated" or improved fallows provides a range of techniques, which make better use of the ecological processes leading to more sustainable practices. These improvements are based on the farmer's own knowledge and experience (Mantel *et al.*, 2006).

The clearing of natural forests for monoculture timber plantations in the steep hills of the CHT is an unsustainable practice as biodiversity is destroyed and massive soil erosion is caused. About 44% of the total area of the CHT is under middle dense forest cover. Only 16% of the CHT is under dense forest cover. Land degradation over two decades (1981-2003) in the Chittagong Hill Tracts was studied and it was found that green biomass and net primary productivity decreased over 62% of the land area by an average annual rate of almost 0.2% (162 kg per hectare), and increased over the remaining area at a similar rate. Annual precipitation decreased over that period, although rain-use efficiency increased over 78% of the land area and decreased over 22%.

Potential black spots of land degradation were identified as those areas with both declining net primary productivity and declining rain-use efficiency. These areas occupy 20% of the CHT. The combined index reveals three black spots: the area around Lake Kaptai; the border between Khgrachhari and Rangamati districts; Naikhongchhari and Alikadam of Bandarban District. The areas indicated have been validated by field investigations.

A major part of the CHT, 9295 km^2 (78% of the total area), is vulnerable to degradation and has limitations for use from a biophysical point of view. Forest degradation and soil erosion means the increased likelihood of landslides and flash floods. Natural disasters whether aggravated by human influence or not, further impact both the environment and the population worsening existing problems of poverty and landownership. For sustainable use, CHT lands require adaptive management with conservation strategies, and land rehabilitation or protection to ensure both productive and sustainable land management. Some vulnerable areas might be better left for nature conservation or rehabilitation. Such considerations need to be based on proper information and judgment and need to be taken into account in broader cross-sectoral planning for the development of the CHT region.

Chapter 1

Introduction

1.1 Background

This report, "State of the Environment of the Chittagong Hill Tracts," describes the current state of the environment and natural resources in the CHT. It is based on the extensive compilation of recent data and information from numerous governmental, non-governmental, tribal, and donor agencies. The data has been compiled into an integrated geospatial database. Where information is incomplete, unavailable or outdated, such as land cover, soil and terrain, field surveys and remote sensing analyses were done to compile the required information. This report includes a background on the socio-economic activity of the area. It also covers the spatial data of the whole CHT region and a comprehensive analysis of the biophysical components of the environment such as topography, soil resources, climate, water resources, agriculture, forestry, and floral and faunal diversity.

The current status of the environment is documented and the environmental changes with risks and pressures are described. Environmental information, such as on land cover change, erosion risks, priority areas for forest and biodiversity conservation, potential areas for production of forest, agriculture, and tree crops will support in decision making for natural resources management. The information has value in the economic and environmental sense, giving options for land management and showing the potential impacts of intervention.

The State of the Environment Report has been prepared by CEGIS and ISRIC as part of the major activities of the Chittagong Hill Tracts Improved Natural Resources Management (CHARM) project. This is a collaborative project being implemented jointly by ISRIC World Soil Information of The Netherlands, Lleida University of Spain, and from Bangladesh, the Center for Environmental & Geographic Information Services (CEGIS) and the Bangladesh Centre for Advanced Studies (BCAS), with support from EU-Asia Pro Eco, Component A, Diagnostic Activities (DIA).

The objective of CHARM is to establish sustainable natural resources management in the CHT. To that end, the project will provide sustainable natural resources management alternatives for improving the environment and decreasing environmental degradation. The project aims at institutional capacity building and provision of an improved information basis for decision-making at different levels. The state of the environment of the CHT is assessed through compiling information on natural resources which provides a comprehensive knowledgebase of the area. For dissemination of relevant information on the status of the CHT environment, an information system has been designed for sustainable land use planning. An inventory has brought together fragmented available data and information from various sources to identify the gaps in the information. The objectives will be achieved through compiling information on the natural resources, developing a user-friendly information system, and reporting on the status of the environment.

The CHT is a part of the Tripura and Arakan Yoma mountains forking from the Himalayan mountain range. The mountains extend south through the Indian states of Assam and Tripura and through the state of Arakan in Myanmar, in the southeast. People from 12 different cultural backgrounds inhabit the unique and beautiful region, characterized by its rolling hills. The environment in the CHT is under pressure showing the downbeat trend with respect to natural resource management. Demographic and environmental conditions are changing due to the increase of population pressure. The traditional slash and burn farming system, locally known as *jhum* cultivation, is becoming unsustainable due to the scarcity of suitable land. *Jhum* cultivation and other factors, such as over exploitation of forests and the creation of the Kaptai reservoir have caused increased land degradation, leading to soil erosion, nutrient decline, and decreased biodiversity.

Information on the status of the environment is required for the formulation of alternative strategies for sustainable management. The pressures on the environment and the underlying causative factors and processes that have been assessed through an environmental diagnostic survey and baseline study are presented in this report.

1.2 Objectives of the Study

Basic information is needed equally at both the grassroots level and policy level to carry out development work. The environmental diagnostic survey provides baseline information on the natural resources of the CHT such as environmental condition; geo-referenced major soil, terrain, climatic, land use and vegetation; social and economic drivers and constraints. The objectives of the study are to:

1. Provide baseline information on natural resources of the CHT through an environmental diagnostic survey, which will indicate the status of the environment and identify opportunities for improvement of land management.

2. To apply and test a successful land use planning methodology/technology developed by an EU-Indonesia cooperation project in a pilot area in the Chittagong Hill Tracts. The procedure will be tailored to fit stakeholder needs and circumstances.

3. Establish an effective partnership for environmental and land management planning in the CHT between EU institutes and the Bangladesh partners.

4. Establish appropriate tools for database analysis and derive useful products, such as erosion risk, potential for forest regrowth, land suitability for crops, flooding hazard, environmental capability.

1.3 Scope of the study

This environmental diagnostic survey quantifies the status of the CHT environment, describing the natural resources of the CHT and their present conditions. The pressures on the environment and the underlying causative factors and processes have been assessed. The report describes the relation and impacts between land use, for instance, the effect of deforestation on water reservoir sedimentation, the relationship between agriculture and water quality, and flooding hazards.

Primary data collection was not within the scope of the project. Hence, the study used data and information from secondary sources to identify the state of the environment. The report provides a reference and foundation for making future natural resource management plans for the CHT area.

1.4 Structure of the report

The data and information has been presented in each chapter in the form of text, tables, graphs and maps. Some of the detailed tables have been included in the Annexes. The second chapter describes the socio-economic activity of the people living and working in the CHT, followed by information on topography and soil resources in Chapter 3. Descriptions of climate and water resources are given respectively in Chapter 4 and Chapter 5. Information on agriculture, livestock and fisheries are covered in Chapter 6. Chapter 7 deals with the forest resources of the CHT. Chapter 7 gives an overview of the floral and faunal diversity of the CHT area. LANDSAT 7 ETM+ images of 2003 were used as primary dataset for the preparation of land cover maps. Chapter 8 describes a study on biomass and vegetation changes as indicators for land degradation in the CHT between 1981 and 2003 using multiple year monthly remote sensing data supported by field visits and land use history. Chapter 9 discusses the floral and faunal diversity and Chapter 10 presents a study on the assessment of conservation and production priorities in the CHT at regional level. Chapter 11 summarizes the conclusions with respect to present landuse, risks and degradation the CHT from the different chapters.

Chapter 2

Socio-economic Baseline

2.1 Socio-economic Setting

The CHT area has around 1.32 million people, which is nearly around 1% of the population of Bangladesh. Its population has increased drastically over last three decades due to immigration during 70's and 80's in the last century. Rural poverty is pervasive. The economy of this region is reliant mostly on agriculture, with horticulture as the main sub-sector. An abode of 12 ethnic minorities, namely, the Chakma, the Marma, the Tripur, the Tanchangya, the Khiyang, the Chak, the Murong, the Pankhu, the Bawm, the Khumi, the Lushai and the Usui, this terrain of indigenous population, including the Bangalees constitues the excellent combination of hill communities in CHT.

Exhaustion of resources in CHT has resulted in economic sluggishness in the region. A vicious circle of low income, low investment capacity at local level, low literacy, pseudo-production functions and dependence on primary production are the main reasons for its sluggishness.

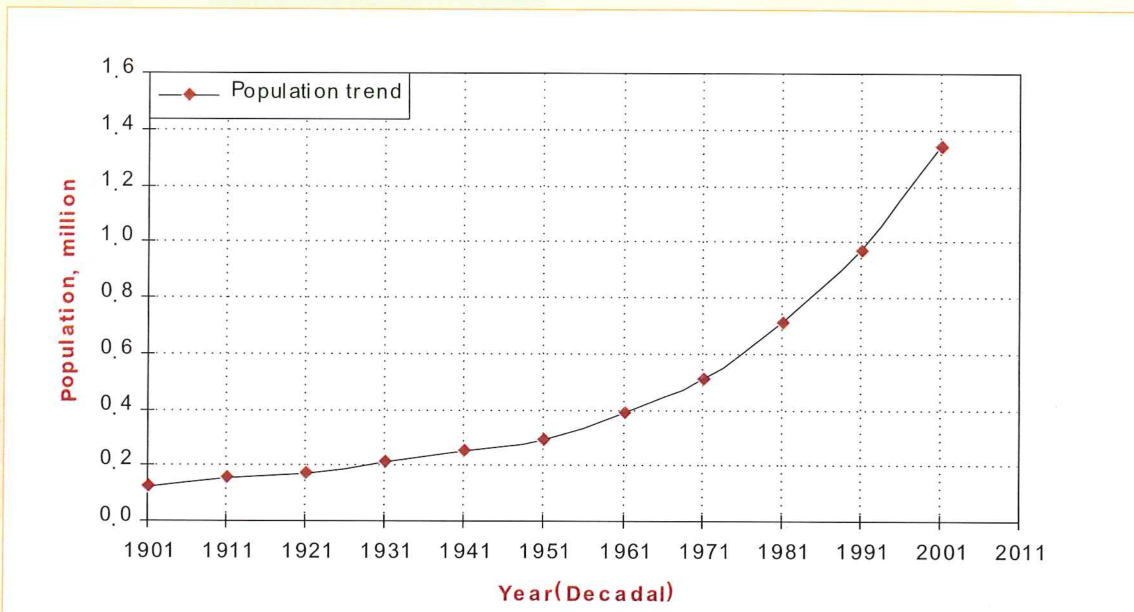
CHT regional council, Hill District Council, Circle Chiefs, Headmen and Karbaris, CHT Development Board, District Administration, Upazila and Union Parishads constitute the institutional structure, with a Ministry of CHT Affairs.There is multiple and overlapping roles and co-ordination has been an issue deserving redress.

2.2 Demography

2.2.1 Population Distribution

The Chittagong Hill Tracts (CHT) borders India's Northeastern region, sharing boundaries with the state of Tripura to the north and northwest and Mizoram to the east. To the south and southeast lies the Arakan province of Myanmar. Mountainous geography and dense forest have been the cause for low population density in the region. Before last fifty years, few people lived in the region, and the population was mainly made up of several indigenous and tribal groups, collectively known as Paharis in Bangla. Historical statistics indicate a density of 10 people per square kilometre in 1901, increasing ten times by 2001. The historical trend of population increase is given below.

Figure 2.1: Historical trend of population in the CHT



Source: Population census 2001, BBS

Government policies accelerated the population growth in the CHT by encouraging migration and land settlement by Bengalis. The trend in the above figure indicates that the rate of population increase was relatively steady until 1951, over the era governed by the British. Early on, the British created the Manual Law of 1900 that gave the sole power of land ownership to tribal people (non-CHT people could not buy or obtain land in the area). In 1947, the CHT was included as a part of the newly created Pakistan. After 1951, different government policies, under Pakistan and later under Bangladesh, invited Bengalis to settle in the CHT area. The indigenous people were not assured of their rights under the new government of Pakistan. While the Manual Law of 1900 was ratified in the Pakistani constitution of 1956, by 1962, the government had made significant adjustments to its regulations, thereby allowing migration to the area by outsiders. As more Bengalis migrated to the area, ethnic conflict between the Paharis and the Bengalis arose. In 1947, only 9% of the population were Bengalis; by 1991 their percentage was 49%, and today it is 51% (UNDP 2003).

Much arable land was lost and thousands of people were displaced due to the building of the Kaptai Hydro-Electric Power Dam (1952-62). Upon its completion in the early 1960s, the area around Kaptai Lake began to be resettled by almost 20 thousand indigenous people.

As a result of the Liberation War and the continuing ethnic conflict, the CHT people formed several forums and committees over the period 1971-1981 to restore peace (i.e. Parbatya Chattagram Sanghati Dal, 1972, Shanti Bahini, 1973 and Chittagong Hill Tracts Development Board (CHTDB), 1976). Furthermore, the government created initatives to resettle the Bangalis in the CHT. With the establishment of peace and the rule of law, and government efforts to resettle, more Bengalis migrated to the Hill Tracts, serving in part to sustain the ethnic tension between the Paharis and migrant Bengalis. In 1991 an international meeting was held in Amsterdam on CHT issues, where the Bangladesh government granted amnesty to the Shantibahini in return for disarmament. Upon the passing of some CHT district-level government bills in the parliament, the population continued to accelerate. From 1991 to 2001 there was much intervention from national, international and non-governmental agencies to discuss the possibilities of peace. Upon the signing of the Peace Accord on December 2, 1997, the influx to the region continued to grow. In 1998 the Ministry of Chittagong Hill Tracts Affairs and the Chittagong Hill Tracts Regional Council were formed. Slowly tourism began to take root; development spurred further population increase (Source: Parbatya Bouddha Mission).

The CHT has an area of 13295 sq. km covering 10% of the total country. But most of the areas are dense forest covering 47% of the total forestland of the country (BBS, 2001). The total population of the CHT according to the 2001 census, was 1.34 million, which consisted of only 1.1% (estimated) of the population of the country. The population of the country is evenly distributed throughout the 64 districts except for the three Hill Tracts districts. The CHT is sparsely populated in contrast to the rest of the country due to the heterogeneous topographic characteristics and differences in economic backgrounds, social organizations, religious customs, birth and death rates, cultivation, food habits, and other social customs. The population growth rate of the CHT is 3.23, which is much higher than the country's average rate (1.54). Migration is the main cause of the high population growth in the area. The proportional distributions of populations by district are: Bandarban 22.4%, Khagrachhari 38.5% and Rangamati 39.1% (LGED, 2006).

About 13 indigenous ethnic groups, collectively known as the *Jumma* or *Pahari* people, live in the area. The three largest groups are the Chakma (24.6%), the Marma (14.6%) and the Tripura (6.3%). The people of the CHT practice diverse faiths: Buddhism (44.7%), Islam (42.3%), Christianity (3.1%), Hinduism (9.3%) and others, including Animism (0.6%). Table 2.1 shows the distribution of the population by sex for each district of the CHT.

Table 2.1: Population distribution in CHT

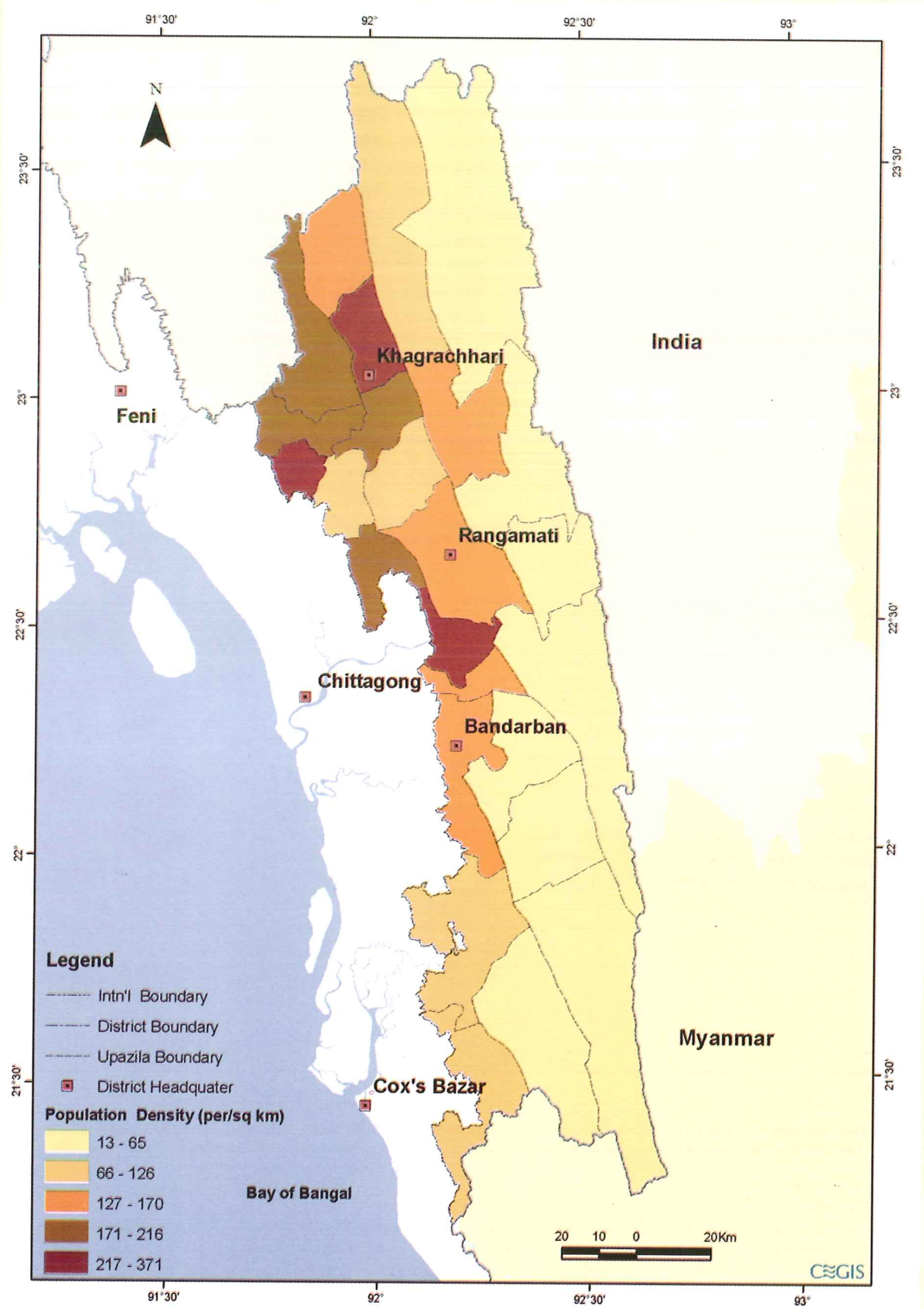
District	Year	Population (000)					Growth rate (%)
		Male	Female	Urban	Rural	Total	
Bandarban	1981	94	77	37	134	171	3.95
	1991	126	105	69	162	231	3.01
	2001	164	137	92	209	301	2.69
	2006	180	152	108	224	332	2.38
	2010	194	164	119	239	358	2.21
	2015	212	179	133	258	391	2.01
Khagrachhari	1981	138	122	72	188	260	3.95
	1991	202	178	110	269	379	2.09
	2001	265	234	148	351	499	4.00
	2006	297	262	167	392	559	3.38
	2010	322	285	182	425	607	3.39
	2015	355	313	202	466	668	3.40
Rangamati	1981	169	133	106	196	302	4.05
	1991	220	181	146	255	401	2.89
	2001	287	238	173	352	525	3.00
	2006	314	266	194	386	580	2.62
	2010	340	290	209	422	630	2.47
	2015	373	323	228	469	696	2.29

Source: Population census 2001, BBS and estimated by CHARM Project

2.2.2 Population Density

The population density per square kilometre in the CHT region is very low compared to the rest of the country. The most densely populated upazilla is Khagrachhari Sadar (305 per sq.km) of the Khagrachhari district (191 per sq.km) and the lowest density is Thanchi upazilla (16 per sq.km.) of the Bandarban district (67 per sq.km), in contrast to the average density of the country (839 per sq. km). Out of the 64 districts of the country, Bandarban ranks 60, Rangamati 59 and Khagrachhari 58 in terms of highest population density (Population Census BBS, 2001). The following table shows the historical, present and projected population density in the CHT region.

Map 2.1: Population Density Map of the CHT



Source: BBS, 2001

Table 2.2: Existing and future population density (per sq. km) in the CHT

Population Density in CHT				
District	Year	Urban	Rural	Total
Bandarban	1981	130	32	38
	1991	226	39	51
	2001	305	50	67
	2006	355	54	83
	2010	392	57	90
	2015	439	62	98
Khagrachha	1981	198	89	103
	1991	992	90	127
	2001	466	151	191
	2006	485	166	221
	2010	530	180	242
	2015	587	198	266
Rangamati	1981	191	35	49
	1991	264	46	66
	2001	313	63	86
	2006	355	69	116
	2010	380	76	126
	2015	410	84	138

Source: Population census 2001, BBS

2.2.3 Sex ratio

The sex group composition of a population group is the outcome of fertility, mortality and migration of the people to an area. The sex ratio (i.e., number of males per 100 females) of the CHT is 1.18 (2001), which is higher than that of the country as a whole (1.07). This high ratio for the region may be attributed by the migration of the Bangalis (1.36) after 1981 (BRAC, 2001). Studies show that the sex ratio for the country along with the CHT is decreasing.

Among the ethnic groups of the CHT area, the distribution of male is higher than the female. The Marmas had the highest sex ratio (1.09), while the Mro had the lowest (1.01). The sex ratio for working age groups, i.e., 15-64, was 1.21 for Bengalis, 1.14 for Chakmas, 1.11 for Marmas, 1.08 for Mros, and 1.12 for Tripuras.

Table 2.3: Existing and future sex ratio in the CHT

District	Year	Sex Ratio
Bandarban	1981	1.22
	1991	1.20
	2001	1.19
	2006	1.18
	2010	1.18
	2015	1.17
Khagrachhari	1981	1.14
	1991	1.11
	2001	1.14
	2006	1.14
	2010	1.13
	2015	1.12
Rangamati	1981	1.27
	1991	1.22
	2001	1.21
	2006	1.18
	2010	1.17
	2015	1.15

Source: BRAC 2001, Projection by CHARM Project

2.2.4 Age distribution

Age distribution helps to indicate how many members of a society are within the working age, as well as indicating when the society will age. The age distribution of the population of the CHT is presented below by district. The census estimation presents age-group distribution at 5-year intervals. This data has been projected for 15 years.

Table 2.4: Age group distribution of population

District	0-14		15-60		60+	
	Total population	%	Total population	%	Total population	%
Bandarban	121,820	40.5	164,520	54.7	14,400	4.8
Khagrachha	212,840	41.2	274,720	53.1	29,340	5.7
Rangamati	203,900	38.8	294,000	56.0	27,200	5.2
CHT	538,560	40.2	733,240	54.6	70,940	5.2

Source: BBS 2003

2.2.5 Household size and distribution

Households are divided in three categories namely, dwelling, institutional and other. The total number of households in the CHT was 0.27 million (Khagrachhari-0.11 million, Rangamati-0.10 million and Bandarban-0.06 million). On average, Bengalis had 5.3, Chakmas had 5.5, Marmas had 5.1, Mros had 5.8 and Tripuras had 5.2 members per household. Although the size of the households in most cases included 4-6 members for all ethnic groups, larger families were not uncommon among Chakmas, and were particularly evident among Mros. In the case of Chakmas, 31% of the households had 6-7 members and 21.8% of Mro households had eight or more members in their families (BBS 2003).

2.3 Health

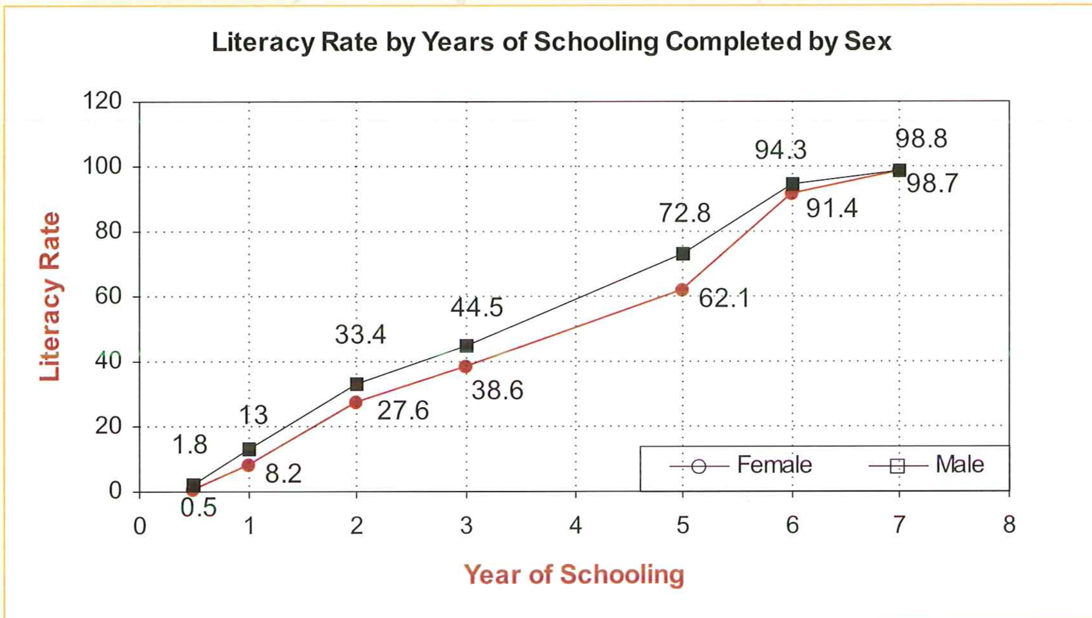
The health of the local people is affected by environmental contamination of common public goods, deforestation, landslides, plant life burning by shifting cultivation (*jhum* cultivation), soil erosion, waste and garbage dumping. A stagnant local economy, poor water supply and inadequate sanitation are major causes of poor health. Furthermore, access to basic health care for the population is a pressing issue, especially in the more remote areas. Many people, particularly children below five years of age, suffer from diarrhoea and pneumonia in the CHT. The prevalence of diarrhoea is 6.9% among CHT people (14.1% among children five years or younger and only 5.7% for those older than five). This prevalence was slightly higher for females than for males (male-6.4%, female-7.3%). It was found that diarrhoea was more prevalent among Bengalis (9.6%) compared to other ethnic groups, and it was the lowest amongst Mros and Tripuras (3.7% each). Malaria and Vitamin A deficiency also cause acute health problems for the CHT people. They suffer from different types of dangerous malarial and blindness diseases (Source: LGED, 2006).

2.3.1 Education

In order for sustainable development to succeed, the local population needs to have basic education, as education provides the framework for being a productive member of the society and for understanding the impact of personal actions. In the CHT, the major obstacles for development, and, thus, for sustainable development, are the interrelated issues of poverty and low rates of education. Currently, three quarters of the CHT population live below the national poverty line and half of the children enrolled in primary school drop out in their first few years (UNDP, 2004 and BBS, 2001).

In Bangladesh, persons seven years and above who can read and write and perform simple mathematical calculations independently are considered literate. The literacy rate is the ratio of the literate population to the total population and is expressed as a percentage. In 2001, the literacy rate in the CHT was 37.35% (Bandarban: 28.07%, Khagrachhari: 42.17% and Rangamati: 41.81%) whereas the national literacy rate was 45.3%. Male literacy in the CHT was 45.13% compared to the national average of 49.6% and female literacy rate was 28.06% compared to the national rate of 40.8% (BBS, 2003, National Population Census 2001, Bangladesh Department of Primary Education, BANBEIS). The following graph shows the relationship between years of schooling and literacy in the CHT.

Figure 2.2: Literacy rate by year of school passing by sex



Source: Rafi, M and Chowdhury, 2001

For the CHT particularly, diverse religious and ethnic backgrounds bring up more questions about education and school completion. Some groups in the different parts of the society may support education more than others. Since the CHT is home to several different ethnic groups, their differing opinions about and access to education is evidenced in the following graph, taken from a household survey by BCAS. This table shows the levels of education completed by members of the different ethnic groups.

Table 2.5: Percentage Distribution of Household Members by Education and by Ethnicity for all of the CHT

Ethnicity	Sex	Level of Education							
		Illiterate	Up to Class V	Below SSC	SSC and equivalent	HSC and equivalent	Bachelor and above	Technical education	Total
Bangali	Male	19.7	46.2	22.6	8.8	2.2	0.5	-	100
	Female	33.3	42	19.8	3.7	1.2	-	-	100
	Both	26.2	44.2	21.2	6.4	1.7	0.3	-	100
Chakma	Male	18.1	33	28.4	12.1	4.2	3.8	0.4	100
	Female	26.8	31.5	29.9	8.6	2	1.2	-	100
	Both	22.2	32.3	29	10.5	3.2	2.6	0.2	100
Marma	Male	32.5	33.8	23.3	9.2	-	1.2	-	100
	Female	51	28.5	14.6	4.6	1.3	-	-	100
	Both	41.4	31.3	19.1	7	0.6	0.6	-	100
Tanchangya	Male	37.2	30.3	17.4	11.6	3.5	-	-	100
	Female	50	25.8	15.7	7.1	1.4	-	-	100
	Both	42.9	28.2	16.7	9.6	2.6	-	-	100
Tripura	Male	24.5	36.3	23.5	5.9	3.9	5.9	-	100
	Female	46.5	24.3	23.2	2	3	1	-	100
	Both	35.3	30.3	23.4	4	3.5	3.5	-	100
Bawm	Male	13.7	27.4	37.3	15.7	3.9	-	2	100
	Female	32	34	30	4	-	-	-	100
	Both	22.8	30.7	33.6	9.9	2	-	1	100
Others	Male	50.8	21.1	18.7	2.3	5.5	1.6	-	100
	Female	66	15.6	9.2	6.4	0.7	2.1	-	100
	Both	58.7	18.2	13.7	4.5	3	1.9	-	100

Source: BCAS, 2006.

The average teacher to school ratio at primary level is 3.15 (Bandarban: 3.05, Khagrachhari: 3.20 and Rangamati: 3.17) in the CHT whereas for the country it is 3.61. On the other hand, the same ratio at secondary level is 12.80 (Bandarban: 12.47, Khagrachhari: 14.00 and Rangamati: 12.03) in the CHT and 11.65 for the country as a whole (BBS, 2003, National Population Census 2001, Bangladesh Department of Primary Education, BANBEIS).

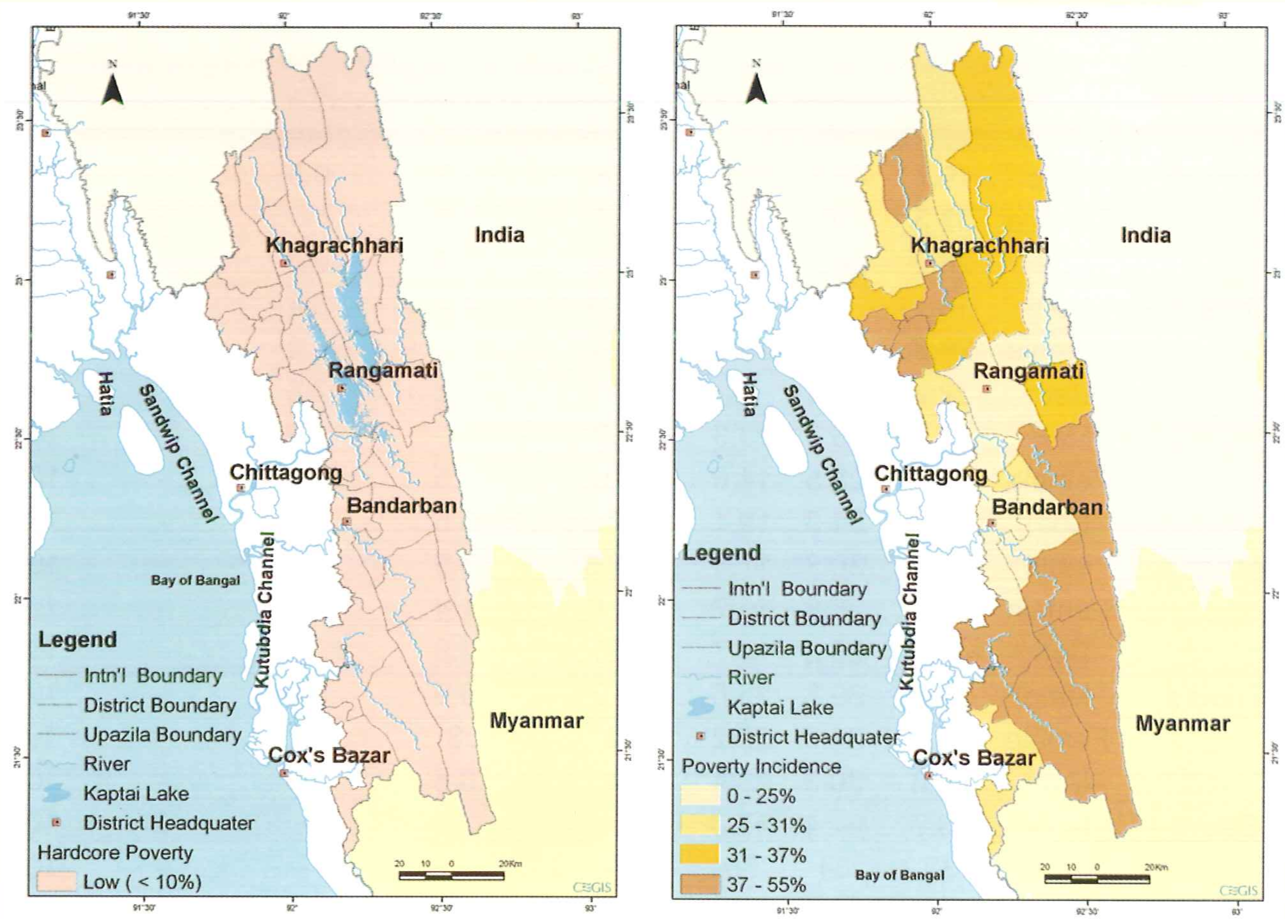
2.4 Sanitation and Drinking Water

People in the CHT do not have sufficent potable drinking water facilities at their houses (in Rangamati 38% has tube-well facilities and 50% use other sources of water, while in Khagrachhari 54% use tube-wells and 40% use other sources). A major part of the population also has no toilet facilities (Rangagati -15%, Khagrachhari- 15%).

2.5 Poverty Situation

The overall poverty incidence below the poverty line is 33.5%. People are deprived of their basic needs there. Access to power and land resources is limited for most of the communities living in the CHT. Electricity supply to the region is still far from adequate (18% of Rangamati and 13% of Khagrachhari have electricity connection). There is about 59% of agricultural land ownership in Rangamati District and 46% in Khagrachhari District. The literarcy rate in the CHT is very low (Rangamati-41% and Khagrachhari- 40%) (Source: UNDP, 2004 and BBS, 2001).

Map 2.2: Poverty Map showing percentage of population below poverty line in the CHT Household Income



Source: WFP, BBS 2004

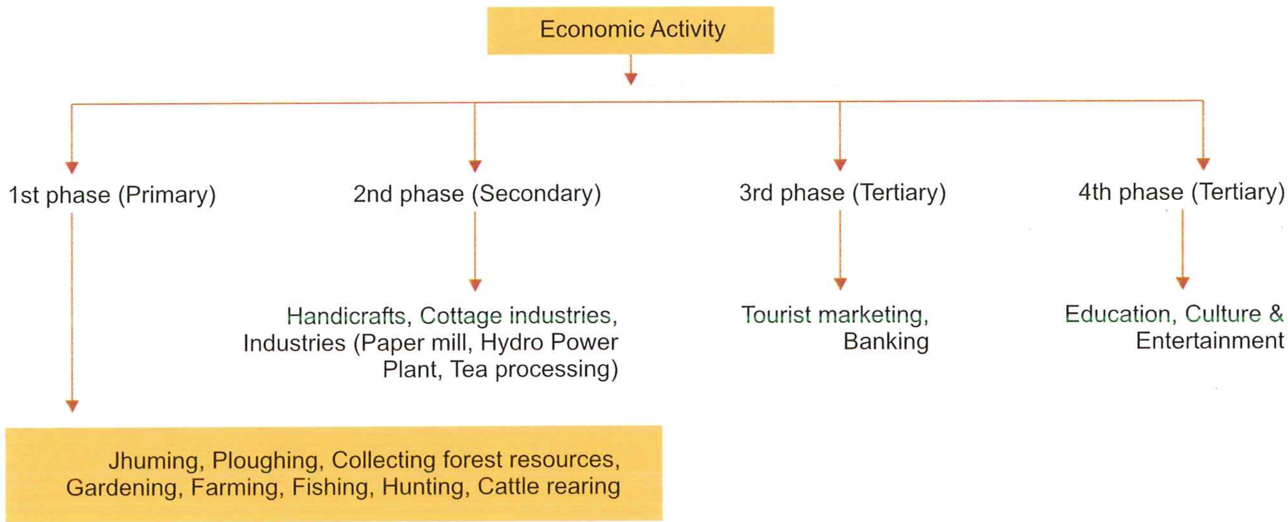
Household Income

In the CHT region the income of most households depends on agriculture (Rangamati-73.79%, Khagrachhari 65.53%). The main sources of household income are: crop, livestock, forestry and fishery (Rangamati- 61.36%, Khagrachhari- 44.79%) and selling agricultural labour (Rangamati- 12.43%, Khagrachhari- 20.74%). Other households reported earning their main income from non-agricultural labour, business, employment, construction, relegious service, rent and remittance and others. In the urban areas household incomes mainly depend on employement and business whereas in the rural areas it is mainly agriculture. (Source: Population Census-2001, Community series, BBS).

The livelihoods of the CHT people are determined in a large part by natural conditions in conjunction with culture, religion and technology. Many live traditional simple lifestyles similar to those of their ancestors. However, this lifestyle comes with a lack of basic education and modern amenities.

People who are engaged or desire to be engaged in the production of economic goods and services are considered economically active people. The economic activities of the people in the CHT are organized in the table given below, showing the primary, secondary and tertiary nature of productivity using existing land, labour, capital and the organizations at large.

Figure 2.3: Broad classification of economically active people



Source: (ADB, 2001b).

The natural resources of the CHT are many the hills, soil, forests, rivers, and the energy of the people. The economic activities of the CHT people differ greatly from the rest of Bangladesh, often involving dangerous work in the natural environment (hunting, honey collection, slash and burn cultivation). While there is some variety in the economic activities of both the Parhari and Bangali people, the economy of the CHT in the rural sector is predominantly agriculture-based, with some commercial enterprises based on agricultural activities. Parahari agriculture is characterized by traditional shifting or swidden cultivation (jhum). The common jhum crops grown on the same plot include paddy, cotton, watermelon, lady's finger (okra), bottle gourd, sesame, and a variety of indigenous seeds.

Both Paharis and Bengalis practice plain land agriculture in the first phase of economic activity, involving the ploughing of land and fishing from rivers, lakes, small streams (khals) and other water bodies. In this phase, people also depend on honey collection and hunting to provide income and food. Agricultural cultivation and dependence on natural resources continue as individuals turn to the second phase of economic activity. Many people supplement their agricultural income with the production of handicrafts in small cottage industries, making furniture, baskets and metalwork. Some of these goods, especially furniture, are being exported outside the CHT. The tourist demand for these products in particular has created incentives for more people to become involved in their production. Some NGOs are promoting these cottage industries as successful business models.

The CHT is in transition between the second and third phases, as there is a beginning of some employment in the tourism and "eco-tourism" sector. Dominated by Bengalis, this industry has potential for growth through proper promotion, assuming that political stability continues.

BCAS conducted a sample survey of 463 households in the three districts of the Hill Tracts. The questions of one of the surveys revealed the employment distribution of the members of these households.

Table 2.6: Distribution of Household Members by Occupation, Gender, and District

Occupation	Name of District											
	Bandarban			Rangamati			Khagrachari			Whole CHT		
	Male	Female	Both	Male	Female	Both	Male	Female	Both	Male	Female	Both
Jhum Farming	136 (27.1)	129 (27.6)	265 (27.3)	59 (15.2)	17 (5.2)	76 (10.6)	26 (6.4)	15 (4.3)	41 (5.4)	221 (17.0)	161 (14.1)	382 (15.7)
Plain land farming	55 (11.0)	40 (8.5)	95 (9.8)	84 (21.6)	21 (6.4)	105 (14.7)	131 (32.2)	72 (20.7)	203 (26.9)	270 (20.8)	133 (11.7)	403 (16.5)
Wage labour	6 (1.2)	2 (0.4)	8 (0.8)	2 (0.5)	-	2 (0.3)	20 (4.9)	4 (1.1)	24 (3.2)	28 (2.2)	6 (0.5)	34 (1.4)
Carpenters/Weavers	-	-	-	2 (0.5)	-	2 (0.3)	1 (0.2)	-	1 (0.1)	3 (0.2)	-	3 (0.1)
Boatman/Rickshaw pullers	1 (0.2)	-	1 (0.1)	-	-	-	3 (0.7)	-	3 (0.4)	4 (0.3)	-	4 (0.2)
Trade and business	25 (5.0)	5 (1.1)	30 (3.1)	9 (2.3)	-	9 (1.3)	25 (6.1)	1 (0.3)	26 (3.4)	59 (4.5)	6 (0.5)	65 (2.7)
Wood Cutter	-	-	-	-	-	-	1 (0.2)	-	1 (0.1)	1 (0.1)	-	1 (0.05)
Lawyer/doctors/engineer	-	-	-	-	-	-	2 (0.5)	-	2 (0.3)	2 (0.1)	-	2 (0.1)
Teacher	8 (1.6)	3 (0.6)	11 (1.1)	6 (1.5)	3 (0.9)	9 (1.3)	9 (2.2)	6 (1.7)	15 (2.0)	23 (1.8)	12 (1.0)	35 (1.4)
Technicians &Mechanics	1 (0.2)	-	1 (0.1)	1 (0.3)	-	1 (0.1)	2 (0.5)	-	2 (0.3)	4 (0.3)	-	4 (0.2)
Government service	9 (1.8)	3 (0.6)	12 (1.2)	12 (3.1)	-	12 (1.7)	9 (2.2)	4 (1.1)	13 (1.7)	30 (2.3)	7 (0.6)	37 (1.5)
Private service	18 (3.6)	6 (1.3)	24 (2.5)	5 (1.3)	2 (0.6)	7 (1.0)	7 (1.7)	8 (2.3)	15 (2.0)	30 (2.3)	16 (1.4)	46 (1.9)
Fisherman/Fish Traders	1 (0.2)	-	1 (0.1)	10 (2.6)	2 (0.6)	12 (1.7)	2 (0.5)	-	2 (0.3)	13 (1.0)	2 (0.2)	15 (0.6)
Hawkers/Vendors	-	-	-	-	1 (0.3)	1 (0.1)	-	-	-	-	1 (0.1)	1 (0.05)
Domestic work	1 (0.2)	63 (13.5)	64 (6.6)	27 (6.9)	152 (46.7)	179 (25.0)	2 (0.5)	114 (32.9)	116 (15.4)	30 (2.3)	329 (28.8)	359 (14.7)
Student	149 (29.6)	132 (28.3)	281 (29.0)	155 (39.8)	123 (37.8)	278 (38.8)	127 (31.3)	96 (27.8)	223 (29.7)	431 (33.3)	351 (30.9)	782 (32.1)
Unemployed	72 (14.3)	62 (13.2)	134 (13.8)	10 (2.6)	3 (0.9)	13 (1.8)	10 (2.5)	7 (2.0)	17 (2.2)	92 (7.1)	72 (6.3)	164 (6.7)
Horticulture	8 (1.6)	10 (2.1)	18 (1.9)	7 (1.8)	2 (0.6)	9 (1.3)	2 (0.5)	1 (0.3)	3 (0.4)	17 (1.3)	13 (1.1)	30 (1.2)
Others	12 (2.4)	13 (2.8)	25 (2.6)	-	-	-	28 (6.9)	19 (5.5)	47 (6.2)	40 (3.1)	32 (2.8)	72 (2.9)
Total	502 (100.0)	468 (100.0)	970 (100.0)	389 (100.0)	326 (100.0)	715 (100.0)	407 (100.0)	347 (100.0)	754 (100.0)	1298 (100.0)	1141 (100.0)	2439 (100.0)

Note: Figures within parentheses represent percentages. ***Source:*** CHARM Project, 2006.

Table 2.7: Distribution of Household Members by Occupation and District

Sl No	Occupation	Bandarban	Rangamati	Khagrachari	Whole CHT
1	*Jhum* Farming	265(27.3)	76(10.6)	41(5.4)	382(15.7)
2	Plain land farming	95(9.8)	105(14.7)	203(26.9)	403(16.5)
3	Wage labour	8(0.8)	2(0.3)	24(3.2)	34(1.4)
4	Carpenters/Weavers	-	2(0.3)	1(0.1)	3(0.1)
5	Boatman/Rickshaw pullers	1(0.1)	-	3(0.4)	4(0.2)
6	Trade and business	30(3.1)	9(1.3)	26(3.4)	65(2.7)
7	Wood Cutter	-	-	1(0.1)	1(0.05)
8	Lawyer/doctors/engineer	-	-	2(0.3)	2(0.1)
9	Teacher	11(1.1)	9(1.3)	15(2.0)	35(1.4)
10	Technicians &Mechanics	1(0.1)	1(0.1)	2(0.3)	4(0.2)
11	Government service	12(1.2)	12(1.7)	13(1.7)	37(1.5)
12	Private service	24(2.5)	7(1.0)	15(2.0)	46(1.9)
13	Fisherman/Fish Traders	1(0.1)	12(1.7)	2(0.3)	15(0.6)
14	Hawkers/Vendors	-	1(0.1)	-	1(0.05)
15	Domestic work	64(6.6)	179(25.0)	116(15.4)	359(14.7)
16	Student	281(29.0)	278(38.8)	223(29.7)	782(32.1)
17	Unemployed	134(13.8)	13(1.8)	17(2.2)	164(6.7)
18	Horticulture	18(1.9)	9(1.3)	3(0.4)	30(1.2)
19	Others	25(2.6)	-	47(6.2)	72(2.9)
20	Total	970(100.0)	715(100.0)	754(100.0)	2439(100.0)

Note: Figures within parentheses represent percentages.

Source: CHARM Project, 2006.

As has already been noted, this survey shows that a significant portion of the population of the Chittagong Hill Tracts is dependent on one or another form of agriculture; the survey also indicates just how varied the income-generating activities of the people are.

There are some larger industries that employ a fair number of individuals, including Karnafuli Rayon and Chemicals Ltd., Bangladesh Forest Industries Development Corporation (BFIDC), Sattar Match Factory, Rangamati Textile Mills, Rangamati Food Products Ltd., Karnafuli Hydro Power Plant, and the largest simple employer, employing 3,000 people, the Karnafuli Paper Mills Ltd. Brick mills and grinding mills also employ people throughout the region. Other smaller household industries include bamboo crafts and rice wine/liquor production. (Source: ADB Industry, Services, and Tourism, 2001.)

2.6 Impact of Population Pressure on the Environment

The land, water and biological resources of the environment are impacted by population denominators in terms of changing the per capita endowment of those resources over time. The people of the Chittagong Hill Tracts are shaping the future of the region by cultivating its soil, by fishing in its streams, and by harvesting its forests. Their livelihoods and their future are inextricably linked with the land and the natural resources of the CHT. Recently, with increased population through natural growth and migration influx, the pressures on the environment have multiplied, meaning that the economic pressures on the people of the CHT have also increased. The poor are more dependent on common natural resources for their livelihoods, whether through agriculture, timber harvesting or fishing. Attention must be paid to the overall economic situation of the people in this region in order to fully address the environmental problems. The people who will carry natural resources management forward are those who depend on natural resources. As each part of the environment is linked to another, all ultimately lead back to how humans can protect and benefit from the environment at the same time.

Chapter 3

Terrain and Soil Resources

3.1 Introduction

The most striking distinction between the Chittagong Hill Tracts and the rest of Bangladesh is the topography of the terrain. In contrast to the plainlands, the CHT has hills and even some mountains, extending off the Himalaya Hindu Kush range. The landform of the CHT is characterized by a succession of pitching anticlines and synclines aligned almost northnorthwest to southsoutheast. It increases eastwards in elevation and consists of mainly consolidated beds of tertiary sandstone, shale and siltstone with recent alluvial deposits in the valleys. The topography and make-up of the soil will help in understanding the suitability of land and future resource management with respect to land zoning.

This chapter covers information on physiography/landform, soils chemical and physical properties - and potential limitations for development.

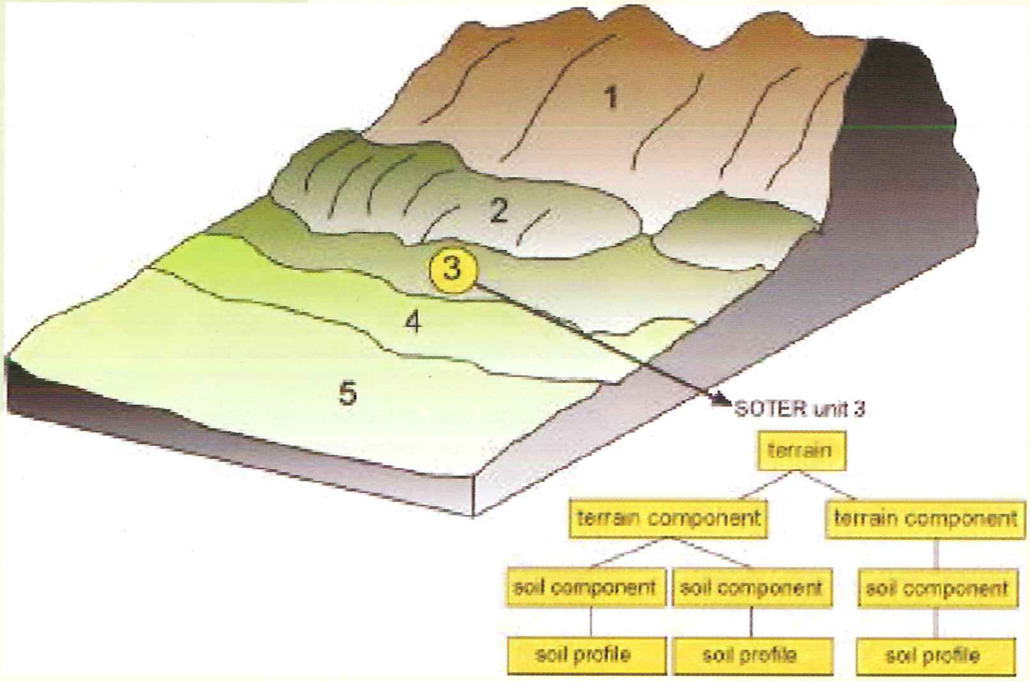
3.2 Data sources

The major data source for soil information of the CHT area is the Reconnaissance Soil Survey Report (Brammer, 1986) of the Soil Resource Development Institute (SRDI). This is a generalization of the Reconnaissance Soil Survey at the scale 1:31,680, which was carried out in 1964 and 1965 by Forestal Forestry and Engineering International Ltd. The "Land Resources Appraisal of Bangladesh for Agricultural Development" project made a computerized version of the reconnaissance maps with associated databases (FAO 1988a,b.c.d). Most of the soil information has been taken from the generalized reconnaissance survey map and report. This soil map is composed of 97 complex mapping units (soil associations) that are characterized by 11 soil series either as a single soil or in combinations. Due to poor accessibility, the number of soil profiles is limited to 49 for the CHT area. Some maps also shows blank patches for the non-surveyed Reserved Forest areas.

Maps with selected soil properties (texture, pH, fertility, available water holding capacity) at the scale 1:50,000 (SRDI, 1988-2001) exist for all upazilas of the CHT, but have limited use as the soil group names are not documented in the reconnaissance map.

In the framework of the CHARM project, the existing soil information was enhanced with interpretations of the Shuttel Radar Terrain Model (SRTM), 90 m digital elevation model (USGS, 2003) and satellite imagery (Landsat and IRS). Landform units were derived from the DEM using a method developed by Dobos *et al.* (2005). The spatial pattern of the soil was improved, slope and relief parameters were quantified and mapping units with almost similar compositions were merged. Consequently, the number of mapping units was reduced to 20. Five new soil series were identified by SRDI for the lower parts of the CHT. Limited field checking took place in the Rangamati and Bandarban areas. The map was digitized and soil and terrain attributes were recorded following the standardized methodology for the Soil and Terrain database (van Engelen and Wen, 1995). The SOTER methodology is the identification of areas of land with a distinctive, often repetitive pattern of landform, lithology, surface form, slope, parent material, and soil. Tracts of land distinguished in this manner are named SOTER units. Each SOTER unit thus represents one unique combination of terrain and soil characteristics. Figure 3.1 shows a landscape with various SOTER units and the representation of a SOTER unit in the database.

Figure 3.1: SOTER units in the landscape and their components in the database



3.3 Geology and Physiography

Geology

The hilly landscape of the CHT is the result of geological uplifting, faulting, tilting, folding and dissection of sedimentary rocks dating back to the Tertiary Period (about 65 to 2 million years ago). These tectonics were associated with the uplift of the Himalayan mountains and subsequently the formation of the Assam and Burma Hills (Indo-Burman Ranges) including those in the eastern folded part of Bangladesh. The geological formations (Map 3.1) comprise folded and compressed consolidated sedimentary rocks. The GSB-USGS Geological map (1990) has been used with some modifications based on image interpretation. They are characterized by a wide range of degrees of consolidation. The main rock types are fine-grained shales, siltstone and sandstone of the Pliocene and Miocene age. The distribution of the various geological formations in terms of their lithology is shown in Map 3.2.

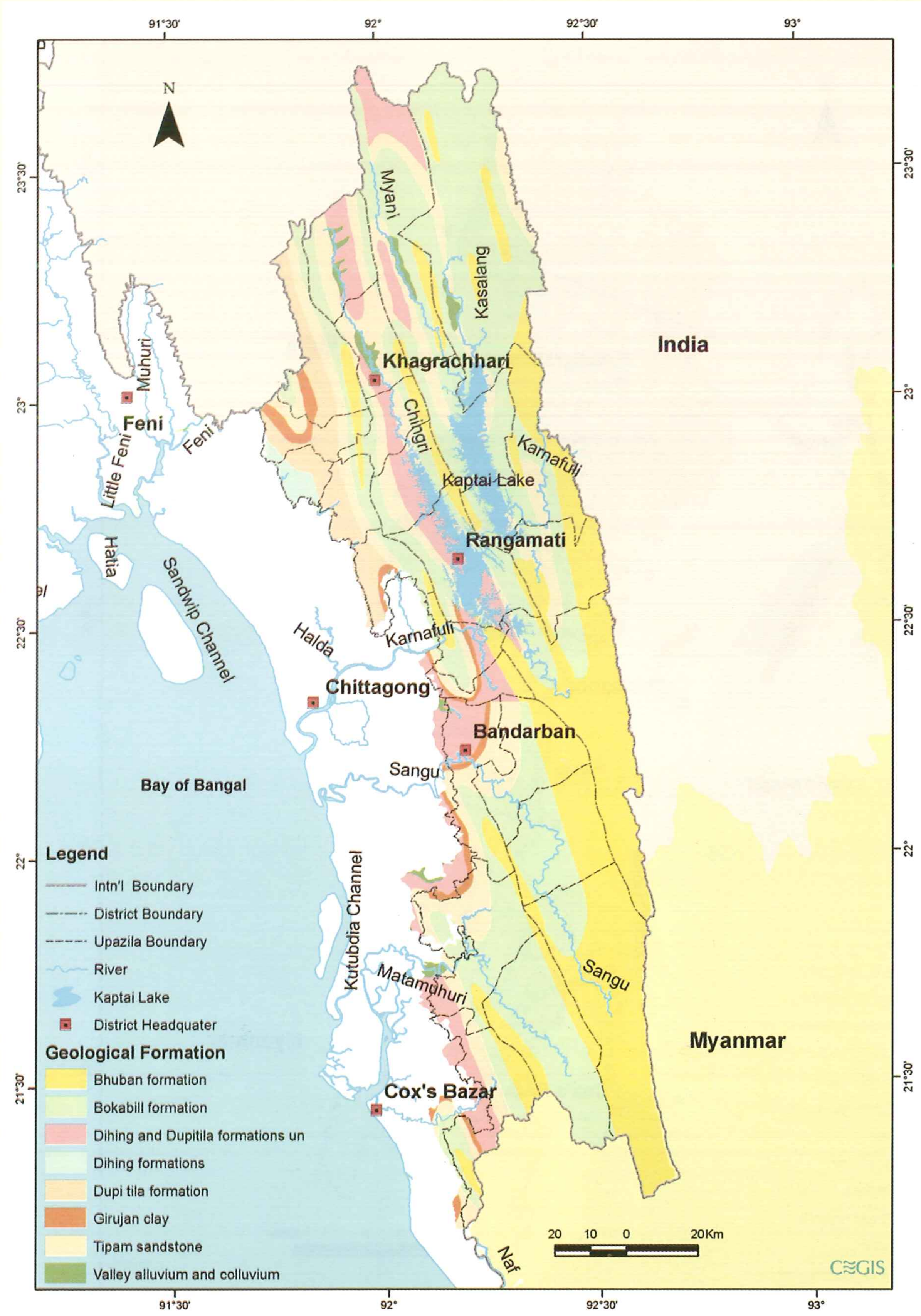
Physiography

Geological processes play an important role in the development of the physiography or landform of an area. The relevant factors are geological processes, rock and soil materials, climate and flora & fauna. The landform as defined by the SOTER methodology is determined by a combination of elevation (Map 3.3), slope gradient (Map 3.4) and relief intensity to a large extent. Six major landforms are identified in the CHT (Map 3.5):

- Medium-gradient mountains
- High-gradient hills
- Medium-gradient hills
- Dissected plains
- Plains
- Valleys

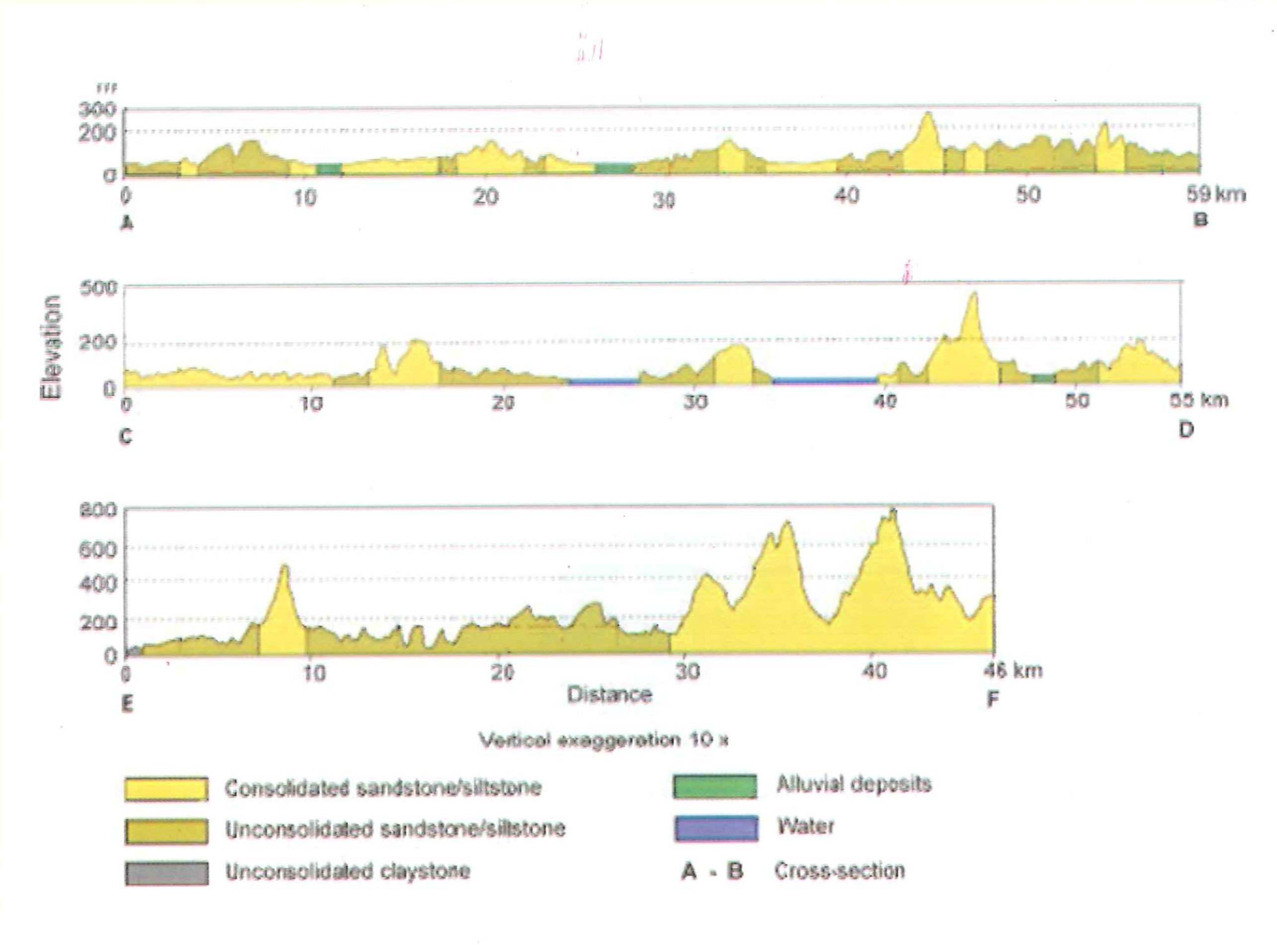
The various mapping units (SOTER units - SU) that characterize each landform are indicated in brackets.

Map 3.1: Geological map of the CHT

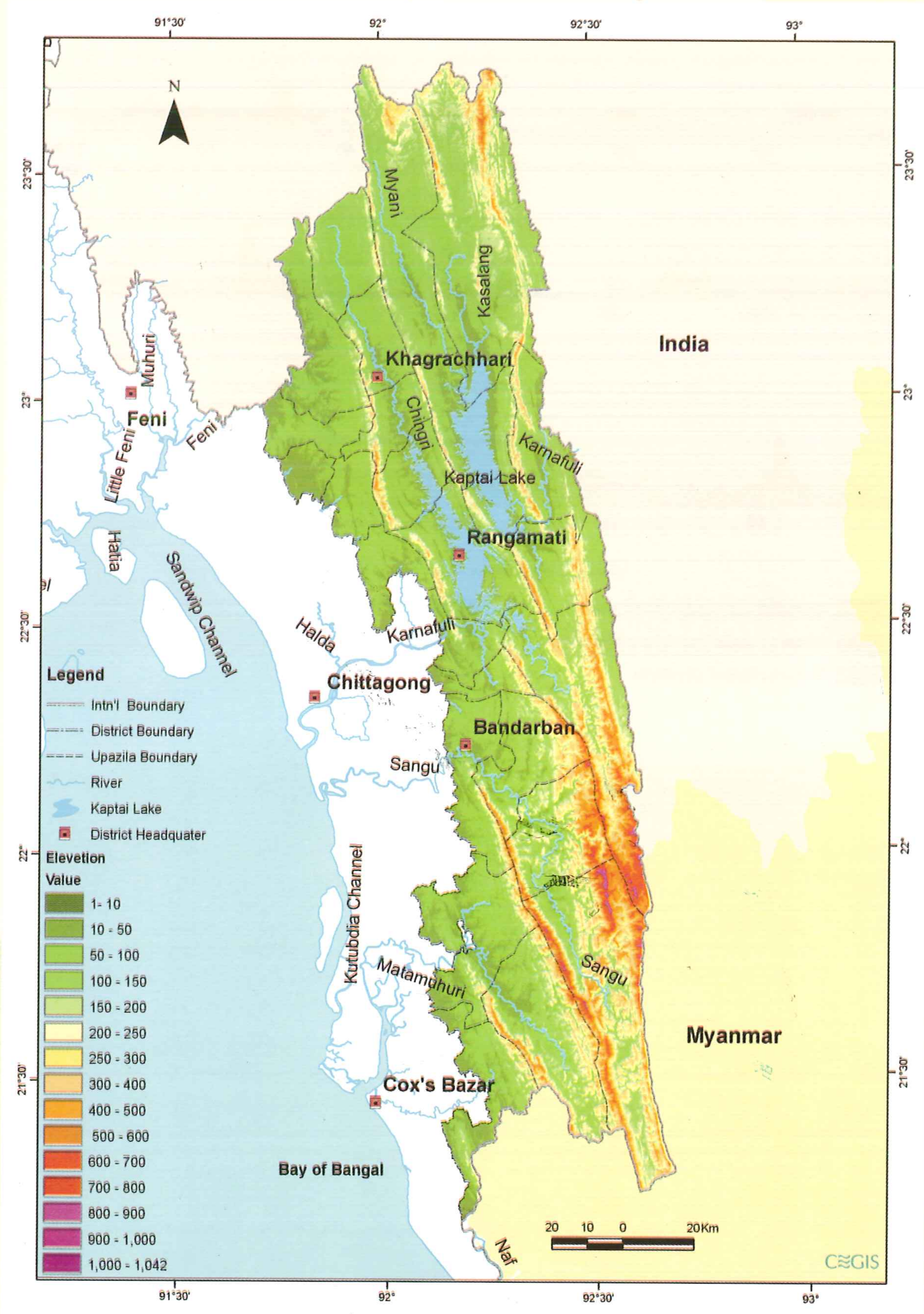


Map 3.2: Distribution of the major Lithological Units in the CHT

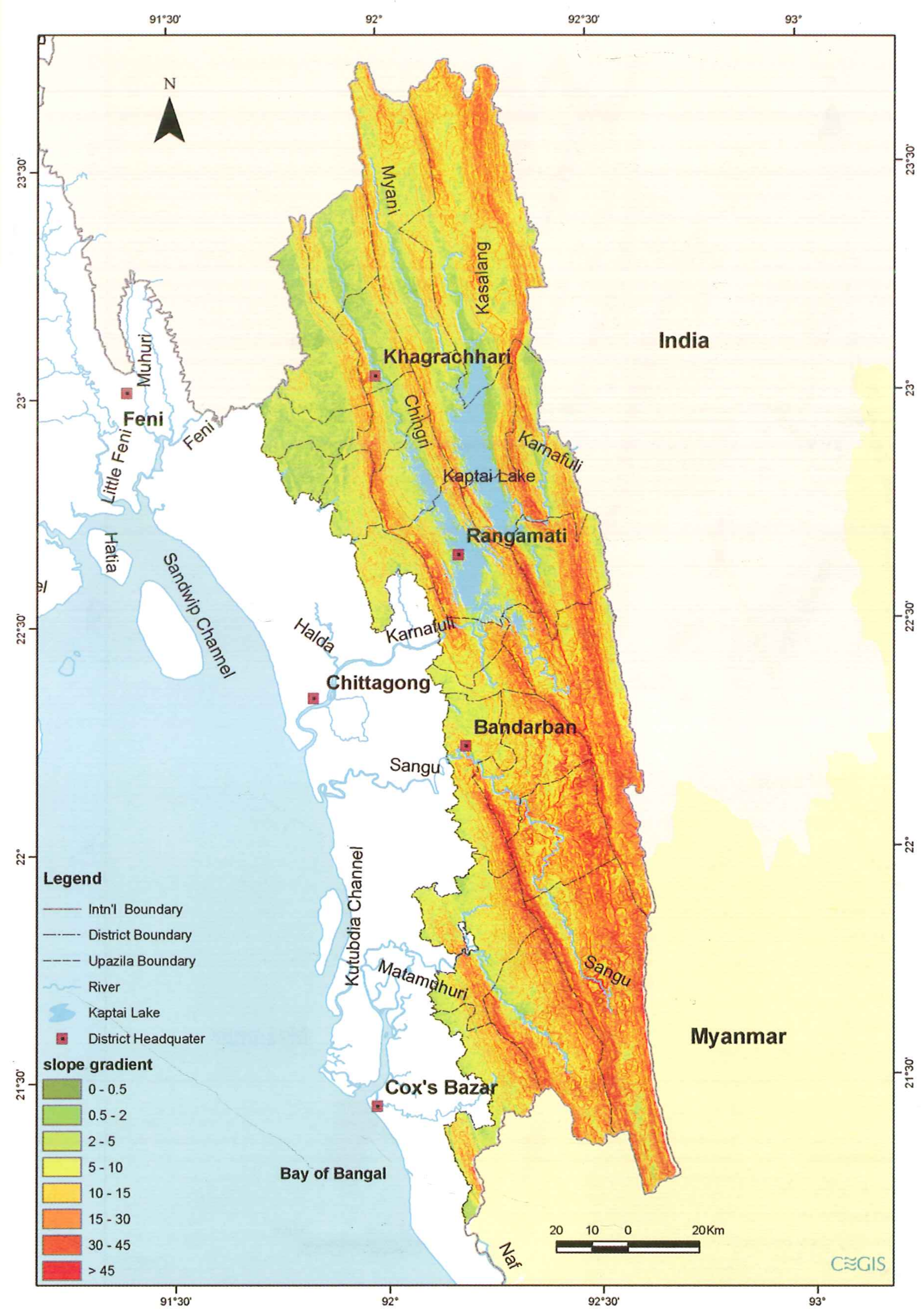
Figure 3.2: Cross-sections from the lithology map



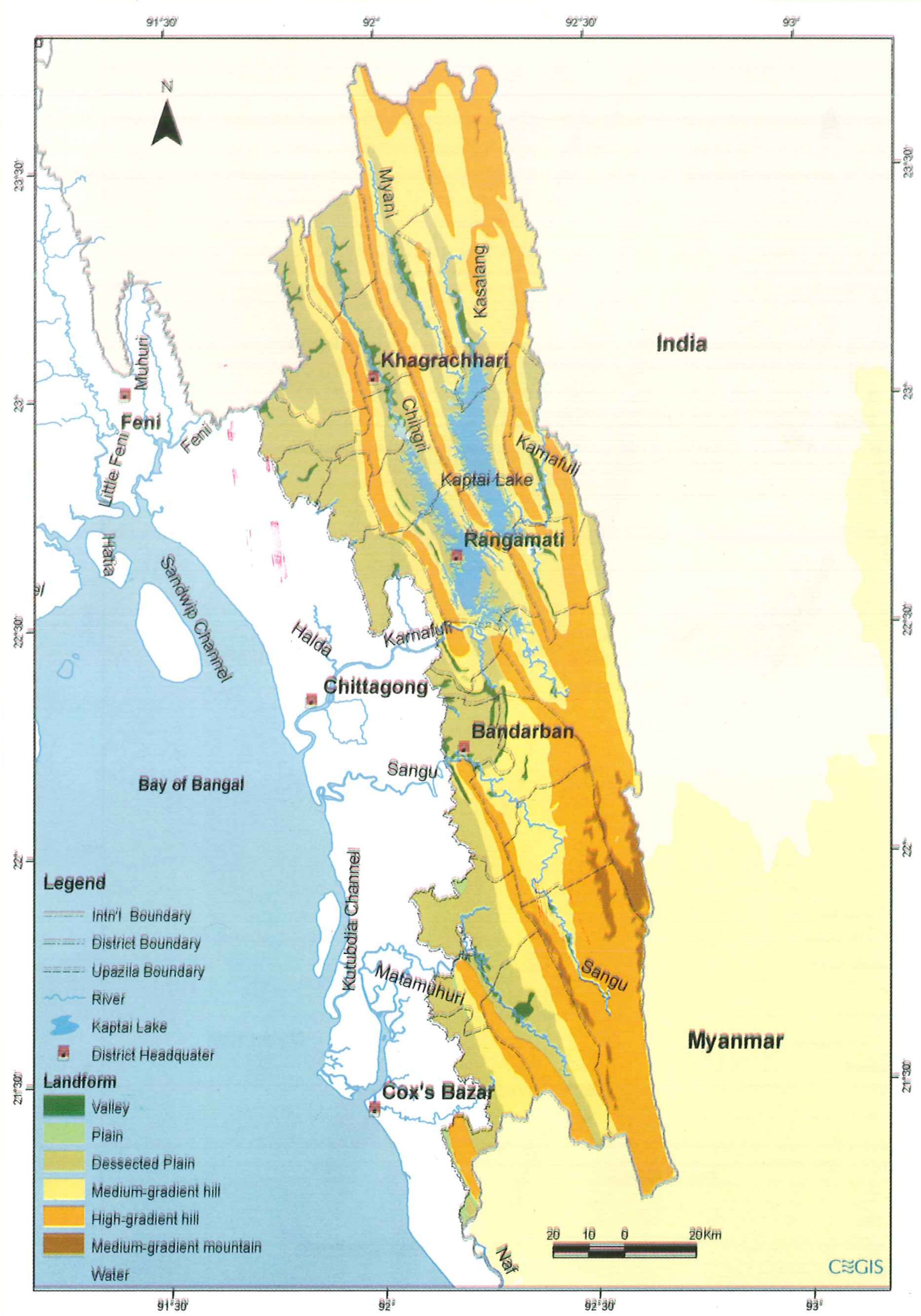
Map 3.3: Elevation (m above Mean Sea Level)



Map 3.4: Slope gradient (%)



Map 3.5: Landform of the CHT



(a) Medium-gradient mountains and high-gradient hills (SU 14, and 1)

The high-gradient hills are characterised by steep slopes - median slopes 21 % with extremes of over 100% - and by a high relief intensity of about 180 m km^{-2}. They stand out as elongated parallel ridges aligned almost northnorthwest to southsoutheast (NNW-SSE). Towards east, the ridges get higher until they reach the highest mountain ranges - over 1000m - that marks the boundary between Bangladesh, Myanmar and India. The ridges are formed by the anticlines of consolidated rocks consisting of alternating beds of Shales, Siltstones and Sandstones of the Bhuban formation.

The elevation of the high-gradient hills ranges from about 50 to 600 m above MSL. The medium-gradient mountains range from 600 m to the highest summits. The cores of the higher anticlines consist of semi-consolidated to consolidated sedimentary rocks mainly sandstones - that have been strongly and deeply dissected. The mountains have very steep slopes and conical sharp peaks.

Figure 3.3: High-gradient hills

(b) Medium-gradient hills (SU 2, 7, 13)

The lower hilly areas between the high-gradient hills are formed by synclines mainly consisting of unconsolidated sandstone and siltstone of the late Tertiary age. These sandstones mainly belong to the younger Tipam Formation and the siltstones manily comprise the Bokabil formation. Unconsolidated siltstones and sandstones of the Dihing and Dupi Tila formations occur in the western part of the CHT.

The hill summits are generally less then 300 m above MSL. Most of the areas are rolling to steep low hills, with rounded tops, with strongly dissected edges and very steep slopes. However, some have almost level relief.

Figure 3.4: Medium-gradient hills

(c) Dissected plains (SU 3, 5, 6, 8, 9, 10, 11, 12, 15, 19)

Within the plains two groups are distinguished: those in the areas adjacent to the hills and those in the west of the CHT. The first group hills are somewhat higher and steeper and have a higher relief while the latter have a subdued relief, lower elevation and gentler slopes. These units are classified as dissected plains: they show the remnants of a plain that is visible in the summits of the area. Valleys have cut the old surfaces resulting into an area of sloping landforms. Slopes are in general less than 10% with occasional extremes up to 30%.

Figure 3.5: Dissected plains

(d) Plains (SU 17, 18, 20)

Only small areas in the southwest of the region are the parts of the Chittagong coastal plain. This part of the CHT is a relatively narrow strip of land sloping gently outward from of the adjoining hills. Sediments washed off the hills and/or deposited by small streams flowing out of the hills form this land. The relief is often rather irregular. The deposits are mainly loamy and sandy in the rather elevated areas and clayey in depressions. Seasonal inundation is mainly intermittent and shallow that occurs from heavy rainfall in the adjoining hills.

Figure 3.6: Valley

Figure 3.7: Coastal plain

(d) Valleys (SU 4, 16)

Valleys occur within these dissected hills. Most of the valleys, particularly those occurring between the high-gradient hills, are very narrow with sharp gradient, and as a result have little accumulation of sediments. During the Pleistocene glacial periods most of these hills were dissected at a deeper level than the present sea-level. The deep valleys were later filled up by sediments as the sea level rose. In the central and northern part of the CHT the Karnaphuli River and its major tributaries have substantial areas of alluvial deposits along their courses. In the south only the Sangu and Matamuhuri rivers have mappable fluvial sediments. The recent floodplains are subject to annual flooding but the older sediments of the higher terraces are not.

3.4 Soils

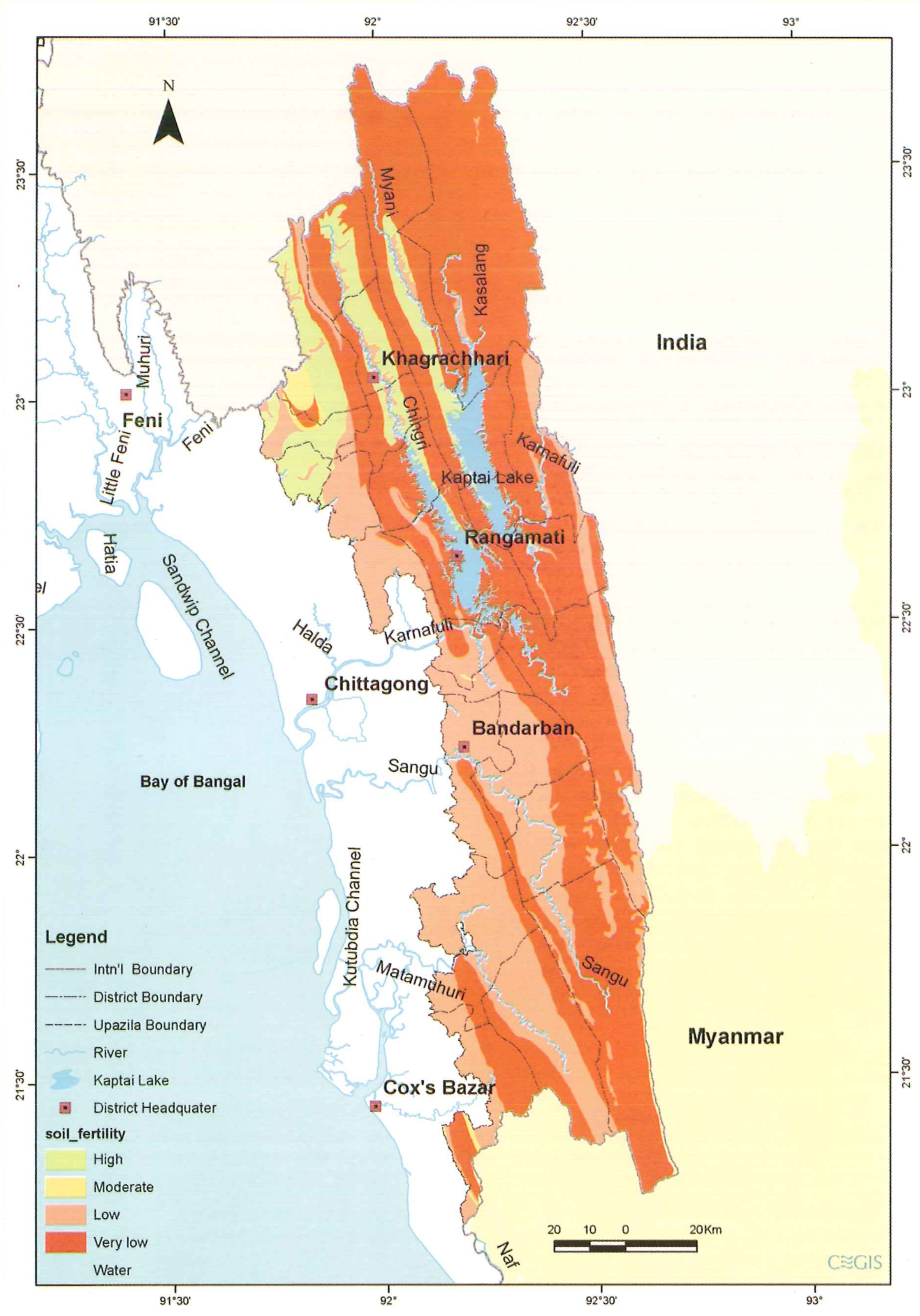
The CHT has 20 mapping units in the SOTER database consisting of 51 soil components characterized by 16 soil components that are described in this chapter. The soil components are further characterized by 31 representative soil profiles. In Bangladesh, soil profiles that have a similar range of characteristics are grouped in so-called soil series. Sixteen soil series were identified by the reconnaissance soil survey (Brammer, 1986) and another five by survey work of SRDI in the Chittagong coastal plain.

The SOTER units can be grouped into three main parent material groups:

- SOTER units on consolidated sandstones, siltstones and shales on the high-gradient hills and medium-gradient mountains (units 1, 2, 7, 13 and 14)
- SOTER units on unconsolidated sandstones and mudstones on the medium-gradient hills and dissected plains (units 3, 5, 6, 8, 9, 10, 11, 12, 15 and 19), and
- SOTER units on alluvial materials of the valleys and plains (units 4, 16, 17, 18 and 20)

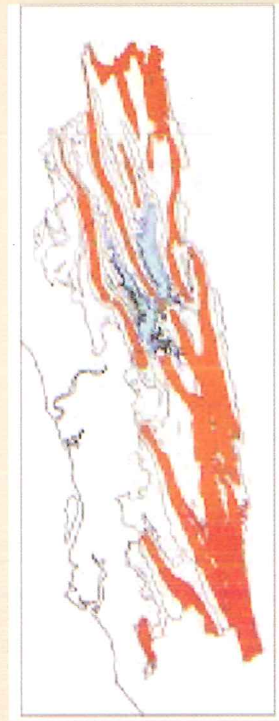
Soils of the CHT are less fertile compared to other parts of Bangladesh, because they mostly originated from the weathering and erosion of bedrocks. Additionally, the soils formed over unconsolidated sedimentary rocks (Dupi Tila Formation) containing significant amounts of kaolinitic clay, which provides a low capacity to retain nutrients. The fertility is further declining rapidly due to unsustainable resources management practices. The soils over siltstones and mudstones are better in this respect because they have mainly illitic clays, which have higher nutrient buffering capacities and are a mineral source of K and Mg. Except under natural forests or well-established tree crops, the content of organic matter is low. Due to the leaching effect during high monsoon rainfall, the nitrogen and potash are washed out. The fertility status of the soils of the CHT is given in Map 3.6.

Map 3.6: Soil fertility status



Soils on consolidated sandstones, siltstones and shales on the high-gradient hills and medium-gradient mountains

SOTER unit 1



This unit occupies the steep high-gradient hills on consolidated sedimentary rocks, mainly fine sandstones interbedded with siltstones. Three soil components can be distinguished within this unit: The larger part of the unit is occupied by two soil types: the Kaptai series that occur in a shallow variant less than 60 cm deep (60%) and a deeper one (25%). The remaining 15% of the unit is characterized by the Belaichari series.

Kaptai soils are well drained, yellowish-brown to strong brown, silty clay loams ranging in depth between less than 60 and more than 150 cm. Rock fragments occur in the lower part of the soils. Belaichari soils are well drained, shallow, yellowish-brown sandy loams, with pieces of rock over hard sandstone.

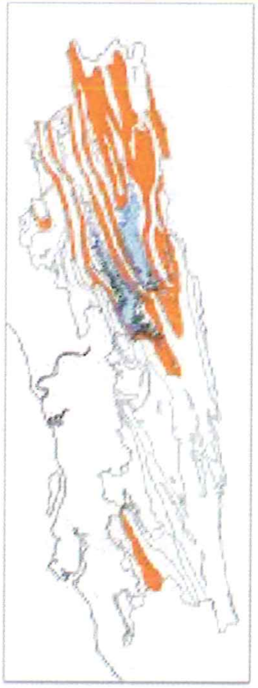
Fertility and moisture-holding capacity of the deep Kaptai soils are relatively good, but the prevalent steep slopes mean severe limitations for agricultural use. The low moisture-holding capacity of the shallow Kaptai soils makes them prone to droughtiness. Belaichari soils are very poor for agriculture. Severe limitations include shallowness and consequent droughtiness, very steep slopes and low fertility.

Figure 3.8: Deep Kaptai soil over siltstone

Figure 3.9: Landscape of deep Kaptai soils

Figure 3.10: Sandstone outcrop with Belaichari soils

SOTER unit 2



This unit lies adjacent to unit 1 and occupies the lower parts of the high-gradient hills developed on consolidated, fine sandstones interbedded with siltstones. There are three soil types in this unit: the deep Kaptai series (60%) and the Rankhiang series (15%) that occur all over the unit where sandstones dominate and the Kankrachari (40%) on the lower positions of the unit where the siltstones occur.

Kaptai soils are well drained, deep, yellowish-brown to strong brown, silty clay loams. Rock fragments occur in the lower part of the soils. Rankhiang soils are deep, yellowish-brown sandy loams over semi-consolidated sandstone. Kankrachari soils vary in depth between shallow and deep, have a light olive-brown colour with some mottles and a silty clay loam to silty clay texture.

Agricultural considerations

Fertility and moisture-holding capacity of the deep Kaptai soils are relatively good, but the prevalent steep slopes mean severe limitations for agricultural use. Rankhiang soils are poor agricultural soils because of their low fertility and moisture-holding capacity, and their occurrence on steep slopes. Kankrachari soils are relatively good agricultural soils in terms of fertility and moisture holding capacity. Again, steep slopes are the main limitations for agricultural use.

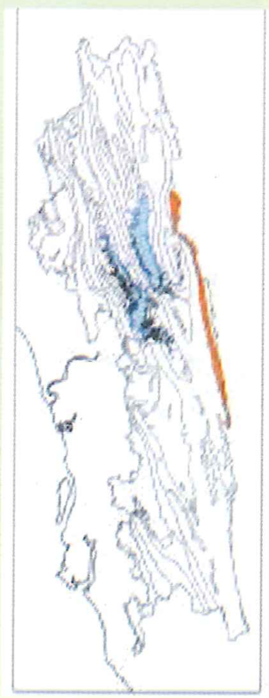
SOTER unit 5

This unit occupies a similar position as unit 2. Its soil composition is somewhat simpler because the lower positions are not dominated by siltstones and therefore the siltstone-associated soils are absent. There are two soil types in this unit: Kaptai deep (65%) and shallow (35%).

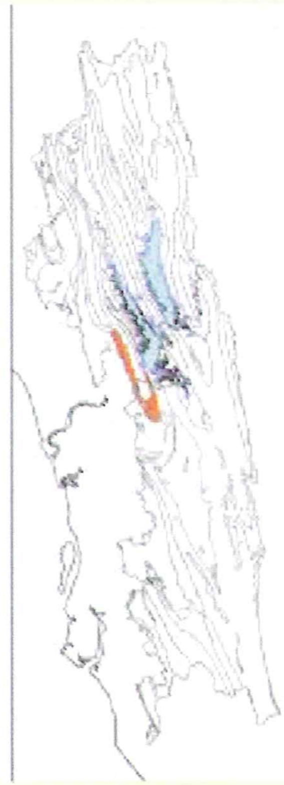
Kaptai soils are well drained, yellowish-brown, strong brown, silty clay loams ranging in depth between less than 60 and more than 150 cm. Rock fragments occur in the lower part of the soils.

Agricultural considerations

Fertility and moisture-holding capacity of the deep Kaptai soils are relatively good, but the prevalent steep slopes mean severe limitations for agricultural use. The low moisture-holding capacity of the shallow Kaptai soils make them prone to droughtiness.



SOTER unit 13

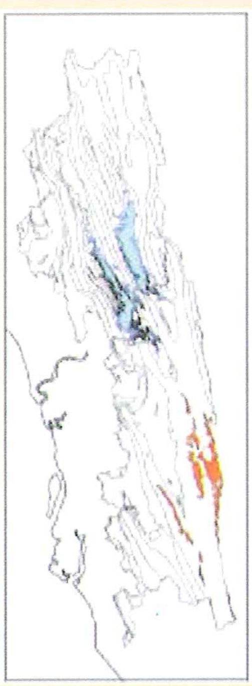


This unit like unit 2 also lies adjacent to unit 1 in the central western part of the study area. It occupies the lower parts of the high-gradient hills developed on consolidated siltstones and fine sandstones. There are four soil types in this unit: deep Kaptai (55%), Kankrachari (24%), Belaichari (14%) and in some small valley bottoms the Karnaphuli series (7%).

Kaptai soils are well drained, deep yellowish-brown, strong brown, and silty clay loams. Rock fragments occur in the lower part of the soils. Kankrachari soils vary in depth between shallow and deep, have a light olive-brown colour with some mottles and a silty clay loam to silty clay texture. Belaichari soils are shallow, yellowish-bown sandy loams, with pieces of sandstone over hard sandstone. Karnaphuli soils are developed over alluvial materials and are quite different from the other soils of this unit. They consist of very deep, moderately well drained, yellowish-brown, sandy loam with layers of silt loam, loamy sand or sand. Their lower position in the terrain is reflected in mottles indicating drainage limitations.

Agricultural considerations

Fertility and the moisture-holding capacity of the deep Kaptai soils are relatively good, but the prevalent steep slopes mean severe limitations for agricultural use. Kankrachari soils are relatively good agricultural soils in terms of fertility and moisture holding capacity. Again, steep slopes are the main limitations for agricultural use. Belaichari soils are very poor for agriculture. Severe limitations include shallowness and consequent droughtiness, very steep slopes and low fertility. Karnaphuli soils have a fairly good moisture-holding capacity and are moderately fertile.



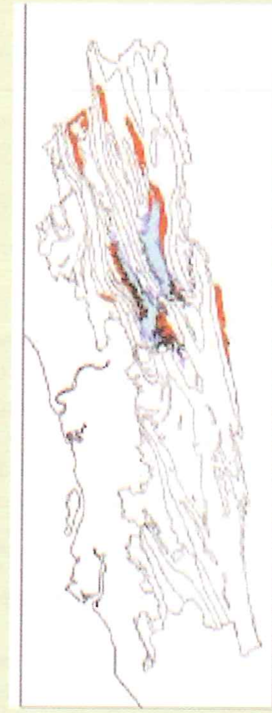
SOTER unit 14

This unit occupies the highest zone in the CHT. The medium-gradient mountains have soils that are very similar to those of unit 1 the high-gradient hills. Due to the steeper relief there are more shallow soils than in unit 1. This is reflected in the higher percentage of the Belaichari series (30%).

Agricultural considerations

Fertility and the moisture-holding capacity of the deep Kaptai soils are relatively good, but the prevalent very steep slopes mean severe limitations for agricultural use. Belaichari soils are very poor for agriculture. Severe limitations include shallowness and consequent droughtiness, very steep slopes and low fertility.

Soils on unconsolidated sandstones, siltstones and mudstones on the medium-gradient hills and dissected plains



SOTER unit 3

This unit occupies the lower parts between the high-gradient hills of unit 1. The relatively softer rocks between the ridges have been eroded into a low lying plain with valleys cutting through it, resulting in a landform that can be classified as a dissected plain. Two deep soil types developed on unconsolidated sandstones occur in this unit: the Teiabil series (67%) and the Hazaribak series (33%).

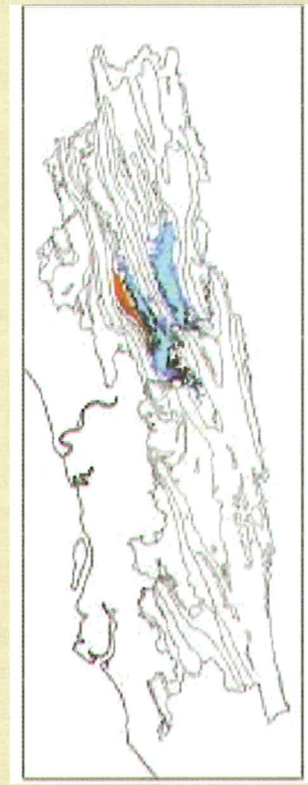
Teiabil soils are well drained, deep, strong brown to yellowish red, sandy clay loam with many red mottles and iron concretions in the subsoil. Hazaribak consists of deep, well drained, yellowish brown sandy loam to loamy sand.

Agricultural considerations

Teiabil soils are relatively poor agricultural soils despite their depth and moderately fine texture. Their fertility and moisture-holding capacity are low, and their occurrence on the summits makes them easily susceptible to erosion. Extreme aridity during the dry season severely limits the agricultural potential of the Hazaribak soils. Low fertility and their occurrence in areas of steep slopes results in further moderate to severe limitations.

Figure 3.11: Hazaribak soil

SOTER unit 6

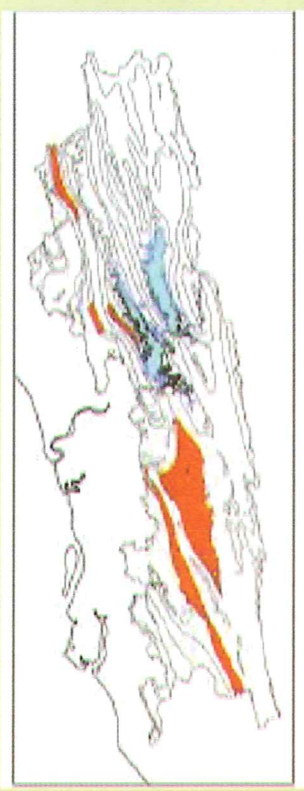


This unit is adjacent to the high-gradient hills in the central part of the region. The relief is more subdued resulting in a landform that is classified as dissected plain. The lithology of the unit is unconsolidated sandstone. Some valleys are wide enough to have their own proper soil on alluvial materials. There are three soil types in this unit: Hazaribak (61%) and Kaptai deep (34%) on the sandstone and Karnaphuli (5% in the valleys).

Hazaribak soils are well drained, deep, yellowish brown sandy loam to loamy sand over unconsolidated sandstone. Kaptai soils are well drained, deep yellowish-brown to strong brown, silty clay loams. Rock fragments occur in the lower part of the soils. Karnaphuli soils are very deep, variable mottled, indicating a moderately well drainage condition and have a dominant texture of sandy loam with layers of silt loam, loamy sand or sand as a result of sedimentation in an alluvial environment.

Agricultural considerations

Extreme aridity during the dry season severely limits the agricultural potential of the Hazaribak soils. Low fertility and their occurrence in areas of steep slopes results in further moderate to severe limitations. Fertility and the moisture-holding capacity of the Kaptai soils are relatively good, but the steep slopes mean severe limitations for agricultural use. Karnaphuli soils have a fairly good moisture-holding capacity and are moderately fertile. These soils occur in a flat topographic position.



SOTER unit 7

This unit is formed by medium-gradient hills on Tipam sandstone. The unit forms the lower zones between the high-gradient hills in the south. It also occurs along the high-gradient hills west of Rangamati. There are two soil types in this unit: Kaptai deep (65%) and Rankhiang (35%).

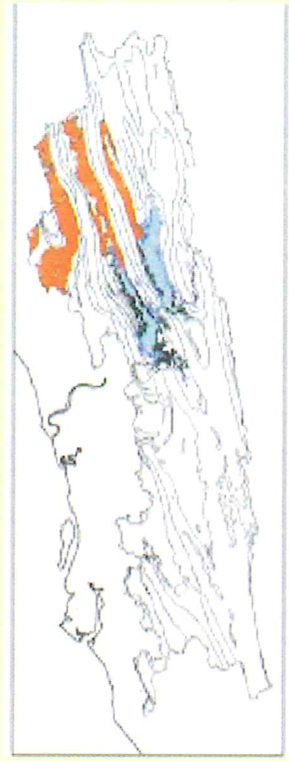
Kaptai soils are well drained, deep, yellowish-brown to strong brown, silty clay loams. Rock fragments occur in the lower part of the soils. Rankhiang soils are deep, yellowish-brown sandy loams over semi-consolidated sandstone.

Agricultural considerations

Fertility and the moisture-holding capacity of the Kaptai soils are relatively good, but the steep slopes mean severe limitations for agricultural use. Rankhiang soils are poor agricultural soils because of their low natural fertility and moisture-holding capacity, and their occurrence on steep slopes.

SOTER unit 8

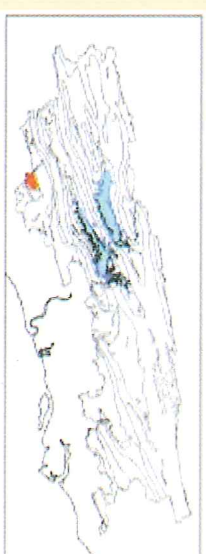
This unit lies between the high-gradient hills in the northern part of the CHT and is developed on unconsolidated sandstones interbedded with siltstones The relief and slopes of this unit are much lower than in the surrounding hills: the unit is classified as a dissected plain. There are five soil types in this unit: Teiabil (55%) on the upper parts of the dissected plains, Hazaribak (20%) and Kaptai deep (15%) on the slopes and Moghachari (5%) and Karnaphuli (5%) in the valley bottoms.



Teiabil soils are well drained, deep, strong brown to yellowish red, sandy clay loam with many red mottles and iron concretions in the subsoil. Hazaribak consist of deep, well drained, yellowish brown sandy loam to loamy sand over unconsolidated sandstone. Kaptai soils are well drained, deep yellowish-brown to strong brown, silty clay loams. Rock fragments occur in the lower part of the soils. Moghachari soils occur in the valley bottoms that areseasonally flooded. The very deep soils are poorly drained, visible in the mottled grey and brown colours. The soil profile reflects the alluvial deposition of the sediments: layers of silty clay loam alternate with clay. Karnaphuli soils are very deep, variable mottled, indicating a moderately well drainage condition and have a dominant texture of sandy loam with layers of silt loam, loamy sand or sand as a result of sedimentation in an alluvial environment.

Agricultural considerations

Teiabil soils are relatively poor agricultural soils despite their depth and moderately fine texture. Their fertility and moisture-holding capacity are low, and their occurrence on the summits makes them easily susceptible to erosion. Extreme aridity during the dry season severely limits the agricultural potential of the Hazaribak soils. Low fertility and their occurrence in areas of steep slopes results in further moderate to severe limitations. Fertility and the moisture-holding capacity of the Kaptai soils are relatively good. Their topography is less favourable for agricultural use. Karnaphuli soils have a fairly good moisture-holding capacity and are moderately fertile. These soils occur in a flat topographic position.



SOTER unit 9

This small unit occupies a dissected plain developed on mainly unconsolidated sedimentary rocks in the Northwest of CHT There are two soil types in this unit: Rankhiang (65%) and Kaptai deep (35%). This unit is very similar to unit 7 except for the percentages of the two soils.

Rankhiang soils are deep, yellowish-brown sandy loams over semi-consolidated sandstone. Kaptai soils are well drained, deep yellowish-brown to strong brown, silty clay loams. Rock fragments occur in the lower part of the soils.

Agricultural considerations

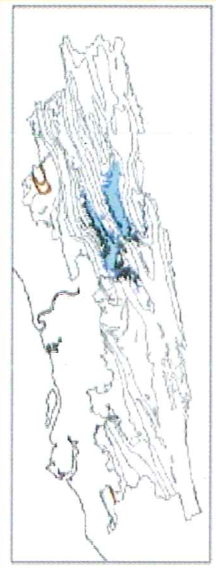
Rankhiang soils are poor agricultural soils because of their low natural fertility and moisture-holding capacity, and their occurrence on steep slopes. Fertility and moisture-holding capacity of the Kaptai soils are relatively good, but the steep slopes mean severe limitations for agricultural use.

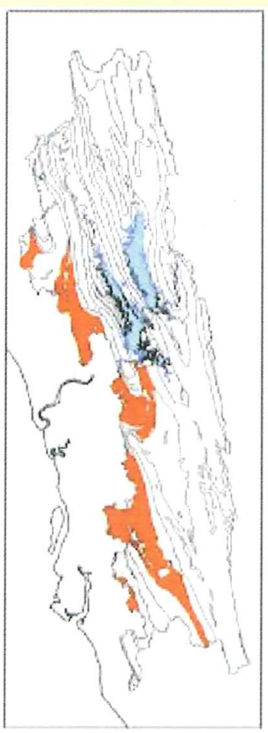
SOTER unit 10

This small unit occupies a dissected plain developed on semi-consolidated sedimentary rocks, mainly sandstone. There is one soil type in this unit: Rankhiang.

Rankhiang soils are deep, yellowish-brown sandy loams.

Agricultural considerations
Rankhiang soils are poor agricultural soils because of their low natural fertility and moisture-holding capacity.





SOTER unit 12

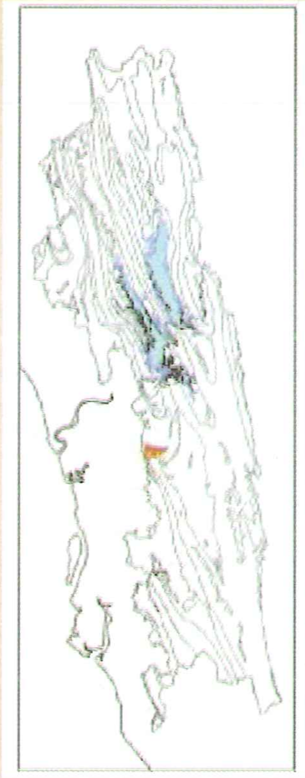
This unit is formed by the dissected plains in the western part of the CHT. They are developed on unconsolidated sandstones. Minor valleys occupy a small part of this unit. There are three soil types in the dissected plains and one in the flat valley bottoms: Hazaribak (55%), Teiabil (25%) and Kaptai deep soils (20%), and Karnaphuli (5%) respectively.

Hazaribak consists of deep, well drained, yellowish brown sandy loam to loamy sand over unconsolidated sandstone. Teiabil soils are well drained, deep, strong brown to yellowish red, sandy clay loam with many red mottles and iron concretions in the subsoil. Hazaribak soils consist of deep, well drained, yellowish brown sandy loam to loamy sand over unconsolidated sandstone. Kaptai soils are well drained, deep, yellowish-brown to strong brown, silty clay loams.

Rock fragments occur in the lower part of the soils. Karnaphuli soils are very deep, variable mottled, indicating a moderately well drainage condition and have a dominant texture of sandy loam with layers of silt loam, loamy sand or sand as a result of sedimentation in an alluvial environment.

Agricultural considerations
Teiabil soils are relatively poor agricultural soils despite their depth and moderately fine texture. Their fertility and moisture-holding capacity are low, and their occurrence on the summits makes them easily susceptible to erosion. Extreme aridity during the dry season severely limits the agricultural potential of the Hazaribak soils. Low fertility and their occurrence in areas of steep slopes results in further moderate to severe limitations. Fertility and the moisture-holding capacity of the Kaptai soils are relatively good. Their topography is less favourable for agricultural use. Karnaphuli soils have a fairly good moisture-holding capacity and are moderately fertile. These soils occur in a flat topographic position.

SOTER unit 15

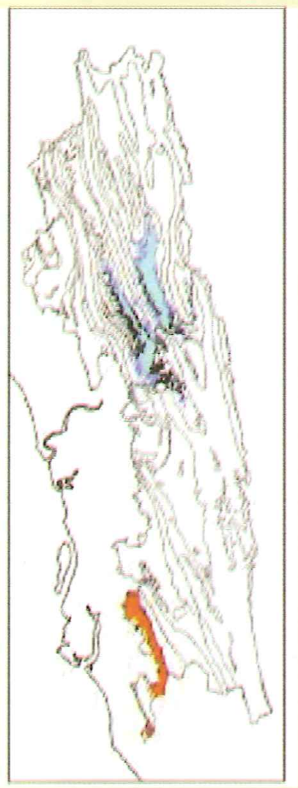


This unit is very similar to unit 12, except for a more simpler soil compostion of the disscted plain areas in the unit. There are only two soil types in the dissected plain area and one in the valley bottom: Hazaribak (60%) and Teiabil soils (25%), and Karnaphuli soils (15%) respectively.

Hazaribak soils consist of deep, well drained, yellowish brown sandy loam to loamy sand over unconsolidated sandstone. Teiabil soils are well drained, deep, strong brown to yellowish red, sandy clay loam with many red mottles and iron concretions in the subsoil. Karnaphuli soils are very deep, variable mottled, indicating a moderately well drainage condition and have a dominant texture of sandy loam with layers of silt loam, loamy sand or sand as a result of sedimentation in an alluvial environment.

Agricultural considerations

Extreme aridity during the dry season severely limits the agricultural potential of the Hazaribak soils. Low fertility and their occurrence in areas of steep slopes results in further moderate to severe limitations. Teiabil soils are relatively poor agricultural soils despite their depth and moderately fine texture. Their fertility and moisture-holding capacity are low, and their occurrence on the summits makes them easily susceptible to erosion. Karnaphuli soils have a fairly good moisture-holding capacity and are moderately fertile. These soils occur in a flat topographic position.



SOTER unit 19

The dissected plains at the foot of the hills in the Southwest of the CHT form this unit. The unit is devloped over unconsolidated rocks, mainly sandstone. There are three soil types in this unit:

Hazaribak (60%), Teiabil (25%) and Lama soils (15%) of which the first two occupy all positions in the landscape. The Lama soils occur at the foot of some of the slopes.

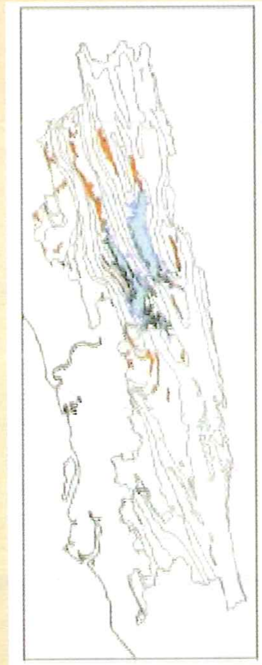
Hazaribak soils consist of deep, well drained, yellowish brown sandy loam to loamy sand over unconsolidated sandstone. Teiabil soils are well drained, deep, strong brown to yellowish red, sandy clay loam with many red mottles and iron concretions in the subsoil. Lama soils are shallow, olive brown or yellowish brown, weakly mottled silt loam to silty clay loam over fragmented siltstone.

Agricultural considerations

Extreme aridity during the dry season severely limits the agricultural potential of the Hazaribak soils. Low fertility and their occurrence in areas of steep slopes results in further moderate to severe limitations. Teiabil soils are relatively poor agricultural soils despite their depth and moderately fine texture. Their fertility and moisture-holding capacity are low, and their occurrence on the summits makes them easily susceptible to erosion.

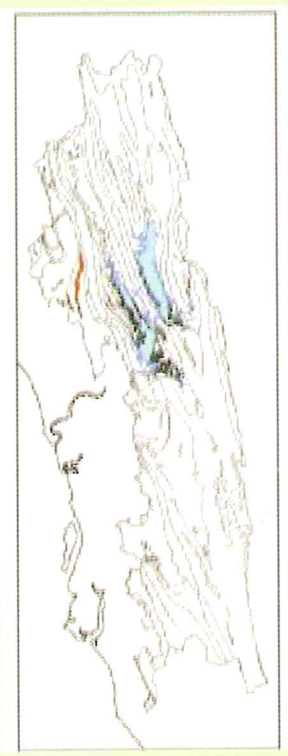
Soils on alluvial materials of the valleys and plains

SOTER unit 4



This unit consists of valleys in the medium-gradient hills and dissected plains of the CHT. The valleys are cut into unconsolidated sandstone or siltstone. The valley bottom is filled with alluvial materials on which two soil types are found: Moghachari soils (65%) on the lowest parts of the floodplain and Karnaphuli soils (35%) on the somewhat higher and better drained positions.

Moghachari soils occur in the valley bottoms that are seasonally flooded. The very deep soils are poorly drained, visible in the mottled grey and brown colours. The soil profile reflects the alluvial deposition of the sediments: layers of silty clay loam alternate with clay. Karnaphuli soils are very deep, variable mottled, indicating a moderately well drainage condition and have a dominant texture of sandy loam with layers of silt loam, loamy sand or sand as a result of sedimentation in an alluvial environment.



SOTER unit 11

This unit consists of a valley in the dissected plains of the western part of the CHT. The valley is cut into unconsolidated sandstone. The valley bottom is filled with alluvial materials on which two soil types are found: Moghachari soils (50%) on the lowest parts of the floodplain and Karnaphuli soils (50%) on the somewhat higher and better drained positions. This unit ressembles unit 4 in its compostion of soils except for their relative importance.

Moghachari soils occur in the valley bottom that is seasonally flooded. The very deep soils are poorly drained, visible in the mottled grey and brown colours. The soil profile reflects the alluvial deposition of the sediments: layers of silty clay loam alternate with clay. Karnaphuli soils are very deep, variable mottled, indicating a moderately well drainage condition and have a dominant texture of sandy loam with layers of silt loam, loamy sand or sand as a result of sedimentation in an alluvial environment.

Agricultural considerations

Moghachari soils have a good moisture-holding capacity and are moderately fertile. These soils occur in a low and flat topographic position that is prone to flooding. Karnaphuli soils have a fairly good moisture-holding capacity and are moderately fertile. These soils occur in a flat topographic position.

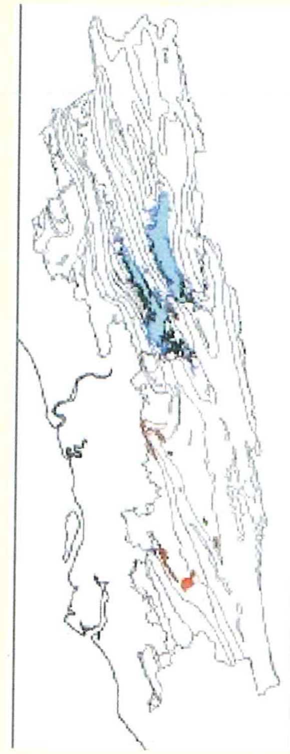
SOTER unit 16

This unit is formed by the valleys of the some of the larger rivers in the southern part of the CHT (Sangu and Matamuhuri rivers) .Two soils occur in these valleys: coarse textured Karnaphuli soils (65%) and somewhat finer textured Ruma soils (35%).

Karnaphuli soils are very deep, variable mottled, indicating a moderately well drainage condition and have a dominant texture of sandy loam with layers of silt loam, loamy sand or sand as a result of sedimentation in an alluvial environment. Ruma soils are also very deep, variable mottled, indicating a moderately well drainage condition and have a dominant texture of silt loam with layers of sandy loam or silty clay loam.

Agricultural considerations

Karnaphuli soils have a fairly good moisture-holding capacity and are moderately fertile. These soils occur in a flat topographic position. The Ruma soils have similar properties with a slightly better moisture-holding capacity.



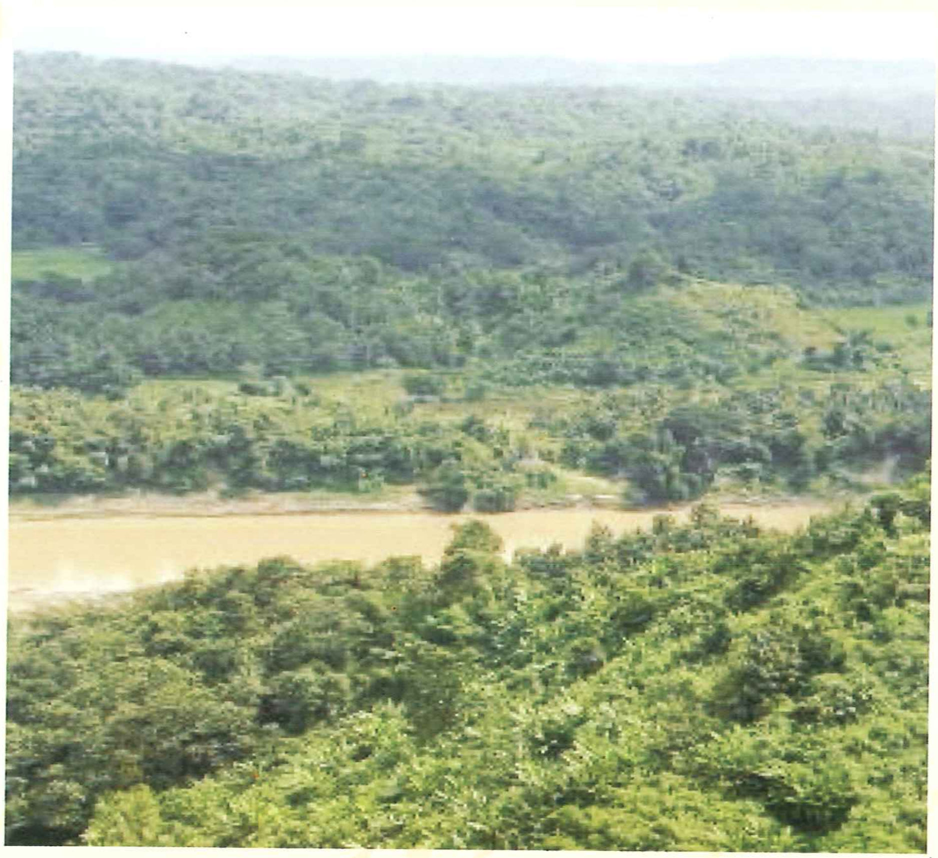
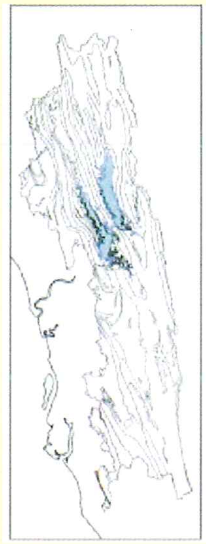


Figure 3.12: Sangu valley with Karnaphuli and Ruma soils

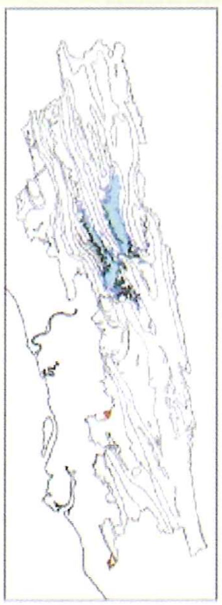


SOTER unit 17

This unit is formed by small areas of the Chittagong coastal plains that occur in the extreme Southwest of the CHT. The unit is developed on colluvial materials washed out from the hills. Flooding of these areas occurs regularly in the rainy season. There is one soil type in this unit.

Mirsarai soils consist of deep, poorly drained, mottle, grey, silt loam.

Agricultural considerations
Mirsarai soils have a good moisture-holding capacity and are moderately fertile. These soils occur in a low and flat topographic position that is prone to flooding.

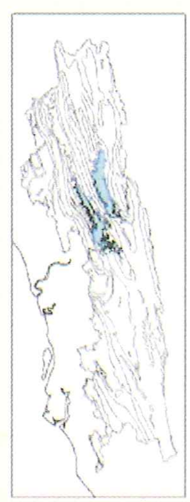


SOTER unit 18

This unit is formed by small tracts of land that are the extension of the Chittagong coastal plains. The unit is developed on colluvial and alluvial materials washed out from the hills. Flooding of these areas occurs regularly in the rainy season. There are two soil types in this unit: Rangamati (65%) on the higher positions and Salban soils (35%) in the lower parts of the unit.

Rangamati soils are deep, well drained, strong brown silty clay loam to silty clay. Salban soils are deep, moderately well drained, slightly mottled, yellowish brown silty loam.

Agricultural considerations
Both soils have a good moisture-holding capacity and are moderately fertile. The Salban soils have slightly impeded drainage conditions.



SOTER unit 20

This unit forms a small part of the coastal plains at the Southwestern fringe of the CHT. There are two soil types in this unit: Subalong (60%) and Jaldi soils (40%).

Subalong soils consist of deep, excessively well drained, yellowish brown, loam on the higher parts of the unit. Jaldi soils are deep, well drained, yellowish brown, silty clay in the lower terrain positions.

Agricultural considerations
Fertility and the moisture-holding capacity of both soils are relatively good.

Table 3.1: Major characteristics of the Soil and Terrain (SOTER) mapping units

SOTER unit	Lithology	Landform	Soils	%	Soil characteristics
1	Consolidated sandstones and siltsones	High-gradient hills (higher parts)	Kaptai (deep)	60	Deep, yellowish-brown to strong brown, silty clay loam, rock fragments in subsoil
			Kaptai (shallow)	25	Shallow, yellowish-brown to strong brown, silty clay loam, rock fragments in subsoil
			Belaichari	15	Shallow, yellowish-brown, sandy loam, with pieces of rock over hard sandstone
2	Consolidated sandstones and siltsones	High-gradient hills (lower parts)	Kaptai (deep)	60	Deep, yellowish-brown to strong brown, silty clay loam, rock fragments in subsoil
			Rankhiang	15	Deep, yellowish-brown sandy loam
			Kankrachari	25	Shallow to deep, light olive-brown with some mottles, silty clay loam to silty clay
3	Unconsolidated sandstones	Dissected plains	Teiabil	67	Deep, strong brown to yellowish red, sandy clay loam with many red mottles and iron concretions in the subsoil
			Hazaribak	33	Deep, yellowish brown sandy loam to loamy sand.
4	Alluvial deposits	Valley	Moghachari	65	Very deep, poorly drained, mottled grey and brown silty clay loamand clay layers
			Karnaphuli	35	Very deep, moderately well drained, yellowish-brown, mottled, sandy loam with layers of silt loam, loamy sand or sand
5	Consolidated sandstones and siltsones	High-gradient hills (lower parts)	Kaptai (deep)	65	Deep, yellowish-brown to strong brown, silty clay loam, rock fragments in subsoil
			Kaptai (shallow)	35	Shallow, yellowish-brown to strong brown, silty clay loam, rock fragments in subsoil
6	Unconsolidated sandstones	Dissected plains	Hazaribak	61	Deep, yellowish brown sandy loam to loamy sand.
			Kaptai (deep)	34	Deep, yellowish-brown to strong brown, silty clay loam, rock fragments in subsoil

SOTER unit	Lithology	Landform	Soils	%	Soil characteristics
			Karnaphuli	5	Very deep yellowish-brown, mottled, sandy loam with layers of silt loam, loamy sand or sand
7	Consolidated sandstones	Medium-gradient hills	Kaptai (deep)	65	Deep, yellowish-brown to strong brown, silty clay loam, rock fragments in subsoil
			Rankhiang	35	Deep, yellowish-brown sandy loam
8	Unconsolidated sandstones	Dissected plains	Teiabil	55	Deep, strong brown to yellowish red, sandy clay loam with many red mottles and iron concretions in the subsoil
			Hazaribak	20	Deep, yellowish brown sandy loam to loamy sand.
			Kaptai (deep)	15	Deep, yellowish-brown to strong brown, silty clay loam, rock fragments in subsoil
			Moghachari	5	Very deep, poorly drained, mottled grey and brown silty clay loamand clay layers
			Karnaphuli	5	Very deep, moderately well drained, yellowish-brown, mottled, sandy loam with layers of silt loam, loamy sand or sand
9	Unconsolidated sandstones	Dissected plains	Rankhiang	65	Deep, yellowish-brown sandy loam
			Kaptai (deep)	35	Deep, yellowish-brown to strong brown, silty clay loam, rock fragments in subsoil
10	Unconsolidated sandstones	Dissected plains	Rankhiang	100	Deep, yellowish-brown sandy loam
11	Alluvial deposi	Valley	Karnaphuli	50	Very deep, moderately well drained, yellowish-brown, mottled, sandy loam with layers of silt loam, loamy sand or sand
			Moghachari	50	Very deep, poorly drained, mottled grey and brown silty clay loamand clay layers
12	Unconsolidated sandstones	Dissected plains	Hazaribak	55	Deep, yellowish brown sandy loam to loamy sand.

SOTER unit	Lithology	Landform	Soils	%	Soil characteristics
			Teiabil	25	Deep, strong brown to yellowish red, sandy clay loam with many red mottles and iron concretions in the subsoil
			Kaptai (deep)	20	Deep, yellowish-brown to strong brown, silty clay loam, rock fragments in subsoil
			Karnaphuli	5	Very deep, moderately well drained, yellowish-brown, mottled, sandy loam with layers of silt loam, loamy sand or sand
13	Consolidated sandstones and siltstones	High-gradient hills (lower parts)	Kaptai (deep)	55	Deep, yellowish-brown to strong brown, silty clay loam, rock fragments in subsoil
			Kankrachari	24	Shallow to deep, light olive-brown with some mottles, silty clay loam to silty clay
			Belaichari	14	Shallow, yellowish-brown, sandy loam, with pieces of rock over hard sandstone
			Karnaphuli	7	very deep yellowish-brown, mottled, sandy loam with layers of silt loam, loamy sand or sand
14	Consolidated sandstones and siltstones	Medium-gradient mountains	Kaptai (deep)	70	Deep, yellowish-brown to strong brown, silty clay loam, rock fragments in subsoil
			Belaichari	30	Shallow, yellowish-brown, sandy loam, with pieces of rock over hard sandstone
15	Unconsolidated sandstones	Dissected plains	Hazaribak	60	Deep, yellowish brown sandy loam to loamy sand.
			Teiabil	25	Deep, strong brown to yellowish red, sandy clay loam with many red mottles and iron concretions in the subsoil
			Karnaphuli	15	Very deep, moderately well drained, yellowish-brown, mottled, sandy loam with layers of silt loam, loamy sand or sand

SOTER unit	Lithology	Landform	Soils	%	Soil characteristics
16	Alluvial deposits	Valley	Karnaphuli	65	Very deep, moderately well drained, yellowish-brown, mottled, sandy loam with layers of silt loam, loamy sand or sand
			Ruma	35	Very deep, moderately well drained, mottled, light olive brown, silt loam with layers of sandy loam or silty clay loam
17	Colluvial and alluvial deposits	Plain	Mirsarai	100	Deep, poorly drained, mottle, grey, silt loam
18	Colluvial and alluvial deposits	Plain	Rangamati	65	Deep, well drained, strong brown silty clay loam to silty clay
			Salban	35	Deep, moderately well drained, slightly mottled, yellowish brown silty loam
19	Unconsolidated sandstones and siltstones	Dissected plains	Hazaribak	60	Deep, yellowish brown sandy loam to loamy sand.
			Teiabil	25	Deep, strong brown to yellowish red, sandy clay loam with many red mottles and iron concretions in the subsoil
			Lama	15	Shallow, olive brown or yellowish brown, weakly mottled silt loam to silty clay loam over fragmented siltstone
20	Colluvial and alluvial deposits	Plain	Subalong	60	Deep, excessively wel drained, yellowish brown, loam
			Jaldi	40	Deep, well drained, yellowish brown, silty clay

Chapter 4

Climate

4.1 Introduction

The climate has an important role in the development of vegetation and production of agricultural crops. Extreme climatic factors increase environmental hazards like landslides, droughts and soil erosion. Heavy rainfall damages crops in the field and washes out the top soil nutrient from barren land. The erratic behavior of rainfall distribution poses a threat for timely agricultural crop production. Droughts also hamper crop production with reduction in yield level. Its severity reduces the amount of available water for domestic and drinking purposes and places the community in a more vulnerable situation. This chapter provides an overview of the climate and its spatial and temporal variations in the CHT area.

4.2 Data sources

The number of climate stations for the CHT is limited. Climatic parameters were investigated for the CHT area using time-series data from the Bangladesh Water Development Board (BWDB) and the Bangladesh Meteorological Department (BMD). Daily rainfall data was collected from BWDB for an extensive period of time (1960-2002). The information is stored in the National Water Resources Database (NWRD) of the Water Resources Planning Organization (WARPO). Other climatic factors such as humidity, sunshine, wind speed and temperature data were collected from BMD. However, it should be noted that there are many gaps in the BWDB and BMD data, and some anomalies in the data caused some stations to be omitted. Climatic stations were selected based on the Thiessen polygon method and 12 BWDB rainfall and 6 BMD climatic stations were used to analyse the conditions. Table 4.1 (See map 4.1) shows the list of stations along with the polygon boundaries of the contributing areas.

Table 4.1: Climatic stations near CHT with location

Data	Station ID	Station Name	Degree Decimal	
			Long.	Lat.
Precipitation	303	Bandarban	92.19	22.22
	310	Dulahazara	92.32	21.66
	315	Kaptai	92.21	22.5
	317	Lama	92.2	21.77
	319	Manikchari	91.83	22.84
	322	Nakhyongochari	92.19	21.42
	323	Narayanhat	91.71	22.8
	324	Nazirhat	91.88	22.68
	327	Ramgarh	91.74	22.98
	328	Rangamati	92.18	22.65
	330	Rangunia	92.08	22.46
	332	Satkania	92.07	22.09

Data	Station ID	Station Name	Degree Decimal	
			Long.	Lat.
Climatic Parameters	11912	Sitakunda	91.66	22.61
	11921	Chittagong	91.81	22.26
	11925	Kutubdia	91.86	21.82
	11927	Cox s Bazar	91.97	21.44
	11929	Teknaf	92.3	20.86
	12007	Rangamati	92.18	22.65

Map 4.1: Hydrometereological stations in the CHT

4.3 Climate

The CHT region experiences a tropical monsoon climate. Annual temperatures vary from 10° to 35°C. A mean minimum temperature of 24°C is experienced during the months of December to January) and a maximum temperature of 34°C during March to May. The dry and cool season is from November to March; the pre-monsoon season (April-May) is hot and sunny; and the monsoon season (June to October) is warm, cloudy and wet. Wind blows from a south-westerly direction during the warm season but from a northerly direction during the cool season. The commencement of the rains in late April is usually accompanied by electrical storms.

Rainfall

The mean annual total rainfall varies from 2400-3800mm in the CHT area. The rainfall distribution in the CHT area is shown in Table 4.2 for both the dry and wet seasons. The Bandarban district experiences the highest rainfall, with the other two districts having similar rainfall distribution. The wet season rainfall is approximately 70-80% of the annual total and the dry season rainfall varies from 18-24%.

Table 4.2: Rainfall distribution in the CHT area

CHT Districts	Mean annual rainfall (mm)	Dry season		Wet season	
		Rainfall (mm)	% of annual rain	Rainfall (mm)	% of annual rain
Bandarban	3121	550	18	2571	82
Rangamati	2419	544	23	1874	77
Khagrachhari	2508	607	24	1901	76

Rainfall increases from North to South-West-South in the CHT (see figure 4.3a).

Temperature

The mean annual temperature is approximately 26° C and the mean minimum and maximum temperature varies from 22-30° C. High temperatures are observed between March and October, and the lowest temperatures during the month of January. The maximum highest temperature was recorded at 40.5° C during May 1995 and the lowest recorded minimum temperature was 5.5° C in February 1961. Over the last few decades, the yearly maximum temperature has been increasing whereas the minimum temperature has remained almost stable. An increasing trend in temperature is observed from 1995 onwards.

The mean humidity is approximately 78% in Bandarban and 76% in Khagrachhari and Rangamati. The maximum humidity is observed during July and August and the minimum in the months of January and February.

The daily total sunshine hours range from four to eight hours in the CHT area. In the monsoon season the mean sunshine hours are around four to five hours; and during the dry season, it varies from seven to eight hours. High wind velocity is observed in the southern part of the CHT area. Mean wind speed is approximately 170 knots per day (kpd), or 315 kilometres per hour, in Bandarban and 103 kpd (190 kph) in Rangamati and Khagrachari. High wind speed is generally observed in the months of June, July and August and low wind speed in the months of November and December.

The annual total Evapo-transpiration (ET) in the CHT area varies from 1250-1350 mm. The highest ET is generally observed in the southern part of the CHT, especially in the Bandarban area. Table 4.3 shows the monthly variation of ET in the three districts of the CHT along with the dry and wet season demands.

Table 4.3: Evapo-transpiration in the CHT area (mm)

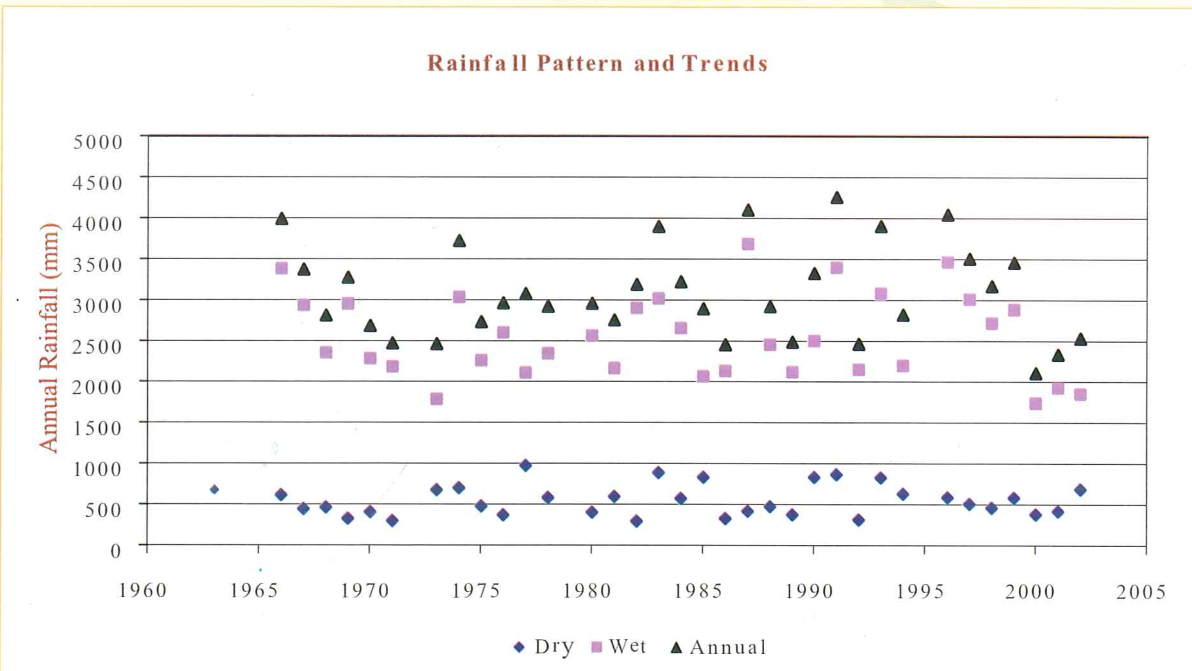
Districts	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	Wet	Dry
Bandarban	87	100	136	148	152	114	107	113	113	112	92	82	1356	560	796
Rangamati	70	86	126	138	142	114	106	113	106	103	80	68	1251	541	709
Khagrachhari	71	86	126	136	142	115	110	113	109	105	82	68	1262	551	711

Source: NWMP (2001)

4.4 Precipitation changes

Figure 4.1 shows the annual total rainfall pattern for Bandarban District. A prominent change in rainfall distribution on a decadal basis (average 10 year window) is observed in the CHT. Figure 4.1 shows the decreasing trend of rainfall from 1960 to 1970 and the increasing trend for the next 10 years' time period in Bandarban District. Similar trends are observed for the Khagrachhari and Rangamati districts (Annex A).

Figure 4.1: Annual rainfall trends in the CHT (Bandarban District)



The distribution of rainy days shows no prominent variation in the CHT. In the dry season there is precipitation 14% of the time but during the monsoon season, rainy days are observed 75% of the time.

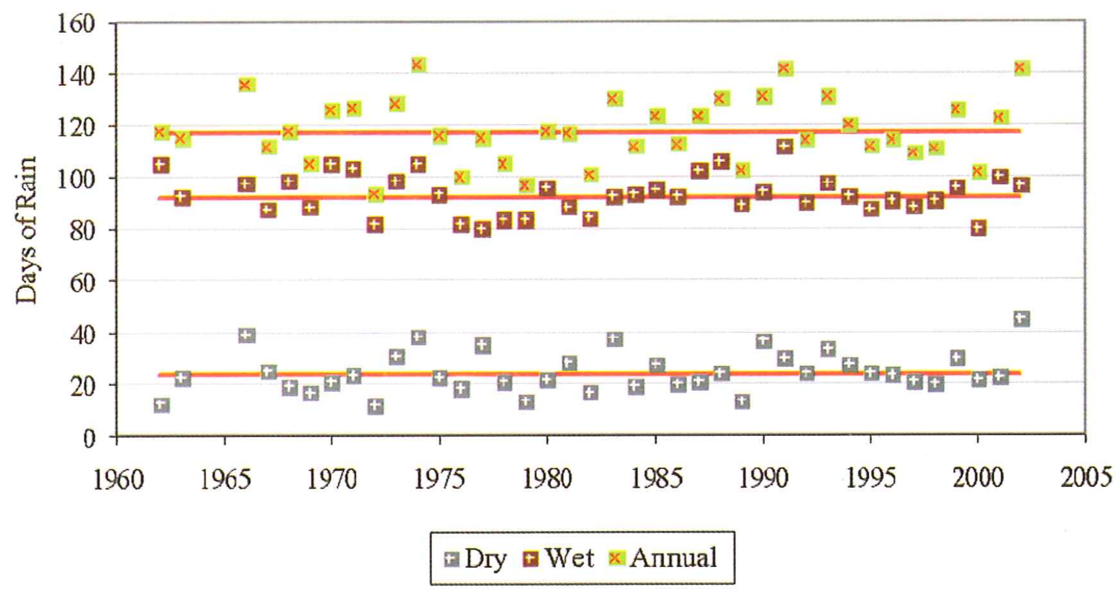
Low rainfall results in high water demand from alternative sources for agriculture crop production as well as domestic and industrial uses. Figure 4.2 shows the pattern of rainy day distribution in Bandarban District. Rainfall distribution is a causative parameter for observing climate change.

Table 4.4: Number of rainy days in the CHT

CHT Districts	Dry season	Monsoon season	Annual total
Bandarban	11 - 45	80 - 112	92 - 143
Khagrachari	15 - 48	60 - 97	76 - 130
Rangamati	15 - 45	72 - 100	87 - 142

There is little variation in climatic parameters between the three districts in the study area (see Annex A). The climatic parameters investigated included rainfall pattern, and distribution, temperature variability, wind speed, sunshine and humidity pattern determine how much these parameters have changed in the last 30 years. Climate change was addressed specifically to measure the influence of climate on natural resources, mainly agriculture, fisheries and forest).

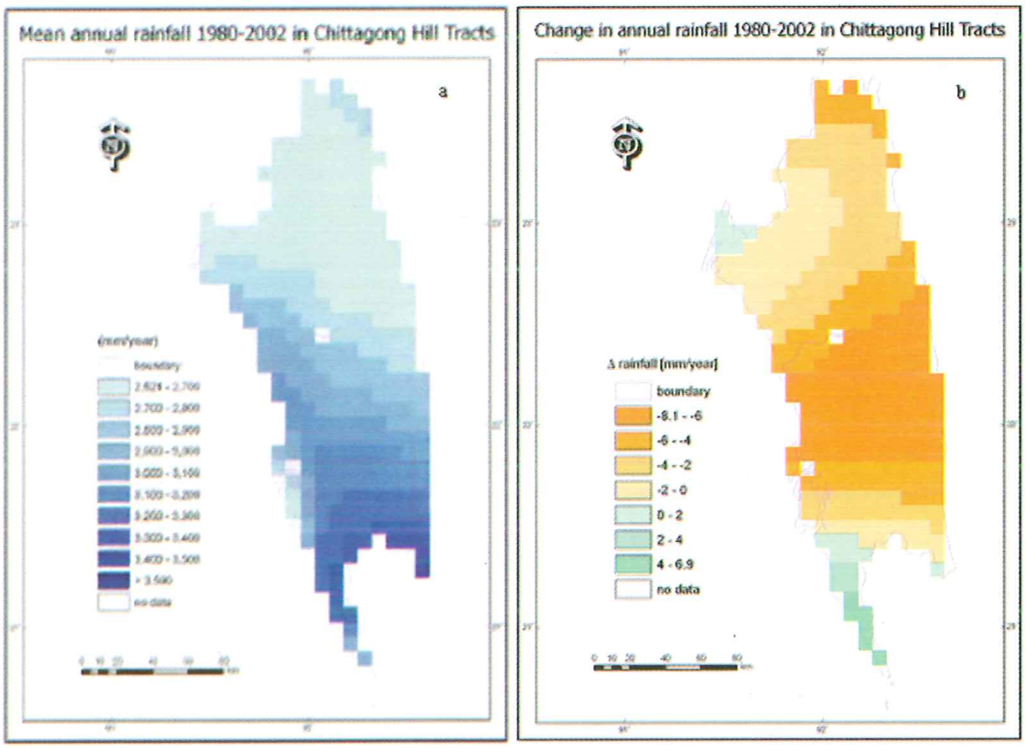
Figure 4.2: Distribution of Rainy Days (Bandarban District)



The spatial pattern and temporal variation in rainfall in the CHT was studied in more detail. The study was done to analyze spatial rainfall patterns and changes over time (Bai, 2006). It was based on a dataset of 1224 monthly grids of meteorological station-observed data, for the period 1901-2002, covering the global land surface at the 0.5 degree resolution. The data includes monthly mean climatology (1961-1990) and time series (1901-2002) of various climate variables, using a thin-spline interpolation considering elevation effects. Data were available for nine climate variables: daily mean, minimum and maximum temperature, diurnal temperature range, precipitation, wet day frequency, frost day frequency, vapor pressure and cloud cover (Mitchell et al., 2005). Monthly precipitation data from the CRU TS 2.1 dataset from January 1980 to December 2002 were used for this study.

Six locations were visited in the field for ground control. Local elderly people and village leaders were interviewed for information on land use changes between 1980 and 2002. In five out of 6 cases of the control points, people observed an increase in temperature and a decrease in rainfall over the past 2-3 decades. The rainfall decrease, although small in magnitude (max 8mm over 2 decades), is confirmed in this regional study. A moderate correlation between biomass and precipitation and temperature was found (correlation coefficients of 0.74 and 0.49, respectively).

Figure 4.3: Spatial pattern (a) and temporal trend (b) in annual rainfall 1980-2002 (Bai 2006)



4.5 Rainfall Excess-Deficit

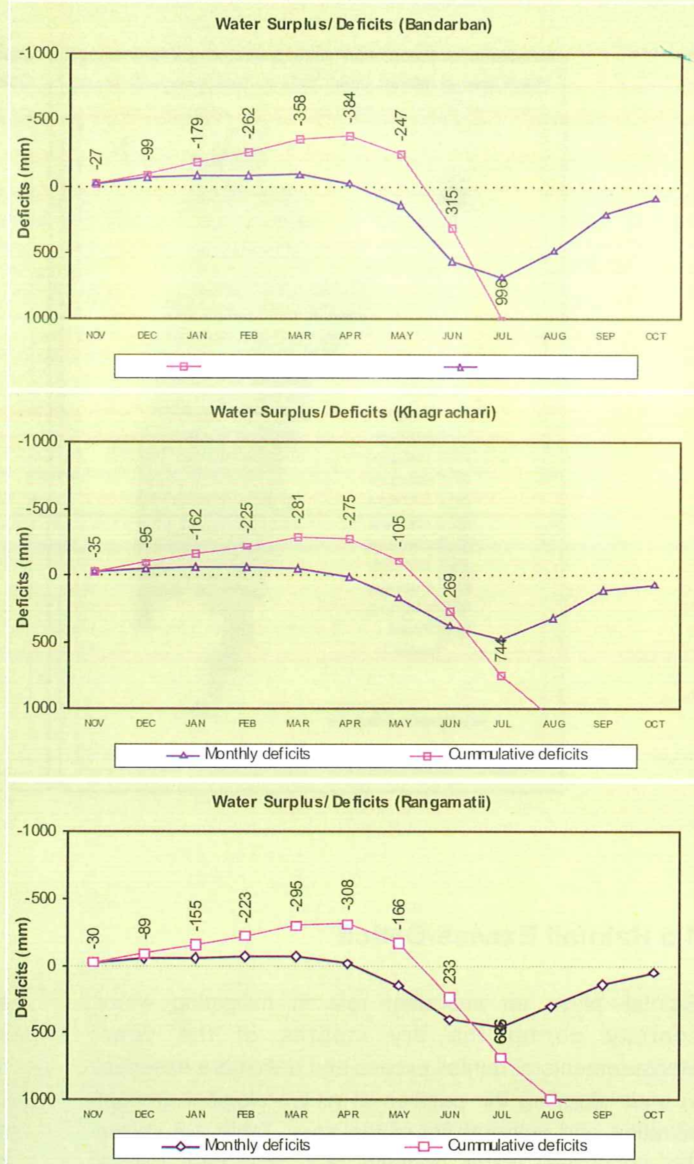
Rainfall plays an important role in mitigating water scarcity during the dry months of the year. Measurements of rainfall excess and deficit are essential in understanding the position of meteorological drought situation and vulnerability of the area. Table 4.5 shows the agriculture water demand (ET) and total rainfall amount in the CHT areas for dry and wet seasons. It shows that the water deficit exists in the dry months of the year, as the demand is higher than the total rainfall. During the dry season, the rainfall meets only 60-80% of the ET requirement indicating a shortage of rainfall for meeting agricultural demands.

Table 4.5: Seasonal balance of rainfall excess and deficit (mm)

Season	Parameter	Bandarban	Khagrachari	Rangamati
Monsoon season (June-October)	50% Dependable Rain (R)	2492	1800	1780
	80% Dependable Rain (DR)	2115	1410	1490
	ETo	559	552	542
	R - ETo	1933	1248	1238
	DR - ETo	1556	858	948
Dry season (November - May)	50% Dependable Rain (R)	504	565	530
	80% Dependable Rain (DR)	375	380	327
	ETo	797	712	710
	R - ETo	**-293**	**-147**	**-180**
	DR - ETo	**-422**	**-332**	**-383**

Figure 4.4: Water Surplus/ Deficits in the CHT (Annual mean rainfall and ET condition).

During the monsoon season, the availability of rainfall matches the crop water demand. During the dry season the deficit is higher than the demand. Demand builds up during the dry months of the year and maximizes in April. Due to the onset of the monsoon season, the rainfall amount increases in the CHT area and water deficit is reduced appreciably, showing a surplus beginning from June.



4.6 Agro-climatic Resources

The CHT area falls under one major agro-ecological region, which is categorized as the North and Eastern Hills. It is also subdivided into a sub region based on soil differences, seasonal flooding and thermal characteristics. Analses of the regional climate of Bangladesh shows two kinds of thermal zones: Rabi temperature zones (T zones); Extreme summer temperature zones (e zones).

Agro-climatically, the entire region of Rangamati, Khagrachari and Bandarban falls under T_{3-4}, e_1, K_6 and p_4 zones (Table 4.6 to 4.9). The line representing the length of crop growing period shown on the agro-eocological map is based on a water balance model. This model relates daily rainfall to the average potential evapo-transpiration rate for each month against a reference available soil storage capacity of 100 mm of moisture in the Kharif season and 250 mm in the Rabi season. The eastern part of the CHT area is relatively cooler than the South-western side with a variation of 10 days and with below 10 °C temperatures.

Table 4.6: Generalized minimum temperature characteristics of thermal (T) zones

Thermal zone	Minimum temperatures					
	<15.0 ^{0}C		<17.5 ^{0}C		<20.0 ^{0}C	
	Days	Period	Days	Period	Days	Period
T3	50 - 70	6 Dec - 4 Feb	80 - 105	24 Nov -14 Feb	30 - 50	10 Nov - 10 Mar
T4	70 - 90	29 Nov - 17 Feb	105 - 120	15 Nov - 9 Mar	40 - 70	2 Nov - 26 Mar

Source: Brammer, 1986; SRDI, 1996-2002

Table 4.7: Maximum temperature characteristics of extreme temperature (e) sub-zones

Extreme temperature zone	Occurrence (days) of maximum temperatures >40^{0}C
e1	0.0 - 0.5

Source:Brammer, 1986; SRDI, 1996-2002

Table 4.8: Generalized moisture characteristics of pre-Kharif transition period (p) zones

Zone	Pre-Kharif days	Transition Period	Dry days	Moist days
p4	40-50	24 Mar - 8 May	24-32	16-18

Source: Brammer, 1986; SRDI, 1996-2002

Table 4.9: Generalized moisture characteristics of pre-Kharif transition period (p) zones

Zone	Kharif growing period		Rabi growing period (R250)	
	Days	Period	Days	Period
K6	220-230	3 May-14 Dec	120-145	21 Oct-2 Mar

Source: Brammer, 1986; SRDI, 1996-2002

Chapter 5

Water Resources

5.1 Introduction

Water is essential to life and livelihood. For drinking, bathing, washing, sanitation and other domestic purposes, people use water from different sources. In the CHT, the main sources of water are the surface water of rivers, lakes, canals and springs, and groundwater from shallow and deep aquifers. Rainwater is an alternative source of water in those areas of the CHT where rainfall is comparatively high. In the CHT water is mainly used for drinking, household, irrigation and commercial purposes. The people in the CHT suffer from different water-related diseases due to the scarcity of safe water and lack of knowledge about proper hygiene.

This chapter will discuss the demand and availability of water and also its importance in relation to the environment of the CHT area. The complexity of the water resources system of the CHT area is comparatively less than other hydrological regions of the country. Primary information, as well as different studies and projects carried out by other agencies, were considered to assess the demand, availability, and degree of impact of water scarcity on other natural resources in the region. The water quality was also considered.

5.2 Surface water

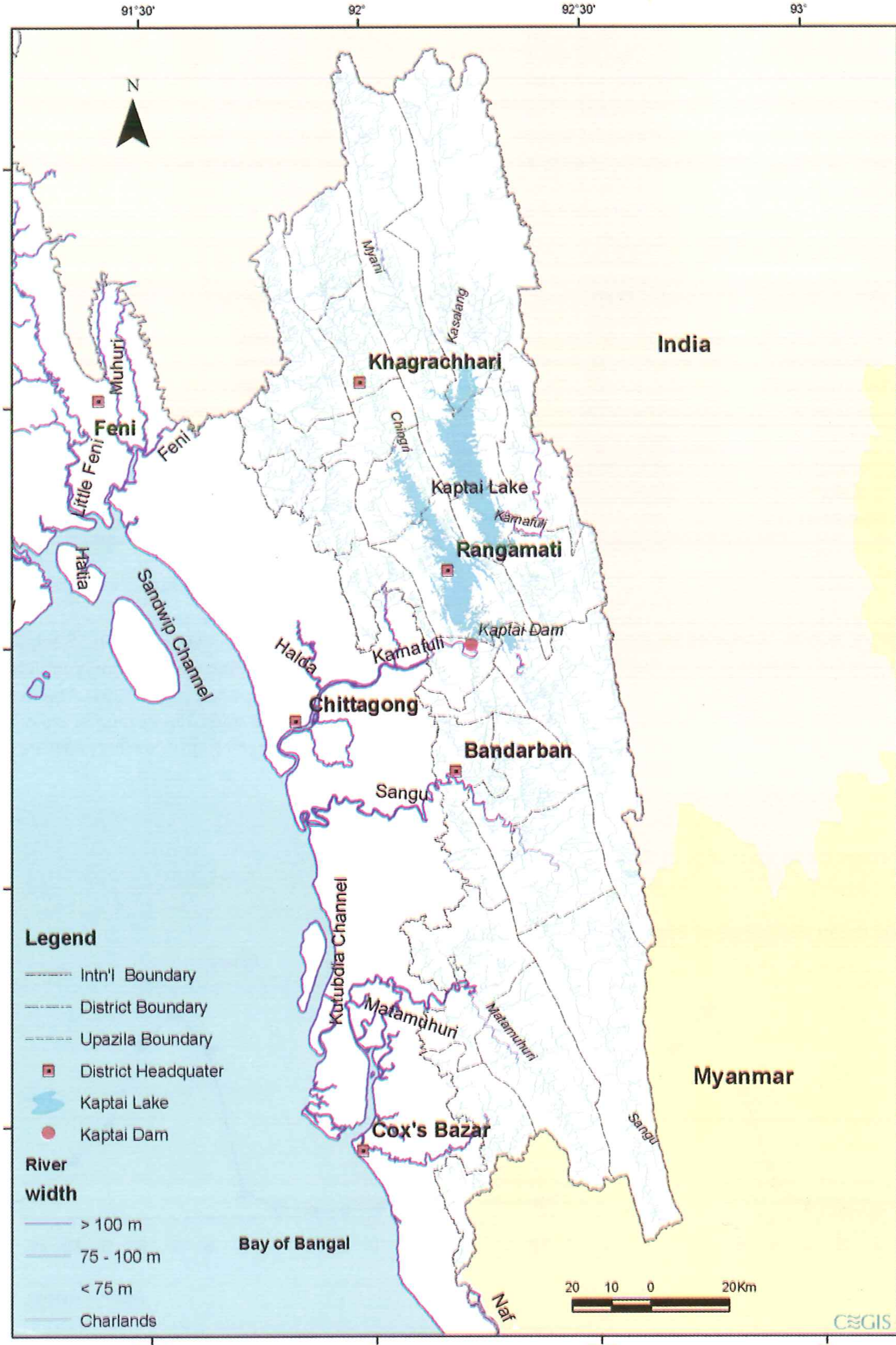
The main source of surface water is rainfall. Surface and groundwater resources are dependent on each other. Depending upon climatic conditions and the relationship between surface and groundwater, many streams receive a major portion of their flow from groundwater. On the other hand, surface streams can also be the main sources of groundwater recharge. In general, groundwater flows into the surface water bodies in the dry season and surface water enters into the ground during the monsoon. Therefore, use of one source usually affects water availability from other sources. In the overall CHT region, surface water mainly comes from springs, streams, canals, rivers and lakes.

5.2.1 River system

The typical drainage patterns on hill slopes consist of a dense dendritic network of gullies fanning out into winding valleys. Most of the rivers in the CHT area flow in a north-south direction. The northern catchments of the CHT area are drained by the Karnafuli River and its tributaries (Chengri, Myani and Kasalong), while in the south the Sangu River constitutes the main drainage system. These rivers have cut deep gorges in a southwest direction before entering the coastal plain and ultimately draining into the Bay of Bengal. In the Chittagong coastal plain, these rivers meander as a result of reduced flow and large quantities of sediment.

About 1400 km of river that flows over the CHT region comprises five rivers mainly named Chengri, Myani, Karnafuli, Matamuhuri and Sangu. These major rivers flowing through the CHT originate outside the country. The three major rivers in the north originate in Tripura and flow south towards Bangladesh into the Kaptai reservoir. Before the creation of the Kaptai reservoir, the Chengri River and Myani River flowed into the Karnafuli River. The Matamuhuri and Sangu Rivers originate in the mountains of Myanmar. All these rivers contribute to the Kaptai reservoir.

Map 5.1: River System with Charas of the CHT



Due to the construction of a hydroelctric dam on the river Karnafuli in the early 1960s, an artificial lake, the Kaptai reservoir, was created. Because of seasonal variations, the reservoir area varies between 55,000 and 68,000 hectares (Chittagong Hill Tracts Region Development Report, ADB report). Usually, the highest water coverage occurs in June and the lowest in November. The Kasalong and Myani tributaries of the Karnafuli River drain into the lake, which is intensively used for culture fisheries and riverway transport.

The length of the Sangu, Karnaphuli and Matamuhuri in Chittagong Region are 287 km, 180 km and 161 km respectively. About 58% of the Sangu River and 40% of the Karnaphuli River flow through the CHT. In Bandarban, the Sangu is the longest river with a length of 176 km. During the wet season, the width of any of the rivers Matamuhuri, Karnafuli and Rangkhaing can be as wide as 100 m or more. The Bagabili, Halda, Dighalchari and Chatrachara rivers also spring back to life in the wet season.

Table 5.1: Major rivers of the CHT

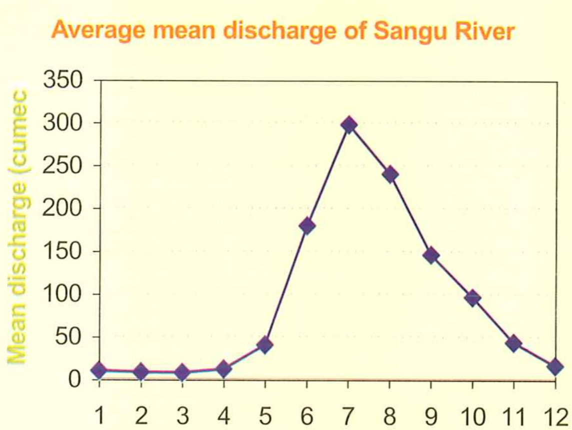
Sl. No.	River Name	Length (km)	Width (m)	Passing District	Originate From
1	Matamuhuri R	97	Above 100	Bandarban	Myanmar
2	Karnafuli R	90	Above 100	Rangamati	Mijoram
3	Rangkhaing R	47	Above 100	Rangamati	Bangladesh
4	Sangu R	177	50-100	Bandarban	Myanmar
5	Myani R	65	50-100	Khagrachari	Tripura
6	Chingri R	86	25-50	Khagrachari	Tripura
7	Feni R	56	25-50	Khagrachari	Tripura
8	Baghkhali R	14	25-50	Bandarban	Bangladesh

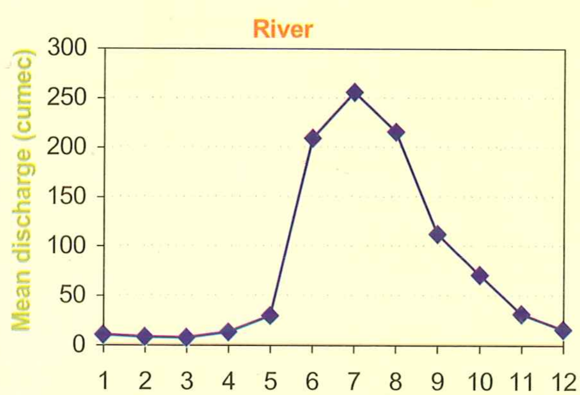
Source: CHARM Project, 2006

The total length of *charas* connected to the rivers and spreading over the CHT region is more than 7,200 km. Among them, 40% flows over Rangamati and 30% in both Bandarban and Khagrachari. These *charas* are steep and so they cannot hold water for long. When these *charas* meet rivers they are flushed out. About 862 km of khals connected to *charas* and rivers flow during the wet season.

The maximum average discharge in Sangu and Matamuhuri River varies between 300 m^3/s in July and below 25 m^3/s in the dry period (1965-1994). The rivers of the CHT region and their approximate length, width, place of origin, and the districts through which they flow are given in the following table.

Figure 5.1: Average mean discharge of Sangu and Matamuhuri rivers





Source: NWRD, 2002

The maximum discharge of the Matamuhuri River was observed to be 4980 m^3/s at the Bandarban station in 1984, and of the Sangu River 3530 m^3/s at the Lama Station in 1990. The maximum discharge occurs from June to August and the minimum flow is usually observed from January to April. The annual average discharge of the Matamuhuri River is 860 m^3/s and that of the Sangu River is about 1100 m^3/s. About 12% of average discharge is observed in the dry season in both rivers.

Table 5.2 shows the water level variations of the major rivers of the CHT area. Daily time series water level data of BWDB are analyzed for a period of 1962 to 2002. Highest water level is observed during the month of July and lowest in March.

Table 5.2: Water level of major rivers in the CHT region (PWD, m)

River	Station	2001		2002		Historical	
		Highest	Lowest	Highest	Lowest	Highest	Lowest
Matamuhuri	Lama	11.18	6.28	13.06	6.27	15.06	5.23
Sangu	Bandarban	11.76	4.84	14.24	4.9	20.64	3.74

Source: NWRD

5.2.2 Perennial waterbodies

The total area occupied by the perennial waterbodies within the CHT region is about 55 thousand hectares of which Kaptai Lake covers about 48 thousand hectares. Kaptai Lake spreads over Rangamati, Langadu Barkal, Nanear Chhari, Jaraichhari, Kaptai and Belaichhari thanas. The lake water area varies between 26,800 hectares in May and a maximum of 74,200 hectares area in October (BBS, 2004). On an average it stores about 43% of water of all the perennial waterbodies in the CHT.

With the commissioning of the Kaptai dam over the river Karnafuli in 1962, nearly 22,000Êhectares of flat, alluvial land were submerged. In addition, 24,000 hectares of sloping foot hills were also submerged. The Kaptai dam project was commissioned with the objective of generating cheap hydroelectric power to mitigate the power crisis of Dhaka and other cities. The initial environmental and social costs of the project were tremendous and have multiplied with the passage of time.

The creation of Kaptai Lake has greatly affected agricultural production in Rangamati District by submerging its fertile land. According to the rule curve for water levels, the water level at the dam site should remain below 27.5m from April to August so that the farmers can grow one crop (Aus or Boro) in the fringe valleys. Apparently, this rule was not respected in the last few years, resulting in the loss of paddy crop in the valleys. Furthermore, the maximum water level in the rainy season also seems to have increased significantly (33.5m in September), leading to huge loss of land that used to be available for monsoon vegetable production.

The fringe valley area was estimated to be about 9,000 hectares. It is not known how much of this was affected by the change in water level regulation. According to DAE-Rangamati estimates, it may be as much as 5,000 hectares. Several communities were interviewed at different locations along the borders of the lake and in the upstreams in order to obtain an idea about how they were affected from the increased water level. It was realised that paddy cultivation and summer vegetable production were severely affected. The total area damaged may reach well over 9,000 hectares including thousands of small plots, which were important for subsistence.

It was also observed that hilly rivers passing through V-shaped gorges could inundate the banks. The Thanchi and Lama bazars are regularly flooded by flash floods from the Shangu and Matamuhri rivers. Panchhari is flooded by Chengi River. The affected areas usually remain waterlogged for a few days after every flood and causes severe damage. The areas are often lashed by cyclones. Landslides are common during the rnonsoon. People report that landslides occur from soil erosion, deforestation, and faulty agricultural practices, etc,. Landslides also cause increased siltation in the rivers. In Lama, people have suggested digging a river loop to prevent regular flooding (Source: Quamrul Islam Chowdhury, Sustainable Development Networking Program).

5.3 Groundwater

The availability and quality of groundwater in Bangladesh is greatly related to and controlled by the major physiographic units of the country. The whole country is divided into three major physiographic units: the Holocene Plains, the Pleistocene Uplands, and the Tertiary Hills. Physiographically, the CHT belongs to the Tertiary Hills unit. According to the simplified hydrogeological classification (Ahmed, 2003), this area belongs to the hydrogelogical province called 'Tertiary Hills'. In the context of groundwater availability and the suitability of groundwater development, the CHT is less suitable than most parts of the country. The folds of the sedimentary strata developed from tectonics have made the geology of the area complex and consequently its hydrogeology as well. Thick beds of consolidated shale limits the vertical recharge of groundwater into the aquifer below. However, along the valley areas (synclines) deep groundwater is available within a depth range of 100 -300 meter. Except some areas in the Khagrachari district, the groundwater table occurs at a greater depth below the ground surface. The primary source of natural groundwater recharge is direct rainfall.

5.3.1 Aquifer system

In areas with folded rocks such as the CHT, regional aquifers often lack continuity. Tertiary sediments/rocks comprising alternating clay and sand dominating formations form aquitards and aquifers of the area. According to the aquifer potential related to the stratigraphy (modified from MPO, 1987), the Dupi Tila Formation of the Middle Pliocene to the Late Miocene age has good aquifer potential in the CHT. This formation is mainly composed of coarse sandstone. Another sand dominating formation called the 'Tipam Sandstone' is considered as a moderate potential aquifer. These two aquifers are separated by a clay dominating aquitard called the 'Girujan Clay'. The other older geological formations are not well described yet. Free flowing aquifers are common in the hilly areas.

5.3.2 Groundwater level

Delineating the groundwater level of a study area is very important because it allows a better understanding of the regional flow patterns. The groundwater level fluctuates with season and abstraction of water from the system. Like many other places of the country, the aquifer of the study area is not fully recharged during the wet season and in most places the groundwater level stands below the ground surface. No declining trend of groundwater level has been observed.

Except for some areas of Khagrachari District, the whole of the CHT has a very low ground water table. The installation and maintenance of groundwater abstraction technologies are costly in these areas.

5.3.3 Groundwater use

The use of groundwater in the study area is comparatively low. The hard bedrock underlying much of the region makes tube well installation difficult. As a result, wells are not drilled deep enough and dry up quickly. Moreover, it is quite expensive to drill a hole and thereby to install a well.

5.3.4 Per capita water consumption

Per capita water consumption is mostly dependent on the distribution of the population of a community in age groups, religion, sex, socio-economic condition, profession, etc. The average water requirements of all age groups and population living under different socio-economic conditions are not equal. Water is used for various domestic purposes such as drinking, cooking, bathing, washing, vegetable gardening, livestock feeding, sanitation, and personal hygiene. Professional and religious practices also influence the use of water. The variation in the source, supply and quality of water as well as availability of alternative water sources influence per capita water consumption of an area. Considering all these factors, the people of the CHT areas are found to consume less water than people living in the plain land areas of Bangladesh.

5.4 Water supply and demand

5.4.1 Drinking water

Water supply is mainly dependent on demand, availability of the source, feasibility in the context of cost-effective technology, and physical features of an area. The availability of low cost options for the water supply system depends on hydrogeological conditions, availability of water source and quality of water in a particular area. No option is suitable or feasible for all areas.

A good tradition of water management is rarely visible in these areas. Drinking water largely comes from perennial water sources such as streams, springs, and rock channels. Water rights are rather undefined compared to land and forest rights. Sustainability of technologies installed for producing water is questionable due to the many challenges in this area such as geographical context, land type, depth to groundwater, hard rocky layer below the ground surface, proper maintenance, replacement of instruments, seasonal disorder, high iron content, bad odour and taste. Often within a few months or years most after installation, water installations are out of order.

As a result, people return to the surface water sources and face difficulties for water collection. Water sources are not protected. But with the lack of conservation practices, the prime water sources are gradually degraded and dried up. In near future, it will be a big challenge to mitigate the demand of safe water in this region. An unsafe water practices are a common phenomena in the remote villages of CHT. Safe water is one of the core problems in CHT rural areas. Around 55% of the households in Khagrachari have access to safe water from tube-well, 39% of households in Rangamati, and 15% of the households in Bandarban.

The hard bedrock underlying much of the region makes tube-well installation difficult. As a result, wells are not drilled deep enough and dry up quickly. Semi-operational wells become dry during the months of February to May. Villagers who rely on rivers or streams also face problems during this period.

The main areas of potential development can be rainwater harvesting (from roofs) and the development of surface water systems using various types of collection devices. Household water storage jars of fero-cement could be an option yet to be developed. Deepset tube-wells also offer advantages in the CHT. With community participation, the maintenance of existing tube-wells can improve availability of drinking water.

5.4.2 Water wells

In recent programmes, much attention is given to simple dug wells, which are around 20 meters deep. Free flowing artesian wells are a possibility around the lakeside. In the hilly areas, where water is a particularly scarce resource for households, more local studies need to be done on the feasibility of wells. It is of particular importance to use geological data to the fullest extent possible, in order to develop a set of models which can be used for the local situation.

The distribution of different types of tube-wells is shown in the table below. Bandarban has a significant number of Tara pumps, which probably reflects the deeper water table compared to the other two districts.

Table 5.3: Well details in the CHT region (1998-99)

District	Shallow tube well	Deep Tube well	Tara pump	Ring well	Pond Sand Filter	Iron remove Plant	Deep set pumps	Total no of wells
Rangamati	931	-	-	1,268	-	-	1,530	4,943
Bandarban	781	-	1,394	887	-	-	461	3,523
Khagrachari	1,544	-	-	956	-	-	1,405	5,160

Source: NWMP, 2001.

The household survey conducted by BCAS emphasized upon drinking water quality and availability related problems. Households in the CHT use a variety of different water sources to get drinking water, but are often unsatisfied with the quality, quantity, and availability of the water.

Table 5.4: Distribution of Households Surveyed by Source of Drinking Water and by District

Source	District			
	Bandarban	Rangamati	Khagrachari	All
Hand tube-well	24 (14.7)	38 (25.3)	115 (76.6)	177 (38.2)
Ring well	18 (11.0)	40 (26.7)	3 (2.0)	61 (13.2)
Dug well	5 (3.1)	26 (17.3)	16 (10.7)	47 (10.2)
Pond	-	-	-	-
Canal/River	56 (34.4)	6 (4.0)	3 (2.0)	65 (14.0)
Deep set tube-well	1 (0.6)	2 (1.3)	3 (2.0)	6 (1.3)
GFS	15 (9.2)	-	-	15 (3.2)
Piped water supply	2 (1.2)	3 (2.0)	-	5 (1.1)
Lakes	-	5 (3.3)	-	5 (1.1)
Spring	5 (3.1)	26 (17.3)	2 (1.3)	33 (7.3)
Jhiri	9 (5.5)	-	-	9 (1.9)
Tube-well+Ring well	3 (1.8)	-	-	3 (0.6)
Tube-well+Khal/River	5 (3.1)	-	5 (3.3)	10 (2.2)
Ring well+Khal/River	6 (3.7)	-	-	6 (1.3)
Tube-well+Others	2 (1.2)	-	1 (0.7)	3 (0.6)
CFS+Khal/River	2 (1.2)	-	-	2 (0.4)
Dug well+Khal/Riv	1 (0.6)	-	1 (0.7)	2 (0.4)
Jhiri+Khal/River	2 (1.2)	-	-	2 (0.4)
Others	7 (4.4)	4 (2.8)	1 (0.7)	12 (2.6)
Total	**163**	**150**	**150**	**463**
	(100.0)	**(100.0)**	**(100.0)**	**(100.0)**

Note: *Figures within parentheses represent percentages*
Source: CHARM Project, 2006.

While these households have access to these sources of drinking water, the water supply is often considered inadequate. During the dry season, 34% of households that depend on tube-wells suffer from water shortage, while 48% of ring-well users, 54% of dug-well users, and 62% of canal/river users find their access to water during the dry season inadequate. Of all the households, only 65% perceive their drinking water to be safe. Additionally, 19% of households have to spend more than two hours a day collecting and storing water; 32% spend between one and two hours, while 49% use less than one hour of the day for this purpose. The responsibility of collecting and storing drinking water falls most frequently on women's shoulders 65% of the time this task is conducted by females, while adult males only are responsible for this task in 17% of the households (BCAS, 2006).

Only 17% of households own their drinking water sources and 24% depend on their neighbors' sources. NGOs own 13% of these sources, and the government owns 9%. Communal properties account for another 12% of the sources, and the remaining 25% are owned by other parties (BCAS, 2006).

5.4.3 Other possibilities and uses

The Eastern Hilly Region has been categorized into two parts: the hills, where irrigation returns feed the plains; and the coastal plain, where they contribute to salinity control. The region as a whole is in deficit of water, but there are still many possibilities for improvement of water uses. Irrigation, supported by natural flows, should be developed, while monsoon storage capacity should also be improved. In the hills there are obvious opportunities for drip irrigation of high value tree crops, which need less water. The main concern is that excessive irrigation on the coastal plain using groundwater might cause saline water to be drawn in, and close monitoring is needed to prevent such intrusion.

Chapter 6

Agriculture

6.1 Introduction

Agriculture is a driving force of the CHT economy. The land is characterized by the traditional shifting 'slash-and-burn' cultivation, known as *jhum*, practiced for thousands of years by the indigenous *Parhari* population. While for over a century authorities have tried to push for a more sedentary lifestyle of the Parahari people, who now make up half the population, it appears that *Jhum* will continue as the main livelihood for many people. In this context, it is then important to focus on how this practice can be performed in a sustainable way, incorporating documented agricultural management practices.

Over the years the definition of agriculture has expanded from simply plainland crop production to include all forms of proper utilization of natural resources. This relates to the production, development, preservation, processing, marketing, and extension of, crops, as well as other agricultural commodities such as fish, meat, eggs, and forest products. It includes horticulture, animal husbandry/livestock, fisheries, and forestry. In this section, the term 'total agriculture' will refer to this over-arching definition. The focus of this section will be on crop production, with some discussion on livestock and fisheries at the end. Forestry will be discussed in a separate section. It should also be noted that most of the statistics on crop production by the Bangladesh Bureau of Statistics (BBS) do not take into account *jhum* production, and only refer to plainland cultivation and horticulture.

In 1962, a dam was put up on the largest river in the CHT, the Karnaphuli River for the development of hydroelectric power. The Kaptai Lake inundated an area of about 68,000 ha. causing displacement of 20-25% of the indigenous population and flooding 40% of the most fertile arable, alluvial lands. Many displaced persons took up *jhum* cultivation. Due to increased pressure on the land, the fallow period was shortened from 10-15 years down to 5-6 years (Hassan and Van Lavieren, 2000). *Jhum* remains the most wide spread form of agriculture, covering 35,000-40,000 ha of the land. The footslope and valley areas, where rice is mainly grown, cover approximately 31,000 ha. Perennial crops, such as fruit, rubber, and tea, cover 17,000 ha. The Kaptai Lake fringeland (valleys, footslopes and hilloks) covers approximately 15,000 ha (ADB, 2001, ADB, CHT Region Development Plan Final Report. 2001).

6.2 Landform

The landforms of the CHT are mainly composed of hills and valleys. The hills are formed with the unconsolidated sediments of the tertiary age, which have been uplifted, folded, faulted and dissected to form linear ranges. The height of the hills influences the local rainfall and temperature. The average temperature decreases with height. The physical and chemical characteristics of the soil change with the elevation of hills and consequently determine the suitability of crops. The hills can be subdivided into high, medium high and low hills based on their height from mean sea level (MSL). The high hills are above 300 m MSL. The medium high hills range from 150 300 m. The hills that lie below 150 m are low hills.

Twenty eight per cent of the CHT comprises high hills, 22% medium high hills, 31% low hills and the rest is valley land. Bandarban and Rangamati mostly have high and medium high hills. But only 7% of Khagrachhari comprises high hilly areas, 45% medium high and low hills, and 45% valleys.

6.3 Land Use

The pressure on the land of the CHT has and will continue to increase. Therefore, it is necessary to understand present land use and land utilization patterns to predict future changes. Land use in the whole of the CHT has been broadly categorized into four classes including Non-agricultural, Agricultural, Forest and Fallow land. The definitions of the land use classes are given below:

Non-agricultural: the area of land that is used for non-agricultural purpose. It also covers the area under settlements and water bodies.

Agricultural land: the area under perennial, *jhum*, annual crops, single, double and triple crops. It is the cultivated area actually cropped regardless of the number of crops grown.

Forest: the area of land that is under forest cover. It includes reserved forest areas and private planted forests.

Fallow land: the area of land that is not normally cultivated. In order to increase the fertility of land the farmers sometimes keep a portion of their land fallow for a year.

The landuse pattern of the CHT area is presented by thana in Map 6.1.

Map 6.1: Land Use Patterns

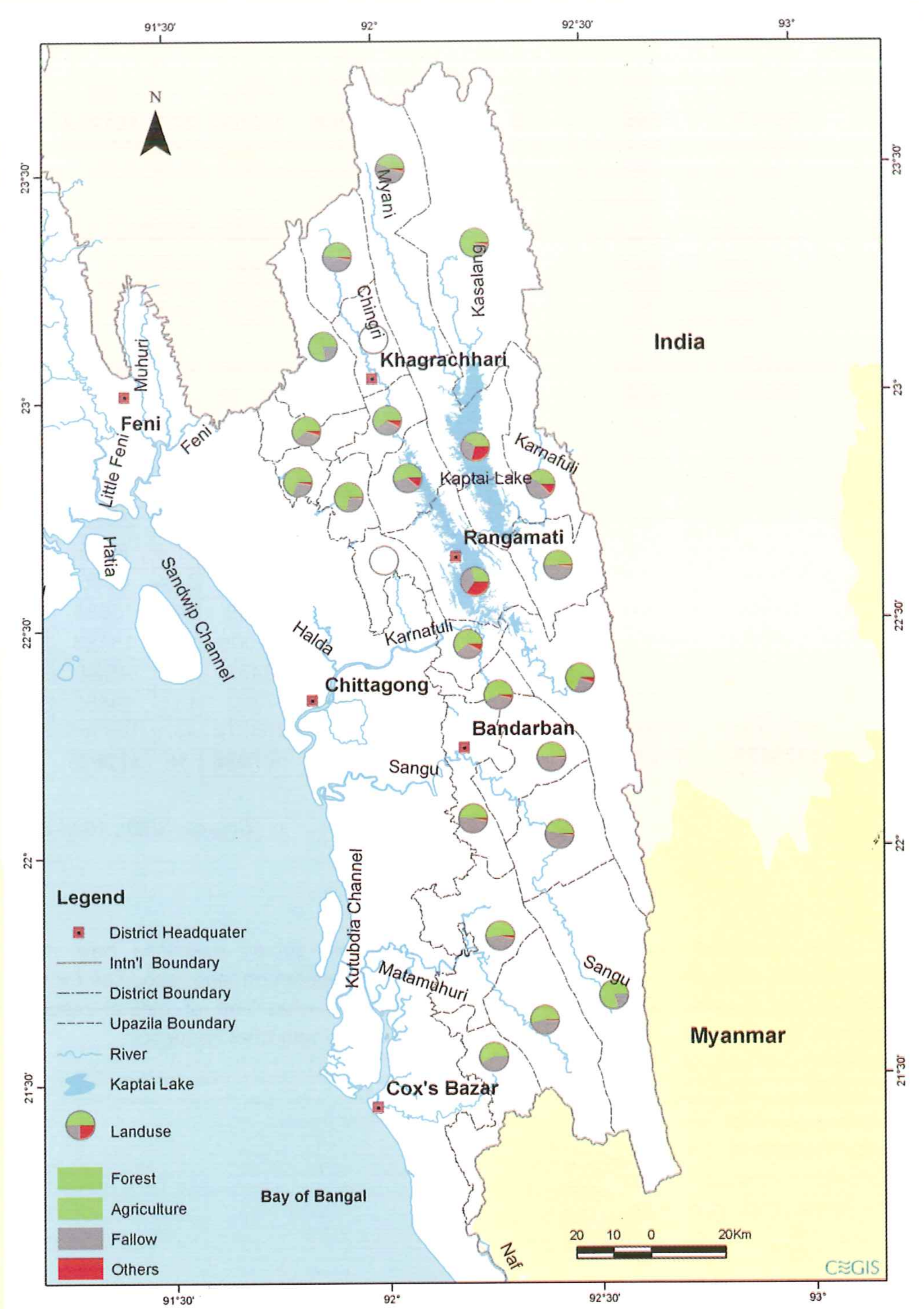


Table 6.1: Present Land use of the CHT by Thana

District	Thana	Total Area (ha)	Non-Agricultural Land		Agricultural Land		Forest		Fallow land	
			Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%
Bandarban	Alikadam	88580	892	1.0	23479	26.5	24188	27.3	40021	45.2
Bandarban	Bandarban Sadar	49555	1344	2.7	15057	30.4	9187	18.5	23967	48.4
Bandarban	Lama	58052	1861	3.2	16463	28.4	13917	24.0	25811	44.5
Bandarban	Naikhongchhari	46361	240	0.5	8267	17.8	18025	38.9	19829	42.8
Bandarban	Rowangchhari	44289	522	1.2	10291	23.2	11768	26.6	21708	49.0
Bandarban	Ruma	61642	1055	1.7	7426	12.1	21513	34.9	31648	51.3
Bandarban	Thanchi	89652	832	0.9	5598	6.2	64954	72.5	18268	20.4
Sub-Total	**Bandarban**	**438131**	**6746**	**1.5**	**86581**	**19.8**	**163552**	**37.3**	**181252**	**41.4**
Khagrachhari	Dighinala	69413	2234	3.2	14610	21.1	16246	23.4	36324	52.3
Khagrachhari	Khagrachhari Sadar	28984	1869	6.5	8565	29.6	7582	26.2	10968	37.8
Khagrachhari	Lakshmichhari	22015	265	1.2	4613	21.0	11121	50.5	6016	27.3
Khagrachhari	Mahalchhari	25123	1980	7.9	8687	34.6	6230	24.8	8225	32.7
Khagrachhari	Manikchhari	16835	461	2.7	6915	41.1	4552	27.0	4907	29.2
Khagrachhari	Matiranga	49211	450	0.9	18717	38.0	19024	38.7	11020	22.4
Khagrachhari	Panchhari	33411	1062	3.2	9919	29.7	6195	18.5	16234	48.6
Khagrachhari	Ramgarh	24087	1174	4.9	7383	30.7	7158	29.7	8372	34.8
Sub-Total	**Khagrachhari**	**269079**	**9495**	**3.5**	**79409**	**29.5**	**78108**	**29.0**	**102066**	**37.9**
Rangamati	Baghai Chhari	191483	4965	2.6	17194	9.0	132927	69.4	36397	19.0
Rangamati	Barkal	72262	9233	12.8	10316	14.3	19206	26.6	33506	46.4
Rangamati	Belai Chhari	74593	4198	5.6	5737	7.7	44690	59.9	19968	26.8
Rangamati	Jurai Chhari	60607	829	1.4	12079	19.9	18676	30.8	29023	47.9
Rangamati	Kaptai	27324	2029	7.4	6211	22.7	10239	37.5	8845	32.4
Rangamati	Kawkhali (Betbunia)	33930	1158	3.4	12858	37.9	11317	33.4	8596	25.3
Rangamati	Langadu	52059	15297	29.4	13805	26.5	7349	14.1	15608	30.0
Rangamati	Nanner Char	38793	4259	11.0	10343	26.7	11008	28.4	13183	34.0
Rangamati	Rajasthali	12551	487	3.9	3658	29.2	3482	27.7	4924	39.2
Rangamati	Rangamati Sadar	54665	19122	35.0	8706	15.9	7382	13.5	19455	35.6
Sub-Total	Rangamati	618267	61577	10.0	100907	16.3	266276	43.1	189505	30.7
Total	**CHT**	**1325477**	**77818**	**6**	**266897**	**20**	**507936**	**38**	**472823**	**36**

Source: SRDI, 1996-2002

At present, 38% of the CHT region comprises forest area, 36% fallow land, 20% agricultural land and 6% non-agricultural land. Forty two per cent of Bandarban comprises fallow land, 38% forest land and about 20% agricultural land. In the Khagrachhari district, 38% of land is fallow, 30% is used for agriculture, 29% is forest land and 3% is of non agricultural use including settlements, water bodies etc. Rangamati has the highest percentage of non-agricultural landuse (10%), 16% agricultural use and 43% forest area, with more than 31% of the land fallow.

The BCAS household survey examined how many households were dependent on land resources for their livelihoods, looking at what kind of natural resource extraction occurred and with what frequency.

Table 6.2: Percentage Distribution of Households According to their Extent of Dependence on Natural Resources

Resources	Extent of Dependence				
	High	Medium	Low	No Dependence	Total
Land for *jhum* culture	35.3	14.9	11.4	38.4	100
Land for crop culture	36.1	29.6	13.3	21.0	100
Land for horticulture/vegetables	27.7	38.1	22.5	11.7	100
Land for other agriculture	16.7	28.5	30.0	24.8	100
Public forest resource	11.6	14.6	33.0	40.8	100
Private forest resources	11.0	30.3	26.0	32.7	100

Source: BCAS, 2006.

According to the report, "a majority of the households (69%) do not produce the required quality [of] fruits and vegetables to meet their own demand," which means that less than one third of the households produce enough to subsist. The same pattern persists with staple crops (rice, wheat, and potato) that 74% of the survey households' produce only 32% of these households produce enough for their demand.

6.4 Land utilization

The agricultural land is classified according to different cropping patterns including perennial, *jhum*-annual, single, double and triple. A cropping pattern is the sequence of crops grown on a single plot of land throughout the year. Different cropping patterns as defined by the Census (BBS 1999a) are given below:

Perennial crops: the area of agricultural land with permanent crops or planted with fruit trees that occupy the land for a long period of time and do not need to be planted for many years after each harvest, e.g. mango, jack fruit, coconut, and banana.

jhum-annual crops: the area under *jhum* cultivation, which is also part of agricultural land, where the crop growth cycle or length of life is 2/3 years. Aus paddy, cotton, melon, cucumber and other vegetables are grown on this land.

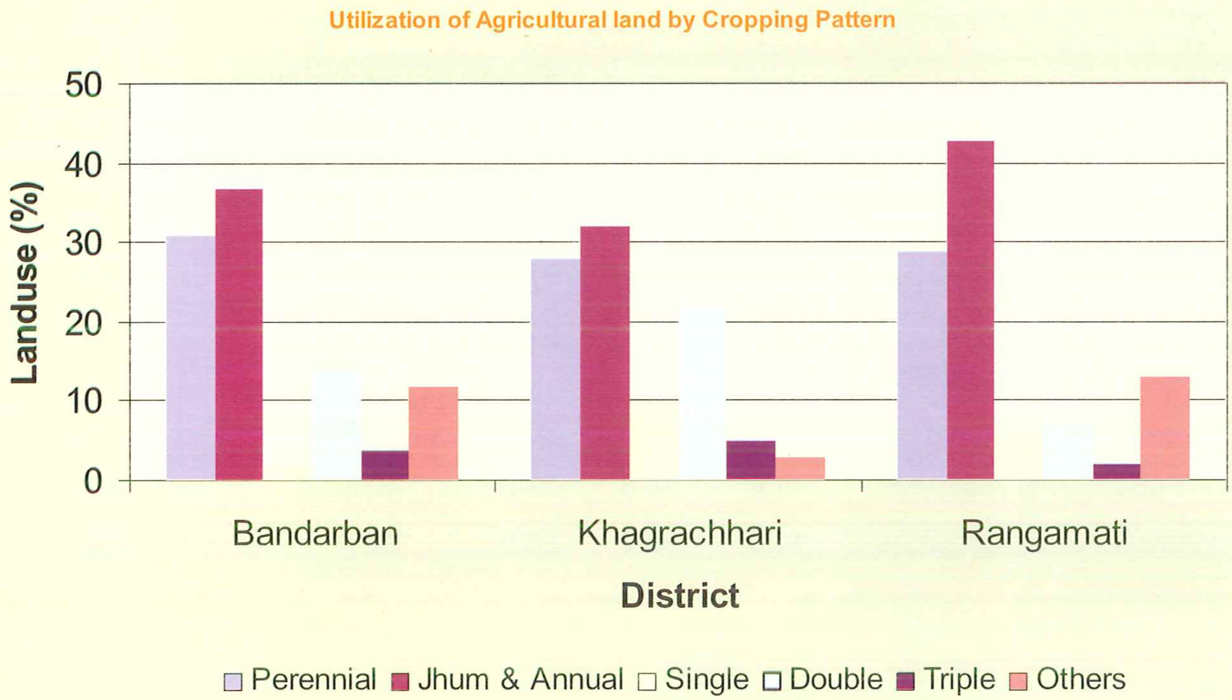
Annual crops: the area used for temporary crops (also part of agricultural land) where crops whose growth cycle or length of life is one year or less. These crops are paddy, jute, sugarcane, pulses, potato and other vegetables.

Single crop: the single cropped area where one crop was raised. Only the actual area of the land is taken into account.

Double-cropped: the double cropped area where two crops were grown. Only the net area of the land is taken into account as double-cropped area.

Triple-cropped: the triple or more cropped area where three or more crops were grown. Only the net area is counted as triple or more cropped area.

Figure 6.1: Utilization of agricultural land by cropping pattern



Source: SRDI 1996-2002

The major parts of the agricultural land of the CHT are used for *jhum*-annual crop cultivation (39%), 30% for perennial crops, 13% for double crops, 9% for annual crops, 6% for single crops and 3% for triple crops. About 38% of the agricultural land in Bandarban is used for the production of *jhum*-annual crops, 31% for perennial crops, 14% for double crops, 12 % for annual crops and the rest is used for single and triple crops such as T. Aman, rabi crops, rabi and kharif vegetables. Different perennial crops such as mangoes, jackfruits, guavas, and cashew nuts are grown in 18 to 61% of the agricultural land in Bandarban. Forest trees such as teak, garjan, and gamar cover 72% area of Thanchi. *Jhum* & annual crops, such as bananas, spices, rice, cotton, and kharif vegetables, are cultivated in about 55% of Naikhongchhari's agricultural land, followed by Alikadam (48%), Rowangchhari (42%) and Bandarban Sadar (34%). In Alikadam 4557 ha are used for *jhum* cultivation, the highest among all the thanas of the CHT.

Thirty percent of agricultural land in Khagrachhari is used for the cultivation. *Jhum* and annual crops covers 32% of land, followed by 28% of the land for perennial crops and 40% of the land for single (10%), double (22%), triple crops (5%) and other crops (3%). In Panchhari, around 45% of the agricultural area is used for *jhum*-annual crop cultivation. Different types of Rabi crops, T. Aman, Aus, Boro rice, are mostly cultivated in Matiranga and Dighinala.

Rangamati has around 16% of agricultural land. In most of the agricultural lands (43%) *jhum* and annual crop cultivation-rice, chili, kharif vegetables, cotton, maize, bananas, papayas, pineapples, and spices are carried out. Perennial crops, mainly fruit trees, are grown in 29% of the agricultural land. Through the *jhum* system, farmers cultivate rice, chili, kharif vegetables, cotton, bananas, papayas, ginger, and turmeric.

6.5 Cropping Intensity

The cropping intensity represents the ratio between the total cropped area and the net-cropped area expressed in percentage. The total cropped area represents the aggregate area of the various crops raised in the same land of the farm. The net-cropped area is the cultivated farm area actually cropped during the respective census year regardless of the number of crops grown. It includes the area used for temporary and permanent crops (fruit trees), with the actual area or physical area used for perennial and non-perennial crops. The following table shows the cropping intensity of the three hill districts.

Table 6.3: Cropped area and crop intensity 1998-99 to 2002-03

District	Bandarban			Khagrachhari			Rangamati		
Year	Net cropped area (000) hectare	Total Cropped area (000) hectare	Cropping intensity (%)	Net cropped area (000) hectare	Total Cropped area (000) hectare	Cropping intensity (%)	Net cropped area (000) hectare	Total Cropped area (000) hectare	Cropping intensity (%)
1998-1999	30	43	146.58	15	25	163.16	45	57	125.89
1999-2000	28	41	146.38	19	30	163.04	40	58	144.44
2000-2001	28	41	144.29	22	36	160	40	61	154.08
2001-2002	26	38	143.08	25	39	159.02	40	63	156.57
2002-2003	27	38	140.91	26	41	157.81	41	63	154.46

Source: BBS, 2005

The cropping intensity of the CHT area is lower compared to the mean value. There is a decreasing trend in the cropping intensity in the CHT from 1998-99 to 2002-03. This decrease in the cropping intensity can be attributed to loss in fertility of soil. The cropping intensity of Khagrachhari is higher compared to Rangamati and Bandarban. In the year 2002-03 the cropping intensity of Khagrachhari was 158% followed by Rangamati (155%) and Bandarban (141%). It means that in Khagrachhari and Rangamati the net-cropped area is 1.5 times of the total cropped area.

6.6 Land Holdings

Land ownership issues lie at the heart of many of the disputes in the CHT and are directly linked with agricultural production and associated environmental issues. Traditionally, *jhummias* only cultivate a plot of land for a year or two then move somewhere else. They often lack ownership of the land. When they cultivate land, they do so only by using communal properties, share tenancy, leasing, or mortgaging. Thus, they have little incentive to invest in the land and implement agricultural management practices. It increases soil erosion and nutrient decline. The table below shows the area and number of holdings under owned land, owner like possession and especially the area under *jhum* cultivation. For census purposes, holdings are a techno-economic unit of agricultural production comprising all land that is used in whole or in part for agricultural purposes and is operated under a single management by one person alone or with others, without consideration of title, size or location. The operated area of a holding is the area owned by the holdings plus the area rented from others minus the owned area given to others for operation. The operated area also includes uncultivated land operated by the holdings including homestead area. Owned land means the area of land that is owned by the holder who has a title deed to the land and the right to determine the nature and extent of its use and to transfer the same. Owner-like possession refers to land that is treated as owned land, but without a legal title to the land. He can operate the land held by the holder in an owner like possession in the same way as owned land, although the holder does not possess a title of ownership.

Table 6.4: Number and area ('000 hectare) of various holdings in the CHT, 1996

District	Operated Area (size class)	Owned land			Land under Owner like Possession			Land under *jhum* Cultivation		
		Holding	Area	Avg. per holding	Holding	Area	Avg. per holding	Holding	Area	Avg. per hold ing
Bandarban	1. Small	14,997	6,537	0.44	288	46	0.16	2,801	1,208	0.43
	Medium	16,068	28,275	1.76	453	278	0.61	5,479	4,453	0.81
	Large	2,348	10,000	4.26	0	0	0.00	659	594	0.90
Total		**33,413**	**44,812**	**1.34**	**741**	**324**	**0.44**	**8,939**	**6,255**	**0.70**
Khagrachhari	Small	27,631	11,980	0.43	4,962	1,706	0.34	4,645	967	0.21
	Medium	18,421	31,171	1.69	4,288	3,873	0.90	3,930	1,779	0.45
	Large	3,096	14,259	4.61	874	1,942	2.22	595	411	0.69
Total		**49,148**	**57,410**	**1.17**	**10,124**	**7,521**	**0.74**	**9,170**	**3,156**	**0.34**
Rangamati	Small	20,030	9,207	0.46	4,130	928	0.22	3,676	1,149	0.31
	Medium	21,228	33,426	1.57	4,667	4,875	1.04	10,408	7,333	0.70
	Large	4,543	18,978	4.18	1,322	2,859	2.16	2,643	2,519	0.95
Total		**45,801**	**61,611**	**1.35**	**10,119**	**8,663**	**0.86**	**16,727**	**11,001**	**0.66**
CHT	**Small**	**62,660**	**27,724**	**0.44**	**9,380**	**2,725**	**0.29**	**11,122**	**3,324**	**0.30**
	Medium	**55,717**	**92,872**	**1.67**	**9,408**	**9,027**	**0.96**	**19,817**	**13,565**	**0.68**
	Large	**9,987**	**43,237**	**4.33**	**2,196**	**4,801**	**2.19**	**3,897**	**3,524**	**0.90**
Total		1,28,364	1,63,833	1.28	20,984	16,553	0.79	34,836	20,412	0.59

Source: BBS, 1999b

Holdings as broadly classified in the census (BBS 1999a) are

(a) Small - A holding having an operated area of 0.02 to 1 hectare (0.05 to 2.49 acres) of land, with a minimum of 0.05 acre as cultivated area.

(b) Medium -A holding having an operated area of 1.01 to 3 hectare (2.50 to 7.49 acres) of land and

(c) Large -A holding having an operated area of more than 3 hectares (7.50 acres).

A small, cultivated area constituting of less than 0.02 hectare (0.05 acre) is generally utilized as a kitchen garden or for vegetables grown within the homestead area. In many cases, the seeds of gourds and squashes are sown along the sides of the structures and houses, but the vines are spread on and around the roofs and the structures. Considering all these factors, the minimum cultivated area was fixed at 0.02 hectare (0.05 acre) for qualification as a farm holding.

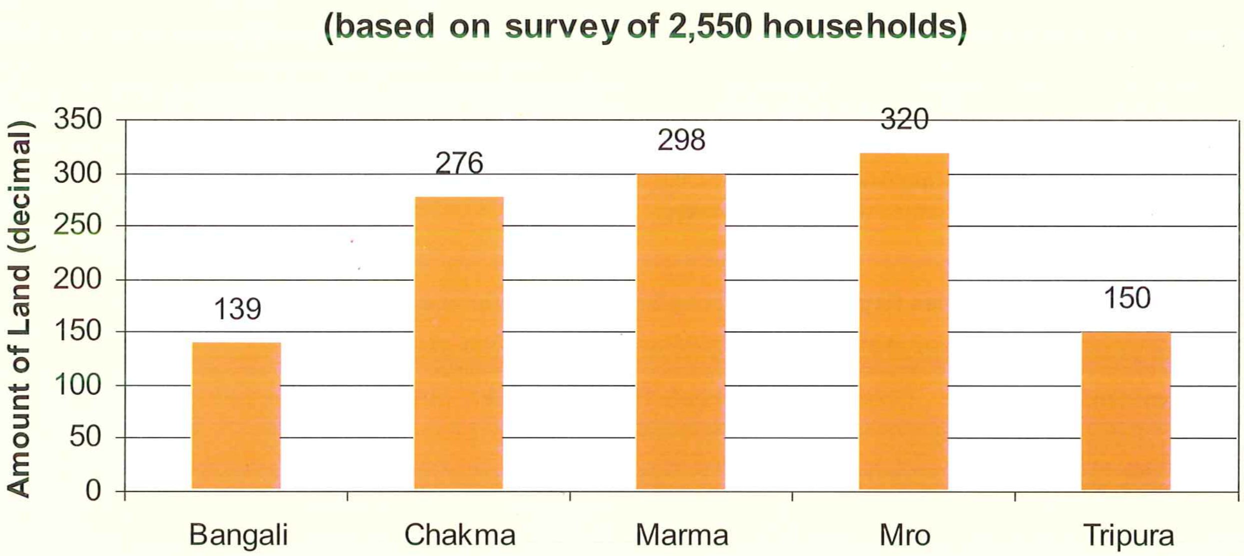
It is seen from the table that in the CHT area 16.35% of the holding is under Owner-like Possession out of the total Owned land. A total number of 34836 holdings are involved in *jhum* cultivation in the CHT. More than 60 percent of the holdings in Bandarban District fall under the size class b constituting one to three hectares of land. The major portion of the *jhum* cultivation is carried out on small and medium areas of land. In Rangamati 58.18% of the farmers carry out *jhum* cultivation on more than three hectares. The percentage of farmers with over 15 acres of land under *jhum* cultivation is very low.

6.7 Land Ownership and Cultivation by Ethnicity

In a recent study by the Bangladesh Rural Advancement Committee (BRAC), whose findings were published in 2001 in a book entitled "Counting the Hills: Assessing Development in the Chittagong Hill Tracts," 150 representative villages (2,550 households) from all three districts were studied for an array of socio-economic indicators. Thirty villages (510 households) from each of the five major ethnic groups (Bangali, Chakma, Marma, Mro, and Tripura) were interviewed. It should be noted that the total ethnic make up of the CHT is as follows: Bangali (48.6% of total population), Chakma (24.5%), Marma (14.6%), Tripura (6.3%), Mro (2.3%), and other (3.7%).

The BRAC study reveals that on average, Mro households own the most land, 320 decimals, and Bengalis actually own the least amount of land, 139 decimals. This land was categorized into homestead (area surrounding the house), cultivated (including both plainland and *jhum* land), orchards (land outside the homestead growing timber or fruit trees), and fallow land. For all ethnic groups except Bangalis, orchards made up the largest area of land for each household, between 40% and 65% of their land holdings. Cultivated land made up between 25% and 40%, while homestead land made up less than 10% of the area, except for Tripuras (15%) and Bangalis (24%). Fallow land was not that much in general, except for that under Banglis, where it made up 23% of the area.

Figure 6.2: Average Amount of Land Owned by Ethnicity



Source: (Rafi and Chowdhury 2001)

According to the table below it is apparent that Mro households cultivated the largest amount of land for *jhum*, 369.7 decimals or 83%. On average, Chakmas, Marmas, and Tripuras used 30% to 50% of their cultivated land for *jhum*. In particular, Chakma households practiced the least amount of *jhum*, using only 35.6 decimals, while they were using almost 80 decimals, or 70% of their land for plainland agriculture. In general, it is accepted that Bengalis do not practice *jhum*; the BRAC survey of 510 Bangali households found that on average 1.4 decimals, or 4% of cultivated land, was used for *jhum*. Interestingly, on the whole, *jhum* was found to be the predominant form of agriculture only for the Mro.

Table 6.5: Average Amount of Land Cultivated by Ethnicity (Decimals)

Ethnic Group	Plain-land		
	Single Crop	Double Crop	*jhum*-land
Bangali	19.1	16.1	1.4
Chakma	65	14.7	35.6
Marma	49.3	16.5	55.1
Mro	53.8	10	329.9
Tripura	62.5	4.9	69.9

Source: (Rafi and Chowdhury 2001)

The difference between the total land cultivated and total land owned is an indication of the land being farmed that is not owned by the cultivators. It is assumed these households are cultivating other people's land in the form of share tenancy, leasing, mortgaging, or by using communal properties. Many who do not own cultivable land still practice cultivation. The largest discrepancy is with the Mro, where 98.4% of the households interviewed practice cultivation, while only 29% own cultivable land (though many own orchards or homestead land). Bengalis do not practice as much cultivation: 27% of households practiced cultivation while 35% owned cultivable land.

6.8 Gross Value Added

While agriculture makes up approximately 35% of the annual CHT gross regional product, with industry making up 14% and the services sector making up 50%, agriculture remains the primary livelihood for an estimated 65% of the population (ADB Report, Agriculture, 2001). In 2000, the CHT agricultural sector (at Tk 6,530 million) made up 1.2% of the total Bangladesh income for agriculture, even though the entire CHT makes up less than 1% of the total population and 10% of the land mass. While the rate of agricultural gross product increased at an average annual rate of 7.4% from 1995 to 2000, it increased at a slower rate than other economic sectors; industry increased at approximately 11% and the services sector increased at 9.5%. In just these 5 years, agriculture went from making up 37% of the economic base to only 35%. Like in many parts of Bangladesh, the people of the CHT are finding it more profitable to move away from traditional farm life and search for alternative or additional work, often to be found in the urban centers.

Table 6.6: Percentage of Gross Regional Product by Economic Sector at Current Market Prices

Economic Sector	1995-1996	1996-1997	1997-1998	1998-1999	1999-2000
Agriculture	36.9%	36.2%	35.6%	35.8%	34.8%
Industry	12.5%	13.0%	13.4%	13.1%	13.5%
Services	50.6%	50.8%	51.0%	51.1%	51.7%

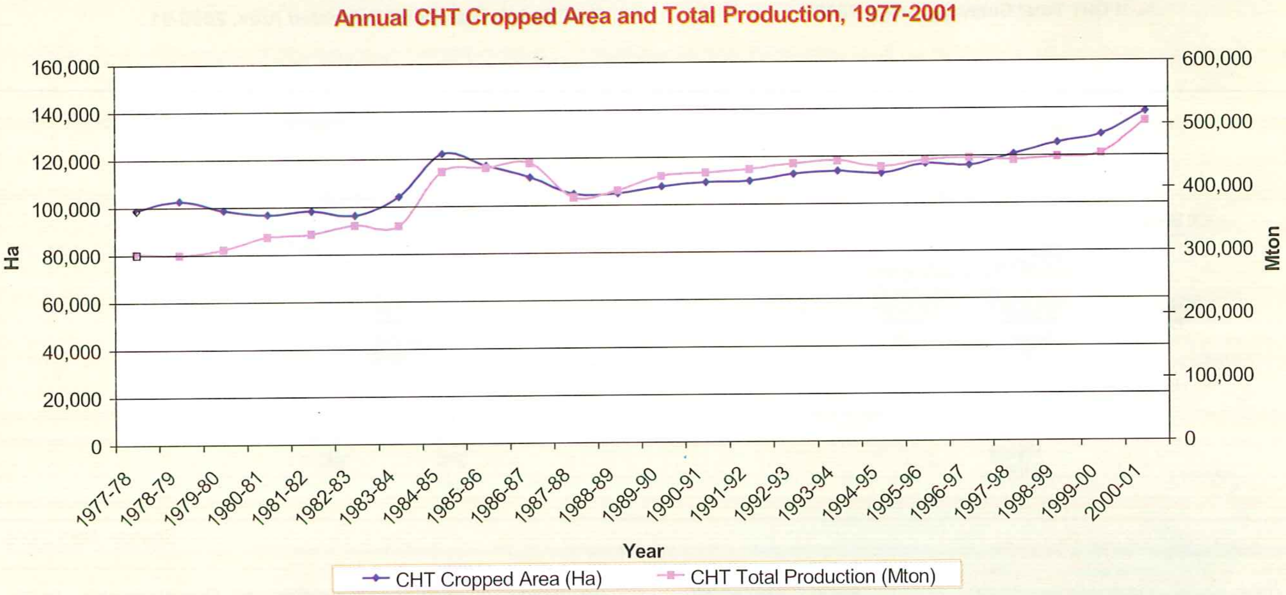
Source: BBS 2005

6.9 Crop Production

The rains, the great monsoons that characterize South Asia, determine the cropping patterns of Bangladesh, and in particular the CHT. In addition, the spatial and temporal arrangement of crops within a cropping year is also largely determined by physical, biological and socio-economic factors. There are three cropping seasons in the CHT: the Rabi (winter/dry) season is from November to February, with an average rainfall of 97mm; the Kharif-I or Pre-Kharif season is from March to May, with an average rainfall of 568mm; and the Kharif-II (summer/wet) season is from June through October, with an average rainfall of 2,101mm (SRDI, 2002).

Agricultural production in the CHT has been steadily increasing over the last 25 years, at an average rate of 1.6% increase in the area of production, based upon the 87 major crops that the Bangladesh Bureau of Statistics records. In 2000, the total production was 502,263 Metric Tons (Mton), in an area of 137900 Ha. The consumption of fresh produce is higher in the CHT than most other places in Bangladesh because of year-round availability and preference by residents. It is estimated that 60% of these crops are sold outside the region. However, there is little added value to these export products, because limited grading and processing takes place in the region (ADB, CHT Region Development Plan Final Report, 2001).

Figure 6.3: Annual CHT Cropped and Total Production, 2001



Source: BBS, 2003 & BBS 2004

The most commonly grown type of crop in the CHT is Aman, including the high yield variety (HYV) and Pajam; in 2000, it was grown on over 31,3000 ha. Fruits (most importantly bananas, pineapples, jackfruits, mangoes, and guavas) and vegetables (most importantly rabi brinjal, kharif brinjal, chalkumra, arum, and other kharif vegetables), grown as horticulture and as part of the *jhum* process, are both grown on more than 18,000 ha. Boro, local aus, spices (mainly chillies, turmeric, ginger, onion, coriander seeds, and garlic) and oil seeds (til, rape/mustard, groundnut, linseed, and castor) are also important crops for the region.

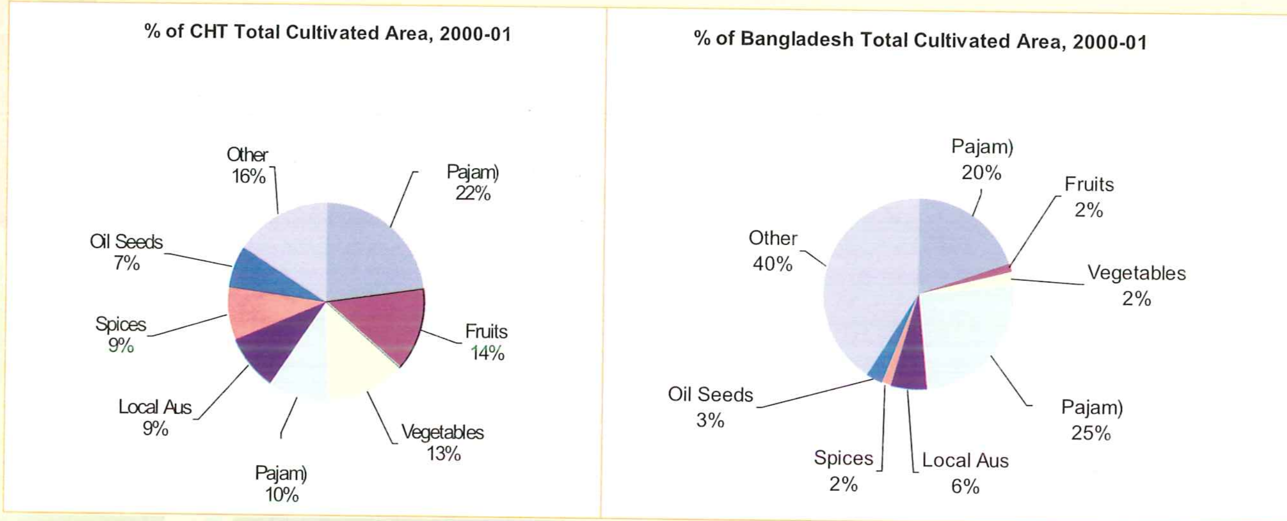
Table 6.7: 2000-01 Crop Productions in the CHT

Crop Type	Area (Ha)	Production (Mton)
Aman (HYV & Pajam)	31,351	83,950
Fruits	18,745	173,300
Vegetables	18,126	98,349
Boro (HYV & Pajam)	13,745	33,030
Local Aus	12,853	18,130
Spices	11,817	27,855
Oil Seeds	9,676	6,432

Source: BBS 2005

It is interesting to note that the agricultural 'make-up' of the CHT is quite different than the rest of the country. With such unique physiography, soils, and climatic patterns, the types of crops grown are also different. Unlike the rest of Bangladesh, horticultural crops, many of which are grown as *jhum*, are the most common form of agricultural production, making up 15% of the regional product. Because the CHT is a hilly area, and not a broad floodplain like the rest of Bangladesh, plainland rice production is not as common (ADB, CHT Region Development Plan Final Report, 2001).

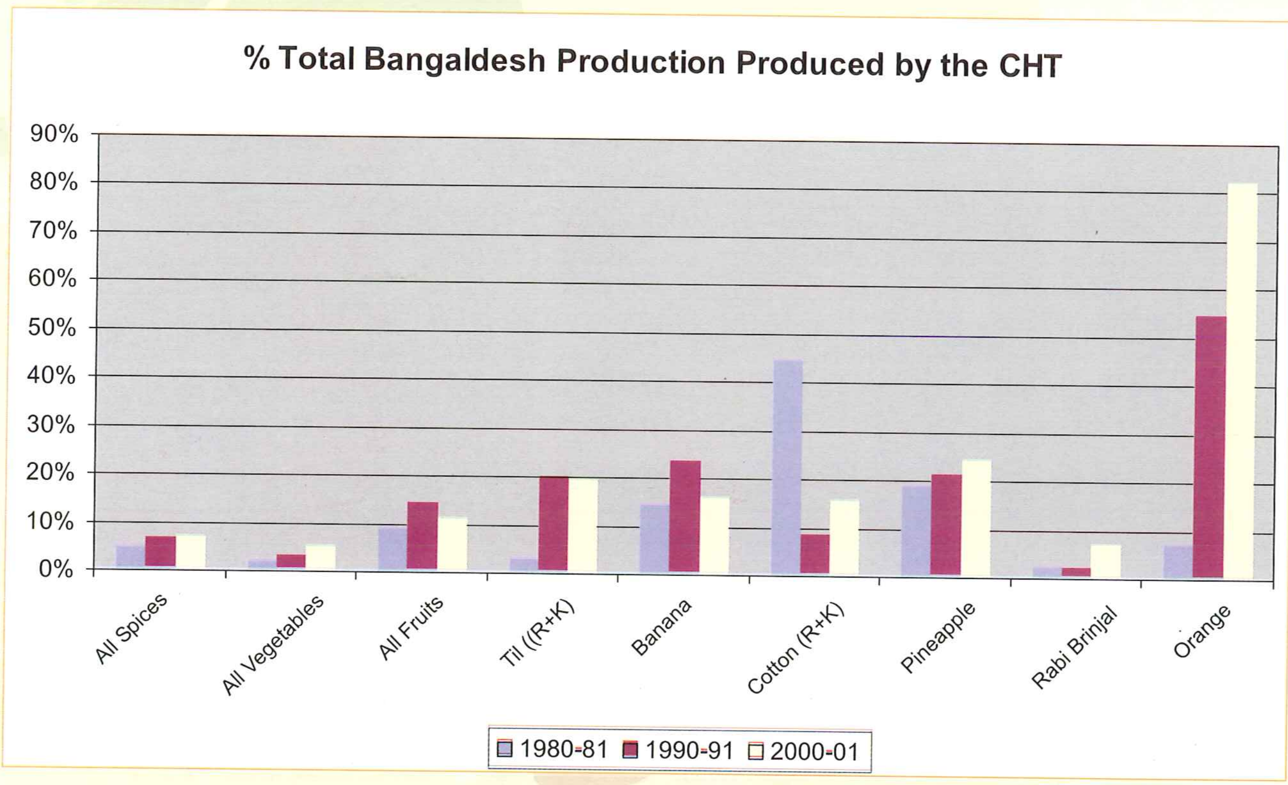
Figure 6.4: Comparison of the CHT and Bangladesh Percent total cultivated area, 2000-01



Source: BBS 2005

While fruits, vegetables, spices and oil seeds make up 14% (18,600 ha), 13% (18,100 ha), 9% (11,800 ha), and 7% (9,700 ha), respectively, of the CHT, these crops only make up between two and three percent (between 200,000 and 400,000 ha) each of the total cultivated area in Bangladesh. Thus, it is important to realize that the CHT produces a significant portion of Bangladesh's fruits, vegetables, spices and oil seeds. The CHT supplies 11% of all of Bangladesh's fruits, 7% of all its spices, and 5% of all its vegetables. From 1980 to 2000, the importance of spices and vegetables coming from the CHT has been increasing.

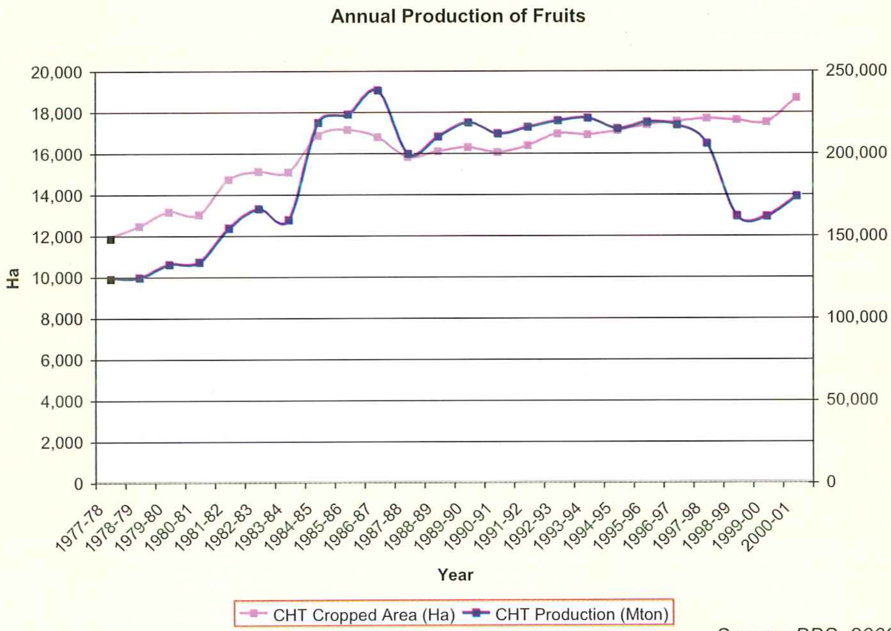
Figure 6.5: Percent of total Bangladesh production produced in the CHT



Source: BBS, 2003 & BBS 2004

The area used to grow fruits in the CHT has steadily been increasing in the last 20 years, from about 12,000 ha in the late 1970s to over 18,000 ha in 2000-2001. There appears to be a drop in the total production of fruits in the mid-1990s, then an increase again by the turn of the century. It is estimated that 65% of fruits arrive at the market between May and July (ADB, CHT Region Development Plan Final Report, 2001).

Fig. 6.6: Annual Production of Fruits



Source: BBS, 2003

Table 6.8: 2003-04 Fruit Statistics

Crop	CHT Area (Ha)	CHT Production (Mton)	CHT Yield (Mton/Ha)	Bangladesh Yield (Mton/Ha)
Banana	6,375.8	90,490.0	14.2	14.3
Pineapple	4,552.7	58,405.0	12.8	12.7
Jackfruit	2,713.4	23,150.0	8.5	10.1
Mango	1,770.5	4,895.0	2.8	4.8
Guava	1,044.1	2,730.0	2.6	4.8
Papaya	613.1	5,210.0	8.5	6.6
Orange	437.1	835.0	1.9	2.0

Source: BBS 2005

Bananas, with a yield higher than 14 Mton/ha, are the most commonly grown fruit in the CHT, covering over 6000 ha, almost 5% of the entire cultivated area in the CHT. In 1990, the CHT produced 23% of all the bananas in the country, but in 2003 they were producing 13% of the bananas of Bangladesh. Sixty percent of the bananas of the CHT come from Rangamati District.

Pineapples have steadily been growing in importance in the CHT: in 1980, the CHT produced almost 19% of the country's pineapples, while in 2003; it was producing over 27%. Khagrachhari actually grows pineapples on the largest area, over 2000 ha or 44% of the total CHT area for pineapples. Rangamati grows pineapples on 1900 ha and Bandarban on 600 ha.

In 1980, the CHT was producing less than 10% of the country's oranges, and in 2003, they were producing over 80% of the country's oranges. Sylhet, with some similar hilly climatic conditions as the CHT, is the only other district in Bangladesh growing this crop.

It should be noted that the yield of papaya in the CHT is 8.5 Mton/ha, while the country's average papaya yield is 6.6 Mton/ha. Other important fruits grown in the CHT include jackfruit, mango, guava, lime/lemon, pomelo, coconut, litchi and melon/watermelon.

6.9.1 Vegetables

Table 6.9: Vegetable Statistics of 2003-04

Crop	CHT Area (Ha)	CHT Production (Mton)	CHT Yield (Mton/Ha)	Bangladesh Yield (Mton/Ha)
Rabi Brinjal	3,522.8	19,375.0	5.5	6.4
Kharif Brinjal	2,616.3	11,380.0	4.3	5.2
Chalkumra	1,948.6	15,160.0	7.8	6.6
Arum	2,662.8	34,230.0	12.9	7.8
Radish	1,052.2	8,525.0	8.1	9.0
Sweet Potato	631.3	6,395.0	10.1	8.9

Source: BBS 2005

Rabi brinjal is the most common vegetable in the CHT, grown in over 3,500 ha. While in 1980, the CHT was producing 2% of the country's rabi brinjal, in 2003, it was producing 8%. The vast majority (80%) of all of CHT's rabi brinjal is produced in Rangamati.

The CHT produces 10% of the country's kharif brinjal, 60% of the country's chalkumra, and 19% of the country's arum (28,000 Mton, or 80%, of which actually comes from Khagrachhari). Other important vegetables grown in the CHT include the following: jhinga, kharif pumpkin, tomato, chichinga, barbate, karala, beans, rabi pumpkin, cucumber, lady's finger, water gourd, cabbage, pui sak, cauliflower, danta, palong sak, and patal.

6.9.2 Fibre-Producing Crops

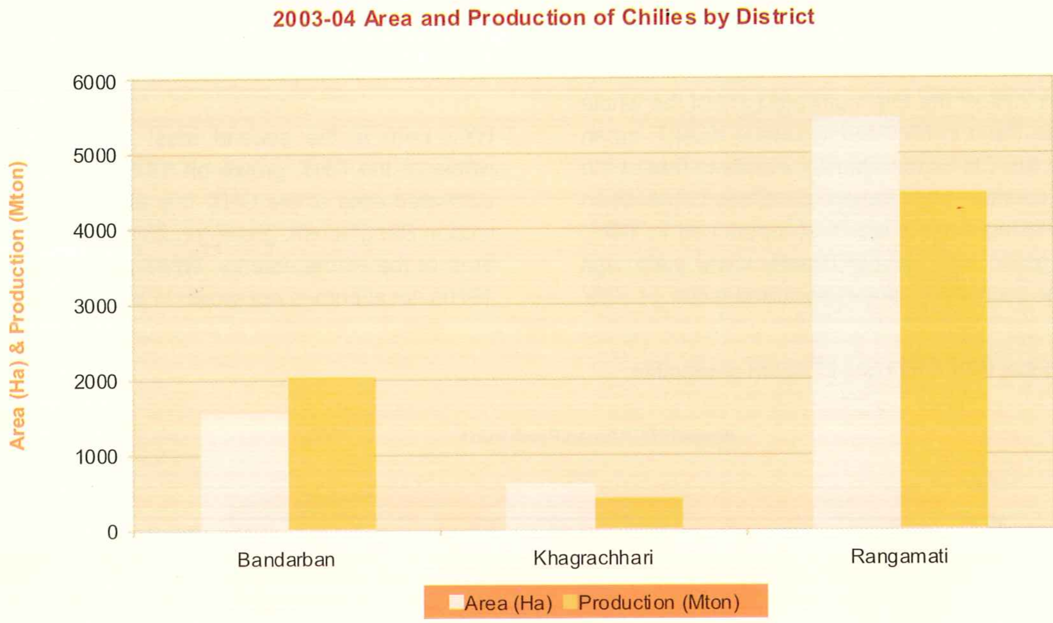
While the total area used for growing cotton in the CHT has decreased significantly in the last 30 years, cotton (rabi and kharif) remains the eighth most commonly grown crop in the CHT. In the 1970s, there was an average annual area of over 6,500 ha, while in 2003 only 4,500 ha of cotton were cropped. In 1980 the CHT was producing 45% of the country's cotton, while in 2003 it was producing 10%. While Bandarban District grows cotton on the largest area, 2,500 ha, or 65% of all the cotton growing area in the CHT, the yield is significantly lower than the other two districts, 0.09 Mton/ha, as opposed to 0.17 Mton/ha for Khagrachhari, and 0.20 Mton/ha for Rangamati. Still, Bandarban produces almost 50% of the CHT's cotton.

While jute is by far the most important fibre-producing crop in Bangladesh, it is not grown much in the CHT. It is only grown in Rangamati on a mere 12 ha.

6.9.3 Spices

Chillies are the fourth most commonly grown crop in the CHT, grown on 7,600 ha or 5.5% of all the cropped area. While Rangamati produces 65%, or 4,470 Mton, of all of the CHT's chillies, Bandarban has a greater yield of chillies, at 1.35 and 1.25 Mton/ha of Rabi and kharif chillies, respectfully. The yield (Mton/ha) for Rabi and Kharif chilies, respectively, in Rangamati is 0.76 and 0.9, in Khagrachhari is 0.66 and 0.64, and in all Bangladesh is 0.83 and 1.00.

Figure 6.7: Area and Production of Chillies by District, 2003-04



Source: BBS 2005

Tumeric is another important spice in the CHT. The 15,500 Mton of tumeric produced in the CHT makes up 22% of the country's total. While Bandarban produces only 21%, or 3,240 Mton, of the CHT's tumeric, the yield is 7.1 Mton/ha, quite a bit higher than 4.3 Mton/ha average yields for the CHT, and 3.8 Mton/ha average yield for all of Bangladesh. This certainly indicates that horiculturalists and *jhummia* in the Bandarban should increase their production of tumeric.

Ginger is the third most important spice in the CHT, covering an area over 1,900 ha. With a production of 16,520 Mton in 2003, the CHT was producing 34% of the country's ginger. The soil and climatic conditions are particularly favourable for this crop, because the yield (Mton/ha) in Bandarban is 6.8, Khagrachhari is 8.7, and Rangamati (producing 47% of the CHT's ginger) is 9.3, compared to the national average yield of 6.1 Mton/ha.

Onion, coriander seeds, and garlic are also important spices in the CHT, however all are grown on less than a total 200 ha each.

Table 6.10: 2003-2004 Rice Statistics

Crop	CHT Area (Ha)	CHT Production (Mton)	CHT Yield (Mton/Ha)	Bangladesh Yield (Mton/Ha)
HYV Aman	39,149	111,740	2.9	2.5
HYV Boro	13,577	40,740	3.0	3.3
Local Aus	11,635	16,480	1.4	1.2
HYV Aus	5,783	13,190	2.3	2.1
Local T. Aman	2,036	3,880	1.9	1.6

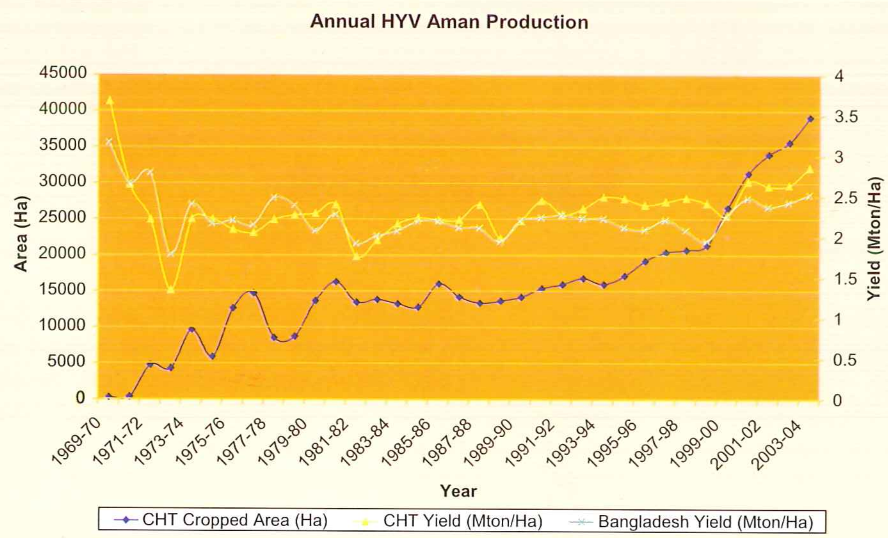
Source: BBS 2005

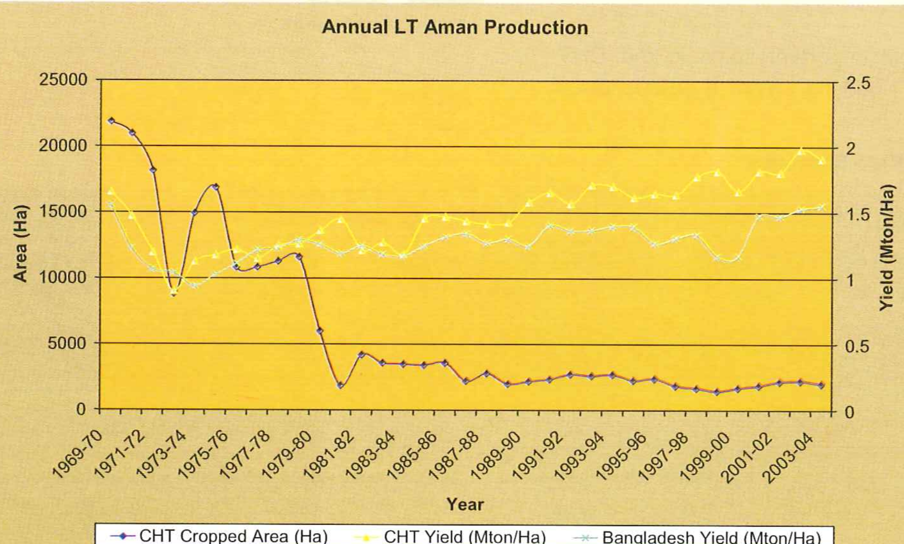
6.9.4 *Rice*

As in the rest of Bangladesh, rice remains the staple agricultural product of the CHT. In particular, HYV aman has become the most important crop in the CHT, grown on almost 40,000 ha, 22% of the total cultivated area of the CHT (and 20% of the total cultivated are of the whole country). The trend in HYV aman versus local T. aman production in the CHT shows similar trends to that of the rest of the country. HYV aman production has been steadily increasing since it was first introduced in 1970, and local T. aman, with its significantly lower yield, has been steadily decreasing since the introduction of HYV aman. In the 1970s, local T. aman was being cultivated on an average annual area of 13,000 ha, while it is now only grown on approximately 2,000 ha. With its lower hills, Khagrachhari yielded 55% (61,700 Mton) of the CHT's HYV aman produced in 2003.

HYV boro is the second most important crop in the whole of the CHT, grown on 13,500 ha, or 10% of the cultivated area of the CHT. It is also the most important crop in Bangladesh, grown on 25% of the total cultivated area of the whole country. While popularly grown in the 1970s, local boro is not grown in the CHT anymore.

Figure 6.8: Annual HYV Aman and LT Aman production





Source: BBS 2005

6.9.5 *Oil Seeds*

Til (rabi and kharif) is the most important oil seed grown in the CHT, and the fifth most important crop in all of the CHT, covering almost 7,000 ha. With a total production of 4,880 Mton in 2003 of the country, the CHT produces 19%. Rangamati produces 80% of the CHT's til, with a yield 0.66 Mton/ha, approximately even with the country's average yield. However, while Bandarban produces only 18% of the CHT's til, its yield is 1.4 Mton/ha, quite a bit higher than the national average. This indicates that Bandarban should consider increasing its til production.

While the CHT produces less than 2% of the country's mustard, it remains an essential oil seed for the area, produced on over 2,600 ha. Khagrachhari produces the most mustard, 68% (2,450 Mton) of the CHT's, and its yield is significantly greater than the national average, 1.8 Mton/ha versus 0.75 Mton/ha for Bangladesh (BBS, 2005).

6.9.6 *Pulses*

Mator is the most important pulse grown in the CHT, grown on over 1,000 ha. In fact, the CHT produces 7% (955 Mton) of the country's motor, with Rangamati producing the vast majority (93%). While Bandarban produces a very small amount of mator, its yield is 1.8 Mton/ha, significantly higher than the CHT average of 0.88, indicating that perhaps this district should increase its production.

Masur is the second most important pulse grown in the CHT, on a total of 350 ha with a yield of 0.88 Mton/ha. Also, while arhar is only grown on 91 ha in the CHT, a total of 85 Mton, 5% of the country's production of arhar. The yield for arhar in the CHT is 0.93 Mton/ha, compared to the national average of 0.54 Mton/ha.

6.10 Jhum Cultivation

Known as *Bukma* in Nepal, *Kaingin* and *Lading* in the Philippines, *Taungya* in Myanmar (Burma) and *Chena* in Sri Lanka, shifting cultivation, known as *jhum* cultivation in Bangladesh, is a traditional agricultural practice of rural people all over Asia. *Jhum* used to be practiced in the CHT with fallow periods of 15 to 20 years, however, with increased population pressure and decreased suitable land in recent decades the cycle has been reduced to three to five years. Only 2.5% of the hill area in the CHT is used annually for *jhum* cultivation. The fallow periods are meant to allow the land to naturally regenerate, but then the nutritional status of the soil is not replenished or improved, and the overall productivity of *jhum* land is decreasing (Borggaard, Garfur *et al.* 2003). However, it remains the common form of agriculture in the CHT, and thus efforts must be made to help the current system become more sustainable through implementing sustainable agricultural management practices.

The traditional *Jhum* system is a communal form of livelihood. Every year, a village of a dozen or so families living close to one another are assigned a *jhum* plot by their elders, or by the local headman or Karbari managing land distribution (ADB, Agriculture Report #3, 2001). In January and February, preparation for the "slash and burn" process begins. The area is cleared of shrubs and undergrowth, often only using a type of cutlass, or long knife, known as a *dao*. The most useful trees, especially bamboo, are saved for later use. The rest of the vegetation is dried and set ablaze by March and April. On occasion, negligence during burning damages horticultural gardens, rubber plantations, and village infrastructure.

Because of the burning process, the soil particles are left broken up and the land clear of weeds; thus little or no tillage is required. The layer of ash from the burned vegetation returns nutrients to the soil and kills off microbes. Many different kinds of cereals, fruits, vegetables, spices and oil seeds are planted in *jhum* fields in April and May. Mixtures of between five and 20 different kinds of crops are grown on the same plot. Smaller seeds such as sesame, chilli and sour leaf are tossed on the *jhum plots*. The *dao*, or other wooden hand tool, is used to make a hole in the ground for planting larger and mixed seeds such as rice, maize, beans, and cotton. After the lands are cleared, a temporary hut, known as a *tang-ghar* is set up on the *jhum* field. Guarding the lands often requires day and night attention, especially from July to September, when animals such as deer, monkey, wild boar, porcupine, and elephants can potentially destroy crops.

When the rains arrive in mid-May, the burning is completed. Upon the commencement of the rains, weeds begin to germinate. Weeds can grow quickly and cover seedling crops within 2 to 3 weeks after planting. Thus, weeding becomes an important labor-intensive part of the *jhum* process. Because weeds are most commonly pulled up by hand (and sometimes with hoe and spade), the topsoil is not loosened very much, which keeps soil erosion to a minimum. Also, the weeds that are pulled up are left on the ground and eventually turn into organic matter; this helps reduce erosion and protect the soil from direct impact from the rain. (Gafur *et al.*, 2003)

The beauty of the *jhum* cycle is that because crops with growing cycles of different lengths are all planted on the same plot, various crops are harvested from the end of the growing season throughout the winter. Cereals, including upland rice and maize, and oil seeds, such as til, have short growing cycle crops and are harvested in October. Cotton, spices (such as tumeric and ginger), and root and tuber crops (such as cocoyam, cassava and yams) are harvested throughout the winter or "rabi" dry season. Bananas have long growing cycles up to two years and are harvested twice or thrice over three years (Rafi and Chowdhury, 2002). The table below compares the *jhum* calendar with that of plain land agriculture.

Table 6.11: Seasonal Calendar for Agricultural Activites in CHT

Month	Plain land	*Jhum* land	Others
January	Thrash and hoard paddy; harrow and cultivate paddy field; harvest mustard	Prepare the hill slopes for *jhum* by clearing jungles. The best bamboo chopped off is saved for use.	Construct and renovate house; women collect fire wood, gin and spin cotton, die threads and cloths (if needed they buy yarn), Make baskets
February	Harvest and thrash mustard; harvest tobacco, chili, potato and vegetables	Same as January	
March	Sow aus; plough land for winter (rabi) crops and jute cultivation (not in all case)		
April	Plough land and sow jute seeds and rice	Burn *jhum* land to clear jungles	Construct *jhummia* huts
May	Sow aman seed in beds prepared for it.	Start planting in land prepared for *jhum* with first rain	Conduct all works related to sowing and planting
June	Harvest aus; Plough and harrow fields for aman	Same as May	
July		Clear weeds; collect vegetables e.g. brinjal planted in *jhum*	
August	Cut, rot and dry jute	Collect vegetables, harvest early rice and sesame and pluck cottons etc. from the *jhum*	
September/ October	Prepare land for mustard, onion, chili, radish, peas, cucumber, brinjal, tobacco, etc. cultivation	Harvest the last rice of the year	Cut bamboo and sun grass for sale
November/ December	Harvest aman and prepare field for aus	The *jhum* cycle ends and in course of time the hill slopes used for *jhum* get covered with jungle and foliage as before	Weave cloths

Source: Bessaignet (1958) pp. 16-17

Environmental Impacts of *Jhum* Cultivation

A study was conducted in 1998 and 1999 to determine the economic and environmental sustainability of *Jhum* cultivation in the CHT. A catchment of about one ha was jhumed in March of 1999, by a *Jhumia* family, in Bandarban. A neighboring catchment of similar size was left fallow. Gauging stations down hill of both catchments measured runoff. Calculations of soil and nutrient loss were determined for both catchments. The difference in loss was the excess loss from *Jhum*. The loss for the whole CHT was calculated assuming the total area of *jhum* was 2.5% of the CHT or 33,237 ha. It was determined that over 980,000 tonnes of soil and over 62,500 tonnes of organic matter are lost due to *jhum* each year. Also, in order to make up for the lost nutrients, it would require close to US$2 million in the purchase of fertilizers. (Borggaard *et al.*, 2003)

Table 6.12: Loss of soil, nutrients, and economic value from *Jhum* cultivation

Parameters	*Yearly loss from entire CHT (tonnes)				Commercial fertilizers used in the country	Cost of fertilizer and equivalent loss (USD)
	Current *Jhum* fields	Fallowed *Jhum* fields	Excess loss from *Jhum*	Loss equivalent to commercial fertilizer		
Soil	1,364,633	383,010	981,623	—	—	—
OM	78,694	16,048	62,646	—	—	—
Total N	5,254	945	4,309	9368	Urea	1·077·270
Na	135	45	90	—	—	—
Ca	2,062	485	1,577	3941	Lime	591,210
Mg	447	107	341	—	—	—
K	427	73	353	707	MP	130,786
P	4.32	1.02	3.3	16	TSP	4,290
S	8.39	2.5	5.88	33	Gypsum	2,451
B	0.6	0.15	0.45	2	Solubor	414
Cu	1.93	0.48	1.45	—	—	—
Fe	249.73	50.84	198.89	—	—	—
Mn	246	33.32	212.68	—	—	—
Zn	2·23	0·66	1·57	4	$ZnSO_4$	6’521

*Yearly total *Jhum* cultivated area in CHT= 2.5 % of 1 329 500 ha = 33 237 ha. Costs tonne1 urea, $CaCO_3$, MP, TSP, gypsum, solubor and $ZnSO_4$ are 115, 150, 185, 260, 75, 185, and 1500 USD, respectively. 1 USD = BDT 54/- (as of March 2001). *Source: Borggaard et al., 2003*

In addition to *jhum* cultivation and major impacts from the felling of trees for the timber industry (both authorized and unauthorized), erosion related problems in the CHT have increased due to unsuitable tillage techniques such as deep plowing on hill slopes to grow tuber crops such as arum potato, ginger, and turmeric. Bangali migrants from the plain areas mainly practice these techniques, often without awareness of proper agricultural management methodologies.

Soil erosion can lead to increased landslides and flash floods. Also, animal habitats are destroyed, decreasing biodiversity. As sediment and other pollutants enter water bodies, there is a decline in water quality. Decreased dissolved oxygen levels and settling of sediment on fish breeding grounds can disrupt aquatic habitats. Also, settling of sediment on the river bottom (sedimentation), can lead to the river bottom rising, which may lead to faster flood times and disrupt navigation of water bodies. Therefore, the need for an integrated approach to natural resource management is evident.

6.11 Crop Damage

Damage to crops due to excessive rainfall and other natural calamities are common place in the CHT. During the summer monsoon rains of 1999, the extent of damage was particularly severe. In the Rangamati region, over 60 ha of summer vegetables were damaged, a loss of 300 Mtons. During the same year, 15 ha of bringal, 20% of the all the bringal that was destroyed in Bangladesh, were destroyed in the CHT, a total loss of 50 Mtons. In addition, the following amounts of crops were destroyed: 12 Mton chichinga, 92 Mton of barbate, 10 Mton cucumbers, and 26,510 Mton of total aus.

In 2003, damage to crops was also notable. In particular, over 600 Mton of total aus (over 350 ha) was damaged to due excessive rainfall, and over 650 Mton (170 ha) of summer vegetables were destroyed.

Table 6.13:Crop Damages by Excessive Rainfall/Flood, Rangamati Region, May-July, 2003

Crop	Loss in production (Mtons)	Total area damaged (ha)
Aus Local	110.0	89.0
Aus HYV	500.0	267.1
Summer Vegetables	656.0	170.8
Banana	44.0	3.0

Source: BBS 2005

In some of the more remote parts of the CHT crop damage by wild animals poses a serious problem. Wild boar is the main problem, while reports of deer, monkey, and porcupine are also common. In Khagrachhari elephants have been reported to be a nuisance. Experts recommend live fencing of a thorny species of shrub or small tree, such as the *Jatropha curcas*, to protect against this type of crop damage. Coordination between locals, along with use of drumming or flares, could be used to protect against elephants by scaring them away (Hassan and Van Lavieren, 2000).

6.12 Fertilizer/Pesticide Use

The use of agro-chemicals remains limited in the CHT. This is mainly because of financial constraints, lack of market access, and low requirement of chemicals for traditional *jhum* cultivation. Some herbicides, such as *round up* and *grammoxone*, are used to control weeds such as sungrass, trailing and climbing weeds. Also, a common trend in the CHT is the use of "biological insect control" for irrigated rice, by setting up roosts for insect-eating birds in crop fields.

However, the use of agro-chemicals is increasing with the increasing production of HYV rices, in particular HYV aman, which need high fertilizer and pesticide inputs because of its narrow gene base and general susceptibility to pests and diseases.

Rat infestation of rice grown on *jhum* plots poses a growing problem. Part of the reason is the elimination of natural predators such as birds of prey, snakes, and some jungle cats. Even worse is the potential that in the next five years the dreaded 'gregarious bamboo flowering' and associated rat infestation could occur. Mysteriously, the muli bamboo (*Melocanna baccifera)* flowers every 50 years, once in their lifetime. This causes a large increase in rats that feed on the dying bamboo flowers and seeds. The rats eventually turn upon agricultural crops, causing widespread famine and devastation. The most famous such occurrence was in 1959, in the Mizoram region of India, which caused a devastating famine (Chhakchhuak, 2002).

Active planning is required to be prepared for the potential gregarious bamboo flowering. Experts recommend the Department of Agricultural Extension to encourage proper use of rodenticides, such as the anti-coagulants *Klerat* or *Matikus* (Hassan and Van Lavieren, 2000).

Pesticide-used data is limited for the CHT. In the 1988-89 growing season, the CHT used the following pesticides: 35 Mton granular, 16 Mton conventional borer pest complexes, 1 Mton soil insecticide, 0.5 Mton acaricide, 0.25 Mton rodenticide, and 14 Mton weedicide (BBS, Statistical Yearbook, 2004).

6.13 Suitable/potentially suitable crops by land type

Based on the suitability analysis of soil and land/terrain characteristics, such as land type, drainage condition, soil texture, and soil consistency, suitable and potential suitable crops (with and without irrigation) for the CHT have been identified. The list of crops (see Annex: B) is derived for the whole year by soil unit and taking into account different land types. Land type is a land classification based on seasonal inundation depth during the monsoon season. The definition of different land types as developed by the SRDI in 'Thana Nirdeshika' is given below:

High land (H), which is not inundated by normal flooding during the monsoon season.

Medium High land (MH), which is inundated up to 90 cm (3 ft) for a time period of two weeks to one month by normal flooding during the monsoon.

Medium Low land (ML), which is inundated 90 cm to 180 cm (3 6 ft) for a couple of months by normal flooding during the monsoon.

Low land (L), which is inundated 180 cm to 275 cm (6 - 9 ft) for a couple of months by normal flooding during the monsoon.

Very Low land (L), which is inundated more than 275 cm (9 ft) for a couple of months by normal flooding during the monsoon.

It is important to realize that the depth limits between flooding classes are not as rigid as the definitions might suggest. Flood-levels in an area may, in fact, vary by as much as a meter or more over different years. They may also reach their peak levels for only a few days at a time during a particular year. They may also reach their peak levels for only a few days at a time during a particular year. What these classes indicate is the level of flooding which farmers expect when they decide which crops to grow in the kharif season on their different kinds of land, based on their long experience of cultivation in particular sites. The depth and duration of seasonal flooding are critically important for agriculture. The flooding characteristics determine the annual cropping patterns.

The crops suitable for cultivation on the high land, medium high land and medium low land are listed in Annex: B, since the CHT has no low land or very low land. The Bandarban district contains 96.5% of high land compared to Khagrachhari (89.15%) and Rangamati (88.66%). High land is suitable for the production of maize, mustard, vegetables - potato, peanut, brinjal, radish; spices; fruits - banana, papaya, pineapple, sugarcane, coconut, betel nut, mango, jackfruit, guava, litchi, sapotha, orange; timber trees - sagun, gamar, koroi, berry, mahogany etc. The medium high land, over 5.6% area of the total CHT region, is suitable for the cultivation of paddy mostly: boro, T aus, and T aman. Only 3015 ha of the CHT are medium low land.

6.14 Livestock

The breeding and raising of livestock, also known as animal husbandry, in the CHT is an important part of many people's livelihoods. It contributes approximately 5% of the region's annual products. During the many religious festivals throughout the year, livestock serve as a source of additional income. The raising of pigs is particularly important for Parhari festivals, while goats and other livestock are used by both Paharis and Bengalis. There has been some introduction of buffaloes into the region, but buffaloes are not fit for the hilly terrain. Often it is cattle that are used instead of buffaloes for transport, pulling carts, hauling timber, and ploughing fields (ADB final report, 2001).

The table shows the breakdown of livestock and poultry in the CHT, according to the 1996 Rural Agricultural Census. The average number of animals per household in the CHT is between four and seven, higher than the national average of between two and four for most livestock. For poultry, the number of animals per household is over 11 in the CHT, while the national average is close to one. The total number of livestock in the CHT is less than one percent of the national total, except for buffaloes, in which case the CHT total makes up more than two percent of the national total. Cattle are the most common livestock and sheep is the least common. On average, between 35-45% of the CHT livestock are found in Khagrachhari and Rangamati each, with 20-30% of the total livestock found in Bandarban, except for sheep, 50% of which are found in Khagrachhari with only 13% found in Bandarban.

Table 6.14: Livestock and Poultry Birds in the CHT ('000s)

Location	Cattle		Buffalo		Goat		Sheep		Fowls		Ducks	
	Holding Reporting	Number	Holding Reporting	Number	Holding Reporting	Number	Holding Reporting	Number	Holding Reporting	Number	Holding Reporting	Number
Bandarban	23	90	1	2	15	49	0	2	38	424	7	37
Khagrachhari	31	113	1	6	22	75	1	6	54	589	11	52
Rangamati	27	103	2	7	23	82	1	5	52	629	10	63
Total CHT	81	306	4	16	59	205	2	13	144	1643	28	151
Bangladesh	8,171	21,572	270	723	5,591	12,920	497	1,690	1,36,007	97,552	7,004	29,116

Source: *The Bangladesh Census of Agriculture (Rural), 1996, BBS*

According to the BRAC study (described earlier), in which 2,550 households were interviewed, the Marma owned the most cattle (48.3%) and the least number of goats (12.4%). In most cases, Bengalis owned fewer animals than Paraharis and the Bengalis did not own any pigs. Bengalis did, however, own the most number of ducks (21.2%), compared to Parahis, in which 10% or fewer households owned them. It should also be noted that Bengalis had a lower market value for all animals.

Table 6.15. Possession of Livestock and Poultry Birds by Ethnicity

Ethnic Group	Cattle			Goat			Chicken			Ducks			Pig		
	% of hh possess	Avg	Market Value (Tk)	% of hh possess	Avg	Market Value (Tk)	% of hh possess	Avg	Market Value (Tk)	% of hh possess	Avg	Market Value (Tk)	% of hh possess	Avg	Market Value (Tk)
Bangali	41.8	3	11,095	21.2	3	1,645	63.3	13.1	556	21.2	7	421	0		
Chakma	43.4	4.1	18,029	24.3	4.7	3,485	77.1	13.9	613	10.3	10.7	658	29	1.9	2,375
Marma	48.3	4	23,217	23.4	3	2,636	79.6	12.6	652	9	8	581	23.4	2.7	1,819
Mro	42.4	4.7	23,571	12.4	3.8	3,803	90.6	14.6	1,082	5.9	3.4	631	83.1	5	3,706
Tripura	36.3	4	16,781	22.9	3.5	2,764	69.8	9.7	621	5.9	4.3	385	35.7	2.9	2,605

Source: *Rafi and Chowdhury 2001, Note: hh household*

There appears to be potential demand for increased livestock production in the CHT, partially because of the high demand for dairy products in Bangladesh, which is currently met through imports. The Bangladesh Livestock Research Institute (BLRI) in Naikhongchari managed to domesticate the Gayal, a large cattle breed found wild in the CHT and sometimes raised by the Mro and Bawm. They also determined that 'Furun', Dumur twigs, Gamar twigs and some vines commonly found in the CHT could serve as good cattle feed. The raising of Gayal could be a profitable business because the meat is considered a delicacy in Bangladesh. (ADB 2002)

While livestock ownership is not very prevalent in the CHT relative to the rest of the country, production of animal husbandry in the CHT should be conscious of the relationships between livestock and the environment. As the population increases further, the practice of animal husbandry will also increase and bring about more of the associated environmental pressures. Excess grazing and animal trampling cause soil compaction. During rain events soil compaction could make it more difficult for the rain to infiltrate the soil, causing more runoff. Increased runoff leads to increased soil erosion and thus the movement of soil particles and other pollutants into the water bodies. On a positive note though, this trampling can help mix the soil and can be used as a preparation of paddy fields. Another major environmental issues related to livestock are animal waste and faeces. While used as a common fertilizer, if not properly managed it may runoff and cause increased (and potentially hazardous) nutrient levels in water bodies (FAO, 2005).

6.15 Fisheries

Fishing provides supplemental income and nourishment for many of the people in the Chittagong Hill Tracts. Numerous rivers flow through the hills, bringing fish along with them. Floodlands and *beels*, a local name for fresh water lagoons, also provide habitat for fish. Furthermore, Kaptai lake boasts 73 fresh water fish species. The table below represents the many indigenous fish species in the CHT.

Table 6.16:List of indigenous fish and shrimps present in hill districts, including Kaptai Lake

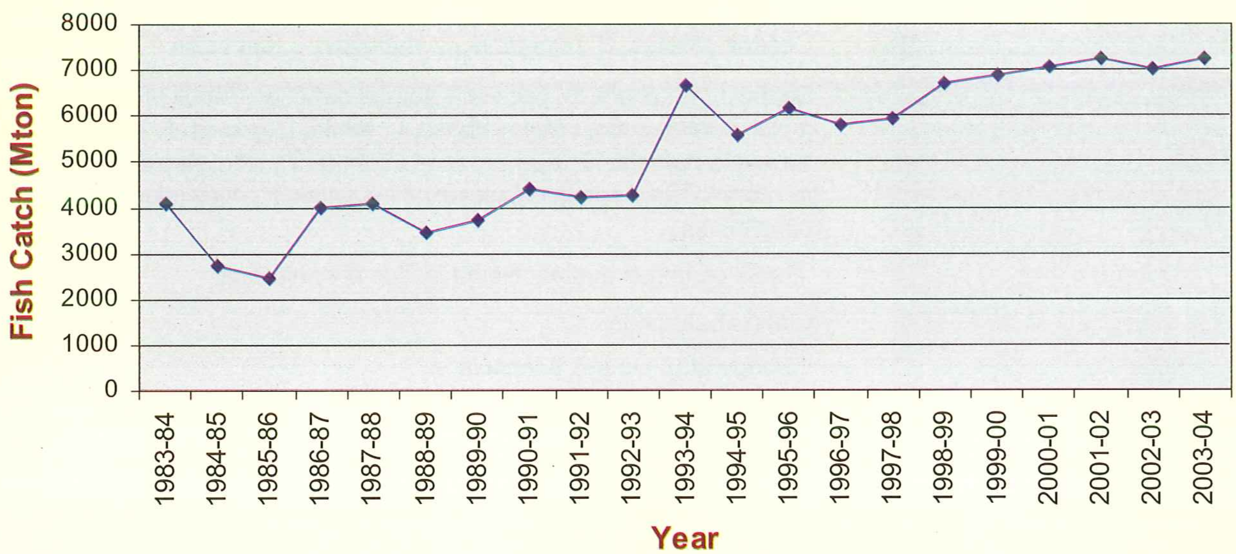
Group	Species
Synbranchidae	Monopterus cuchia
Tetradontidae	Tetradon cutcutia
Belonidae	Xenentodon cancila
Hemirhamphidae	Dermogensis pussilus
Cyprinodontidae	Aplocheilus punchax
Channidae	Channa striatus, C. punctatus, C. marulius, C. orientalis
Cyprinidae	Salmostoma phulo, S. bacaila, Esomus danricus, Amblypharyngodon mola, Rohtee cotio, Labeocalbasu, L. rohita, L. gonius, L. bata, L. angra Cirrhinus mrigala, C. reba, Puntius sophore, P. ticto, Aspidoparia jaya, A. morar, Danio sondhii, Crossocheilus latius, Puntius jelus, P. chola, P. conchonius
Cobitidae	Lepidocephalus guntea, Nemacheilus zonanternas
Clariidae	Clarias batrachus
Siluridae	Wallago attu, Ompok bimaculatus
Heteropneustidae	Heteropneustes fossilis
Schilbeidae	Ailia coilia, Pseudeutropius atherinoides, Eutropiichthys vacha
Bagridae	Mystus aor, M. cavasius, M. bleekeri, M. vittatus, Batasio tengana
Sisoridae	Gagata youssoufi
Notopteridae	Notopterus chitala, N. notopterus
Engraulidae	Setipinna phasa
Clupeidae	Gudusia chapra, C orica soborna, Gonialosa manminna
Mastacembelidae	Macrognathus aculeatus, Mastacembelus armatus, M. pancalus
Mugilidae	Rhinomugil corsula
Anabantidae	Colisa lalius, C. fasciatus, Anabas testudineus
Gobidae	Glossogobius giuris
Nandidae	Nandus nandus
Pristolepidae	Badis badis
Sciaenidae	Johnius coitor
Centropomidae	Chanda ranga, C. nama, C. baculis, C. lala
Shrimps	Macrobrachium rosenbergii M. lamarri

Source: *Aziz and Hossain, 2002.*

Since the creation of the Kaptai Lake reservoir, per capita fish comsumption has risen, but still remains lower than the rest of the country, as the majority of the fish produced is sent to markets outside the CHT. An increase in fisheries production and the promotion of fisheries culture could help increase fish consumption as well as further production as an alternative source of revenue. (Aziz and Houssain, 2002).

Kaptai lake represents the potential for the growth of fishery production in the CHT. Managed by the Bangladesh Fisheries Development Corporation (BFDC), the fishery of Kaptai Lake helps bring in a total catch production of 7000 tonnes per annum. BFDC cites that another 4,000 tonne catch is utilized for local consumption or sold in markets. It is estimated, based upon truck capacity and frequency of transport movement, that the actual catches may amount up to 15,000 tons annually (ADB, 2002). In the present situation, however, an increase in production is unlikely because moderate fishing methods in the short term are required to sustain and nurture a larger fish population; while the fish population has been hurt by continunal overfishing, environmental degradation, and poor enforcement of fishing regulations.

Figure 6.9: Total Fish Catch from Kaptai Lake by Year

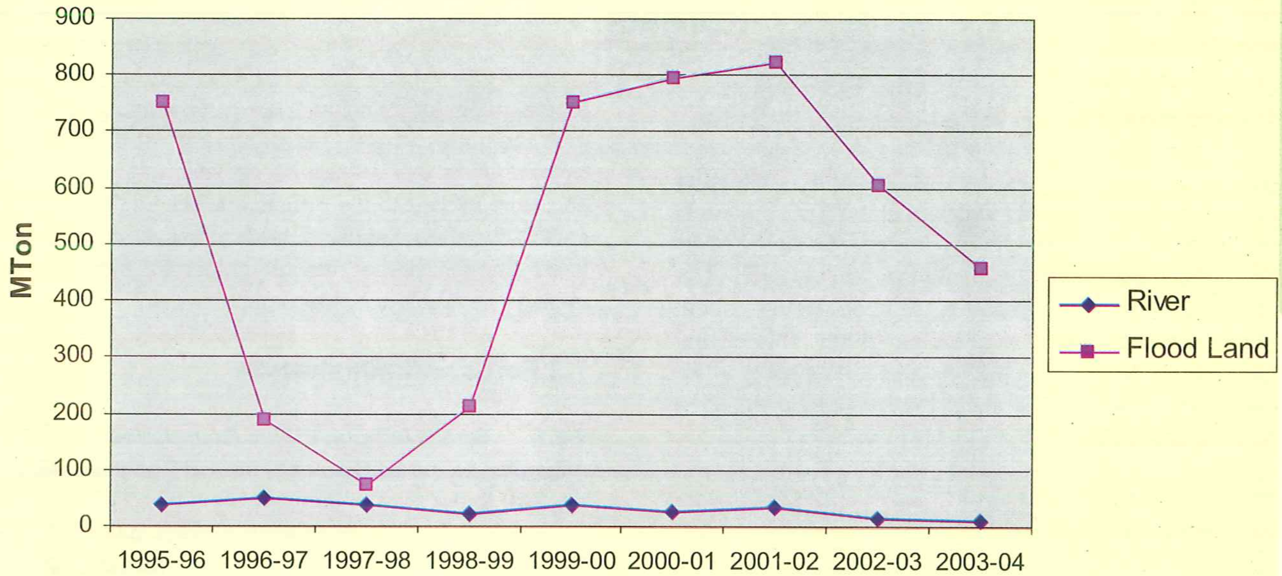


Source: (DoF, 1995-96; DoF, 1996-97; DoF, 1997-98; DoF, 1998-99; DoF, 1999-00; DoF, 2000-01; DoF, 2001-02; DoF, 2002-03; DoF, 2003-04)

The annual fish catch data of Kaptai lake shows that there has been an increasing trend from 1983-84 to 2003-04. The total fish catch in 1983-84 was 4057 metric ton, increasing to 6635 metric ton in 1993-94 and 7238 metric ton in 2003-04.

Local consumption of fish depends heavily on river and floodland catches. However, fish supply from inland water is unstable and subject to fluctuations in environment and weather. The following chart illustrates the total yields over the past nine years from floodlands and rivers.

Figure 6.10: Annual Fish Catch from Inland Water of Bandarban District



Source: (DoF, 1995-96; DoF, 1996-97; DoF, 1997-98; DoF, 1998-99; DoF, 1999-00; DoF, 2000-01; DoF, 2001-02; DoF, 2002-03; DoF, 2003-04)

The annual catch from rivers has declined from 38 to 11 metric tons. More dramatically, the chart shows a sharp drop in floodland catches from 1995-1996 and again in 2003-2004. This sharp fall in fish catch may be the result of the destruction of natural fish habitats, overfishing, environmental degradation, and lack of proper management.

The river and floodland natural fish supplies are fragile and sensitive to changes in environment and habitat. As a result, more energy and resources could be put into the development of culture based fisheries, which have not yet been fully developed in the CHT. Many of the species of fish indigenous and introduced in the CHT may not be suitable for commerical production. However, some foreign species may prove profitable through introduction into local waterbodies. The major Indian carps, exotic carps, and silver barb would all be suitable for pond and peg cultivation, but would not be viable for cage production. On the other hand, the Thai catfish, tilipia, GIFT, and freshwater giant shrimp could be cultivated for pond, cage, and peg productions. While African catfish could be cultivated in cage and in pen, its production has been banned and is not recommended (Aziz and Hossein, 2002).

Several entities are working to increase the commerical cultivation of fish populations: DoF is working to modernize fish culture activities; the Bangladesh Fisheries Research Institute is developing pen and cage culture as well as low cost cage feed; and the Bangladesh Fisheries Development Corporation is trying to increase fish population with the introduction of Indian carps. Pen and cage culture offers much potential for increased production, especially in streams and rivers. Some work has already been done; in the 1990s 11.5 ha of nursery ponds and 92 ha of other water bodies were used for fish culture by modifying creek flow and small dam construction. Many benefits can be gathered from increased production, such as greater profits and livelihoods, as well as improved nutrition. While all these organizations and agencies have become involved, the fundamental step in increasing sustainable production and consumption of fish is participation from the people who will be taking care of and surviving off water (Aziz and Hossein, 2002).

Chapter 7

Forests

7.1 Introduction

About 14 percent of the area of the country is under forest cover; 43% of which belongs to the CHT (Abdus *et al.*, 1999). The per capita forest cover of the CHT is 0.81 hectare compared to 0.016 ha for the whole country. The major forest products are timber, bamboo and fuel wood. Bamboo grows almost everywhere. About 44% of the total area of the CHT is under middle dense forest cover. Only 16% of the CHT is under dense forest cover (see paragraph 7.1.2).

The forestlands in the reserved forests have potential for sustainable cultivation, but are still being rapidly degraded due to monoculure plantation, illegal logging, shifting cultivation, and poor management. If the present trend continues, these reserved forests will be devastated, and converted into unproductive forestland. The policy of the Forest Department had been to convert the natural forests into allegedly more commercially productive plantations through a system of artificial regeneration. This has had a serious impact on the natural environment, and has resulted in increased soil erosion and silting in rivers and reservoirs. There is an urgent need for bringing these areas under intensive multiple use forest management and planning. Unfortunately, this will not be possible until the present problems related to the forests are settled. The forestry sector therefore needs to be addressed on a priority basis through proper natural resources planning and management before it is too late.

7.2 Forest Administration

7.2.1 Forest Administrative Boundaries

According to the BBS source, the CHT contains 43% of the total forest area of Bangladesh. It has 21.72% of the country's Reserved and Protected forest, and 99.75% of Bangladesh's Unclassified State forest. All the Unclassified forest area lies within the CHT area. The total forest area by district as shown in the table below only includes the forest area under the control of the Department of Forest and the Ministry of Land and excludes the Private Planted forests. There is a total of 1111943.88 hectares of forest area in the CHT with 50.75% in Rangamati, 29.09% in Bandarban and 20.17% in Khagrachhari District. It is estimated that less than half of this area actually has tree cover.

Table 7.1: Classification of forest area (ha), 2002-03

Sl.	District	Bandarban (Area in ha)	Khagrachhari (Area in ha)	Rangamati (Area in ha)	Total in CHT (Area in ha)	Total in BD (Area in ha)
	Classification					
1	Reserved & Protected Forest (RF & PF)	107,739	38,783	2,55,111	401,634	1,848,850
2	Acquired Forest	0	0	0.61	0.61	8,442
3	Unclassed Forest	15,639	1,701	0	17,340	17,340
4	Total Forest Area (uder control of FD)	123,378	40,484	255,112	418,974	1,878,473
5	Unclassified State Forest (USF)	200,066	183'759	309,136	692,961	694,688
6	Khas F. Area	0	0	8.70	8.70	24,083 NA
7	Planted Forests (Private)	26,184	8,930	22,259	57,373	
8	Total Forest area under MoL (row 5)	200,066	183,759	309,136	692,961	4,688 69
9	Total Forest area under FD & MoL (row 4,8)	323,444	224,243	564,257	1,111,944	97,245 2,5

Source: *BBS, 2005 *ADB, 2001*

Reserved and Protected forest (RF & PF): The RFs are owned and administered by the Forest Department. The PFs are administered by the district collectorates, although their forest resources are controlled and managed by the Forest Department. In RFs, no entry into or use of lands is permitted unless specifically allowed by the Forest Department, but entry and use of PF lands is allowed unless specifically forbidden.

Unclassified Forest: These are the unclassified state forests that have been transferred to the Forest Department for management.

Unclassified State Forest (USF): USFs are a residual category of partly forested lands, under the control of the district collectorates, which the indigenous people consider as their forest and swidden commons. It is under the authority of the Ministry of Land, the Commissioner of Chittagong and now the DC/HDC in the districts.

Khas Forest Area: These are public lands registered in the name of any individual or corporate body, regarded by land administration officials as belonging to the state.

Planted Forests (Private): These forests have been created through plantations owned by individuals.

The USF lands are public lands, the status of which can be changed through a set procedure involving local governments, the central government, institutional stakeholders and the actual population. Conversion of status is indicated in the Gazette of Bangladesh. The procedure establishes that notifications should be given to the inhabitants, giving opportunity for claim settling (Forest Act 1927). The conversion is very important because it establishes DoF as the ruling agency of the land, and by extenstion the ruling agency of the people living on it. The process of conversion of administrative status of land opens up avenues for investment, but also creates a temporary hiatus in the actual authority of landa discrepancy between actual occupation and authority. Reserved and protected forests are officially out of bounds for anyone. Representatives of the national government, in conjunction with local authorities, administer the other forests. Despite their categorization as "forests", most of these lands, including the RFs, are now bereft of significant vegetative cover, whether judged by denseness, height or biodiversity. The following table provides an estimate of the different types of forests in the CHT.

Table 7.2: Forest Area ('000' hectare) of Rangamati District by Thana from 2001-02 to 2002-03

Forest Class / Thana	RF & PF		Total F. Area under F.D		USF		Khas F. Area		Total Forest Area (ha)	
	2001-02	2002-03	2001-02	2002-03	2001-02	2002-03	2001-02	2002-03	2001-02	2002-03
Baghai Chhari	137,805	135,084	137,805	135,084	33,799	33,799	0	0	171,604	168,883
Barkal	236	236	236	236	73,023	78,050	0	0	73,259	78,286
Belai Chhari	60,146	60,146	60,146	60,146	13,751	15,305	0	0	73,896	75,450
Jurai Chhari	16,153	16,153	16,153	16,153	34,032	34,032	0	0	50,185	50,185
Kaptai	12,719	12,711	12,719	12,711	15,548	27,361	0	0.40	28,267	40,072
Kawkhali (Betbunia)	5,229	5,229	5,229	5,229	11,368	11,368	0	0.29	16,597	16,597
Langadu	3,041	5,762	3,041	5,762	32,977	33,382	0	0	36,018	39,144
Nanner Char	6,070	6,070	6,070	6,070	26,928	26,928	0	0	32,998	32,998
Rajasthali	10,888	10,888	10,888	10,888	10,545	13,135	0	0	21,433	24,023
Rangamati Sadar	2,935	2,833	2,935	2,833	35,777	35,777	0	8.01	38,712	38,618
Total	255,222	255,111	255,222	255,112	287,748	309,136	0	8.70	542,970	564,257

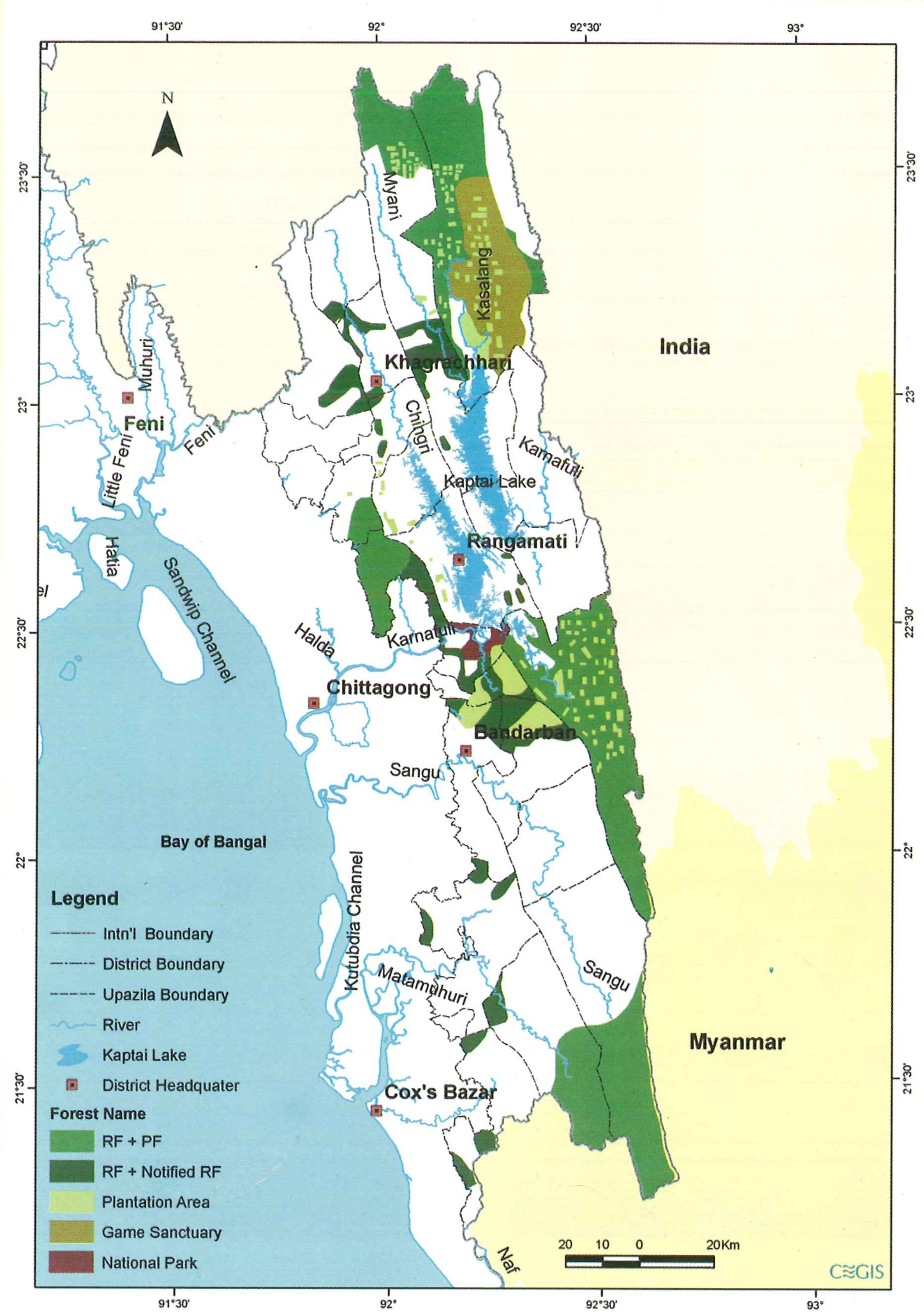
***Source:** BBS, 2005*

The total forest administrative area of Rangamati District has increased 3.92% from the year 2001-02 to 2002-03 as seen from the above table. The Unclassified State Forest area has increased 7.43% within a year whereas the forest area under the Forest Department has slightly decreased. Most of the changes occurred in the Kaptai, Rajasthali and Langadu thanas. An analysis of the forest data of the last five years of Khagrachhari and Bandarban shows that the forest area boundary of these two districts did not undergo any change. It seems that despite the existing disagreement of the local people, the forest area has been extended.

The government has declared seven wildlife sanctuaries, four national parks and one game reserve in the forest areas through notification in the official gazette. In addition, there are two wildlife sanctuaries in the forest areas, which have not been notified under the Wildlife Order. These 14 protected areas cover about 225000 ha, which is 1.56 percent of the total land area. All the protected areas are part of the reserved forest. Public entry into the reserved forests, without the permission of the Forest Department, is prohibited. There is no commercial harvesting in the protected areas. Reserved forests that are not declared as a protected area may be managed for regular forest products but require an approved forest management plan. The Pablakhali Wildlife Sanctuary of Rangamati with an area of 42,087 hectres was established in 1962/1983. The Rampahar Shitapahar Wildlife Sanctuary (3026 ha) established in 1974 in Rangamati has not yet been notified under the Wildlife Order (Reza *et al.* 1992).

Figure 7.1: 60% of the CHT is under medium to high dense forest cover

Map 7.1: Administrative Forest Map of the CHT



7.2.2 *Forest area from RS data*

The landcover of the CHT area including forests has been classified using a LANDSAT Enhanced Thematic Mapper (ETM) image of 2003. Based on the calculation of Forest Canopy Density (FCD), the forests have been classified into the following classes:

- Herb-Shrub and Grass (1 - 5% FCD)
- Low Forest (5-25% FCD)
- Middle Dense Forest (25-40% FCD)
- High Dense Forest (40-100% FCD)

The range of percentages of FDC values for the above classes was selected based on field information and other secondary data. Field survey was carried out in different parts of the study area. A total of 119 sites were visited during the field survey. Figure 2 shows the spatial distribution of the field monitoring sites in the LANDSAT ETM images of 2003.

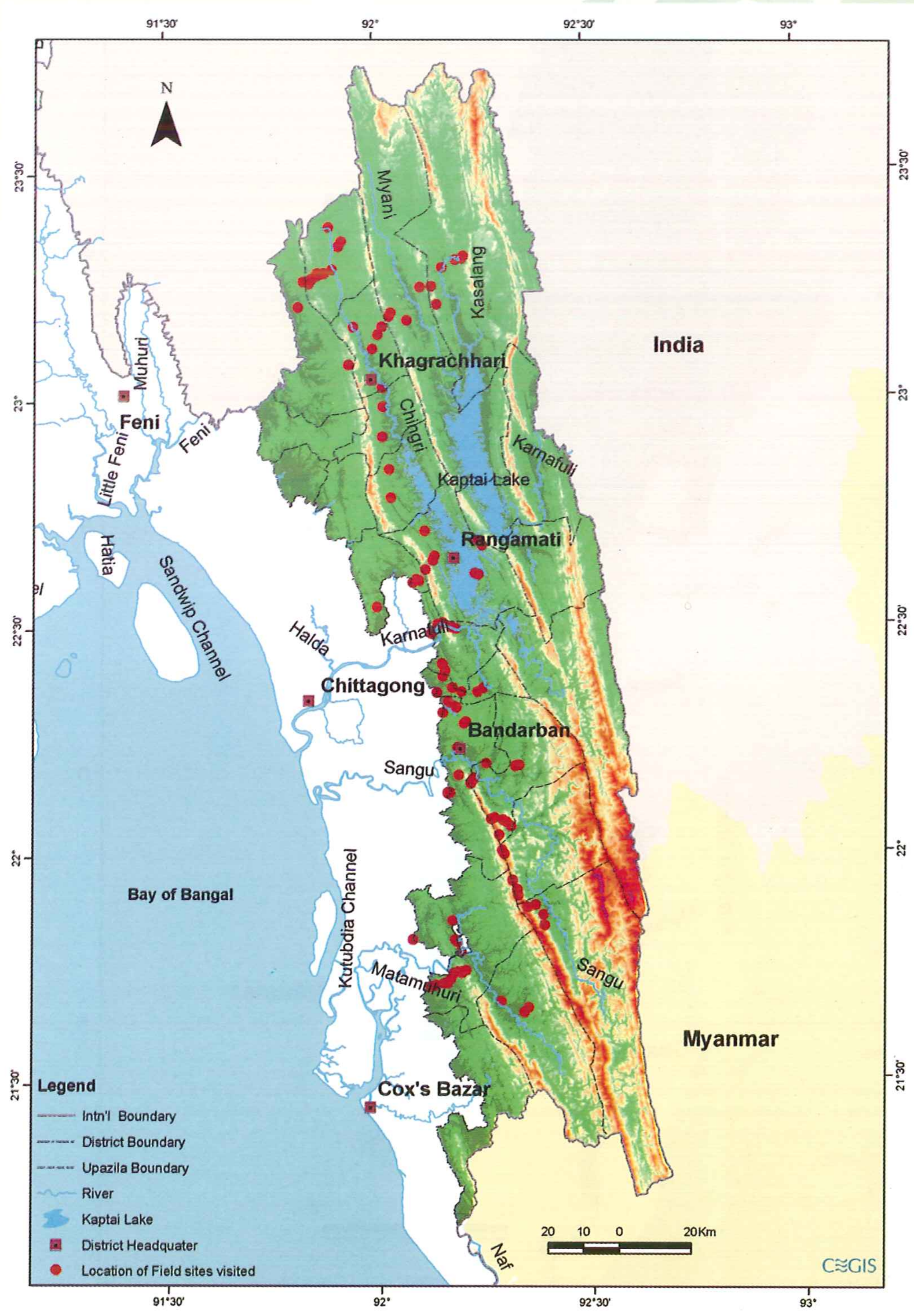
The classified FCD layer was integrated with the other classes such as "River and Water bodies" and "Fallow or Agricultural land". Settlements were extracted from high resolution IRS Panchromatic (Black and White) images. It was also integrated with the final land use map. The map shows the area of different land uses derived from LANDSAT ETM+ images of 2003. The percentage of high dense forests is only 15%. About 42% of the total area is covered with medium dense forests while 21% is covered with low-density forests.

Figure 7.2: Sample of field photos taken during the field survey for land cover assessment:
a) agricultural field, b) rubber plantation, c) estimation of vegetation cover, d) bamboo forest

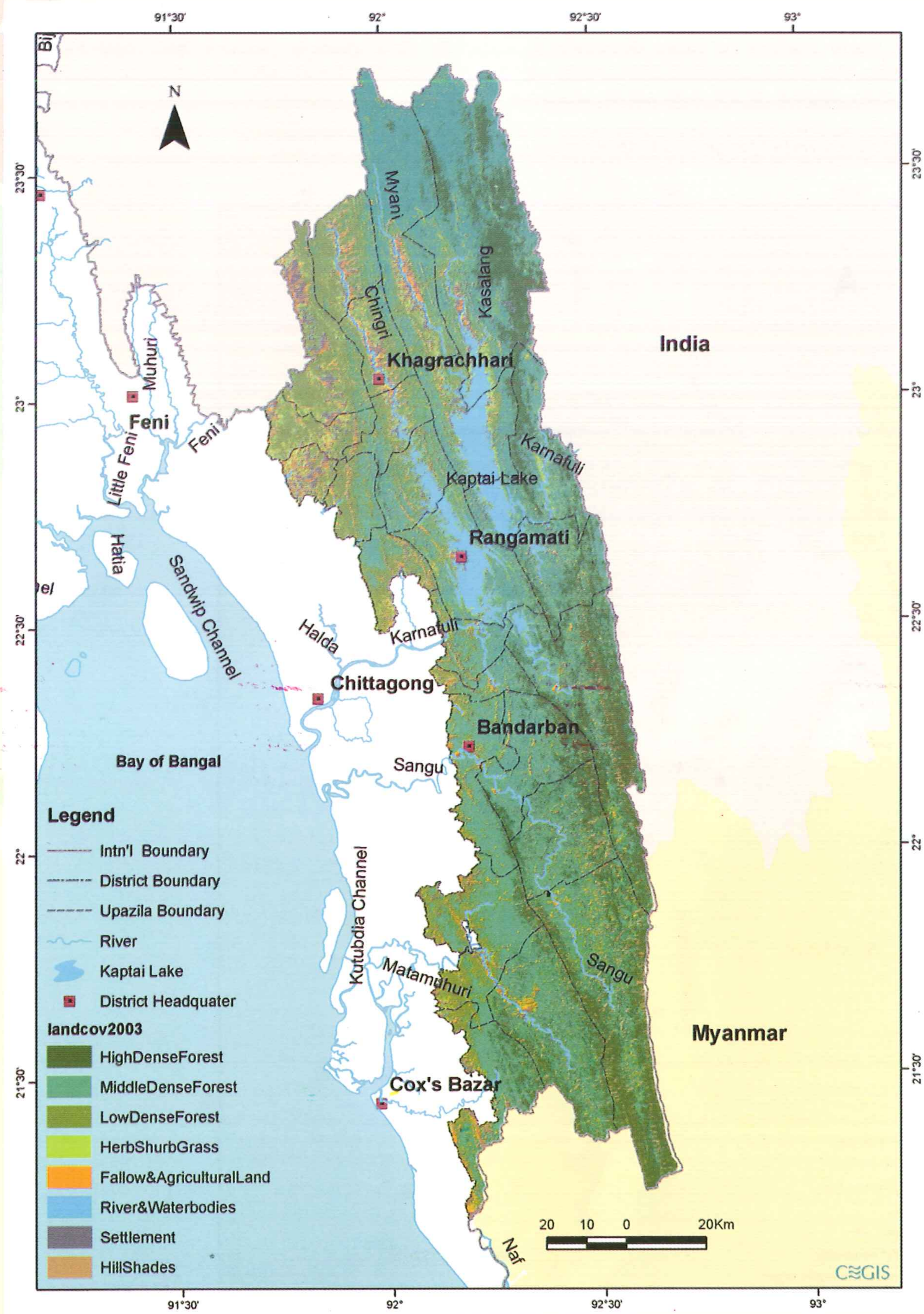
7.2.3 *Ground truth data*

A field survey was carried out in different parts of the study area. A total of 119 sites were visited during the field survey. Figure 2 shows the spatial distribution of field monitoring sites in the LANDSAT ETM images of 2003. The main purpose of this field survey was to observe different landuse and land cover on the ground. The canopy density, number of 5mX5m trees, and the average tree height were measured for forest land use. The GPS reading (latitude and longitude) and photographs of each site were taken during the field survey.

Map 7.2: Field sites visited for ground truth observations in June 2006



Map 7.3: Land Cover Map of the CHT



The Forest Canopy Density layer was integrated with other themes such as "River and Water bodies" and "Fallow or Agricultural land". Settlements were extracted from high resolution IRS Panchromatic (Black and White) images. It was also integrated with the final land use map. The following Table-3 shows the area of different land uses derived from satellite images.

Table-7.3: Area in hectares of different land cover classes

Class Name	Area (Hectare)
Fallow or Agricultural land	51,521
Herb-Shrubs-Grass	64,331
Low Dense Forest	284,334
Middle Dense Forest	554,240
Dense Forest	202,643
River and Water Bodies	78,212
Settlements	58,819
Hill Shades	31,433
Total Area	1,325,533

About 44% of the total area of the CHT is under middle dense forest cover. Only 16% of the CHT is under dense forest cover.

7.3 Forest types

7.3.1 Natural Forests

The CHT is situated in the humid tropical forest zone. The natural forests of the CHT are mainly characterised as mixed evergreen and deciduous forests. The forest trees can be ecologically classified into the following types, which intermingle with each other (source: Ishaq, 1971)

a) Evergreen

Tropical wet evergreen forests: These forests occur in deeep valleys or shaded cold places with plentiful water available for plants. The largest trees grow up to a 100 ft. The dominant tree species are Garjan (*Dipterocarpus spp.*), Dhakijam (Syzygium grande), Civit (*Swintonia floribunda)*, Chundul (*Tetrameles nudiflora*), Telsur (*Hopea adorate*), and Narikeli (*Pterygota alata*).

Tropical mixed or semi-evergreen forests: This species covers vast areas of undulating hilly ground and alluvial flats. The tallest trees range from 150 to 200 ft. This forest overlaps with evergreen or deciduous type of forests depending on local influence. The garjan (Dipterocarpus spp) a dominant upper story species is found in groups and patches. The other species found in this region are Tali (Dichopsis polynatha), Chapalish (Artocarpus chapalasha), Pitraj (Ammora wallechii), Raktan (Lophopetalum fimbriatum), Khairjam (Eugunia cymosa), Simul (Salmalia malabaricum), and Bandorhola (Duabanga sonneralisides).

b) Deciduous

Tropical moist deciduous forests: This forest type is found in valleys and channel banks. The dominant species occuring in the top canopy are Kadam (Anthocephalus kadam), Patali (Trevia nudiflora), Jarul (Lagerstroemia speciosa), and Shimul (Bombax ceiba).

Tropical open deciduous forest: This type of forest occurs on the exposed southern slopes with a south to westerly aspect. The principal species are Champa (Michalia champaca), Koroi (Albizia spp), and Toon (Cedrella toona).

c) Savannah

Savannah occurs in a major part of the unclassed state forest (USF). It is found in areas which have been slashed and burnt for shifting cultivation. This type of forest area without trees and covered by sungrass (*Imperata cylindrica*) and Khagra (*Saceftram spontaneum*) is known as savannah.

d) Bamboo

Bamboo is a very prominent species that occurs in the CHT. It is usually found as a single or mixed species. Bamboo species are found throughout the forests either in pure patches or as undergrowth. There are eight species of bamboo within the ecologically different land types of the CHT extending from the channel banks to the hilltops. Muli, mitenga, daloo and orah are some of the species, which have high commercial value.

The Tropical Moist Evergreen Forests and Semi-Evergreen Forests with closed canopy once covered the CHT area in abundance. Tropical Moist Evergreen Forests were found in the moist lower valleys. These species-rich, three-storied tropical lowland rainforests of the area have almost dissappeared. The canopy tree species (reaching up to 45 m in height) included the Swintonia floribunda, Dipterocarpus, Hopea, Sterculia, Tetramelis nudiflora, and Artocarpus. The middle storey was dominated with tree species of the Meliaceae and Leguminoseae families. The Semi-Evergreen Forests (or Tropical Mixed Forests) of hill slopes and associated (higher) valleys were characterised by an open canopy that had a large number of deciduous trees, but with a well-developed understorey of smaller trees and shrubs, epiphytes and climbers. The dipterocarp species (*Dipterocarpus turbinetas* or garjan) that occur as clusters is becoming rare (ADB 2001c). The Swintonia or civit, Sterculia, Salmalia, and Tetrameles are some of the other canopy species. The second storey is well developed with species of Amoora, Mesua, Cedrella, and Bombax. The third stratum includes diverse species.

The secondary species, such as bamboo species, vines and ferns, invade areas where the canopy is open. The sub-climax low open forests are formed on drier and exposed hill slopes with shallow soils. Dense bamboo stands develop in sub-climax forest areas that were affected by fire, cleared, or opened up. Eventually, such bamboo stands can become a stable fire sub-climax, completely replacing the primary forest species (ADB 2001c). The tropical evergreen or semi-evergreen types provide 40% of the commercial timber production (Gain, 1998).

Bamboo thickets, bushes, and low forests of non-commercial shrubs and planted forests are found in most of RF and USF areas. The maximum yield from bamboo stands is 2.8 tons /hectare under ideal conditions. The cutting cycle of bamboo is three years. Frequently cut and burned bamboo thickets on drier slopes could eventually be replaced by pioneering grass and herb species, i.e. the Imperata cylindrica (sun or sann grass), and the Eupatorium odoratum. Removal of natural forest stands and agricultural burning practices cause the expansion of bamboo trees. The bamboo stands become a stable fire sub-climax with time, replacing the primary forest species. The distribution of bamboo areas in the CHT is presented in the table below.

Table 7.3: Bamboo distribution in CHT

Site Type	District	Area (Hectares)
Pure stands	Kassalong	17,000
	Rangkheong	34,000
	Sangu-Matamuhuri	25,000
USF		65,000
RF undergrowth		120,000

Source: *FD as cited in (ADB, 2001a)*

Muli is the most important species that occurs as undergrowth and as pure bamboo thickets on well-drained slopes in a sub-climax form. Reaching a height of 10-15 meters and a diameter of eight cm, the new shoots are formed every year and are harvested in 2-3 years. Muli stands propagate over huge areas as they are fire-induced sub-climax vegetation (rhizomes survive fires from *jhumming*). Mitenga, daloo and orah, the remaining three commercially important species, grow in association with muli in mixed bamboo thickets and sometimes as the understorey of high forests. These species exhibit reduced pioneering characteristics under pre-existing shade and reasonably moist sites. They grow in a cluster of 40-100 shoots with a height of 1225metres and 512.5Êcm diameter (ADB 2001c).

Table 7.4: CHT Bamboo species

Local Name	Latin Name	Notes
Muli	Melocanna bambusoides	Dominant; commercial
Dabo	Teinostachyum dulloca	Commercial
Mitenga	Bambusa tulda	Commercial
Orah	Dendrocalamus longispathus	Commercial
Kaliserri	Oxytenanthera auriculata	Commercial size; limited areas
Kali	Oxytenanthera nigricilliata	Small size; commercially limited
Bariala	**Bambusa vulgaris**	**Small size; commercially limited**
Basali	**Teinostachyum griffithii**	**Small size; commercially limited**

Source: *FORESTAL (1966) as cited in (ADB, 2001a)*

Bamboo species "flower" gregariously and die immediately after flowering. This phenomenon occurs in the CHT every 40Êto 60Êyears. In 1959/1960 the dying of bamboo clumps in the CHT occurred on a large scale, which suggests that the next event may happen soon.

7.3.2 Plantation forestry

Commercial plantations have replaced the natural forest containing tree species such as Garjan, Gamar, Chapalish, Toon, Koroi, Shimul, Civit, Chandul and Champa. The Bangladesh government in its "Revised Working Plan for the Forests of Chittagong Division for the years 1978-79 to 87-88", adopted monoculture, "to replace the existing irregular, depleted and less productive forests by a man made plantation forest with more valuable and productive species suited to the soil and country's requirements."

Plantations are forest stands established by planting and/or seeding in the process of afforestation or reforestation. They can be either:

- introduced species (all planted stands), or
- intensively managed stands of indigenous species that meet all the following criteria: one or two species at the time of planting; even age class; regular spacing.

In Bangladesh monoculture has been carried out under the names of "social forestry", "participatory" or "community forestry". Plantations of teak, rubber, eucalyptus, acacia and other exotic species are termed as simple plantation forestry". Hill forest plantations established between 1974 and 1990 totalled 80,407 hectares, out of a total of 247,830 hectares country-wide (BBS Statistical Yearbook, various years).

Table 7.5: Forest species harvest (rotation) ages

Species		Rotation age
Common name	Scientific name	
Teak	Tectona grandis	30 – 40
Gamar	Gmelina arborea	11
Garjan	Dipterocarpas spp.	45
Kadam	Anthocephalus chinensis	12
Simul		14
Keora	Sonneratia apetala	12

Source: BBS Statistical Yearbook (various years)

The table below shows the details of the plantation area in the USF of the CHT area. It shows that within a period of 15 years (1975 to 1990) the plantation area under the USF of the CHT increased from 8281 ha to 22393 ha.

Table 7.6: Plantation development from 1975 to 1990 (in ha)

Plantation / Year	1974-75	1975-76	1976-77	1977-78	1978-79	1979-80	Total
USF	287	1,214	1,781	1,651	1,123	2,225	8,281
Total in BD	4,981	9,692	13,009	11,956	13,306	15,538	68,482
Plantation / Year	Second five-year plan						
	1980-81	1981-82	1982-83	1983-84	1984-85		Total
USF	1,983	6,151	3,845	3,743	6,961		22,683
Total in BD	16,280	21,875	20,221	22,336	22,805		103,517
Plantation / Year	Third five-year plan						
	1985-86	1986-87	1987-88	1988-89	1989-90		Total
USF	6,253	4,644	4,553	3,669	3,274		22,393
Total in BD	18,473	16,215	16,116	11,174	13,953		75,831

Source: *Reza et.al. 1992*

Impact of Plantation Forestry

Monoculture plantations in the hilly areas have the following negative impacts-

- Numerous native species have been destroyed;
- The indigenous people who have been living in the hill slopes for years have lost their habitat and land for *jhum* cultivation.

Segun trees are known for their beauty and strength and used for furniture. They are a foreign species first imported during the British era. Segun was first brought from Burma in 1872 and was sowed in Sitapahar in Chittagong. Segun has the following negative impacts on the local environment and soil

- It causes huge soil erosion especially during the rainy season.
- No other trees grow beneath the segun tree.
- Soil erosion due to segun cultivation gathers silt in the Kaptai Lake bed.
- Segun is susceptible to diseases and insects.

Teak also has been planted commercially in the CHT area. Monoculture plantation of teak is ecologically unsound because

- It increases fire hazards.
- It is susceptible to attack from teak defoliators and teak canker insects.

Rubber plantation, a new venture undertaken by the Bangladesh Forest Industry Development Corporation (BFIDC), has proved to be environmentally and economically unsuccessful. This has hastened the deforestation of the CHT area.

7.3.3 Agroforestry

Agroforestry is a tree based farming system, which provides both forest and agriculture crops through landuse practices. Agroforestry can be promoted through a combination of perennial species, including utility and firewood and somewhat shade tolerant annual species such as tubers (Dioscorea spp., Amorphophallus), spices (turmeric, cardamom) and pineapples.

Improved agroforestry practices were introduced through the 'Upland Settlement Project' by the CHTDB with the goal of rehabilitating landless and marginal *jhummias* in the CHT. A total of 60 project villages have been established, 40 in Khagrachari and 20 in Bandarban District. Based on a study conducted in 15 of these villages some benefits and drawbacks of agroforestry have been identified which are given in the following table 7.7.

Table 7.7: Evaluation of the agroforestry system in the CHT

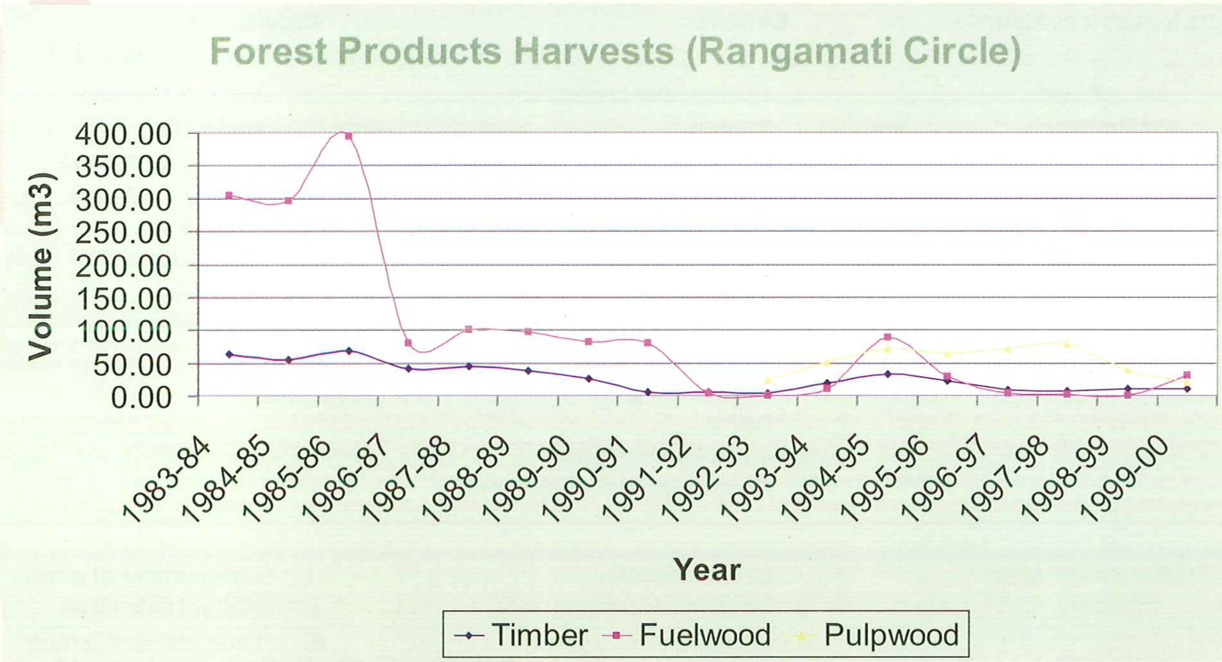
Agroforestry system	Benefits	Drawbacks
1. Homestead agroforestry	i. Sustainable production system ii. Multiple crapping system iii. Environmentally friendly iv. More long-run benefit v. Maximum utilization of site possible vi. Market demand of the products vii. Supportive government policy viii. Institutional support ix. Conservation of biodiversity	i. Lack of planting materials ii. Small plot or land iii. Insecurity of land ownership iv. Marketing of the products v. New technology
2. Rubber-based agro-forestry	i. Labor intensive ii. Employment opportunity iii. Institutional and policy support	i. Low number of crops ii. Natural calamities iii. Insecure land tenure
3. *Jhum* cultivation	i. Multiple production system ii. Pest control iii. Culturally adaptable iv. Simple management v. Law cost technology vi. Indigenous practice vii. Immediate benefit viii. Possibility of refinements	i. Suit erosion ii. Low production iii. Weeds iv. Land tenure
4. Plough land cultivation	i. Labor intensive ii. Productivity high iii. Government support	i. Wild animals ii. High input iii. Weeds

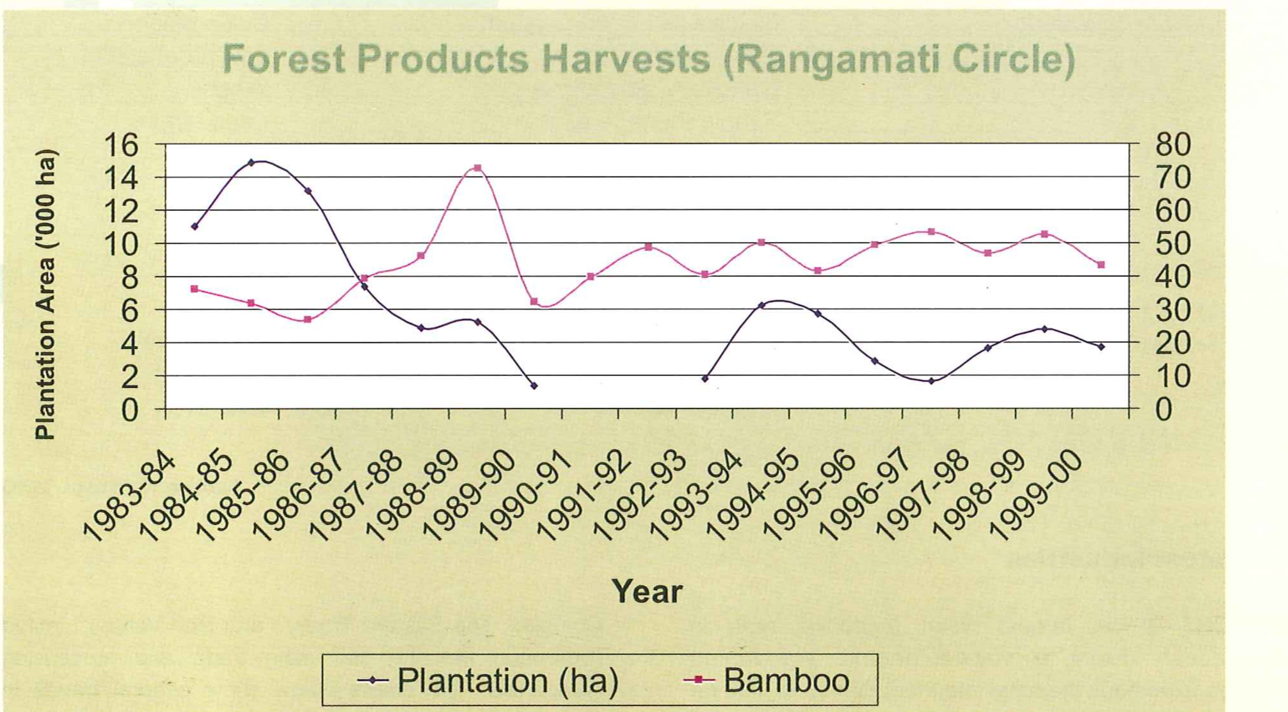
Source: *Nath et al., 2005*

7.4 Forest Industries

The CHT is the largest wood producing area in Bangladesh. From a socio-economic standpoint, bamboo is perhaps the most important non-food plant for Bangladeshis, as it is used for housing, construction, and furniture. The three major forest-related industries in the CHT are the Karnafuli Pulp Mill, Sattar Match Factory, and BFIDS Lumber Processing and Sawmill Complex. The Eastern Traders and Red Veneer Limited (Betbunia) are the two main trade and processing companies. The charts below show general trends in forest harvesting in the Rangamati Circle. It appears that harvesting has been generally decreasing since the mid-1980s, with timber harvesting decreasing by over 90% from 395 m^3 in 1985 to 30 m^3 in 1999.

Figure 7.2: Forest Product Harvests (Rangamati Circle)





Source: (ADB, 2001a)

7.4.1 *Pulp and Paper*

While paper is not produced in the CHT, pulp, an intermediary product, is primarily developed at the Karnafuli Pulp Mill (KPM), located in Chandragona near Kaptai. KPM is the single industry employing the most number of people, a total 3,000 (less than 10% Parhari), and many more indirectly for work related to forest extraction (most of whom who are Parhari). When the mill was set up in 1953, it was the largest mill in Asia. It was constructed with approximately $13 million in foreign funds, including $4.2 million from the World Bank. It was granted 95,830 ha of Reserve Forest on a 99-year lease. In 1968 the lease was revised to a total of 51,100 ha; of which 33,750 ha comprised the Rainghkong Reserve Forest and 17,350 the Kassalong Reserve Forest. The mill was nationalized in 1971 and is now controlled by the Bangladesh Chemical Industries Corporation (BCIC).

The installed capacity of the KPM in 1990 was 33,000 tons, with production at over 30,200 tons. Currently, the KPM does not perform extraction of wood; they buy wood from private contractors. It also uses the pulp from the Sylhet Pulp and Paper Mills and pulp from abroad, which, actually, is more expensive than the pulp produced at KPM. On site, there is a gas-converted solar power plant, water treatment plant, research and development centre, a recovery unit and a converting plant for different kinds of paper products. The KPM produces writing, printing and typing papers, corrugated boards, wax-coated papers, paper cones, gummed tapes, and bitumin paper (www.banglapedia.com).

The KPM uses pulp obtained from fibrous raw material, mainly bamboo. It requires about 90,000 tons of bamboo annually to meet the capacity. Because of decreasing stocks, the mill is turning more towards broad-leaved species such as *gamara* to meet its demands. It is recommended that the mill turn to hill farmers for their supply; however, due to current price controls, this is not feasible.

Since the mill has been continuously losing money for many years, there is evidence that it is not very profitable and may even be heading towards liquidation. Though the 1998 estimated turnover was 1.2 billion Tk, it lost over 215 million Tk in the 1997-98 year and 88 million Tk in the 1998-99 year. It is recommended that serious management restructuring, including privatization, be considered to avoid bankruptcy.

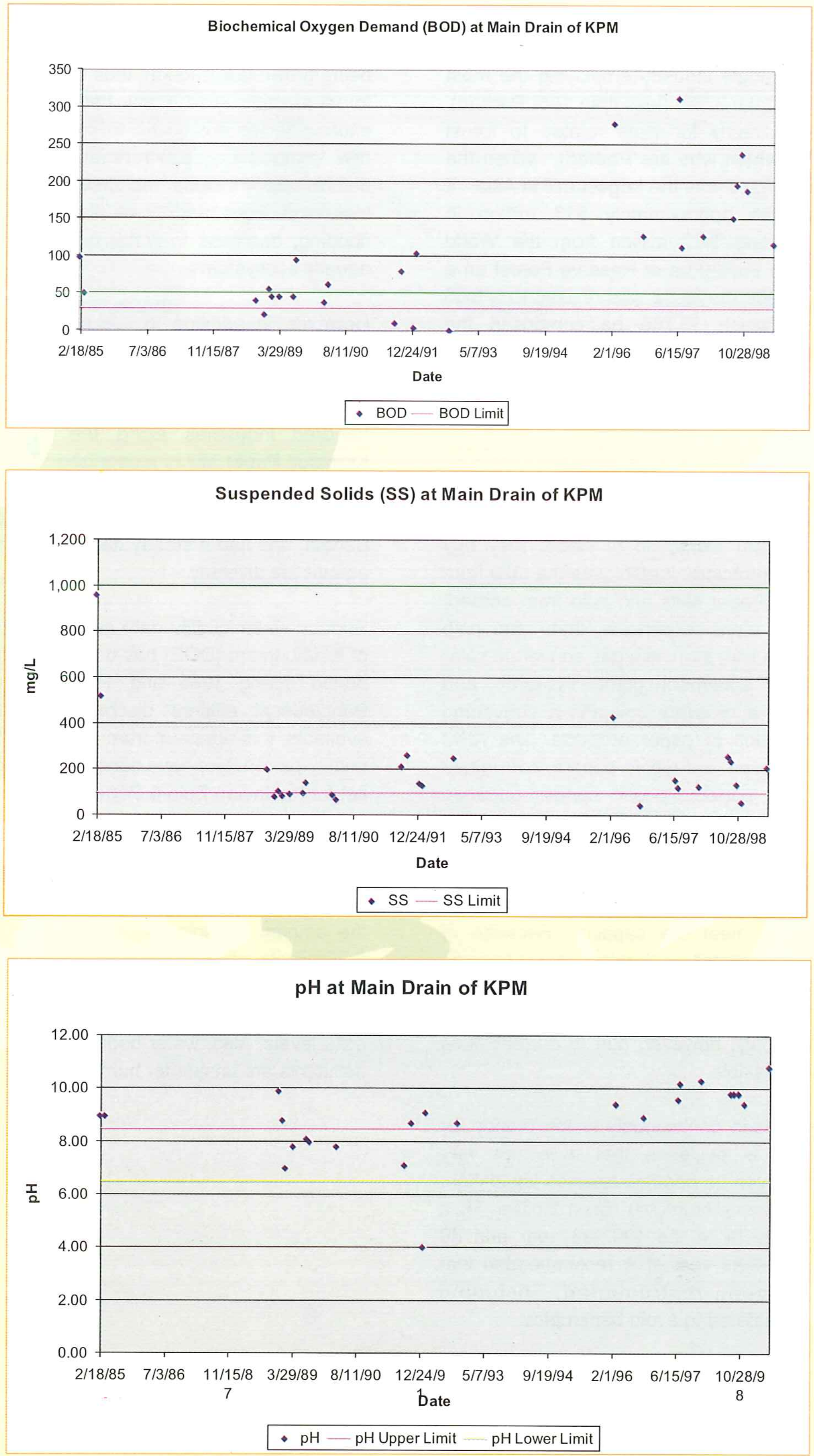
The amount of bamboo required to supply the Karnafuli Paper Mill has taken a severe toll on the environment of the CHT. Millions of tons of bamboo and softwood have been cut down for paper production. New bamboo is not being grown fast enough, thus the mill is turning to other forest species. Also, many hectares of plantations with exotic species are grown to supply the paper mill with raw materials. Environmental impacts from this deforestation include increased soil erosion, nutrient loss, land slides, and eventual sedimentation, increased flooding, decrease in water quality, and destruction of aquatic ecosystems.

However, in addition to the environmental impacts of deforestation, the Karnafuli Paper Mill and other industries are polluting the waterways of the CHT through effluent discharge. While there are over one hundred industries along the Karnafuli River, the Karnafuli Paper Mill is recognized as one of the biggest culprits in terms of water pollution, especially in the CHT. The river, which eventually empties into the Bay of Bengal, has had a steady decrease in water quality and aquatic life diversity.

Surface water quality data collected by the Department of Environment (DOE) has been sporadic, but data for a period during 1985 and 1999 was available. While Bangladeshi effluent discharge standards were not available, it is apparent from the charts below that water quality parameters have consistently exceeded the limits set for the Indian Pulp & Paper Mills DOE, 1993.

Biological oxygen demand (BOD) is a measure of the amount of oxygen used when organic matter undergoes decomposition by microorganisms, and is an indicator of the amount of biological "pollution" in the water. High BOD levels correlate with low dissolved oxygen levels, which in turn places stress on fish habitats. Aquatic organisms are also very sensitive to P^{H} and suspended solid levels. Also, water bodies with high levels of these pollutants are unsafe for human contact.

Figure7.3: Water Quality Data from the Main Drain of KPM, 02/1985 06/99



Source: DOE, 1993

7.4.2 *Sawmills and Timber Processing*

Most of the wood leaving the CHT is unprocessed; meaning that there is little "added-value" to the forest products. While in 2001 there was an estimated 29 sawmills in Bandarban, 29 in Rangamati, and 39 in Khagrachhari, many of which were not reaching maximum capacity, there were over 1,300 sawmills in the Chittagong city area. Most of the processing is completed near the major port city of Chittagong.

It is generally accepted that the sawmill industry is declining in the CHT. The return on investment for the whole region is 12.6%, with a total turnover of almost 49.0 million Tk (11.4 million Tk in Bandarban, 15.7 million Tk in Khagrachhari, 21.9 million Tk in Rangamati), which is encouraging. Ultimately, however, the industry is suffering from the decrease in available wood. The low return on investment in saw mills in Rangamati (7.24%), due to relatively expensive land prices, might force these mills to move other places.

Table 7.8: Return from Saw Mills in the CHT

District	Number	Average Monthly Profit (Tk)	Return on Investment
Bandarban	23*	6,365.00	33.85%
Khagrachhari	39	7,285.00	33.52%
Rangamati	29	12,548.00	7.24%

* While at the time there was an estimated 29 saw mills in Bandarban, this data is based on 23.

***Source:** ADB Industry, Services and Tourism, 2001*

BFIDC has been carrying out timber extraction for over 40 years. They own a Lumber Processing and Sawmill Complex near Kaptai. BFIDC is the only organization in Bangladesh that is authorized to perform mechanized timber extraction from the CHT, mainly from the Kassalong and Ranigkhong Reserve Forests. The estimated 1998 turnover for the BFIDC Lumber Processing and Sawmill Complex is 9.9 million Tk, and it is reported that they are losing money every year. There are recommendations for BFIDC to slow down or perhaps halt their extraction processes due to the rapidly decreasing virgin forests. In addition, there are environmental and managerial concerns with the processing plant. It is recommended that an environmental assessment take place and privatization of the plant be considered.

The Bangladesh Timber and Plywood Industries Ltd. is a private company with an estimated turnover in 1998 of 1 million Tk.

7.4.3 *Furniture*

Furniture shops are the most thriving small-scale industry in the CHT, in part due to their temporary nature and use of rented space, which eliminates the need to actually purchase land. The total turnover is 71.6 million Tk (17.8 million Tk in Bandarban, 23.5 million Tk in Khagrachhari, 30.3 million Tk in Rangamati). The total return on investment for the CHT is 125%, with Khagrachhari having a return on investment greater than 75% and Bandarban and Rangamati with a return on investment of 150%.

Table 7.9: Return from furniture shops in the CHT

District	Number	Average Monthly Profit (Tk)	Return on Investment
Bandarban	51	5,141	154.61%
Khagrachhari	30	6,078	77.84%
Rangamati	62	4,145	165.54%

***Source:** ADB Industry, Services and Tourism, 2001*

The furniture industry primarily produces household items such as beds, dinning tables, chairs and benches, though some argue that the quality and craftsmanship are questionable. The vast majority of these are shipped out of the CHT, mainly to Dhaka. If there were more direct links with the larger retail markets, the future of this industry could be bright.

7.5 Deforestation

The annual rate of deforestation in Bangladesh is 0.8 (8.8 thousand ha). Deforestation is caused by both natural and manmade factors. Natural factors include fire, disease, and weather induced stress. But often human activities such as land clearing for agriculture, over grazing, over extraction of timber, harmful and illegal logging practices worsen the situation, not to mention the underlying indirect causes of poverty, inequitable resource tenure, population pressure, corruption, misguided policies and institutional pressures.

The consequences of depletion of dry tropical forests for fuelwood may be serious since it affects the local populations directly and immediately. The trends are (GoB 1993):

- In the closed canopy moist forests, large areas of forest have been modified in structure and floristic composition by logging and deforestation;
- All virgin forests suitable for production will either be deforested or logged within a century at present rates;
- Where species diversity is often the highest (more accessible lowland forest), the impact in terms of direct resource depletion and species loss is also the highest;
- In the more remote areas where resource values for timber production are lower, there is accelerated soil erosion;
- The most densely populated and accessible forests are the most endangered;
- Loss in resource values, implicit at present rates, will result in permanent damage to species and genetic resources.

The forests of the CHT area, including high forest areas, have been disappearing with time. The timber type natural forest area of the Kassalong reserve in the CHT decreased from 52,700 ha in 1963 to 41,400 ha in 1990. The 1963 and 1990 inventory revealed that plantation areas increased drastically from 2.91 % to 17.5%. The area under the category 'others' including non-forested, non productive, water and swamp areas has experienced a sharp rise within a span of 27 years. Both mixed forest areas (timber-bamboo and bamboo-timber) and areas with bamboo trees have decreased.

Figure 7.4: Percentage of forest types in the Kassalong and Rainkhiong reserves

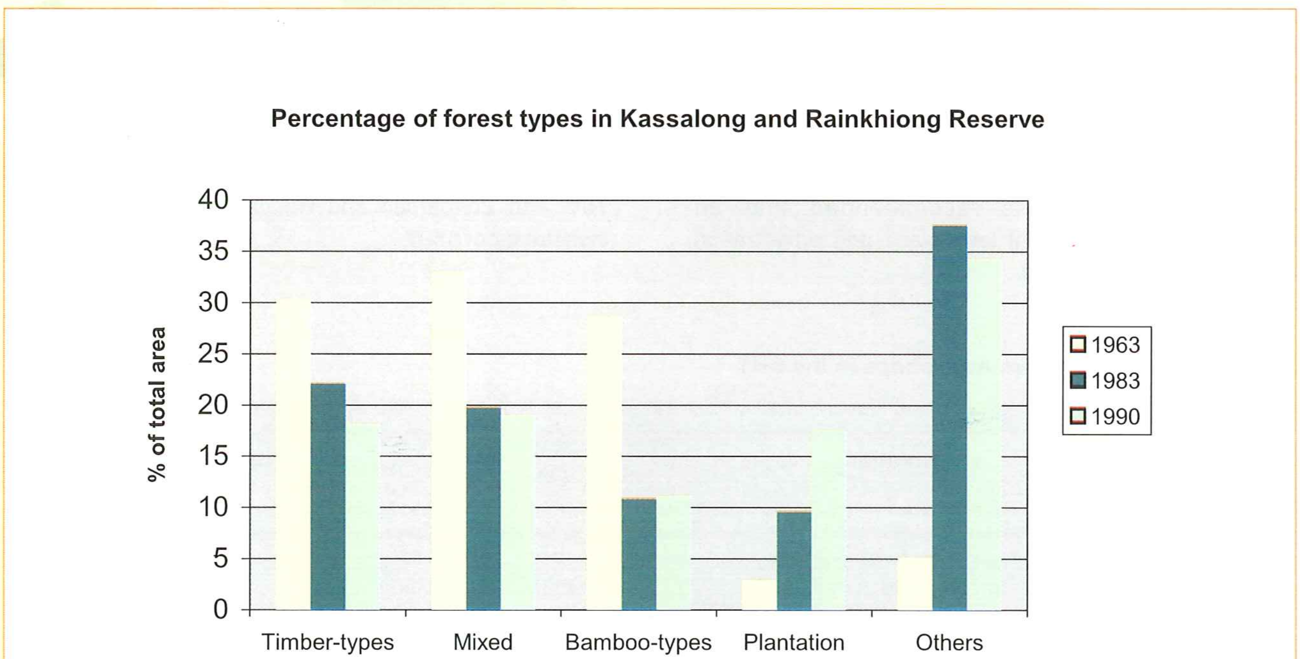
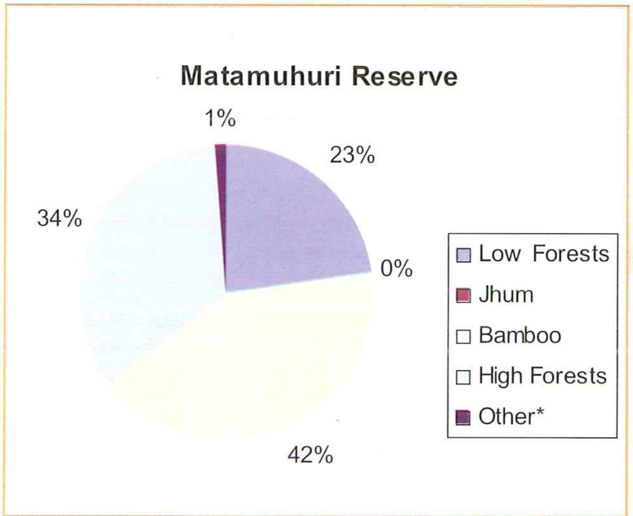
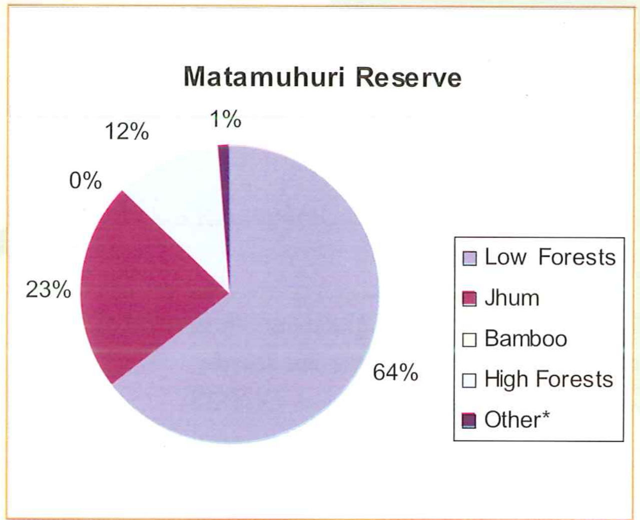


Figure 7.5: Area of forest types in the Sangu and Matamuhuri reserves





The Sangu and Matamuhuri reserve forest areas also went through similar changes with low forest increasing from 22% in 1961 to 64% in 1984. The high forest area also declined from 34% to 12%.

Encroachment of forest area

About 2200 ha (ADB, 2001) of reserved forest area of Rangamati have been encroached by some vested quarters living around the tropical forest. Encroachment problems occur in the Reserved Forests area as there is no clear boundary demarcation supported by cadastral maps. There is also no data available regarding the encroachment of the forest areas of Khagrachhari and Bandarban.

Chapter 8

Land degradation in the Chittagong Hill Tracts, Bangladesh, between 1981-2003

8.1 Assessment of biomass and rainfall changes as indicators for land degradation using NASA GIMMS

Deforestation is a major cause of environmental degradation in the CHT. Net primary productivity or biomass production is an integrated measure of productivity. Its deviation from the norm can indicate biomass degradation or improvement. Biomass can be assessed by remote sensing of the Normalized Difference Vegetation Index (NDVI - the difference between reflected near-infrared and visible wavebands divided by the sum of these two wavebands). Fortnightly advanced very high-resolution radiometer (AVHRR) NDVI composites from the NASA Global Inventory Monitoring and Modeling Systems (GIMMS) 1981-2003 at 8 km spatial resolution and climate variables were used to analyze biomass degradation in the CHT. ArcGIS Spatial Analyst and ERDAS IMAGINE and SPSS 12.0.1 for windows were used to calculate NDVI indicators and climate variables. The annual NDVI minimum, maximum, maximum-minimum, mean, sum, standard deviation (STD) and coefficient of variation (CoV) were derived for each pixel and their temporal trends were determined by regression and mapped to depict spatial changes. A negative slope of regression indicates a decline of biomass and a positive slope of regression indicates an increase except for STD and CoV, which indicate trends in variability. Green biomass and net primary productivity were estimated from NDVI data using MODIS 8-day values for the 4 years 2000-2003. Percentage and absolute changes in net primary productivity were calculated for the CHT. Urban and irrigated areas were masked using contemporary global datasets.

Rain-use efficiency (the ratio between green biomass (NDVI) and rainfall) was calculated to further assess whether this trend reflects biomass degradation or variability in rainfall; combined trends of biomass and rain-use efficiency were considered as a more robust indicator of biomass degradation.

8.2 Results and conclusions

In the Chittagong Hill Tracts over the period of 1981-2003, green biomass and net primary productivity decreased over 62% of the land area by an average annual rate of almost 0.2% (162 kg per hectare), and increased over the remaining area at a similar rate; for the CHT as a whole, the net primary production was downwards by 44 kg per hectare per year in the 23-year period.

Table 8: Changes in net primary production 1981-2003 in the CHT

	Positive	Negative	Average
Land area (pixels, %)	38	62	
% NPP change/year	0.78	0.80	-0.21
NPP [DM, kg ha-1year-1]	160	161	-44

Annual precipitation was downwards over the period. Biomass productivity lagged behind the antecedent precipitation and temperature by ca. 3-4 months with a correlation coefficient of 0.74 and 0.49 (correlation is significant at the 0.01 level), respectively. Over the period, rain-use efficiency increased over 78% of the land area, and decreased over 22%.

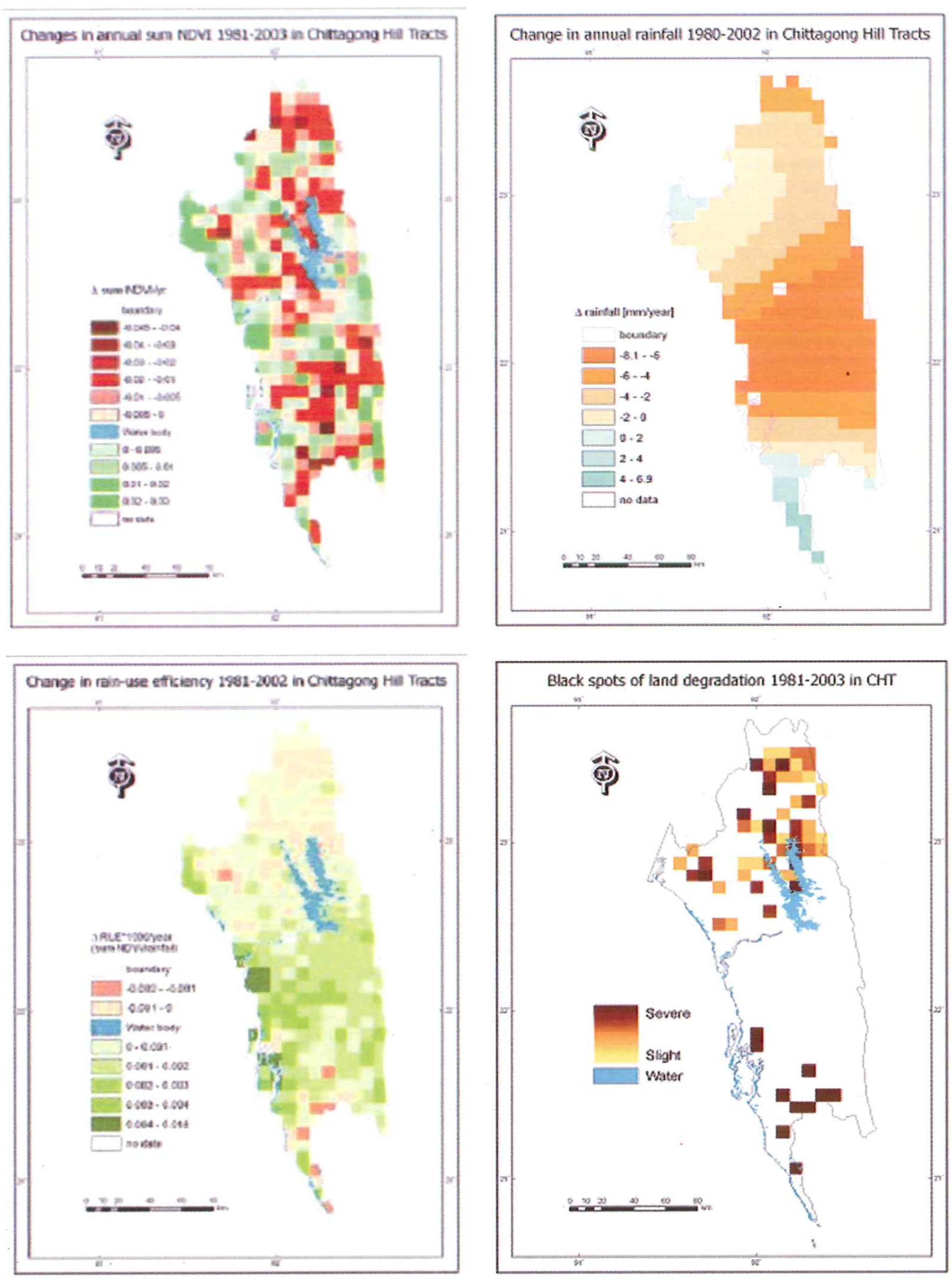
Potential black spots of land degradation were identified as those areas with both declining net primary productivity and declining rain-use efficiency. These areas occupy 20% of the CHT. The combined index reveals three black spots: the area around Lake Kaptai; the border between Khgrachhari and Rangamati districts as well as Naikhongchhari and Alikadam of Bandarban District. The remotely sensed indicators of land degradation are only indicators of complex social, economic and biophysical situation. The areas indicated have been validated by field investigations.

The maps in Figure 8.1 demonstrate the patterns and trend of biomass and net primary productivity as well as rainfall over 23 years. A combination of the declining net primary productivity and declining rain-use efficiency could be identified as potential black spots of land degradation.

This part of study is described in detail in the full report.

Source: Bai ZG 2006. Assessing land degradation in the Chittagong Hill Tract, Bangladesh, using NASA GIMMS, CHARM Project Report. ISRIC, BCAS, CEGIS, UdL, Wageningen.

Figure 8.1: a) Change in annual sum NDVI 1981-2003 in CHT, b) Change in annual rainfall 1980-2002 in CHT, c) Change in rain-use efficiency 1981-2002 in CHT, and d) Black spots of land degradation 1981-2003 in the CHT



Chapter 9

Floral and Faunal Diversity

9.1 Introduction

As a habitat, the CHT supports many different kinds of animals and plants, the diversity of which is threatened by the increasing pressures of a human population also dependent on that habitat. The CHT's biodiversity is a fragile network that has been affected by the increased human presence in the region. Cataloging and maintaining information on the animals and plants of the region is necessary to strike a balance between the natural life of the CHT and increased human presence. The country supports a wealth of biodiversity, including 113 species of mammals, 628 species of birds, 126 species of reptiles, 22 species of amphibians, 708 species of freshwater and marine fish, 400 species of mollusks and over 5, 000 species of vascular plants. Many of these species are of international significance, such as the Asian Elephant, Royal Bengal Tiger, Gharial, Gangetic Dolphin and Hoolock Gibbon (IUCN, 2007). The CHT, as a large portion of Bangladesh's natural environment, contains many of these important species. The CHT has a heritage of rich biodiversity, which is threatened because of continuous human interventions. The decline in the biodiversity of the CHT has been caused by two important factors. The construction of the Kaptai hydroelectric power project inundated a large portion of the CHT with standing water, destroying a large forest area and along with it the habitat of many animal species, as well displacing humans. The increase of population density and arrival of outsiders in the CHT have also impacted the sustainability of the region's biodiversity.

The government declared the natural forests of the hilly areas as protected areas, game sanctuaries and national parks in order to preserve biodiversity. The National Environment Policy, declared in 1992, has a clear mandate for the enhancement of biodiversity, but it is yet to be implemented fully. Measures should be taken to preserve local knowledge and to implement techniques of natural resource management. As a result, full effort and involvement from the local people is essential to improve the situation and protect biodiversity.

9.2 Flora

The flora of the CHT resembles the flora of Arakan. The major species are Garjan, Civit, Chandul and Champa. There is a lack of information on the floral diversity of the CHT. The senior groups/citizens of the ethnic communities have a vast knowledge about traditional agricultural practices and the use of medicinal plants for curing different types of diseases. They pass on their knowledge from generation to generation but do not disseminate their wisdom outside their own tribe or territory. Because the knowledge of traditional uses is limited to tribes, both this knowledge and biodiversity itself are at risk of disappearing.

High increase in population combined with forest degradation, unsustainable land use patterns, and soil erosion, threaten floral diversity. The following table shows the threatened plant species of the CHT area.

Table 9.1: Threatened plant species of the CHT

Common Name	Scientific Name
Ban supari	*Areca trianda*
Kadam bet	*Calamus erectus*
Chhoto bet mara	*Calliowdra umbrosa*
Cycad	*Cycas pectinata*
Modon mosta	*Dehaasia kurzii*
Dholi garjan	*Dipterocarpus gracilis*
Bon jalpai	*Elacocarpus ganitus*
Dephal	*Garcinia scandens*
--	*Gretum scandens*
Homalina	*Homalium schlichii*
Kurud pata	*Licuala peltana*
Jangli am	*Mengifera longipes*
Uri am	*Mengifera sylratica*
Mon kata	*Pajanelia longifolia*
Ram supari	*Pinanelia gracilis*
Jigra	*Pithecellobium angulatum*
Bans pata	*Podocarpus neriifolia*
Joygga gola	*Prunus cylanica*
Chalmogra	*Hydrocarpus kurzii*
Chandul	*Tetrameles nudi flora*
Lasua garjan	*Valica lanceiflia*
Lota am	*Willugh beia edulies*
Han sak	*Xanthophyllum flavescens*
Biolam	*Anisoptera glabra*

Source: *(ADB, 2001a)*

The present status of trees of the CHT area has been determined through a qualitative survey conducted by BRAC in 150 villages in the CHT. The findings are not quantative, but give a general sense of the state of tree diversity. The CHT has been divided into five different regions based on the height from sea level and physical infrastructure, especially Kaptai Lake (indicated in map 8.1). The regions are described below:

Table 9.2: Different Regions of the CHT

Region	Height From Sea Level (Ft)	Thana
I	1000 - 1500	Includes three thanas of Bandarban District: Thanchi, Ruma, and Royanchari. It is the most inaccessible part of the CHT.
II	500 - 1000	Includes four thanas of Bandarban District: Bandarban, Alikadam, Lama, and Naikhonchari.
III	0 - 500	Includes nine thanas of Khagrachari District: Dighinala, Khagrachari, Laxmichad, Mohalchari, Manikchati, Matiranga, Panchari, Ramgarh, and Baghaichari.
IV	250 - 1000	Includes four thanas of Rangamati District: Barkal, Belaichari, Jurachari, and Langadu. The region is located on the east of Kaptai Lake.
V	250 - 500	Includes five thanas of Rangamati District: Kawkhali, Kaptai, Naniarchar, Rajasthali, and Rangamati. The region is located on the west of Kaptai Lake.

Map 9.1: Regions of the Chittagong Hill Tracts by Elevation from Sea Level

The trees have been categorised into four types such as timber, fuel, fruit and others. The inventory of trees (see Table 2 in Annex C) includes the number of trees that exist, or are cut down or extinct. Gamari, teak, koroi, and gorjon are the trees that are most common in the CHT, followed by mango, jackfruit, and jarul trees. Timber trees, such as gamari, teak, koroi, chapalis, gutgute, badi, chakku, and guda species were cut down more in the region. On the other hand, fruit trees like mango, jackfruit, coconut, and betle nut trees were not usually cut down. The trees that were more frequently cut down have disappeared except gamari and gorai. Gorjon and chapalis were the major trees that have been eliminated from many areas. Households have planted trees, but these are mainly fruit trees. Unfortunately, some valuable trees, such as koroi and chapalis, were cut down and never replanted (Rafi and Chowdhury 2001).

Since a full quantative survey of the area has not been conducted, the information provided by respondents had to be used to understand the environmental diversity in the region. The number of fruit trees, such as jackfruit, coconut, guava, pineapple, betelnut, and banana trees, has declined considerably according to a study conducted in the Khagrachari district. Most people (70%) believe that there has been a 5-15% decrease in the number of fruit trees over the last ten years. They also identified the following reasons for the decline of the fruit trees (Mahfuzullah, 2003):

- Natural process of extinction
- Lack of land
- Cutting down trees for use as fuel wood
- Cutting down trees for sale
- Cutting down trees for making furniture
- Trees are not planted anymore
- Lack of maintenace
- Cutting down of trees by other people

9.3 Fauna/Wildlife

Elephants are the main attraction of the CHT area's animal life. The other animals in the area are bisons, the Sambur, the Barking Deer, leopards, the Royal Bengal Tiger and panthers. The CHT also has several different bird species such as the Imperial Pigeon, the Green Pigeon, the White Winged Wood Duck, the Maina, and the Bhimraj. The number of wildlife species has decreased because of indiscriminate hunting, and habitat conversion and destruction over the years. A depressing example of the degradation is the gradual extinction of tigers from the area (Gain, 1998).

Bangladesh is a signatory of CITES (Convention on International Trade in Endangered Species of wild flora and fauna), of the RAMSAR Convention (Convention on Wetlands of International Significance), of the World Heritage Convention, and of the Convention on Biodiversity Conservation. Bangladesh joined CITES on 18 February 1982. Wildlife protection is provided for in the Bangladesh Wildlife (Preservation) Act of 1973, with Amendment in 1974. This Act identifies three schedules of animals with their corresponding categories for hunting and protection:

- Animals that may be hunted on an Ordinary (Part 1) or Special (Part II) Game Hunting Permit. This schedule lists one species of crab, three turtle species, 11 duck/teal species, three herons/egrets and ten waders. The Bengal fox, the black-naped hare and the wild boar are are the only mammals listed.
- Animals, hunted as trophies or as meat, for which the possession, transfer or import requires a Certificate of Lawful Possession.
- All animal species enjoying Full Protection. This schedule includes most of the larger mammals, birds and reptiles recorded for Bangladesh.

At present there are only provisions for nominal fines and imprisonment for illegal hunting. Bangladesh has the lightest penal measures (imprisonment: two years; fine: Taka 2,000) in Southeast Asia for illegal trade of elephants. The government needs to make the punishment more severe. Taking advantage of the loopholes in the Act and its enforcement, poachers have been hunting down the endangered animals and selling their skins abroad at high prices.

The present available data gives evidence of the ongoing depletion of wildlife. However, there is little information on the actual status of wildlife in the CHT such as inventory, recruitment, or habitat ranges. The following table shows the larger mammal species that still appear in the CHT, while showing that some are on the verge of becoming extinct or at least no longer exist in large parts of the region.

Table 9.3: Large mammal species still assumed to be found in the CHT

Latin Name	Common Name	Status
Nycticebus coucang	Slow Loris	P [1/]
Hylobates hoolock	Hoolock Gibbon	P ** [2/]
Presbytis entellus	Hanuman Langur	P *
Selenarctos thibetanus	Asiatic Black Bear	P
Helarctos malayanus	Sun Bear	P
Arctonyx collaris	Hog-Badger	P
Lutra lutra	Otter	P
L.perspicillata	Smooth-Coated Otter	P
Aonyx cinerea	Small-Clawed Otter	P
Cuon alpinus	Dhole, Wild Dog	P *
Neofelis nebulosa	Clouded Leopard	P **
Panthera tigris	Tiger	P ***
Panthera pardus	Leopard	P *
Felis bengalensis	Jungle Cat	P
Elephas maximus	Asiatic Elephant	P
Cervus unicolor	Sambar	P
Muntiacus munjak	Barking Deer	P
Axis porcinus	Hog-Deer	P
Bos gaurus	Gaur	P **
Capricornis sumatrensis	Serow	P
Belomys pearsoni	Hairy-Footed Flying Squirrel	
Callosciurus pygerythrus	Irriwaddy Squirrel	P
C.flavimanus	Yellow-Handed Squirrel	
Ratufa bicolor	Giant Squirrel	P
Petaurista alborufus	Red & White Flying Squirrel	P
P.petaurista/P.elegans	Giant Flying Squirrel	P
Manis javanica	Pangolin	P *

[1/] P = fully protected, [2/] * = likely threatened, ** = likely endangered, *** = likely extinct

Source: *Third Schedule of Wildlife Preservation Act as cited in (ADB, 2001a)*

The animals of the CHT are useful to people in various ways such as for food and hunting. The body parts of some animals are used for medicine and decoration.

Table 1 in Annex C provides the status of the animals including their numbers, and whether they are currently being hunted or extinct. Deer, wild pigs, wild cocks, monkeys, and porcupines are found in major parts of the CHT area. The presence of tigers, guishaps, rabbits, foxes, wildcats, and snakes are also reported. Elephants are found mainly in Alikadam, Lama, and Naikhonchari thanas (Region II) except in the Khagrachari district (Region III). Pythons exist mostly in regions I and II, which are the most inaccessible areas at higher altitudes in the CHT. Bears have been eliminated in some parts of these regions and also in Region IV. The honuman and wild goats have been spotted in some villages in regions I and II. Villagers in all areas of the CHT hunt various animals, mainly wild pigs, deer, and wild cocks. Monkey and porcupine are also frequently hunted. Both villagers and visitors hunt tigers. Visitors in Region II hunt elephants. Most animal species seem to have disappeared from Region IV. Many villages reported that elephants and tigers no longer exist in their areas. Six villages of Region IV reported the disappearance of pythons from their areas. Despite common knowledge that many of the animals were on the verge of disappearing, the villagers did not take any measures to preserve them (Rafi and Chowdhury 2001). Deteriorating biodiversity is a problem for the animal and plant species as well as for the humans who depend on these resources for their basic needs. Thus, it is imperative that people are educated about the importance of maintaining a sustainable relationship with the flora and fauna of their environment, so that they can work to preserve those resources.

Chapter 10

Conservation and Production Priorities

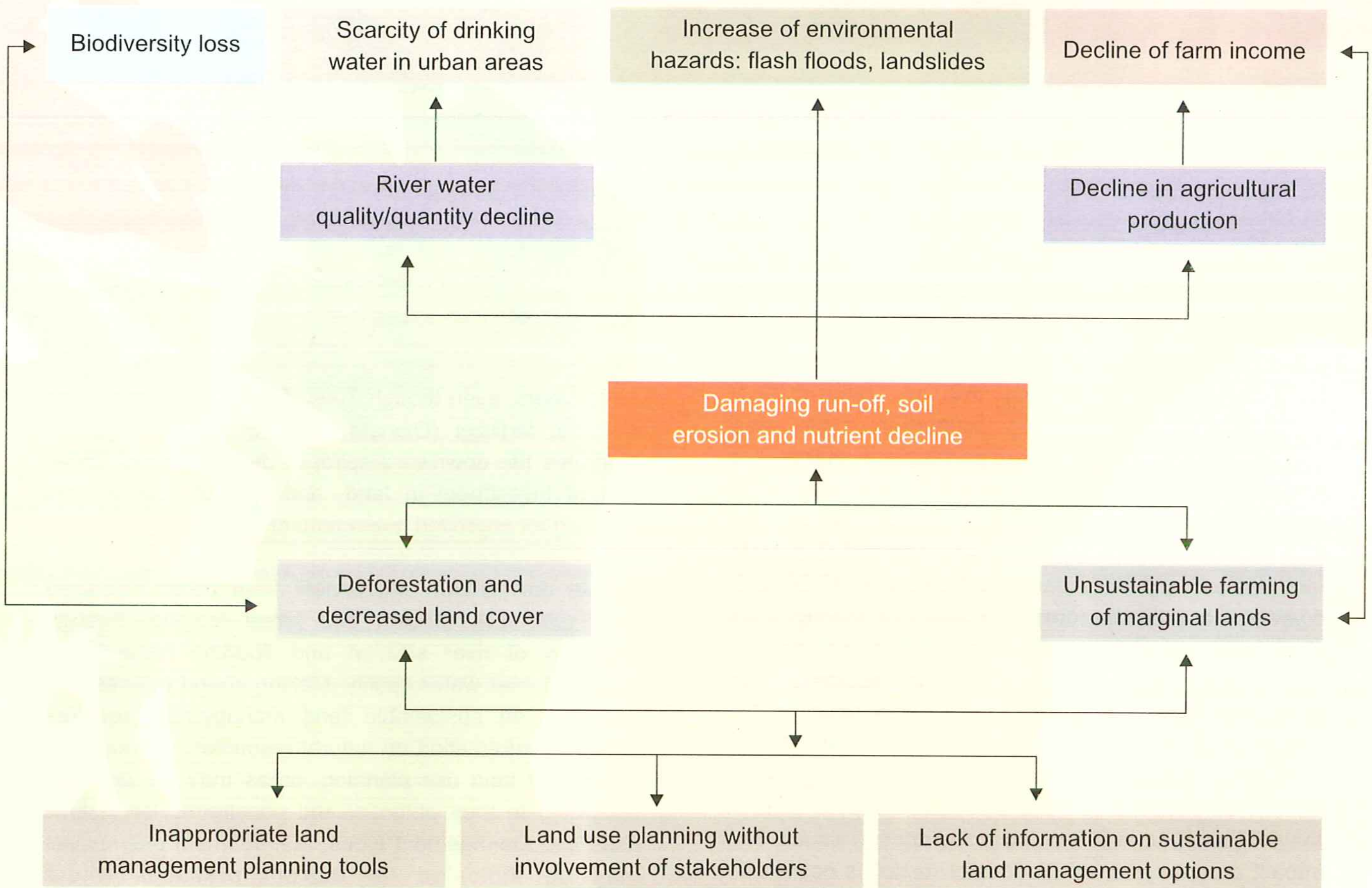
10.1 Environmental threats and potential in the CHT

CHT lands are degrading due to deforestation, shortening of the shifting cultivation cycle, and consequent soil erosion, floods and water pollution. The slash and burn system (*jhum*) as practiced in the CHT is sustainable if practiced with long enough fallows, but due to an increased population and scarcity of suitable land, the fallow periods have shortened from 15-20 to 3-5 years. Inappropriate forest and plantation management also contribute to severe land degradation. Soil erosion and forest degradation, resulting in declining crop production and loss of biodiversity, also have off-site effects on downstream and urban areas, i.e: flash floods, landslides, Kaptai dam-siltation and declining water quality. Extensive erosion is a serious threat to soils in the CHT and is one of the major degradation issues. The impact on production of the loss of topsoil is noticed by farmers in a production decline of 50% during the past 10-12 years, even though 70% of the *jhum* farmers use synthetic fertilizer (Olarieta JR *et al.* 2006). Figure 1 illustrates the downward spiral of declining productivity, lack of investment in land, and lack of support and planning for improved management.

People downstream will benefit from better managed land, with less erosion and forest logging, through reduction of river siltation and flooding hazard and improved river water quality. Making sound policies and decisions on sustainable land management requires adequate information on natural resources. Through the process of land use planning, areas may be identified according to their potential and constraints for various uses and management types. Management alternatives may be indicated for current practices where appropriate.

Figure 10.1: Conservation practice fruit garden: planting bamboo on the borders with lake Kaptai to control mass movement. Photo: J. R. Olarieta.

Figure 10.2: Problem analysis-land management practices in the Chittagong Hill Tracts.



10.2 Methology for assessment of regional conservation priorities

A methodology was developed to indicate potential environmental hazards of land management and to assess priorities for production and conservation. The result of the analysis is a map indicating the vulnerability of areas under current land cover and based on an analysis of ecosystem stability and resilience to the impacts of human interventions. Based on this analysis a map was created that indicates broad management classes with indication of priority for conservation (highly vulnerable to degradation) or production (lowly vulnerability to degradation).

The zonation for the assessment of priorities for conservation and recommendation for sustainable watershed management is the result of a multi-layered analysis of environmental constraints on watershed management (Tyrie et al., 1999). It encompasses relevant environmental constraints concerning soil erosion and land degradation, actual land cover, and social constraints through land use and tenure issues, and forest land status (RF, USF, PF). Each of the mapped classes represents a unique combination of these basic factors, which provide a basis for a sustainable management strategy.

The land classification method is based on the following features:

Land Status. Forest Reserve Land, inside or outside of Forest Reserve Land. The term Reserve Forest refers to 'state-claimed forest land' and is a tenurial designation referring to land the national government claims for the state forest. The Ministry of Forestry has the authority to manage the forest.

Erosion Risk as designated by the Erosion Risk Assessment module (Soter Water Erosion Assessment Program SWEAP). Greater than 180 tons/ha/yr is considered an excessively high potential erosion risk (note: this is not an assessment of actual erosion risk, vegetative cover is not included in the calculation and indicates the potential impact of vegetation removal).

Critical and Fragile Land as defined by environmental type, but based on propensity to degrade, e.g. Mountain forestland.

Ruggedness. Areas classified as having a low erosion risk, but with steep slopes are separated out at the land system level based on 3 classes of dominant slopes (<15%, 15%-30%, >30%; based on (NMFP, 1994)).

Land cover

Protection Factor (C-factor) is the degree of protection from soil erosion provided by present land cover. Areas with a low land cover (<0.15%) are considered more fragile or more erodible in combination with sloping terrain.

Presence of downstream infrastructures

The sedimentation of Kaptai Lake is an economic and environmental hazard. All watersheds draining into Kaptai Lake have been identified. Whether an area is part of a watershed that drains into Kaptai Lake is used as a criterion as it is an indicator for the downstream impact of potential degradation and soil erosion. Land areas that drain into Kaptai Lake are given higher priorities for conservation, rehabilitation and reforestation.

Slope

Very steep slopes (>45%) are indicative of the sensitivity of areas for degradation upon disturbance. This was taken into account in the analysis, and Private Forest land and Unclassed State Forest land with extreme slopes, under low vegetation cover, and draining into Kaptai lake are classified with priorities for reforestation and conservation of watersheds and critical ecosystems.

Figure 10.3: Conservation practice of slashing rows across the slope. Photo: J.R. Olarieta.

The definition of each class and the management strategy recommended is given in Table 1.

<u>Environmental Capability screening</u>

The environmenal capability assessment methodology as described by Tyrie and Gunawan (1999) is based on screening areas on the basis of a set of environmental criteria. Using a set of decision rules areas are selected that require conservation and protection. The remaining areas are then allocated to appropriate, or rather, sustainable broad land management types.

Erosion risk and identification of fragile systems are key criteria in the environmental capability classification.

Erosion Risks Potential erosion for a land unit is estimated using a modified Universal Soil Loss Equation approach (Wishmeier and Smith, 1978). Soil erodibility is estimated from soil and topographic datasets. Slope length is estimated from topographic data (representative values are used). A map of spatial patterns of mean annual rainfall zones was used from Bai (2006) and representative climate stations were identified within these zones for feeding the erosion model.

Rainfall erosivity is estimated using the modified Fournier approach. The potential erosion is called USLI (Universal Soil Loss Indicator NMFP 1994) Vegetation cover is not included at this stage because the objective is to establish the underlying erosion potential before starting to manage vegetation or forest cover. Vegetation cover (c-factor) is included in the analysis to calculate USLE the "actual erosion risk". The SWEAP programme allows the selection of various vegetation cover and land management types, thereby offering the possibility of assessing the erosion risk of actual land use but also for scenarios of different cover and management types. These 'what-if' scenarios allow the selection of the most appropriate c-factor or management type under the local conditions that meets the management objective.

Ecosystem Fragility Not all environments have the same inherent stability. From an ecological and production perspective those ecosystems which are unlikely to recover to their former quality after disturbance, such as logging or burning, can be considered critical or fragile. Thresholds are reached in such systems that will cause a change in the inherent properties and possible loss of unique biodiversity and conservation value. With change and degradation the resilience of these ecosystems often decreases, and therewith the productive capacity and the ability to regenerate successfully. Critical systems should not be exploited. Fragile systems should be exploited only on a limited basis or not at all. They include ecosystems such as mangroves and montane forests, forests on limestone, ultra-basic rocks, or ecosystems on steep slopes and shallow soils.

Environmental Capability Screening

The rules described above and others are included in a database routine, which evaluates each land facet within the CHT regional database. A set of environmental criteria has been developed, which allow an environmental capability assessment. Figure 2 outlines the decision process and defines the criteria. Areas requiring conservation and protection are identified first. The remaining areas are allocated to the appropriate land management class (i.e. production or rehabilitation). Table 10.1 presents the results for the CHT area.

Table 10.1: Classes with production/conservation priorities according to biophysical criteria.

Function	Code	Class	Definition	Natural Resource Management Proposal
INSIDE FOREST RESERVE LAND				
Production forest and plantations	RF	Reforestation of stable reserve forest	Reforestation of forest reserve land that is currently under bush or grass land with possible production component	Reforestation for production if not under other uses. Short rotations allowed with standard conservation practices.
	PFf	Forested Production Forest	Production Forest. Forested areas low risk of erosion < 180 tons/ha/year. Not rugged (1)	Regular production forest under MoF guidelines with RIL procedures
	PF	Non-forested Production Forest	Reforestation for Production. Non-forested areas, low erosion risk and not rugged (1)	Reforestation for production. Short rotations allowed with standard conservation practices.
	RFR	Reforestation and rehabilitation	Reforestation for soil conservation and land rehabilitation possibly with limited production component, low erosion and very rugged	These lands require protection. Reforestation applying standard conservation practices and with limited production prospects.
	RFRC	Reforestation and conservation	Reforestation for regreening and for watershed rehabilitation	Critial watersheds with high erosion risk and low vegetation cover that require protection to prevent sedimenation to Kaptai lake and dam.
	RFC	Conservation of critical watersheds	Conservation of watersheds and critical ecosystems	Fragile and high erosion risk areas that have a minimum cover that should be conserved to prevent degradation and downstream impacts.

UNCLASSIFIED STATE FOREST LAND AND PRIVATE FOREST LAND				
Varied	USFRH	Land for regular production purposes	Low erosion risk area, fallow or agricultural land or presently under grassland or scrub, possible as part of rotation scheme of slash-and-burn farming	Agro-forestry or regreening programmes based in non-forested areas. MoF, DoE, DoA to provide advice and assistance for production purposes.
	USFPL	Land for production and sustainable practices	Land with limited erosion risk and presently partly forested and not rugged	Sustainable management practices for production purposes
	USFRLP	Land requiring soil conservation practices with limited production possibilities	Lands with high erosion risk and low soil cover, not draining into Kaptai lake	Land requiring soil conservation for watershed protection
	USFRP	Lands for reforestation and regreening	Lands with high erosion risk and low soil cover, draining into Kaptai lake	Land rehabilitation and conservation for watershed protection to prevent sedimenation to Kaptai lake and dam
	USFWC	Conservation of watersheds and critical ecosystems	Fragile ecosystems, mountain forest or plantations	Management for conservation and rehabilitation where necessary

10.3 Results

Table 1 shows the area of classes in the CHT with production or conservation priorities according to biophysical criteria.

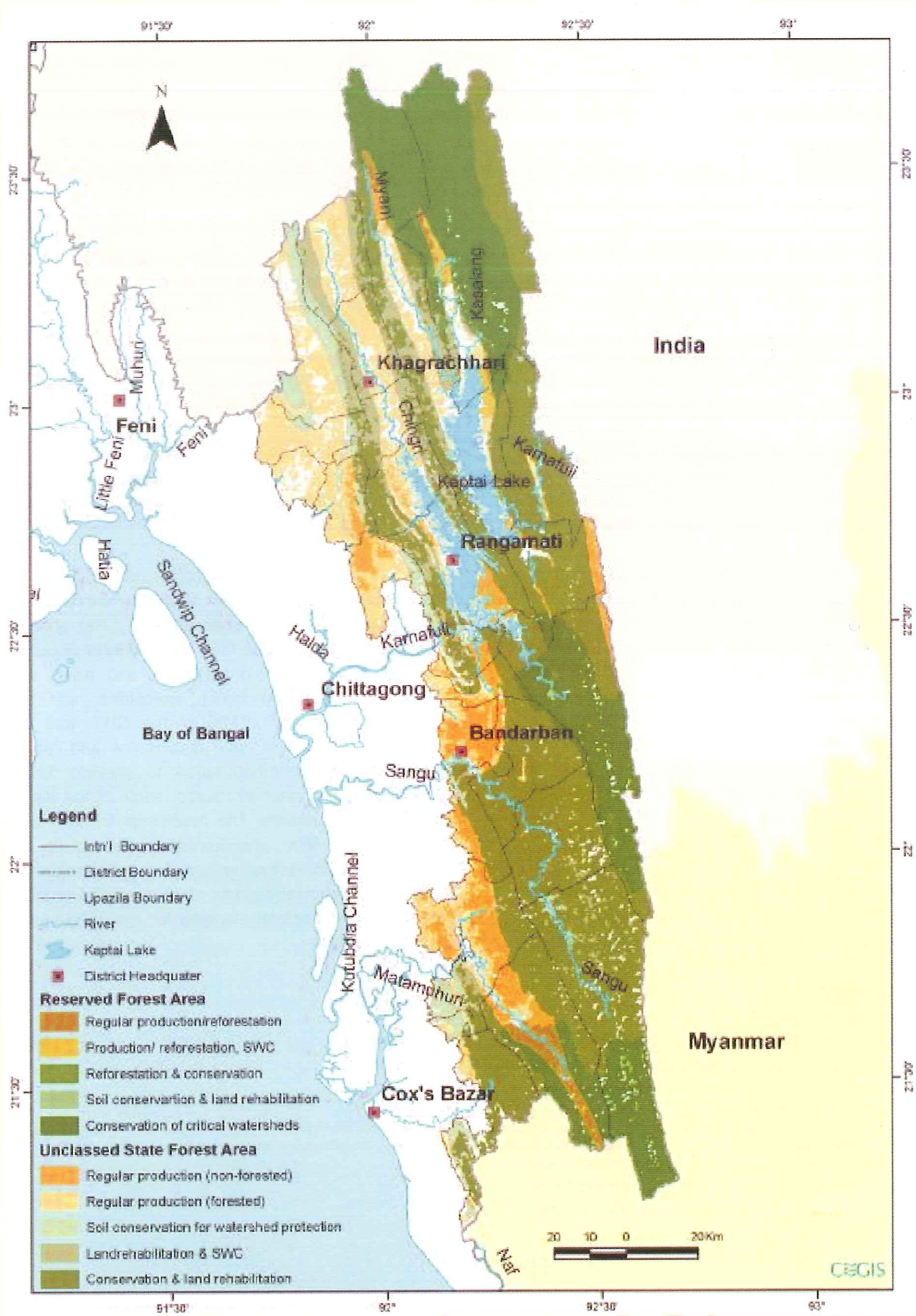
From a biophysical point of view an area of 9295 km^2 (78% of the total area) has limitations for use and requires some form of conservation, land rehabilitation or protection. For sustainable use, CHT lands require adaptive management with conservation strategies to ensure both productive and sustainable land management. Some vulnerable areas might be better left for nature conservation or rehabilitation. Such considerations need to be based on proper information and judgment and need to be taken into account in broader cross-sectoral planning for the development of the CHT region.

Table 10.2: Area of land with recommended production/conservation priorities

Conservation and production priority class	Total area (km^{-2})
Conservation & land rehabilitation	4895
Conservation of critical watersheds	2709
Land rehabilitation & SWC	769
Soil conservation for watershed protection	578
Soil conservation & land rehabilitation	12
Production/ reforestation, SWC	70
Reforestation & conservation	86
Regular production/reforestation	176
Regular production (forested)	1832
Regular production (non-forested)	794
	11921

Mapping and documentation of the natural resources and their management is a way to illustrate the biophysical resources. Decision on policy priorities may be supported by environmental information such as land cover change, erosion risks under current land cover, priority areas for forest and biodiversity conservation, and areas with potential for production forest, agriculture, and tree crops. Such information values land in an economic and environmental sense, giving options for land management and showing potential impacts of interventions.

Map 10.1 Regional Conservation and Production Priorities



Chapter 11

Conclusions

Foregoing assessments of the state of the environment of the CHT reveal an overall degrading picture, pointing finger to the imperatives of immediate management and mitigatory interventions for its rehabilitation and sustainability. Policies are required that support improved agricultural production in the CHT and at the same time favour improving environmental quality and reduction of the risk of environmental hazards. Formulation of such policies and decision making in planning and the management of natural resources require adequate baseline information on the environment, processes, and actors. Therein lies the importance of this study on the state of the environment.

Every parcel of environmental resources in the CHT has been shared by an increasing number of immigrant populations. So, per capita endowment of these resources is at a low ebb. Change of forest cover is an important factor in degradation or conservation in the CHT. The main causes of forest degradation, leading in biodiversity loss and accelerated soil erosion, are forest conversion for plantations and shortened fallows in the *jhum* system. No spatial information was available on the trends of vegetation or land use change for the CHT. A land cover map of the CHT was created from remote sensing analysis supported by field checks throughout the CHT. It was found that less than half of the CHT (44%) had a middle dense vegetation cover and only 16% of the total land area was under dense vegetation.

In an analysis of biomass changes in the CHT for the period 1981-2003, three critical areas or 'potential black spots' of land degradation were identified where both net primary productivity and rain-use efficiency declined: the area around Lake Kaptai; the border between Khgrachhari and Rangamati districts; Naikhongchhari and Alikadam of Bandarban District. Since the early 1980's, the green biomass and net primary productivity decreased over more than half (62%) of the land area by an average annual rate of almost 0.2 per cent (162 kg per hectare), and increased over the remaining area (38%) at a similar rate. These figures underscore the need for a continuous process of monitoring forest cover and biomass. Further analysis is required of the processes, causes, and the impacts of environmental change and their spatial distribution. Up-to-date forest cover information should be available to all stakeholders in natural resources management in the CHT.

Annual precipitation decreased between 1981 and 2003, although rain-use efficiency, which is defined as the ratio of net primary production to precipitation, increased over 78 per cent of the land area, and decreased over 22 per cent.

Access to safe drinking water is a key concern for communities in the CHT and is a major problem in Bandarban, where only 15% of the households have access to tube-well water. The steep topography and the hard bedrock underlying much of the region make tube-well installation difficult. As a result, wells are not drilled deep enough and dry up quickly.

Policy formulation and prioritization of strategies in natural resources management should be supported by environmental information such as land cover change, erosion risks under current land cover, priority areas for forest and biodiversity conservation, and areas with potential for production forest, agriculture, and tree crops. More than half (64%) of the CHT area are sensitive to degradation upon disturbance and require conservation and/or rehabilitation to prevent further degradation and protect structures, such as the Kaptai dam at the downstream. The methology for assessing regional conservation priorities as presented in this report may help to assess options for land management and estimate potential impacts of interventions required in broader cross-sectoral planning for the development of the CHT region.

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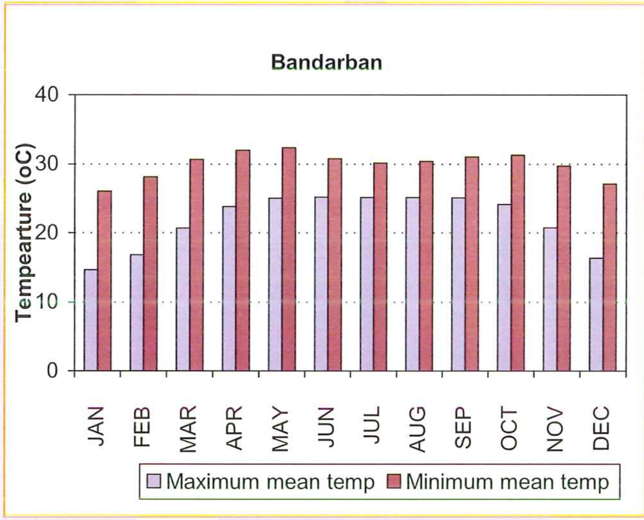
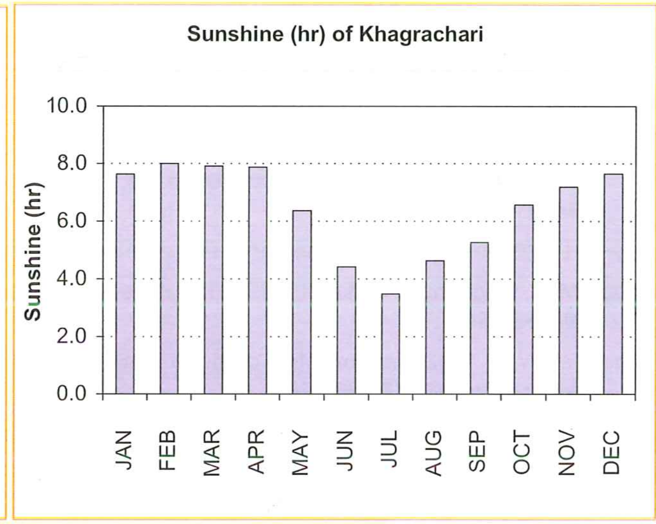
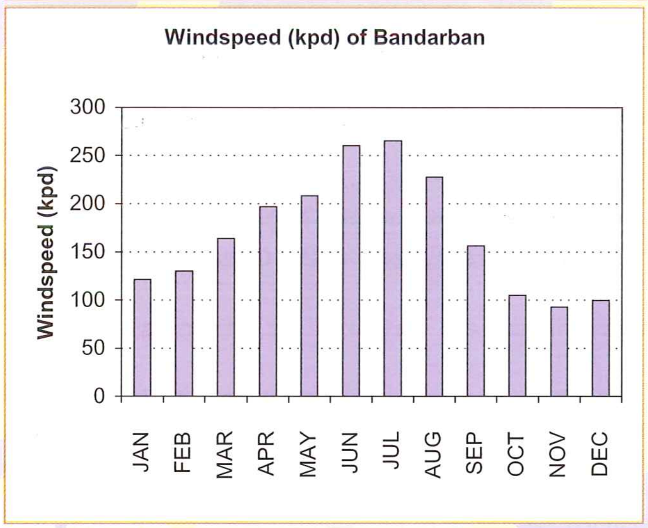
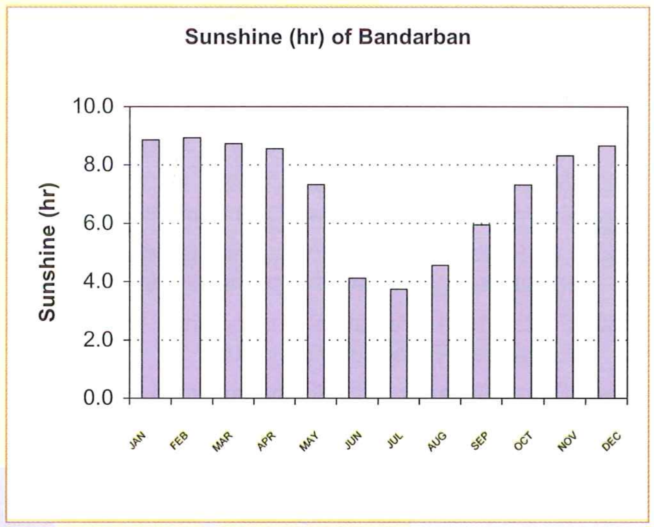
Annex A: Climatic Parameters of the CHT

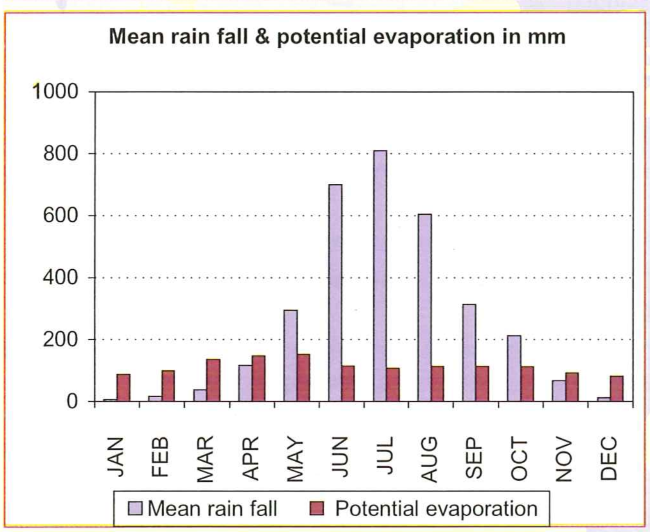
Fig. 1 Climatic parameters at Bandarban











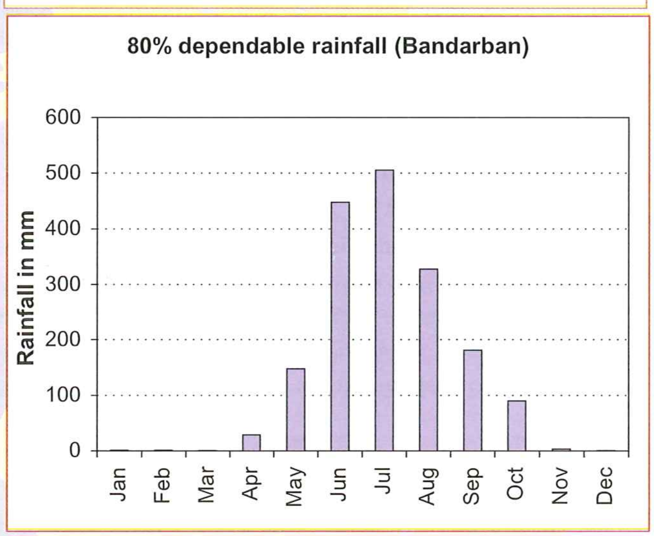


Fig. 2 Climatic parameter at Khagrachari

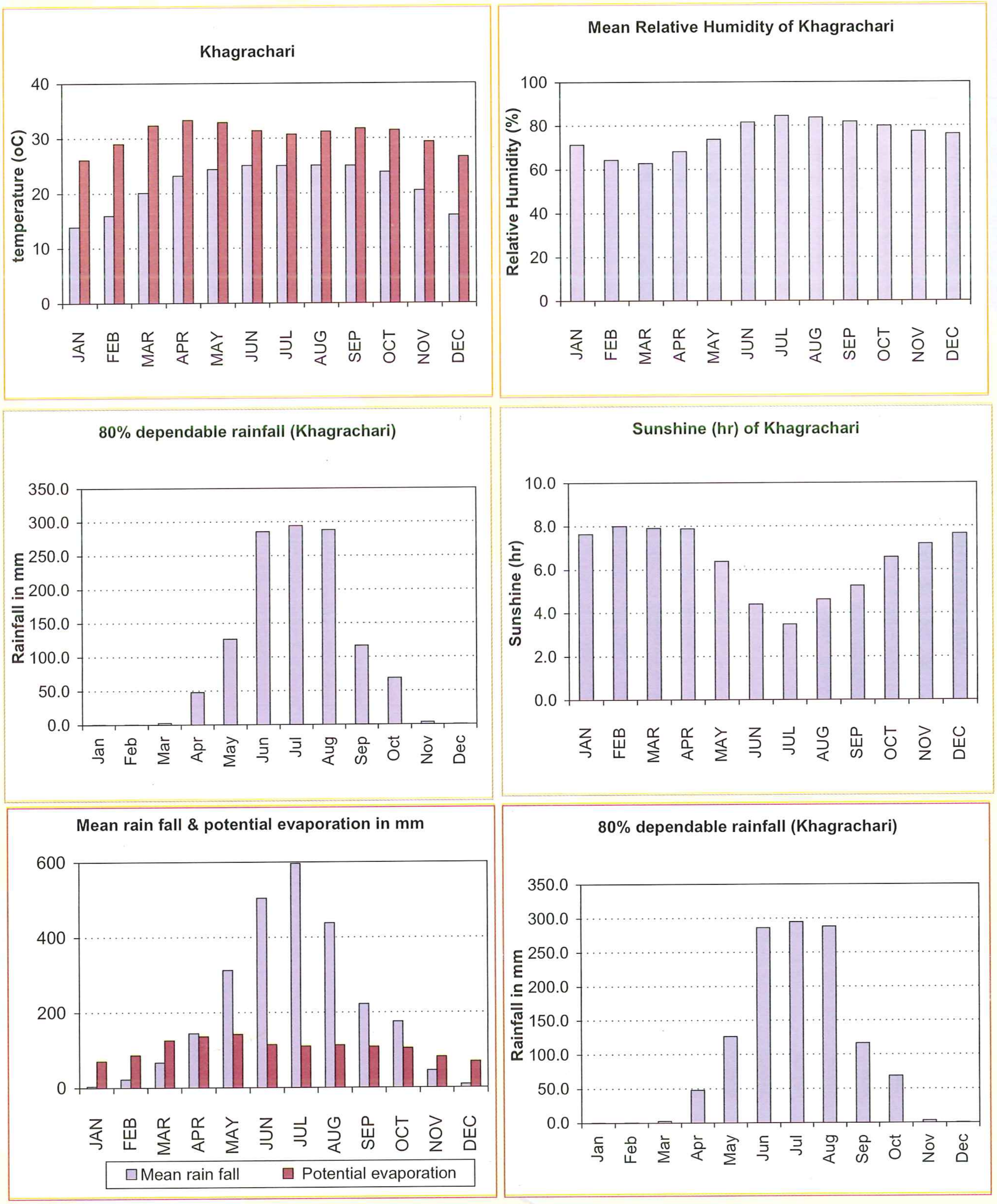
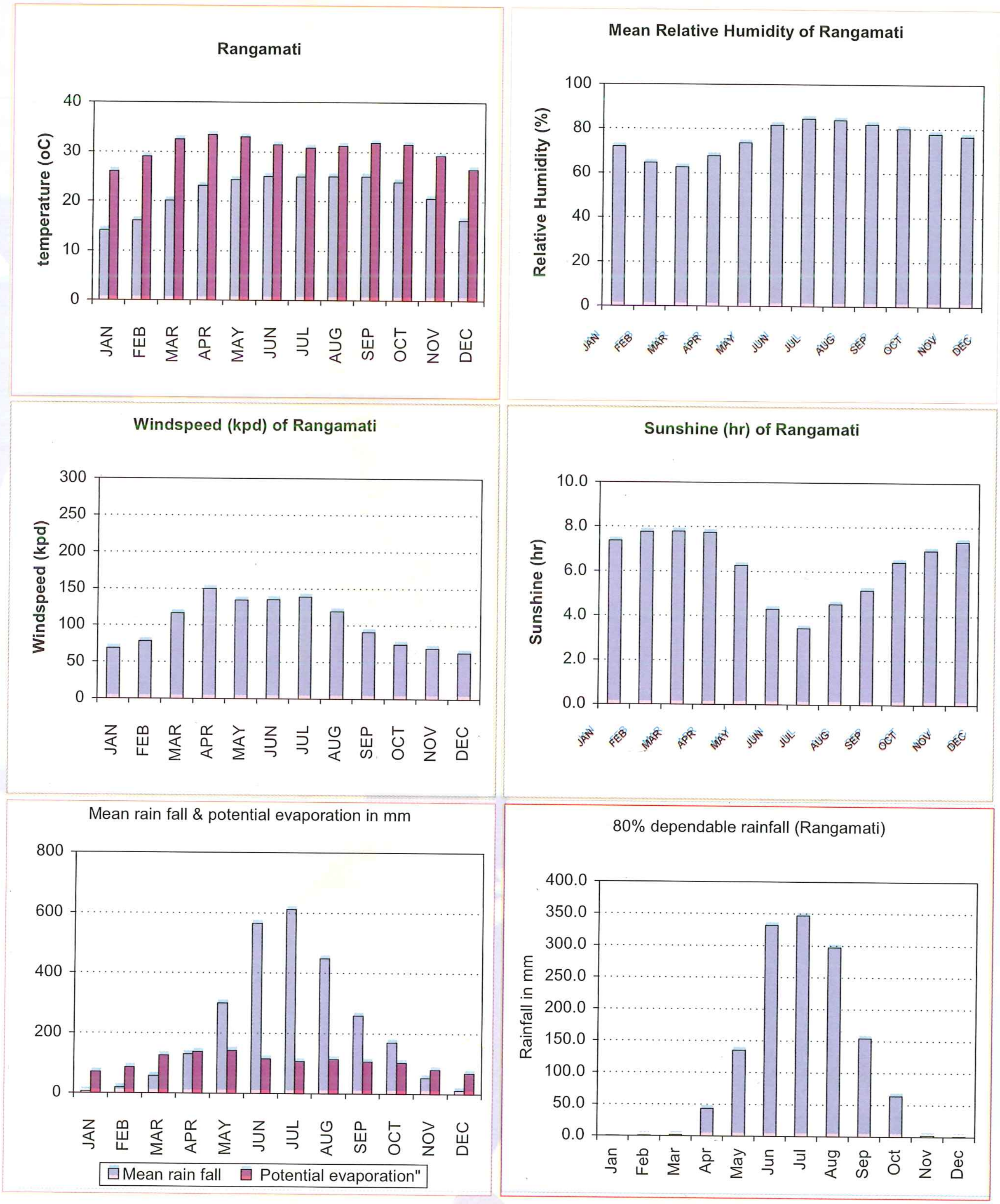


Fig. 3 Climatic parameters at Rangamati



Annex B: Suitable/Potentially Suitable Crops by Land Type and Thana

District/ Upazilla	Land Type	Suitable crops		Potential crops	
		Without Irrigation	With Irrigation	Without Irrigation	With Irrigation
Bandarbon					
Alikadam (87688)	**H (85427)**	Maize, Mustard, Sun-Flower, Potato, Peanut, Tomato, Brinjal, Radish, Turnip, Spices, Onion, Garlic, Carrot, Long Bea, Bitter Guard, Snake Guard, Lady's Finger, Cucumber, Bean, Guard, Pumpkin, Banana, Papaya, Pine apple, Ginger, Turmeric, Arum, Sugar Cane, Coconut, Betel Nut, Mango, Jackfruits, Guava, Litchi, Arum, Sapotha, Orange, Sagun, Gamar, Koroi, Berry, Mahogany, Jarul Etc.	Maize, Mustard, Sun-Flower, Potato, Peanut, Tomato, Brinjal, Radish, Turnip, Spices, Onion, Garlic, Carrot, Long Bea, Bitter Guard, Snake Guard, Lady's Finger, Cucumber, Bean, Guard, Pumpkin, Banana, Papaya, Pineapple, Ginger, Turmeric, Arum, Sugar Cane, Coconut, Betel Nut, Mango, Jackfruits, Guava, Litchi, Arum, Sapotha, Orange, Sagun, Gamar, Koroi, Berry, Mahogany, Jarul Etc.	Maize, Potato, Cauliflower, Cabbage, Tomato, Brinjal, Chili, Lady's Finger, Water Melon, Arum, Banana, Papaya, Lemon, Sapotha, Guava, Mango, Coconut, Gamar, Garjan, Jarul, Mehagoni Etc.	Maize, Potato, Cauliflower, Cabbage, Tomato, Brinjal, Chili, Lady's Finger, Water Melon, Arpum, Banana, Papaya, Lemon, Sapotha, Guava, Mango, Coconut, Spices, Pulse.
	MH (2261)	T Aman. T Aus. Boro, Maize, Potato, Cauliflower, Cabbage, Tomato, Brinjal, Chili, Lady's Finger, Water Melon, Arum.	T Aman. T Aus. Boro, Maize, Potato, Cauliflower, Cabbage, Tomato, Brinjal, Chili, Lady's Finger, Water Melon, Arum.	T Aman. T Aus.	T Aman. T Aus.
Bandarbon Sadar (48211)	**H (46591)**	Maize, Mustard, Sun-Flower, Potato, Peanut, Tomato, Brinjal, Radish, Turnip, Spices, Onion, Garlic, Carrot, Long Bea, Bitter Guard, Snake Guard, Lady's Finger, Cucumber, Bean, Guard, Pumpkin, Banana, Papaya, Pineapple, Ginger, Turmeric, Arum, Sugar Cane, Coconut, Betel Nut, Mango, Jackfruits, Guava, Litchi, Arum, Sapotha, Orange, Sagun, Gamar, Koroi, Berry, Mahogany, Jarul Etc.	Maize, Mustard, Sun-Flower, Potato, Peanut, Tomato, Brinjal, Radish, Turnip, Spices, Onion, Garlic, Carrot, Long Bea, Bitter Guard, Snake Guard, Lady's Finger, Cucumber, Bean, Guard, Pumpkin, Banana, Papaya, Pineapple, Ginger, Turmeric, Arum, Sugar Cane, Coconut, Betel Nut, Mango, Jackfruits, Guava, Litchi, Arum, Sapotha, Orange, Sagun, Gamar, Koroi, Berry, Mahogany, Jarul Etc.	Maize, Potato, Cauliflower, Cabbage, Tomato, Brinjal, Chili, Lady's Finger, Water Melon, Arum, Banana, Papaya, Lemon, Sapotha, Guava, Mango, Coconut, Gamar, Garjan, Jarul, Mehagoni Etc.	Maize, Potato, Cauliflower, Cabbage, Tomato, Brinjal, Chili, Lady's Finger, Water Melon, Arum, Banana, Papaya, Lemon, Sapotha, Guava, Mango, Coconut, Spices, Pulse.

District/ Upazilla	Land Type	Suitable crops		Potential crops	
		Without Irrigation	With Irrigation	Without Irrigation	With Irrigation
	MH (1620)	Maize, Mustard, Peanut, Pulse, Potato, T Aman.	Maize, Mustard, Peanut, Pulse, Potato, T Aman. T Aus.	Aus, T Aman ,T Aus.	Boro, T Aus, T Aman.
Lama (56256)	H (54202)	Maize, Mustard, Sun-Flower, Potato, Peanut, Tomato, Brinjal, Radish, Turnip, Spices, Onion, Garlic, Carrot, Long Bea, Bitter Guard, Snake Guard, Lady's Finger, Cucumber, Bean, Guard, Pumpkin, Banana, Papaya, Pineapple, Ginger, Turmeric, Arum, Sugar Cane, Coconut, Betel Nut, Mango, Jackfruits, Guava, Litchi, Arum, Sapotha, Orange, Sagun, Gamar, Koroi, Berry, Mahogany, Jarul Etc	Maize, Mustard, Sun-Flower, Potato, Peanut, Tomato, Brinjal, Radish, Turnip, Spices, Onion, Garlic, Carrot, Long Bea, Bitter Guard, Snake Guard, Lady's Finger, Cucumber, Bean, Guard, Pumpkin, Banana, Papaya, Pineapple, Ginger, Turmeric, Arum, Sugar Cane, Coconut, Betel Nut, Mango, Jackfruits, Guava, Litchi, Arum, Sapotha, Orange, Sagun, Gamar, Koroi, Berry, Mahogany, Jarul Etc	Maize, Potato, Cauliflower, Cabbage, Tomato, Brinjal, Chili, Lady's Finger, Water Melon, Arum, Banana, Papaya, Lemon, Sapotha, Guava, Mango, Coconut, Gamar, Garjan, Jarul, Mehagoni Etc.	Maize, Potato, Cauliflower, Cabbage, Tomato, Brinjal, Chili, Lady's Finger, Water Melon, Arum, Banana, Papaya, Lemon, Sapotha, Guava, Mango, Coconut, Spices, Pulse,
	MH (2054)	Maize, Mustard, Peanut, Pulse, Potato, T Aman, Arum	Maize, Wheat, T Aman. T Aus. Boro, Arum	T Aman. T Aus	T Aman. T Aus, Boro
Naikhachari (46121)	H (45814)	Maize, Mustard, Sun-Flower, Potato, Peanut, Tomato, Brinjal, Radish, Turnip, Spices, Onion, Garlic, Carrot, Long Bea, Bitter Guard, Snake Guard, Lady's Finger, Cucumber, Bean, Guard, Pumpkin, Banana, Papaya, Pineapple, Ginger, Turmeric, Arum, Sugar Cane, Coconut, Betel Nut, Mango, Jackfruits, Guava, Litchi, Arum, Sapotha, Orange, Sagun, Gamar, Koroi, Berry, Mahogany, Jarul Etc	Maize, Mustard, Sun-Flower, Potato, Peanut, Tomato, Brinjal, Radish, Turnip, Spices, Onion, Garlic, Carrot, Long Bea, Bitter Guard, Snake Guard, Lady's Finger, Cucumber, Bean, Guard, Pumpkin, Banana, Papaya, Pineapple, Ginger, Turmeric, Arum, Sugar Cane, Coconut, Betel Nut, Mango, Jackfruits, Guava, Litchi, Arum, Sapotha, Orange, Sagun, Gamar, Koroi, Berry, Mahogany, Jarul Etc	Maize, Potato, Cauliflower, Cabbage, Tomato, Brinjal, Chili, Lady's Finger, Water Melon, Arum, Banana, Papaya, Lemon, Sapotha, Guava, Mango, Coconut, Gamar, Garjan, Jarul, Mehagoni Etc.	Maize, Potato, Cauliflower, Cabbage, Tomato, Brinjal, Chili, Lady's Finger, Water Melon, Arum, Banana, Papaya, Lemon, Sapotha, Guava, Mango, Coconut, Spices, Pulse,
	MH (307)	Maize, Mustard, Peanut, Pulse, Potato, T Aman, Arum	Maize, Mustard, Peanut, Pulse, Potato, T Aman. T Aus, Arum	Aus, T Aman, T Aus	Boro, T Aus, T Aman

District/ Upazilla	Land Type	Suitable crops		Potential crops	
		Without Irrigation	With Irrigation	Without Irrigation	With Irrigation
Rowangchari (43767)	H (41777)	Maize, Mustard, Sun-Flower, Potato, Peanut, Tomato, Brinjal, Radish, Turnip, Spices, Onion, Garlic, Carrot, Long Bea, Bitter Guard, Snake Guard, Lady's Finger, Cucumber, Bean, Guard, Pumpkin, Banana, Papaya, Pineapple, Ginger, Turmeric, Arum, Sugar Cane, Coconut, Betel Nut, Mango, Jackfruits, Guava, Litchi, Arum, Sapotha, Orange, Sagun, Gamar, Koroi, Berry, Mahogany, Jarul Etc	Maize, Mustard, Sun-Flower, Potato, Peanut, Tomato, Brinjal, Radish, Turnip, Spices, Onion, Garlic, Carrot, Long Bea, Bitter Guard, Snake Guard, Lady's Finger, Cucumber, Bean, Guard, Pumpkin, Banana, Papaya, Pineapple, Ginger, Turmeric, Arum, Sugar Cane, Coconut, Betel Nut, Mango, Jackfruits, Guava, Litchi, Arum, Sapotha, Orange, Sagun, Gamar, Koroi, Berry, Mahogany, Jarul Etc	Maize, Potato, Cauliflower, Cabbage, Tomato, Brinjal, Chili, Lady's Finger, Water Melon, Arum, Banana, Papaya, Lemon, Sapotha, Guava, Mango, Coconut, Gamar, Garjan, Jarul, Mehagoni Etc.	Maize, Potato, Cauliflower, Cabbage, Tomato, Brinjal, Chili, Lady's Finger, Water Melon, Arum, Banana, Papaya, Lemon, Sapotha, Guava, Mango, Coconut, Spices, Pulse,
	MH (1990)	Maize, Mustard, Peanut, Pulse, Potato, T Aman, Arum	Maize, Wheat, T Aman. T Aus, Arum	Aus, T Aman ,T Aus	Boro, T Aus, T Aman
Ruma (60587)	H (60442)	Maize, Potato, Cauliflower, Cabbage, Tomato, Brinjal, Chili, Lady's Finger, Water Melon, Arum, Banana, Papaya, Pineapple, Ginger, Turmeric, Arum, Sugar Cane, Coconut, Betel Nut, Mango, Jackfruits, Guava, Litchi Etc	Maize, Potato, Cauliflower, Cabbage, Tomato, Brinjal, Chili, Lady's Finger, Water Melon, Arum, Banana, Papaya, Pineapple, Ginger, Turmeric, Arum, Sugar Cane, Coconut, Betel Nut, Mango, Jackfruits, Guava, Litchi Etc	Maize, Potato, Cauliflower, Cabbage, Tomato, Brinjal, Chili, Lady's Finger, Banana, Papaya, Lemon, Sapotha, Guava, Mango, Coconut, B Aus	Sugar Cane, Brinjal, Chili, Potato, T Aus
	ML (145)	Maize, Potato, Cauliflower, Cabbage, Tomato, Brinjal, Chili, Lady's Finger, Water Melon, Arum, Banana, Papaya, Pineapple, Ginger, Turmeric, Arum, Sugar Cane, Coconut, Betel Nut, Mango, Jackfruits, Guava, Litchi Etc	Maize, Potato, Cauliflower, Cabbage, Tomato, Brinjal, Chili, Lady's Finger, Water Melon, Arum, Banana, Papaya, Pineapple, Ginger, Turmeric, Arum, Sugar Cane, Coconut, Betel Nut, Mango, Jackfruits, Guava, Litchi Etc	Maize, Potato, Cauliflower, Cabbage, Tomato, Brinjal, Chili, Lady's Finger, Banana, Papaya, Lemon, Sapotha, Guava, Mango, Coconut, B Aus	Sugar Cane, Brinjal, Chili, Potato, T Aus

District/ Upazilla	Land Type	Suitable crops		Potential crops	
		Without Irrigation	With Irrigation	Without Irrigation	With Irrigation
Thanchi (88820)	**H (88671)**	Maize, Mustard, Sun-Flower, Potato, Peanut, Tomato, Brinjal, Radish, Turnip, Spices, Onion, Garlic, Carrot, Long Bea, Bitter Guard, Snake Guard, Lady's Finger, Cucumber, Bean, Guard, Pumpkin, Banana, Papaya, Pineapple, Ginger, Turmeric, Arum, Sugar Cane, Coconut, Betel Nut, Mango, Jackfruits, Guava, Litchi, Arum, Sapotha, Orange, Sagun, Gamar, Koroi, Berry, Mahogany, Jarul Etc	Maize, Mustard, Sun-Flower, Potato, Peanut, Tomato, Brinjal, Radish, Turnip, Spices, Onion, Garlic, Carrot, Long Bea, Bitter Guard, Snake Guard, Lady's Finger, Cucumber, Bean, Guard, Pumpkin, Banana, Papaya, Pineapple, Ginger, Turmeric, Arum, Sugar Cane, Coconut, Betel Nut, Mango, Jackfruits, Guava, Litchi, Arum, Sapotha, Orange, Sagun, Gamar, Koroi, Berry, Mahogany, Jarul Etc	Maize, Potato, Cauliflower, Cabbage, Tomato, Brinjal, Chili, Lady's Finger, Water Melon, Arum, Banana, Papaya, Lemon, Sapotha, Guava, Mango, Coconut, Gamar, Garjan, Jarul, Mehagoni Etc.	Maize, Potato, Cauliflower, Cabbage, Tomato, Brinjal, Chili, Lady's Finger, Water Melon, Arum, Banana, Papaya, Lemon, Sapotha, Guava, Mango, Coconut, Spices, Pulse,
	MH (149)	T Aman	T Aman. T Aus, Maize, Potato, Cauliflower, Cabbage, Tomato, Brinjal, Chili, Lady's Finger, Water Melon, Arum	T Aman. T Aus	T Aman. T Aus
Khagrachhari					
Dighinala (67179)	**H (61455)**	Maize, Mustard, Sun-Flower, Potato, Peanut, Tomato, Brinjal, Radish, Turnip, Spices, Onion, Garlic, Carrot, Long Bea, Bitter Guard, Snake Guard, Lady's Finger, Cucumber, Bean, Guard, Pumpkin, Banana, Papaya, Pineapple, Ginger, Turmeric, Arum, Sugar Cane, Coconut, Betel Nut, Mango, Jackfruits, Guava, Litchi, Arum, Sapotha, Orange, Sagun, Gamar, Koroi, Berry, Mahogany, Jarul Etc	Maize, Mustard, Sun-Flower, Potato, Peanut, Tomato, Brinjal, Radish, Turnip, Spices, Onion, Garlic, Carrot, Long Bea, Bitter Guard, Snake Guard, Lady's Finger, Cucumber, Bean, Guard, Pumpkin, Banana, Papaya, Pineapple, Ginger, Turmeric, Arum, Sugar Cane, Coconut, Betel Nut, Mango, Jackfruits, Guava, Litchi, Arum, Sapotha, Orange, Sagun, Gamar, Koroi, Berry, Mahogany, Jarul Etc	Maize, Potato, Cauliflower, Cabbage, Tomato, Brinjal, Chili, Lady's Finger, Water Melon, Arum, Banana, Papaya, Lemon, Sapotha, Guava, Mango, Coconut Etc.	Spices, Pulse, Banana, Papaya, Pineapple, Ginger, Turmeric, Arum, Sugar Cane, Betle Leaves.
	MH (5724)	Aus, Maize, Pulse, Potato, Mustard, Arum	Boro, T Aus, T Aman, Maize, Pulse, Potato, Mustard, Arum	Aus, T Aman, T Aus	Boro, T Aus, T Aman

District/ Upazilla	Land Type	Suitable crops		Potential crops	
		Without Irrigation	With Irrigation	Without Irrigation	With Irrigation
Khagrachhari sadar (27115)	**H (25609)**	Maize, Mustard, Sun-Flower, Potato, Peanut, Tomato, Brinjal, Radish, Turnip, Spices, Onion, Garlic, Carrot, Long Bea, Bitter Guard, Snake Guard, Lady's Finger, Cucumber, Bean, Guard, Pumpkin, Banana, Papaya, Pineapple, Ginger, Turmeric, Arum, Sugar Cane, Coconut, Betel Nut, Mango, Jackfruits, Guava, Litchi, Arum, Sapotha, Orange, Sagun, Gamar, Koroi, Berry, Mahogany, Jarul Etc	Maize, Mustard, Sun-Flower, Potato, Peanut, Tomato, Brinjal, Radish, Turnip, Spices, Onion, Garlic, Carrot, Long Bea, Bitter Guard, Snake Guard, Lady's Finger, Cucumber, Bean, Guard, Pumpkin, Banana, Papaya, Pineapple, Ginger, Turmeric, Arum, Sugar Cane, Coconut, Betel Nut, Mango, Jackfruits, Guava, Litchi, Arum, Sapotha, Orange, Sagun, Gamar, Koroi, Berry, Mahogany, Jarul Etc	Maize, Potato, Cauliflower, Cabbage, Tomato, Brinjal, Chili, Lady's Finger, Water Melon, Arum, Banana, Papaya, Lemon, Sapotha, Guava, Mango, Coconut, Gamar, Garjan, Jarul, Mehagoni Etc.	Maize, Potato, Cauliflower, Cabbage, Tomato, Brinjal, Chili, Lady's Finger, Water Melon, Arum, Banana, Papaya, Lemon, Sapotha, Guava, Mango, Coconut, Spices, Pulse,
	MH (506)	Aus, Maize, Pulse, Potato, Mustard, Arum	Boro, T Aus, T Aman, Maize, Pulse, Potato, Mustard, Arum	Aus, T Aman, T Aus	Boro, T Aus, T Aman
Laksmichari (21750)	**H (21590)**	Maize, Mustard, Sun-Flower, Potato, Peanut, Tomato, Brinjal, Radish, Turnip, Spices, Onion, Garlic, Carrot, Long Bea, Bitter Guard, Snake Guard, Lady's Finger, Cucumber, Bean, Guard, Pumpkin, Banana, Papaya, Pineapple, Ginger, Turmeric, Arum, Sugar Cane, Coconut, Betel Nut, Mango, Jackfruits, Guava, Litchi, Arum, Sapotha, Orange, Sagun, Gamar, Koroi, Berry, Mahogany, Jarul Etc	Maize, Mustard, Sun-Flower, Potato, Peanut, Tomato, Brinjal, Radish, Turnip, Spices, Onion, Garlic, Carrot, Long Bea, Bitter Guard, Snake Guard, Lady's Finger, Cucumber, Bean, Guard, Pumpkin, Banana, Papaya, Pineapple, Ginger, Turmeric, Arum, Sugar Cane, Coconut, Betel Nut, Mango, Jackfruits, Guava, Litchi, Arum, Sapotha, Orange, Sagun, Gamar, Koroi, Berry, Mahogany, Jarul Etc	Maize, Potato, Cauliflower, Cabbage, Tomato, Brinjal, Chili, Lady's Finger, Water Melon, Arum, Gamar, Garjan, Jarul, Mehagoni Etc.	Maize, Potato, Cauliflower, Cabbage, Tomato, Brinjal, Chili, Lady's Finger, Water Melon, Arum, Banana, Papaya, Lemon, Sapotha, Guava, Mango, Coconut Etc.

District/ Upazilla	Land Type	Suitable crops		Potential crops	
		Without Irrigation	With Irrigation	Without Irrigation	With Irrigation
	MH (160)	Aus, T Aman, Maize, Pulse, Potato, Mustard, Arum	Boro, T Aus, T Aman, Maize, Potato, Cauliflower, Cabbage, Tomato, Brinjal, Chili, Lady's Finger, Water Melon, Arum	Aus, T Aman	Boro, T Aus, T Aman
Mohalchari (23143)	**H (19385)**	Maize, Mustard, Sun-Flower, Potato, Peanut, Tomato, Brinjal, Radish, Turnip, Spices, Onion, Garlic, Carrot, Long Bea, Bitter Guard, Snake Guard, Lady's Finger, Cucumber, Bean, Guard, Pumpkin Etc.	Maize, Potato, Cauliflower, Cabbage, Tomato, Brinjal, Chili, Lady's Finger, Water Melon, Arum, Banana, Papaya, Lemon, Sapotha, Guava, Mango, Coconut, Gamar, Garjan, Jarul, Mehagoni Etc.	Banana, Papaya, Pineapple, Ginger, Turmeric, Arum, Sugar Cane, Coconut, Betel Nut, Mango, Jackfruits, Guava, Litchi, Arum, Sapotha, Orange, Sagun, Gamar, Koroi, Berry, Mahogany, Jarul Etc	Maize, Potato, Cauliflower, Cabbage, Tomato, Brinjal, Chili, Lady's Finger, Water Melon, Arum, Banana, Papaya, Lemon, Sapotha, Guava, Mango, Coconut, Spices, Pulse,
	MH (2701)	Aus, T Aman, Maize, Pulse, Potato, Mustard, Arum	Boro, T Aus, T Aman, Maize, Potato, Cauliflower, Cabbage, Tomato, Brinjal, Chili, Lady's Finger, Water Melon, Arum, Arum	Aus, T Aman, T Aus	Boro, T Aus, T Aman
	ML (1057)	B Aus, B Aman, T Aman, Maize, Pulse, Mustard	Boro	B Aus, Aman, T Aman	Boro, T Aman

District/ Upazilla	Land Type	Suitable crops		Potential crops	
		Without Irrigation	With Irrigation	Without Irrigation	With Irrigation
Manikchari (16374)	H (13972)	Maize, Mustard, Sun-Flower, Potato, Peanut, Tomato, Brinjal, Radish, Turnip, Spices, Onion, Garlic, Carrot, Long Bea, Bitter Guard, Snake Guard, Lady's Finger, Cucumber, Bean, Guard, Pumpkin Banana, Papaya, Pineapple, Ginger, Turmeric, Arum, Sugar Cane, Coconut, Betel Nut, Mango, Jackfruits, Guava, Litchi, Arum, Sapotha, Orange, Sagun, Gamar, Koroi, Berry, Mahogany, Jarul Etc	Maize, Mustard, Sun-Flower, Potato, Peanut, Tomato, Brinjal, Radish, Turnip, Spices, Onion, Garlic, Carrot, Long Bea, Bitter Guard, Snake Guard, Lady's Finger, Cucumber, Bean, Guard, Pumpkin, Banana, Papaya, Pineapple, Ginger, Turmeric, Arum, Sugar Cane, Coconut, Betel Nut, Mango, Jackfruits, Guava, Litchi, Arum, Sapotha, Orange, Sagun, Gamar, Koroi, Berry, Mahogany, Jarul Etc	Maize, Potato, Cauliflower, Cabbage, Tomato, Brinjal, Chili, Lady's Finger, Water Melon, Arum, Banana, Papaya, Lemon, Sapotha, Guava, Mango, Coconut, Gamar, Garjan, Jarul, Mehagoni Etc.	Maize, Potato, Cauliflower, Cabbage, Tomato, Brinjal, Chili, Lady's Finger, Water Melon, Arum, Banana, Papaya, Lemon, Sapotha, Guava, Mango, Coconut Etc.
	MH (2402)	Aus, T Aman, Maize, Pulse, Potato, Mustard	Boro, T Aus, T Aman, Maize, Potato, Cauliflower, Cabbage, Tomato, Brinjal, Chili, Lady's Finger, Water Melon, Arum	Aus, T Aman, T Aus	Boro, T Aus, T Aman
Matiranga (48761)	H (44595)	Maize, Mustard, Sun-Flower, Potato, Peanut, Tomato, Brinjal, Radish, Turnip, Spices, Onion, Garlic, Carrot, Long Bea, Bitter Guard, Snake Guard, Lady's Finger, Cucumber, Bean, Guard, Pumpkin, Banana, Papaya, Pineapple, Ginger, Turmeric, Arum, Sugar Cane, Coconut, Betel Nut, Mango, Jackfruits, Guava, Litchi, Arum, Sapotha, Orange, Sagun, Gamar, Koroi, Berry, Mahogany, Jarul Etc	Maize, Mustard, Sun-Flower, Potato, Peanut, Tomato, Brinjal, Radish, Turnip, Spices, Onion, Garlic, Carrot, Long Bea, Bitter Guard, Snake Guard, Lady's Finger, Cucumber, Bean, Guard, Pumpkin, Banana, Papaya, Pineapple, Ginger, Turmeric, Arum, Sugar Cane, Coconut, Betel Nut, Mango, Jackfruits, Guava, Litchi, Arum, Sapotha, Orange, Sagun, Gamar, Koroi, Berry, Mahogany, Jarul Etc	Maize, Potato, Cauliflower, Cabbage, Tomato, Brinjal, Chili, Lady's Finger, Water Melon, Arum, Banana, Papaya, Lemon, Sapotha, Guava, Mango, Coconut, Gamar, Garjan, Jarul, Mehagoni Etc.	Maize, Potato, Cauliflower, Cabbage, Tomato, Brinjal, Chili, Lady's Finger, Water Melon, Arum, Banana, Papaya, Lemon, Sapotha, Guava, Mango, Coconut Etc.
	MH (4166)	Aus, T Aman, Maize, Pulse, Potato, Mustard	Boro, T Aus, T Aman, Maize, Potato, Cauliflower, Cabbage, Tomato, Brinjal, Chili, Lady's Finger, Water Melon, Arum	Aus, T Aman	Boro, T Aus, T Aman

District/ Upazilla	Land Type	Suitable crops		Potential crops	
		Without Irrigation	With Irrigation	Without Irrigation	With Irrigation
Panchari (32349)	**H (31467)**	Maize, Mustard, Sun-Flower, Potato, Peanut, Tomato, Brinjal, Radish, Turnip, Spices, Onion, Garlic, Carrot, Long Bea, Bitter Guard, Snake Guard, Lady's Finger, Cucumber, Bean, Guard, Pumpkin, Banana, Papaya, Pineapple, Ginger, Turmeric, Arum, Sugar Cane, Coconut, Betel Nut, Mango, Jackfruits, Guava, Litchi, Arum, Sapotha, Orange, Sagun, Gamar, Koroi, Berry, Mahogany, Jarul Etc	Maize, Mustard, Sun-Flower, Potato, Peanut, Tomato, Brinjal, Radish, Turnip, Spices, Onion, Garlic, Carrot, Long Bea, Bitter Guard, Snake Guard, Lady's Finger, Cucumber, Bean, Guard, Pumpkin, Banana, Papaya, Pineapple, Ginger, Turmeric, Arum, Sugar Cane, Coconut, Betel Nut, Mango, Jackfruits, Guava, Litchi, Arum, Sapotha, Orange, Sagun, Gamar, Koroi, Berry, Mahogany, Jarul Etc	Maize, Potato, Cauliflower, Cabbage, Tomato, Brinjal, Chili, Lady's Finger, Water Melon, Arum, Banana, Papaya, Lemon, Sapotha, Guava, Mango, Coconut , Gamar, Garjan, Jarul, Mehagoni Etc.	Maize, Potato, Cauliflower, Cabbage, Tomato, Brinjal, Chili, Lady's Finger, Water Melon, Arum, Banana, Papaya, Lemon, Sapotha, Guava, Mango, Coconut, Spices, Pulse,
	MH (882)	Aus, T Aman, Maize, Pulse, Potato, Mustard, Arum	Boro, T Aus, T Aman, Maize, Wheat, Arum	Aus, T Aman, T Aus	Boro, T Aus, T Aman
Ramgor (22913)	**H (21824)**	Maize, Mustard, Sun-Flower, Potato, Peanut, Tomato, Brinjal, Radish, Turnip, Spices, Onion, Garlic, Carrot, Long Bea, Bitter Guard, Snake Guard, Lady's Finger, Cucumber, Bean, Guard, Pumpkin, Banana, Papaya, Pineapple, Ginger, Turmeric, Arum, Sugar Cane, Coconut, Betel Nut, Mango, Jackfruits, Guava, Litchi, Arum, Sapotha, Orange, Sagun, Gamar, Koroi, Berry, Mahogany, Jarul Etc	Maize, Mustard, Sun-Flower, Potato, Peanut, Tomato, Brinjal, Radish, Turnip, Spices, Onion, Garlic, Carrot, Long Bea, Bitter Guard, Snake Guard, Lady's Finger, Cucumber, Bean, Guard, Pumpkin, Banana, Papaya, Pineapple, Ginger, Turmeric, Arum, Sugar Cane, Coconut, Betel Nut, Mango, Jackfruits, Guava, Litchi, Arum, Sapotha, Orange, Sagun, Gamar, Koroi, Berry, Mahogany, Jarul Etc	Maize, Potato, Cauliflower, Cabbage, Tomato, Brinjal, Chili, Lady's Finger, Water Melon, Arum, Banana, Papaya, Lemon, Sapotha, Guava, Mango, Coconut, Segun, Gamar, Gorjon, Koroi, Berry, Jarul, Mahogany, Bamboo.	Spices, Pulse, Banana, Papaya, Pineapple, Ginger, Turmeric, Arum, Sugar Cane, Betel Leaves. Gamar, Garjan, Jarul, Mehagoni Etc.

District/ Upazilla	Land Type	Suitable crops		Potential crops	
		Without Irrigation	With Irrigation	Without Irrigation	With Irrigation
	MH 1089	Maize, Pulse, T Aman, Aus, Arum	Chili, Potato, Brinjal, Mustard, Maize, Boro, T Aus,T Aman, Arum	Aus, T Aman, T Aus	T Aus, T Aman, Boro,
Rangamati					
Baghaichari (186518)	H (185070)	Maize, Mustard, Sun-Flower, Potato, Peanut, Tomato, Brinjal, Radish, Turnip, Spices, Onion, Garlic, Carrot, Long Bea, Bitter Guard, Snake Guard, Lady's Finger, Cucumber, Bean, Guard, Pumpkin, Aus, T Aman, Coconut, Betel Nut, Mango, Jackfruits, Guava, Litchi, Arum, Sapotha, Orange, Sagun, Gamar, Koroi, Berry, Mahogany, Jarul, Banana, Papaya, Pineapple, Ginger, Turmeric, Arum, Sugar Cane.	Wheat, Maize, Potato, Radish, Lady's Finger, Chili, Tomato, Cauliflower, Cabbage, Turnip, Carrot, Brinjal, Snake Guard, Pal Bal, Bitter Guard, B Aman, B Aus Perennial: Coconut, Betel Nut, Mango, Jackfruits, Guava, Litchi, Arum, Sapotha, Orange, Sagun, Gamar, Koroi, Berry, Mahogany, Jarul, Banana, Papaya, Pineapple, Ginger, Turmeric, Arum, Sugar Cane.	T Aman, T Aus, B Aman, Vegetables, Pulse, Sugar Cane	T Aman, T Aus, B Aman, Vegetables, Pulse, Sugar Cane
	MH (971)	Maize, Mustard, Sun-Flower, Potato, Peanut, Tomato, Brinjal, Radish, Turnip, Spices, Onion, Garlic, Carrot, Long Bea, Bitter Guard, Snake Guard, Lady's Finger, Cucumber, Bean, Guard, Pumpkin, B Aus, B Aman, T Aman, Banana, Papaya, Pineapple, Ginger, Turmeric, Arum, Sugar Cane, Coconut, Betel Nut, Mango, Jackfruits, Guava, Litchi, Arum, Sapotha, Orange, Sagun, Gamar, Koroi, Berry, Mahogany, Jarul.	Maize, Mustard, Sun-Flower, Potato, Peanut, Tomato, Brinjal, Radish, Turnip, Spices, Onion, Garlic, Carrot, Long Bea, Bitter Guard, Snake Guard, Lady's Finger, Cucumber, Bean, Guard, Pumpkin, B Aus, B Aman, T Aman, Banana, Papaya, Pineapple, Ginger, Turmeric, Arum, Sugar Cane, Coconut, Betel Nut, Mango, Jackfruits, Guava, Litchi, Arum, Sapotha, Orange, Sagun, Gamar, Koroi, Berry, Mahogany, Jarul	Vegetables, Pulse, Sugar Cane, Musterd, T Aman, T Aus, B Aman	Vegetables, Pulse, Sugar Cane, Mustard, T Aman, T Aus, B Aman
	ML (477)	Boro Rice		Boro	Boro

District/ Upazilla	Land Type	Suitable crops		Potential crops	
		Without Irrigation	With Irrigation	Without Irrigation	With Irrigation
Barkal (63029)	H (63029)	Maize, Mustard, Sun-Flower, Potato, Peanut, Tomato, Brinjal, Radish, Turnip, Spices, Onion, Garlic, Carrot, Long Bea, Bitter Guard, Snake Guard, Lady's Finger, Cucumber, Bean, Guard, Pumpkin, Banana, Papaya, Pineapple, Ginger, Turmeric, Arum, Sugar Cane, Coconut, Betel Nut, Mango, Jackfruits, Guava, Litchi, Arum, Sapotha, Orange, Sagun, Gamar, Koroi, Berry, Mahogany, Jarul.	Maize, Potato, Cauliflower, Cabbage, Tomato, Brinjal, Chili, Lady's Finger, Water Melon, Banana, Papaya, Pineapple, Ginger, Turmeric, Arum, Sugar Cane, Coconut, Betel Nut, Mango, Jackfruits, Guava, Litchi, Arum, Sapotha, Orange, Sagun, Gamar, Koroi, Berry, Mahogany, Jarul.	Wheat, Maize, Potato, Mustard, Chili, Brinjal, Ginger, Turmeric, Banana, Papaya, Lemon, Sapotha, Guava, Mango, Coconut, Segun, Gamar, Gorjon, Koroi, Berry, Jarul, Mahogany, Bamboo.	Wheat, Maize, Potato, Mustard, Chili, Brinjal, Ginger, Turmeric, Spices, Banana, Papaya, Lemon, Sapotha, Guava, Mango, Coconut, Timber Trees.
Bilaichari (70395)	H (70369)	Maize, Mustard, Sun-Flower, Potato, Peanut, Tomato, Brinjal, Radish, Turnip, Spices, Onion, Garlic, Carrot, Long Bea, Bitter Guard, Snake Guard, Lady's Finger, Cucumber, Bean, Guard, Pumpkin, Banana, Papaya, Pineapple, Ginger, Turmeric, Arum, Sugar Cane, Coconut, Betel Nut, Mango, Jackfruits, Guava, Litchi, Arum, Sapotha, Orange, Sagun, Gamar, Koroi, Berry, Mahogany, Jarul Etc	Maize, Potato, Cauliflower, Cabbage, Tomato, Brinjal, Chili, Lady's Finger, Water Melon	Ginger, Turmeric, Brinjal, Chili, Coconut, Berry, Betel Nut, Jackfruit, Nuts, Banana, Papaya, Gamar, Garjan, Jarul, Mehagoni Etc.	Spices, Pulse, Banana, Papaya, Mango, Jackfruit, Litchi, Lemon, Nuts, Sugar-Cane Etc
	MH (26)	Maize, Onion, Garlic, Pulse, Mustard, Sunflower, Groundnut, Aus, T Aman.	Wheat, Maize, Potato, Radish, Lady's Finger, Chili, Tomato, Cauliflower, Cabbage, Turnip, Carrot, Brinjal, Snake Guard, Pal Bal, Bitter Guard Etc.	T Aman, T Aus,	T Aman, T Aus

District/ Upazilla	Land Type	Suitable crops		Potential crops	
		Without Irrigation	With Irrigation	Without Irrigation	With Irrigation
Jurai Chhari (59778)	H (59222)	Cotton, Wheat, Spice, Pulses, Aus Rice, T Aman, Long Bea, Pumpkin, Eggplant, Maize, Cucumber, Bean, Banana, Papaya, Pineapple, Cotton, Karai, Bamboo, Lemon, Rubber, Mango, Jackfruit, Cashew Nut, Guava Etc.		Gamar, Garjan, Jam, Jarul, Mehagoni, Mango, Jackfruit, Guava, Citrus, Bamboo, Rubber, Banana, Papaya, Pineapple, Cotton	
	MH (556)	Cotton, Wheat, Spice, Pulses, Aus Rice, T Aman, Long Bea, Pumpkin, Eggplant, Maize, Cucumber, Bean Etc		Aus, T Aman,	Boro, Chilly, Potato, Eggplant, Maize, Rabi Vegetables, T Aman
Kaptai (25295)	H (24306)	Maize, Mustard, Sun-Flower, Potato, Peanut, Tomato, Brinjal, Radish, Turnip, Spices, Onion, Garlic, Carrot, Long Bea, Bitter Guard, Snake Guard, Lady's Finger, Cucumber, Bean, Guard, Pumpkin, Aus,T Aman, Banana, Papaya, Pineapple, Ginger, Turmeric, Arum, Sugar Cane, Coconut, Betel Nut, Mango, Jackfruits, Guava, Litchi, Arum, Sapotha, Orange, Sagun, Gamar, Koroi, Berry, Mahogany, Jarul Etc	Maize, Potato, Cauliflower, Cabbage, Tomato, Brinjal, Chili, Lady's Finger, Water Melon, Arum, T Aman, Banana, Papaya, Pineapple, Ginger, Turmeric, Arum, Sugar Cane, Mango, Guava, Lichi, Lemon, Betle Leaves Etc.	T Aman, B Aus, Banana, Papaya, Pineapple, Ginger, Turmeric, Arum, Sugar Cane.	T Aman, Banana, Papaya, Pineapple, Ginger, Turmeric, Arum, Sugar, Cane, Betel Leaves.
	MH (989)	Maize, Mustard, Peanut, Pulse, Potato, T Aman, Arum	Boro, T Aus, B Aman, Arum	T Aman, B Aus	Boro, T Aus, B Aman

District/ Upazilla	Land Type	Suitable crops		Potential crops	
		Without Irrigation	With Irrigation	Without Irrigation	With Irrigation
Kawkhali (32772)	H (32259)	Tomato, Brinjal, Chili, Stem, Lady s Finger, Maize, Bitter Gourd, Par bal, Cucumber, Snake Gourd, Long Bea, Bean, Gourd, Pumpkin, Banana, Papaya, Pineapple, Cotton, Turmeric, Ginger, Sugar Cane, Gamar, Mahogany, Garjon, Jarul, Chapalish, Zarul, Koroi , Coconut, Biter Nut, Mango, Jackfruit, Guava, Litchi, Plum, Sapotha, Orange,	Wheat, Maize, Potato, Ladies Finger, Chili, Radish, Tomato, Cauliflower, Cabbage, Knoll-Kal-Turnip, Carrot, Brinjal, Snake Gourd, Bitter Gourd, Banana, Papaya, Sugar Cane, Arum, Cotton, Betel Leave, Lemon	Banana, Papaya, Ginger,Termaric, Vegetables, Timber Tree.	Ginger, Turmeric, Banana, Papaya, Timber Trees.
	MH (513)	Aman Rice, Pulse, Sun-Flower, Arum	Boro, T Aman, Maize, Potato, Cauliflower, Cabbage, Tomato, Brinjal, Chili, Lady's Finger, Water Melon, Sugar Cane	T Aman, Arum.	T Aman, Sugar Cane, Pulse.
Longodu (36762)	H (34813)	Maize, Wheat, Onion, Garlic, Pulse, Mustered, Nuts, Ladies Finger, Snake Guard, Par bal, Banana, Pineapple, Ginger, Turmeric, Cotton, Lemon, Sapotah, Guava, Mango, Coconut, Betel Nut Etc.	Potato, Chili, Brinjal, Mustard, Maize, Arum, Boro, Aus, Aman, Sugar Cane, Brinjal, Chili Etc.	Ginger, Turmeric, Aus, Aman, Banana, Papaya, Lemon, Sapotha, Guava, Mango, Coconut Etc.	Sugar Cane, Brinjal, Chili, Potato, Aus, Aman.
	MH (1566)	Maize, Wheat, Onion, Garlic, Pulse, Mustered, Nuts, Aus, T Aman.	Wheat, Maize, Potato,Mustard , Chili, Brinjal, Boro, T Aus, T Aman.	Aus, T Aman,	T Aus, T Aman, B Aman.
	ML (383)		Boro	Boro	Boro
Nanierchar (34534)	H (32292)	Maize, Onion, Garlic, Pulse, Mustard, Sunflower, Groundnut, Lady's Finger, Snake Guard, Par bal, Banana, Papaya, Pineapple, Cotton, Ginger, Turmeric, T Aman, Aus, Sagun, Gamar, Koroi, Berry, Jarul, Bamboo, Rubber, Mango, Jackfruit, Guava, Sapotha, Lemon.	Wheat, Maize, Potato, Radish, Lady's Finger, Chili, Tomato, Cauliflower, Cabbage, Turnip, Carrot, Brinjal, Snake Guard, Pal Bal, Bitter Guard, Sugar Cane, Brinjal, Chili, T Aman,	Mango, Jackfruit, Guava, Lemon, Sapotha, Aus, T Aman, Segun, Gamar, Gorjon, Koroi, Berry, Jarul, Mahogany, Bamboo.	Sugar Cane, Brinjal, Chili, Potato, T Aus, T Aman.

District/ Upazilla	Land Type	Suitable crops		Potential crops	
		Without Irrigation	With Irrigation	Without Irrigation	With Irrigation
	MH (1289)	Maize, Pulse, Mustard, Nuts, Onion, Garlic, Aus, T Aman.	Maize, Potato, Wheat, Chili, Mustard, T Aman, T Aus.	Aus, T Aman,	T Aman, T Aus.
	ML (953)	Boro Rice	Rice: T Aman, T Aus.	Rice: Boro.	T Aus, T Aman, Boro, B Aman.
Rajashali (12064)	H (11508)	Maize, Mustard, Sun-Flower, Potato, Peanut, Tomato, Brinjal, Radish, Turnip, Spices, Onion, Garlic, Carrot, Long Bea, Bitter Guard, Snake Guard, Lady's Finger, Cucumber, Bean, Guard, Pumpkin, T Aman, Banana, Papaya, Pineapple, Ginger, Turmeric, Arum, Sugar Cane, Coconut, Betel Nut, Mango, Jackfruits, Guava, Litchi, Arum, Sapotha, Orange, Sagun, Gamar, Koroi, Berry, Mahogany, Jarul Etc	Maize, Potato, Cauliflower, Cabbage, Tomato, Brinjal, Chili, Lady's Finger, Water Melon, T Aman, Banana, Papaya, Pineapple, Ginger, Turmeric, Arum, Sugar Cane, Coconut, Betel Nut, Mango, Jackfruits, Guava, Litchi, Arum, Sapotha, Orange, Sagun, Gamar, Koroi, Berry, Mahogany, Jarul Etc	T Aman, B Aus, Banana, Papaya, Lemon, Sapotha, Guava, Mango, Coconut Etc.	Wheat, Maize, Potato, Mustard, Chili, Brinjal, Ginger, Turmeric, Spices, T Aman, Banana, Papaya, Pineapple, Ginger, Turmeric, Arum, Sugar Cane,
	MH (556)	Maize, Potato, Cauliflower, Cabbage, Tomato, Brinjal, Chili, Lady's Finger, Water Melon, Arum, Aus,T Aman	Arum, T Aman, T Aus, Boro	T Aman, R Aus	T Aman, R Aus
Rangamati Sadar (35543)	H (35289)	Long Bea, Bitter Gourd, Snake Gourd, Gourd, Pumpkin, Cucumber, Ladies Finger, Lima Bean, Brinjal, Radish, Tick, Berry, Gamar, Garjan, Mehegoni, Bamboo, Tea, Rubber, Berry, Litchi, Lemon, Jackfruit, Areca Nut, Guava, Cashew Nut, Plum, Banana, Arum, Papaya, Pine Apple, Chili, Cotton	Maize, Potato, Ladies Finger, Brinjal, Chili, Tomato, Cauli Flower, Cabbage, Radish, Gourd, Pumpkin Etc.	Bamboo, Rubber, Tea Banana, Papaya, Arum, Gamar, Garjan, Jam, Jarul, Mehagoni, Tick, Spices, Bamboo, Rubber, :Mango, Jackfruit, Guava, Lemon, Litchi, Orange Etc	Brinjal, Potato, Chili, T Auks, T Aman, Banana, Papaya, Lemon, Guava Etc
	MH (254)	Maize, Pulse, Mustard, Nuts, Potato, Aus,	Wheat, Maize, Potato, Ladies Finger, Chili, Radish, Tomato, Cauliflower, Cabbage, Knoll-Kal-Turnip, Carrot, Brinjal, Snake Gourd, Bitter Gourd Etc.	Aus, T Aman,	T Aus, T Aman, Boro

Source: SRDI, 1996-2002

Annex C: Biodiversity Threats in the CHT

Table 1. Animals Present, Hunted, and Now Extinct by Regions (Cell Frequency Represents Number of Regions)

Animal	Animal Present	Hunted By Villagers	Hunted By Outsiders	Hunted Most	Extinct
Region I (26 villages)					
Tiger	15	7	7	3	4
Deer	26	27	19	25	
Wild pig	25	24	19	23	
Monkey	14	10	5	6	
Porcupine	14	14	5	4	
Beer	8	3	3	1	
Snake	1				
Fox	9	4	2	2	1
Rabbit	3	1	2		1
Elephant	2				11
Wild cock	13	13	4		
Honuman	1	1	1	1	
Wild cat	7	6	3	3	
Guishap	7	7	3		
Wild goat	2	2	2	1	
Python	10	7	2	1	1
Mongoose	3	3		2	
Region II (45 villages)					
Tiger	18	13	6		8
Deer	45	38	27	35	1
Wild pig	40	31	26	32	1
Monkey	26	15	4	4	1
Porcupine	19	18	5	5	1
Beer	17	12	5	2	3
Snake	8	6	4	2	
Wild dog	3	1	1		
Fox	19	8	6	2	

Animal	Animal Present	Hunted By Villagers	Hunted By Outsiders	Hunted Most	Extinct
Rabbit	5	2	3	1	
Elephant	8		1		11
Wild cock	13	12	8	8	
Honuman	3	1	1		
Wild cat	17	3	4	1	1
Guishap	7	7	3	2	
Wild goat	2	2	2		
Python	14	13	5	3	6
Hill rat	2	1			
Khatas	1				
Mongoose	1				1
Birds	1	1		1	
Wild cow					2
Region III (54 villages)					
Tiger	12		1		4
Deer	43	31	22	21	4
Wild pig	36	36	28	33	3
Monkey	2	2	2	2	
Porcupine	6	6	2	3	1
Beer	1	1	1		4
Snake	2	2	1		
Fox	5	5	2		1
Rabbit	11	11			1
Wild cock	26	26	11	12	
Wild cat	3	3	1		
Guishap	3	3	1		
Python	1	1			
Mongoose	1	1			
Region IV (13 villages)					
Tiger	5				
Deer	11	8	6	4	
Wild pig	9	7	6	9	

Animal	Animal Present	Hunted By Villagers	Hunted By Outsiders	Hunted Most	Extinct
Monkey	4		1	1	
Porcupine	2		2	1	
Beer	6				
Wild dog	1				
Fox	3				
Elephant	4				
Wild cock	3	1	1	1	
Python	2	2			
Rhino	1				
Peacock	1				
Haina	I				
Region-V (12 villages)					
Tiger	1				1
Deer	10	6	4	4	1
Wild pig	9	7	3	7	
Monkey	7	1	2		
Porcupine	4	3	2	2	
Beer	2				
Snake	2				
Fox	5	9			
Rabbit	1	1		1	
Elephant	2		1		
Wild cock	5	4	2	3	
Wild cat	3	2		1	
Guishap	1				
Python	1	1			
Mongoose	1	1			

Table 2. Trees Existing, Hacked and Extinct By Regions (Cell Frequency Represents Number Of Regions)

Tree	Existing	Hacked more	Scarce	Extinct	Tree	Existing	Hacked more	Scarce	Extinct
Region I (26 villages)									
Gamari	25	23	-	-	Banyan	2	-	-	-
Gorai	2	1	-	-	Wood apple	3	-	-	-
Teak	24	17		-	Lali	3	2	1	
Mango	11	1	1	-	Guda	4	4	2	2
Jackfruit	10	1	1	-	Mahogany	-	-	-	2
Rong	5	3	2		Silk cotton	2	1	1	1
Koroi	19	15	10	-	Gojari	1	1	-	-
Shibli	-	-	-	6	Sur	1	-	-	-
Gorjon	16	10	9	-	Lichi	1	-	-	-
Tamarind	7	-	-	1	Shilkoroi	6	2	2	2
Jarul	3	2	2	-	Beetle nut	1	-	-	-
Champa	2		1	-	Golgotia	1	1	-	-
Chapalis	11	3	2	3	Chameli	1	1	-	-
Chakku	1	1	1	-	Tetra	-	-	-	1
Chamla	1		-	-	Badi	-	-	-	1
Gutgute	4	3	2	-	Gadan	-	-	-	1
Coconut	7	-	-	-	Grapefruit	4	-	-	-
Region II (45 villages)									
Gamari	38	33	16	1	Blackberry	6	2	1	1
Gorai	7	7	3	-	Tekpal	2	-	-	-
Jati gorai	4	4	3	-	Com	1	1	-	-
Teak	36	10	5	-	Dakutum	3	2	2	-
Mango	4	3	4		Kiraijja	1	1	-	-
Jackfruit	11	2	3	-	Batana	1	-	-	-
Rong	10	8	4	-	Silk cotton	4	2	1	-
Koroi	23	21	19	-	Shal	1	1	-	-
Shibli	1	-	-	-	Eucaliptus	3	2	1	-
Gorjon	26	18	22	8	Hargaja	1	-	1	-
Tamarind	5	-	-	-	Sibit	1	-	1	-
Jarul	2	1	1	2	Gojari	1	-	-	-
Champa	2	1	1	-	Sur	1	1	-	-
Chapalis	12	5	7	8	Shilkoroi	7	7	6	2
Gutgute	8	6	4	-	Eucaliptus	1	-	-	-
Coconut	6	-	-	1	Beetle nut	1	-	-	-
Grapefruit	2	-	-	-	Date	1	-	-	-
Bamboo	2	1	-	-	Silk cotton	1	-	1	-
Wood apple	1	-	-	1	Irgi	1	1	-	-
Geoya	1	1	-	-	Dhanmara	2	-	-	-
Darmara	1	-	-		Amlaki	1	1	1	-
Guda	5	4	4	2	Chameli	-	-	-	-
Mahogany	4	2	1	4	Bandaroolal	-	-	-	1
Rom	-	-	-	l	Barana	-	-	-	2
Kadam	-	-	-	1					
Region III (54 villages)									
Gamari	43	36	13	1	Batana	1	1	1	-
Teak	36	23	2	1	Shal	1	-	-	-

Tree	Existing	Hacked more	Scarce	Extinct	Tree	Existing	Hacked more	Scarce	Extinct
Mango	21	9	7		Lichi	3	1	-	-
Jackfruit	12	2	-	1	Shilkoroi	2	1	2	1
Koroi	30	21	19	3	Beetle nut	5	1	-	1
Gorjon	17	9	10	20	Date	2	-	1	-
Jarul	14	2	1	9	Silk cotton	1	-	-	-
Champa	3	1	1	2	Jujube	1	1		-
Chapalis	11	8	4	3	Konok	5	3	3	-
Badi	1	1	1		Popa	1	1	1	-
Chakku	2	1	1	-	Atyal	1	1	-	-
Gutgute	5	4	3	-	Minjuri	2	2	1	-
Coconut	5	1	-	1	Arganja	1	1	-	-
Grapefruit	3	-			Agar	1	1	1	-
Bamboo	1	1	1	-	Palm	1	1	1	-
Banyan	11	1	4	-	Kadam	1	-	-	-
Gaoya	1	-	-	-	Corn	1	-	1	-
Rubber	3	-		-	Dhanmara	1	1	-	-
Darmara	1		-	-	Deoya	1	1	-	-
Guda	12	10	8	4	Amluki	1	-		-
Mahogany	2	-	1	-	Chameli	1	-	1	1
Black berry	12	3	2	-	Gora	-	-	-	1
Region IV (13 villages)									
Gamari	8	6	2	-	Badi	1	2	1	-
Teak	8	2	2		Chakku	2	2	-	-
Koroi	8	7	2	1	Saruj	1	-	-	-
Gorjon	5	2	4	4	Chamla	1	-	1	-
Jarul	3	-	1	1	Lali	2	2	-	-
Champa	1	-	1	2	Guda	1	-	-	-
Chibik	1	1		-	Silk cotton	1			-
Chapalis	4	2	3	-	Loha	1	-	-	-
Region V (12 villages)									
Gamari	11	10	1	-	Lali	1		-	-
Teak	11	9	1	-	Guda		-	-	1
Mango	6	1	-	-	Mahogany	1	-	-	-
Jackfruit	6	3	-	-	Black berry	3	-	1	-
Koroi	10	6	8		Silk cotton	1		-	-
Gorjon	2	2	2	4	Shilkoroi	2	1	1	-
Jarul	3		1	3	Beetle nut	1	-	-	-
Champa		-	-	1	Date	1	-	-	-
Saruj	1	-	-	-	Shishu	t	-	1	-
Coconut	2	-	-		Krisnachura	1	-	1	-
Grapefruit	1	-	-	-	Kanak	1			-
Banyan	1	-	-	-					

The environment in the Chittagong Hill Tracts (CHT) is under pressure. New methods must be developed, applied, and tested for sustainable management of the natural resources. Practical information is required at both the field and policy level. The Chittagong Hill Tracts improved natural Resources Management (CHARM) project aims at building capacity of different stakeholder groups for promoting sustainable natural resources management in the Chittagong Hill Tracts (CHT). CHARM targets a better understanding of sustainable management of the natural resources and the provision of an improved information basis for decision making with involvement and participation of target groups.

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