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Drivers of land use change and policy analysis: the case of Bangladesh

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DRIVERS OF LAND USE CHANGE AND POLICY ANALYSIS: THE CASE OF BANGLADESH

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To

Shahanshah Hazrat Syed Ziaul Hoque Maizbhandari

ABSTRACT

Land is a very important and scare resource of Bangladesh. It should be managed carefully to ensure the best possible use of this limited resource for the benefit of the maximum number of people and their development. It is felt that land use priorities have to strike a balance between the competing needs of agriculture, forestry, fisheries, livestock, settlements, and urban and industrial development. This study aimed to explore the existing land use patterns in Bangladesh in order to understand existing land use dynamics and predict future land uses. The study focussed particularly on forestlands.

The study was based on both primary and secondary data sources. Data were collected at different spatial scales; national, divisional, district and village level. Land use and demographic data at national, divisional and district levels were collected from different government sources and published books, journals and reports. Village data were collected from a survey in 12 randomly selected villages at different locations in Bangladesh. Land use data were analysed and modelled to explore historic variations in land uses and predict future land uses at national, divisional, district and village scales.

There was observed variability in land uses in different scales such as, national, divisional, district, and thana/village level. Time and population pressure were found to be the major driving forces to determine land use and land use changes in Bangladesh. Village land use was found to be most important especially for agricultural production as the majority of the rural population depend on it for their survival. Homestead forests were found to have potential to substantially increase the country's total tree cover. However, as the country is slowly advancing towards development urbanization and industrialization are emerging as major conflicting land uses converting very good agricultural land to non-agricultural purposes. To overcome the loss of these lands farmers are trying to increase food production from the remaining lands without considering the productive capacity of the lands. However the full potential yield from the agricultural sector is yet to be achieved. Widespread scientific agriculture and better management of the land resources could lead to sound economic growth of the country. Land tenure was also found to constrain potential yield. This results in a lack of inspiration and encouragement to produce more food from the land. It is now imperative to adopt a land reform programme providing the farmers with ownership rights over the land they cultivate and encouraging every household in the rural areas to plant more trees, thereby providing them with seedlings and technical support to protect the country from environmental deterioration.

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LIST OF ABBREVIATIONS

ADB = Asian Development Bank
BARC = Bangladesh Agricultural Research Council
FAO = Food and Agricultural Organisation
FD = Forest Department
FMP = Forestry Master Plan
GDP = Gross Domestic Products
ha = Hectare (1 ha = 2.47 acre)
HYV = High Yielding Variety
Kg = Kilogram
LGED = Local Government Engineering Department
Mha = Million hectares
MOA = Ministry of Agriculture
MOEF = Ministry of Environment and Forests
M.ton = Metric Ton (1 M.Ton = 1000 Kg)
NEMAP = National Environment Management Action Plan
NGO = Non Government Organisation
sq. km. = Square Kilometre
SPARRSO = Space Research and Remote Sensing Organisation
SRDI = Soil Resources Development Institute
TK. = Taka (Bangladesh currency) (1 US$ = 54 TK.)
UNDP = United Nations Development Programme
USF = Unclassified State Forests
US$ = United State dollar
WARPO = Water Resources Planning Organisation.

CHAPTER 1

GENERAL INTRODUCTION

1.1. Research Background.

Bangladesh has an area of 147,570 sq. Km, and lies in the Indo-Gangetic Plain of South Asia between 20^0 34' and 26^0 38' north and 88^0 01' and 92^0 41' east, bordered by India to the West, North and Northeast, Myanmar to the Southeast and Bay of Bengal to the South (BBS, 1999c). The territory is situated on one of the largest, complex deltas in the World where the Ganges, Brahmaputra and Meghna rivers enter the Bay of Bengal. With a sub-tropical monsoon climate, it experiences three seasons a year: a hot or summer season from March to June; a warm and humid monsoon season from June to September and a cool dry season from October to February. Rainfall varies from 1500 to 5000 mm a year. Given its situation in the low-lying plain of Bengal, the variability in annual rainfall and the occurrence of typhoons, Bangladesh often experiences natural disasters such as floods, droughts and typhoons (Giri and Shrestha, 1996).

1.1.1. Land Use.

Agriculture is the main occupation of the people employing 68.5 per cent of the labour force. This sector directly contributes around 35 per cent to the gross domestic product. Bangladesh has got much fertile land but due to paucity of capital and lack of knowledge of new inputs and techniques its yield per unit area is one of the lowest in the world. Bangladesh is currently marginally deficient in food grains (BBS, 1997a).

Graff (1993) reported that developing countries generally have a high overall population density and a relatively high percentage of their people must make a living in agriculture; industrial and service sectors are still underdeveloped. He also showed that less than 0.8 ha arable land is available per economically active person in developing countries compared to more than 12 ha in developed countries. Giri and Shrestha (1996) pointed out that the pressure of population on the land and its resources is a major factor affecting sustainable development in Bangladesh. Whether by over

exploitation or mismanagement, changes in land use, and therefore in land cover, are taking place at an unprecedented rate. Once encapsulated with dense forests, Bangladesh is now almost devoid of forests except in selected areas of the country. The remaining forests are situated mainly in remote areas in the east, southeast and southwest of the country.

Land is a very important and scarce resource of Bangladesh. It should, therefore, be managed very carefully to ensure the best possible use of this limited resource for the benefit of the maximum number of people and their development. Virtually all available land is utilised for agriculture, forestry, fishing, settlements and urban development. It is felt that land use priorities have to strike a balance between the competing needs of agriculture, forestry, fisheries, livestock, settlements and urban development. Major land use conflicts arise from uncoordinated action amongst the ministries and agencies concerned with land management. Yet, very little attention has been paid to formulating a national land use policy to conserve and make best possible use of this highly scarce natural resource.

The importance of land use decisions and policies has been recognised by several international meetings. The World Forestry Congresses, The Jakarta Declaration, 1978 and the Paris Declaration 1991 emphasised the paramount importance of the forests and land use aspects. Fresco *et al.* (1996) pointed out that changes in land use and land cover play an important role in the climate system. They have an impact on the interactions between land and atmosphere, contribute to changes in the bio-geochemical cycles of the earth and the atmosphere levels of green house gases, and are a major factor in sustainable development and human responses to global changes. As a consequence of the global character of these issues, international co-operation and international agreements play an important role in land use/cover and climate change related policies. The United Nations Conference on Environment and Development 1992 provides a programme of action for sustainable development worldwide: Agenda 21, where the relationship between changes in the atmosphere and land use and resources is mentioned explicitly. It is stated that 'land use resource policies will both affect and be affected by changes in the atmosphere' (Fresco *et al.*, 1996).

1.1.2. Land Use Conflicts.

Countries in the Asia-Pacific Region are facing a severe crisis, with increasing conflicts arising from the need to produce more food and fuel wood and at the same time, maintain an adequate degree of environmental protection despite increasing pressure on existing forests for fuel wood, fodder and timber for both domestic and industrial uses. Forest areas in the Region continue to decline as a result of deforestation and conversion of logged-over productive forests for agricultural purposes. Protection and sustainability of these resources depends on the political will and commitment to strengthen the land use policies and their implication in the field. The demands for arable land for forestry, grazing, wildlife, tourism, industry and urban development are often greater than can be met by land resources available in many countries. This results in conflicts over land use.

Land is the habitat of man and its use is crucial for the economic, social, and environmental advancement of all countries - indeed for human survival. Although it is part of man's natural heritage, access to land is controlled by ownership patterns; it is partitioned for administrative and economic purposes, and it is used and transformed in a myriad ways.

Population growth, technological and social hazards, and environmental degradation all have to be taken into greater account today by policy makers, resource planners, and administrators who make decisions about the land. They need more detailed land information than has been traditionally available. Although the printed map is still useful, computerised systems offer improved ways of acquiring, storing, processing, and retrieving such information.

Land use is the combined human action affecting land cover. From a global change perspective, land cover is the most important thing, and for the assessment of many aspects of sustainability - biodiversity, erosion, nutrient balances - understanding the linkage between cover and use is essential (Fresco, 1994). Land use must be economically viable and socially acceptable. For any particular land use, certain areas are better suited than others. Efficiency is achieved by matching different land uses with the areas that will yield the greatest benefits.

1.2. Problem Statement.

Land is fundamental to human activities and its realization and management are key factors for sound regional development. Inappropriate land use has led to some serious problems as evidenced by recent global environmental problems, such as the degradation of tropical forests, desertification of arable land, and so forth, which concern the survival of human beings. Now, these issues have been clearly recognized, and it is expected that the problem of land use will be considered seriously and that policies will be formulated to solve them (Kitamura and Kobayashi, 1993).

Bangladesh is an over populated country. Population density is increasing day by day, and hence the pressure on land resources is also increasing. The population of Bangladesh stood at 111.4 million (density 755 per sq. Km) according to the last population census in March 1991 and it is expected to reach 129.6 million (density 900 per sq. Km) by 2000 AD (BBS, 1997a). Land is a scarce commodity in Bangladesh. Per capita available cropland has diminished by about 50% in Bangladesh from 1970 to 1990, which stood at only 0.08 ha against world average of 0.27 ha (Verheye, 1997). As a consequence total forest area is decreasing considerably. It is estimated that Bangladesh loses its forestlands by about 3.3% every year (World Bank, 1994 as cited in Rasheed, 1995), while it was about 3.9 per cent between 1981 and 1990 (FAO, 1990). In the absence of a clear-cut land use policy, the forest department has to yield to pressures especially from private enterprises, corporations and other government organisations. Deforestation, faulty cropping patterns and other unscientific management practices cause severe erosion resulting in degradation of soils and seriously disturbing the environmental balance (FAO, 1993). Hussain (1984) and Filius (1986) also emphasised the need for a comprehensive land use policy for the nation as a whole. Hasan and Mulamoottil (1993) recommended prohibiting urban landowners from owning agricultural land unless they themselves are involved in cultivation. Government should devise mechanisms to protect good agricultural land from urban and other encroachments. Government should also undertake serious measures to ensure a suitable land use policy thereby saving forest and stopping flooding and desertification of vast areas of the country. They also recommended that tenancy of the rural sharecroppers should be secured. Tenants should be allowed to cultivate a particular piece of land as long as they wish.

The dense population exerts great pressure on the forest for fuel wood, construction timber and agricultural implements. At the same time demand for agricultural and pastureland is also high. These have resulted in the destruction and loss of substantial reserved forest areas. At present, demand for forest resources greatly exceeds supply, and the situation of deficit is likely continue into the next century (FAO, 1993).

The pressure of population on the land and its resources is a major factor affecting sustainable development in Bangladesh. Whether by overexploitation or mismanagement, changes in land use, and land cover, are taking place at an unprecedented rate (Giri and Shrestha, 1996). The importance of land use planning to ensure rational and prudent use of land in a land-hungry country like Bangladesh cannot be over-emphasized. A comprehensive land use policy for social management of this most scarce resource, together with an innovative policy approach on bifurcation of land rights, will help to meet the developmental needs of the agricultural sector in the rural areas as well as land requirements of cities and towns for non-agricultural purposes in the urban sector (Choudhury, 1987). The suggestion of bifurcating current single-right-of-land use into two separate rights existing use and development use - is mainly dictated by the social benefits consideration in the context of a sharp rise of land prices in the urban periphery where public investments in the infrastructure have led to substantial increase in the market price of otherwise undeveloped land.

Verheye (1997) showed that in predominantly rural societies land is traditionally used for crop production. However, with an increasing population more people get involved in non-agricultural activities, leading to growing urban and industrial environment. Under those conditions, cities are expanding and infrastructural works have to be developed, creating competition for land in peri-urban areas. Cropland and forests are converted into building grounds and trees are cut for fuel wood and charcoal production. This leads ultimately to land degradation, soil/water pollution, and other forms of unsustainable land uses. All of those land use types claim nevertheless their rights, and land conflicts cannot be avoided.

The level of urbanization has been rising steadily over the years, from 4 percent in 1951 to 9 percent in 1974 to 15 percent in 1981 (Choudhury, 1987). Urban growth in Bangladesh is

expected to proceed at a faster rate in the coming years because of the high rate of population growth and the influx of the rural population to the cities and urban areas in search of employment. It is now estimated that there will be an increase of approximately 20 million people in the urban areas over the next 15 years, which will require substantial investment in land development and infrastructure to meet the requirements of such a huge expansion in the urban population. Large parcels of land contiguous to the metropolitan cities and other urban areas are likely to be taken out of agriculture and converted into non-agricultural use unless strict measures can be taken for protecting fertile agricultural land.

Mckillop and Sarker (1992) concluded that net economic benefit could be maximised by releasing less productive forestlands for low-intensity agriculture or for environmental production. The possibility that environmental protection might be enhanced while, at the same time, maximising economic benefits is of significance, in view of the challenge that many developing countries face of striking a balance between economic growth and environmental quality.

Again, changes in land use from one form to another could be an important determining factor for the economic growth of a country. This may be especially true for a developing country like Bangladesh. There should be a well-defined integrated land use policy so that all the resources could be used at their maximum level.

1.3. Research Objectives.

The main aim of this study is to provide insights into the overall land use problems that should enable more effective land use policies to be formulated.

Specifically the objectives of this study are:

a) to characterise the changes in land use in Bangladesh.
b) to analyse the trends of land use change.
c) to model historical land use dynamics in an attempt to predict future changes in land use, with particular attention to forest land.
d) to recommend an appropriate integrated land use policy for Bangladesh.

1.4. Materials and Methods.

For the study secondary data/information (published data or from appropriate government/other organisation) as well as primary data were collected. The study was conducted in different phases:

Phase 1: Collection of a range of data and information including different types of maps and satellite data on Bangladesh. A review of literature was undertaken to find out the results of similar types of works around the world. In order to understand the changes in land use and as well as in the basic needs of the population time series data were given priority. Land use and other related data were collected on national, divisional and district level separately in order to model the relationship between land use and population data. At the same time primary data at some selected villages in the form of household survey with a semi-structured questionnaire form, as mentioned below, was collected.

Data Requirements:

Maps (on Bangladesh):

- Administrative map (showing divisional boundary, river system, road system, etc.)
- Forest map
- Agricultural map
- Topographic map
- Land cover map
- Agro-ecological map
- Land quality map

Demographic & Socio-economic data:

- Population (rural & urban) at division & district level
- Income (living standard), at division, district & village level.
- Food (basic needs), production/yield at division, district & village level.
- Agricultural production and requirements at division, district & village level.
- Fuel wood - production and requirements at division, district & village level.

- Livestock- production and requirements at division, district & village level.
- Fisheries- production and requirements at division, district & village level.
- Settlement- production and requirements at division, district & village level
- Urban development division & district level.

Land use (area, demand, etc.):

- History at national, divisional and district level.
- Agriculture: area covered, yield and productive capacity at national, divisional, district and village level.
- Forestry: area covered, yield and demand at national, divisional and district level.
- Nature conservation/ recreation: area covered and income/benefits
- Livestock: yearly production, demand at national, divisional and district level.
- Fisheries: yearly production, demand at national, divisional and district level.
- Settlement: type, area, expansion rate, type of land used at national, divisional, district and village level.
- Urban development: type, rate, land type at national, divisional and district level.

Data Sources:

Maps were collected from different government organisations (on request) like Soil Resources Development Institute (SRDI), Space Research and Remote Sensing Organisation (SPARRSO) and a range of data were collected from Bangladesh Bureau of Statistics (various publications), Agricultural Offices at selected zones, Water Resources Planning Organisation (WARPO), Local Government and Rural Development (LGED), Bangladesh and other government/nongovernmental organisations and related published or unpublished materials.

Primary Data Collection

A village household survey was carried out to get data about land use, needs and demand for sample household at the micro level. In order to enable this survey the country was first divided into three zones based on availability of forests, namely,

- no/very little forest area (northern and north-western part),
- moderate forest area (central part) and
- forest rich area (south-eastern part).

In each zone two districts (replication) were selected randomly from where two thanas were selected from each district based on the distance from the district city centre; one was very near and the other far away. In each thana one village was randomly selected. Sample households were selected based on the following categories:

- Rich (very rich and rich)
- Moderate
- Poor (poor and very poor)

Then from each category 4 sample households were selected randomly. After selection of households the head of the household was interviewed with a pre-structured questionnaire to obtain data on the demographic and socio-economic conditions of that particular household. A particular emphasis was given to understanding the general history of land use and the causes of land use change (Figure 1.1).

Other secondary data

Due importance was given to collecting national as well as all district and division level data so that a clear picture of land use and related matters for the whole country could easily be presented.

Bangladesh

Zone A → District P	→ Thana X →	1 Village →	4 sample households	
(no forest area)	(near to city)	(random)	from 3 categories	12 samples
	Thana Y →	1 Village →	4 sample households	
	(away from city)	(random)	from 3 categories	12 samples
→ District Q	→ Thana X →	1 Village →	4 sample households	
	(near to city)	(random)	from 3 categories	12 samples
	Thana Y →	1 Village →	4 sample households	
	(away from city)	(random)	from 3 categories	12 samples
Zone B → District P	→ Thana X →	1 Village →	4 sample households	
(moderate forest area)	(near to city)	(random)	from 3 categories	12 samples
	Thana Y →	1 Village →	4 sample households	
	(away from city)	(random)	from 3 categories	12 samples
→ District Q	→ Thana X →	1 Village →	4 sample households	
	(near to city)	(random)	from 3 categories	12 samples
	Thana Y →	1 Village →	4 sample households	
	(away from city)	(random)	from 3 categories	12 samples
Zone C → District P	→ Thana X →	1 Village →	4 sample households	
(forest rich area)	(near to city)	(random)	from 3 categories	12 samples
	Thana Y →	1 Village →	4 sample households	
	(away from city)	(random)	from 3 categories	12 samples
→ District Q	→ Thana X →	1 Village →	4 sample households	
	(near to city)	(random)	from 3 categories	12 samples
	Thana Y →	1 Village →	4 sample households	
	(away from city)	(random)	from 3 categories	12 samples

Total Households = 144 samples

Figure 1.1. Sample layout showing sample sizes in the study villages in Bangladesh.

Phase 2: Data handling and analysis. After collection of data and information, data was analysed using Microsoft Excel, SPSS, and Minitab 13. A land use map of Bangladesh was prepared using Cartalinx digitising software and the IDRISI GIS package. National, divisional and district level land use databases were prepared using existing data from different published books, journals or articles. Different land use models were established, based on these databases, to enable investigations of possible future land uses.

Model Development

During data analysis different land use models were developed. Linear and negative exponential regression models were considered to show the trend of possible land use change at different scales, such as national, divisional, district and village level. Models that explained more variation in the data sets were considered and discussed with possible causation. Some other non-linear models, such as, cubic and power models were also tried but not were not included as they did not explain more variation in the data sets. However, due to a limited number of observations (e.g. national and divisional data sets) and lack of time series data (e.g. divisional and district data sets) the linear or negative exponential models failed to explain the land uses in Bangladesh in most of the cases. To overcome this situation multivariate analysis was considered that explained more variations among the data sets with a limited number of variables. Multiple regression models explained trends more realistically as they include more causations of a possible effect and explain the interactions among different explanatory variables. Stepwise regression analysis was conducted and shown with relative significance value for each explanatory variable in the model. Variables that explained more variations for a certain effect using linear models were included first for the stepwise regression analysis in SPSS and resultant models were explained with reliability (R^2 value) and significance (P value) of the models established (although in some cases models with smaller reliability and significance were used to show the possible causes of desired land use changes).

Phase 3: Interpretation and Recommendations. Existing policies were analysed and discussed in order to consider how well they satisfy the needs of the present situation. Possible policy options were suggested. The best policy options satisfying the future needs of the country were recommended for application with due importance.

1.5. Thesis Structure.

The thesis comprises a total of nine chapters. A brief description of each chapter is given as follows:

Chapter One — This chapter provides a general introduction to the thesis, focusing on land use and problems related to land use in Bangladesh. This chapter also outlines the research objectives, methods and a summary of the thesis structure.

Chapter Two — This chapter presents a literature review of land use, land use change and modelling land use with emphasis on developing countries. It also includes a general overview on wise use of land to keep pace with the development needs and discusses conflicts and future consequences among major land uses in Bangladesh.

Chapter Three — This chapter describes current policies related to land use in Bangladesh. It also includes discussion on the performance of the existing policies and a discussion on the need for a national land use policy for Bangladesh.

Chapter Four — In this chapter history of land use in Bangladesh especially forest and agriculture has been given prominence in order to find out how changes happened through the ages. In particular population and land use characteristics are explored within the overall changes in land use, and their relationships to economic development are explained at the national level.

Chapter Five — In this chapter population and land use characteristics have been analysed with respect to divisional scale. Attempts were made to find out the changes happening in the socio-economic and demographic characteristics of the population and as a result all the changes to its land uses in different divisions.

Chapter Six — In this chapter population and land use characteristics have been analysed with respect to district scale. Attempts were made to find out the changes happening in the socio-economic and demographic characteristics of the population and as a result all the changes to its land uses in different districts.

Chapter Seven — This chapter presents the village survey results, analysis and a discussion of the results. It highlights a description of the study area, respondents; their attitudes towards land cultivation, relationship between socio-economic aspects and land holding types, respondents' perceptions about cropping pattern and other types of land uses and a discussion of the results and analyses.

Chapter Eight — This chapter contains a general discussion of the study results. It addresses the overall discussion on land use and its changes in Bangladesh based on previous chapters, predicts future land uses at national, divisional and district scale, and highlights the limitations of the study and future research priorities on land use and conflicts among different land uses in Bangladesh.

Chapter Nine — This chapter recommends some policy measures for a national land use policy in Bangladesh.

CHAPTER 2

LITERATURE REVIEW

2.1. Introduction.

Land as an entity is finite, while the natural resources it supports can vary over time and according to management conditions and uses. As each nation moves to the next level of economic or development intensity, human requirements and economic activities place ever-increasing pressures on land resources, creating competition and conflicts and resulting in non-optimal use of both land and land resources (Olembo, 1994). Intelligent and sensitive planning of the use of land resources can be an appropriate early tool. By examining all uses of land in an integrated manner, it should be possible to build consensus and minimise conflicts through informed negotiations among competing uses, to make the most efficient trade-offs and to link social and economic development with environmental protection and enhancement, thus helping to achieve the objectives of sustainable development. The essence of the integrated approach finds expression in the co-ordination of the sectoral planning and management of activities concerned with the various aspects of the use of land resources.

Bangladesh is the most densely populated country in the World with nearly 900 people per sq. Km (WARPO, 2000). Hence conflicts between different major land uses, such as forestry, agriculture, fisheries, and urban and industrial development are acute. Bangladesh is yet to formulate a National Land Use Policy to minimize the conflicts between the competing land uses and try to guide the whole nation towards wise use of its limited land resources. Some existing sectoral policies concerning land use are presented in Chapter 3. This chapter presents a general overview of ideas concerning wise use of land to keep pace with the development needs.

There are wide knowledge gaps regarding conflicting land uses and future consequences in Bangladesh. Although several authors have worked on models of land use and land use change especially in the form of change into different crops, few have considered major competing land

uses. This study aims to discuss conflicts and future consequences among major land uses in Bangladesh.

2.2. Defining Land Use.

Land use can be defined as the purpose to which humans put land (Turner and Meyer, 1994). Land use can also be defined as the human activities that are directly related to land, making use of its resources or having an impact on it through interference in ecological processes that determine the functioning of land cover (Mücher *et al.*, 1993 as cited in Veldkamp and Fresco, 1996). Usually land is used for many purposes. The most relevant of these is that it provides and creates space for agricultural and industrial production, as well as space for settlement. Beyond that, it also provides natural environment for conservation and amenities for better living environment (Kitamura and Kobayashi, 1993). It is also the focus of conflict between a wide range of land uses including agriculture, mining, forestry and nature protection, leisure, human settlement and urban and industrial development. Competition between users grows more under increasing population pressure and in countries with a mixed economy (Verheye, 1997).

Land has always been: - a source of minerals, fertilisers and non-renewable energy, - an influence on climate, - a source of fresh water, - a source of biodiversity, - a source of food, fibre, agricultural and forestry products, and renewable energy, - a biological means of recycling waste, - a living and working space for man, meeting also recreational and infrastructural needs and requirements. While land is important as a resource, it is not necessarily the same land that is required for all purposes. Basically there is biologically fertile or potentially fertile land, as well as land which cannot be used at all, or only seasonally or partially, in any biological process (Friedheim and Kassam, 1994). Light, temperature, energy, available water, and natural or induced soil fertility are the determining factors. It seems necessary to accept or to establish an interrelationship between the different uses of land. Even more important, we must determine the present and future minimum requirements of land quantity and quality for a growing number of people and for a sustainable life. Such investigations are required on global, regional, and national levels.

Vink (1975) defined land use as any kind of permanent or cyclic human intervention to satisfy human needs, either material or spiritual or both, from the complex of natural and artificial resources that together are called "land". In other words, land use is the application of human controls, in a relatively systematic manner, to the key elements within any ecosystem, in order to derive any benefit from it.

Land use is basic to human life. Urban and rural uses are major factors in living standards, environmental quality and civilisation itself. According to Coleman (1987) a surprisingly large proportion of the world's problems spring from the misuse, disuse, overuse, under use or abuse of land, and wiser policies are constantly being sought. Kitamura and Kobayashi (1993) have pointed out that inappropriate land use has led to serious problems as degradation of tropical forests, desertification of arable land, and so forth, which concern the survival of human beings.

Land cover denotes the quantity and type of surface vegetation, water, and earth materials (Turner and Meyer, 1994). Land cover can be conceptualised as the layer of soils and biomass, in particular vegetation, that covers the land surface. About 90% of the land surface of the earth is covered by vegetation of some sort (Fresco, 1994).

Land tenure arrangements (whether traditional or 'modern', formal or informal) are of vital importance to environmental management- organising, decision-making, and implementing activities with respect to the use of natural resources. Perceptions regarding use and ownership of agricultural land, pastures, forests and water resources influence people's actions, including their willingness to invest time and money in the conservation measures needed for sustainability of these resources (Bakema, 1994). In the face of severe degradation and over exploitation, existing regulations and enforcement capacity may not be adequate; these need to be tailored to the needs of users, and sensitive to local definitions. Field experiences over the last decade suggest that environmental management is more effective when the direct users of natural resources have a say in how these resources are allocated and used (Bakema, 1994). A community is more likely to take responsibility if the benefits of their involvement and investments are visible and accrued to themselves. But, in the case of land tenure, support from other levels of government is vital.

2.3. Land Use Change.

Changes in the cover, use, and management of the land have occurred throughout history in most parts of the world as population has changed and human civilizations have risen and fallen (Perlin, 1991; Turner *et al.*, 1990 as cited in Dale *et al.*, 2000). Over the centuries two important trends are evident: the total land area dedicated to human uses (e.g., settlement, agriculture, forestry, and mining) has grown dramatically, and increasing production of goods and services has intensified both use and control of the land (Richards, 1990 as cited in Dale *et al.*, 2000). Land use change is generally shown in terms of a change in area for a particular land use/cover class over a specific period of time (Farrow and Winograd, 2001).

Land use change at any location may involve either a shift to a different use or an intensification of the existing one. According to Turner and Meyer (1994) land use change is likely to cause some land cover change, but land cover may change even if the land use remains unaltered. A forest will steadily shrink if a constant rate of timber extraction or shifting cultivation exceeding regrowth is maintained.

Again, land use change is a continuous, evolving process, and is the single most important manifestation of human interaction with the biosphere. The scale and rate of change of land use is greater now than at any time in history due to rapid technological change and to population growth. Land use practices and land use change play an important contributory role in the human impact on the atmosphere and ultimately on the whole biosphere. Most of the competition for space between human and other species is demonstrated by the conversion of land to agriculture, infrastructure, urban development, industry and unsustainable forestry (Adger and Brown, 1994).

2.3.1. Drivers of Land Use Change.

The many ways that people have used and managed land throughout history has emerged as a primary cause of land cover change around the world. Thus, land use and land management increasingly represent a fundamental source of change in the global environment (Dale *et al.*, 2000). Land use change is driven by a combination of socio-economic (e.g. income levels,

infrastructure, demographic structure), political (e.g. land tenure, subsidies, nature protection) and biophysical (e.g. soil and climate characteristics) factors, the so-called land use drivers (De Koning *et al.*, 1999; Stomph *et al.*, 1994; Veldkamp and Fresco, 1996, 1997). Kates and Haarmann (1992) explained that the major determinants of land use and land use change are physical, climatic and demographic factors, levels of poverty, and the economic and institutional structures of resource use. Economic factors include the demand for primary commodities such as agricultural products and forest products. The institutional factors, which underpin these systems of exchange, also determine the systems of use of resources. Usher (1992) also pointed out that human economic and social conditions influence pattern of land use, and that technological innovations affect how land is managed. These all are changing facets of human societies that affect the way land is used for the benefit of individual owners or for the members of the society.

Land cover modification and conversion is driven by the interaction in space and time between biophysical and human dimensions (Turner et al., 1993 as cited in De Koning et al., 1999; Veldkamp and Fresco, 1996). Human use is the most important factor in land cover modification and conversion rather than the natural change (Veldkamp and Fresco, 1996). Social and economic forces within a region often dictate how land is used. Land use practices developed over a long period under different environmental, political, demographic, and social conditions may prove inappropriate to future conditions (Ojima *et al.*, 1994).

Population change is often investigated as one of the driving forces of global land use change (Heilig, 1994). Dale *et al.* (2000) considered human population growth as an ultimate cause for many land use changes. Larger populations need more roads, vehicles, houses, communication structures; and they use more water, energy, and food. However the association between people and land is not simple, because it does not operate in isolation. Demographic effects can be aggravated or dampened by the effects of other forces driving global land-use change, such as technological innovation, change of lifestyles, or political decisions (Dale *et al.*, 2000; Heilig, 1994).

The competing forms of land use, forests and other agricultural land, are often linked directly to population growth (Viitanen, 1996). However, other activities or processes also can lead to deforestation. While the pressures from an ever increasing human population, and its impact on land use, are recognised and studied, these other activities should also be studied carefully in order to fully understand deforestation. The intensity of any form of land use, as well as development of other economic activities that decreases the direct dependency on forest resources for fuel wood and construction are important variables, which should be included in any model describing deforestation.

The densely populated regions of Southeast Asia can be described as areas of land deficit. Figure 2.1 shows the negative repercussions of this deficit. Given these repercussions, it is very desirable that land is correctly allocated between the various types of land use. Population growth, by increasing the demand for more agricultural land to produce more food, encourages the conversion of forests to agriculture. Since it is the people living in the rural areas who turn to agriculture as a livelihood, one would expect deforestation to increase with rural population density (Cropper and Griffiths, 1994). Population growth also increases the demand for wood, both for timber and for fuelwood, leading to wood scarcity. This in turn leads to deforestation (Filius, 1986; Tole, 1998) on one hand and deterioration of agricultural land on the other hand as more and more agricultural residues, needed to maintain the nutrient contents of the agricultural land, are being used as fuel in the rural areas due to wood scarcity (Figure 2.1). Amelung and Diehl (1992) also showed the agricultural sector as one of the main sources of deforestation. If this situation happens to exist for long there will be no forest in the country. Other driving forces of agricultural expansion are the degradation of the biophysical environment, increased demand for land to grow cash crops and technological change (Nielsen and Zöbisch, 2001; Stéphenne and Lambin, 2001). There is no other way except careful planning of the land resources among different competing land uses for sound economic and environmental development of a country.

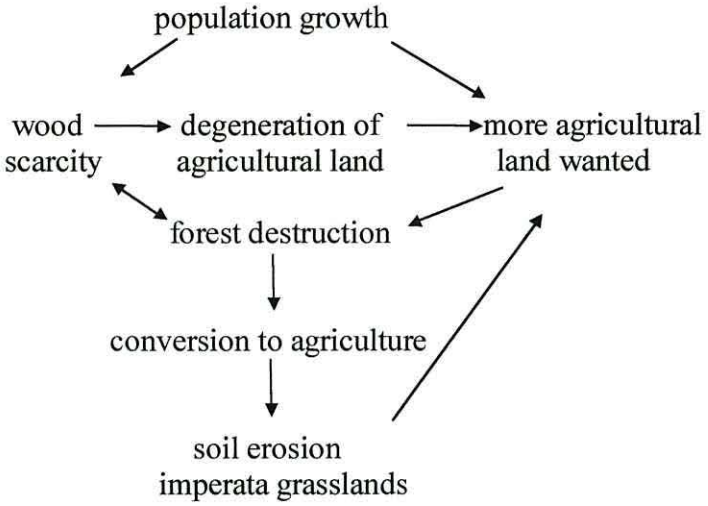


Figure 2.1. The process of wood scarcity, demand for agricultural land and forest destruction (Source: Filius, 1986).

2.3.2. Effects of Land Use Change.

Changes in land use reflect the history of mankind. They are linked with economic development, population growth, technology, and environmental change. Rates of land use change often parallel rates of population growth, whereas they generally diminish locally with increased economic development (Houghton, 1994). During the past several thousand years, humans have taken an increasingly large role in the modification of the global environment (Ojima *et al.*, 1994). In the last few centuries, however, and particularly in the last several decades, the effects of land use change have become global, not only in the sense that changes in land use and their effects are present almost everywhere on the earth, but in the sense that they contribute to global changes in climate through increasing emissions of greenhouse gases (Houghton, 1990, 1994). Land use activities are calculated to contribute from 20-75 % of all atmospheric emissions of important greenhouse gases (Penner, 1994). If the present growth trends in the World population, industrialization, pollution, food production and resource depletion continue unchanged, the limits to growth on this planet will be reached sometime within the next hundred years. The most

probable result will be a rather sudden and uncontrollable decline in both population and industrial capacity (Meadows *et al.,* 1972 as cited in Dudley, 1992).

Changes in land use and land cover have important consequences for natural resources through their impacts on soil and water quality, biodiversity, and global climatic systems (Chen *et al.*, 2001; Houghton, 1994). Land use change also affects soil properties either in a positive or negative way (Schoorl and Veldkamp, 2001). Deforestation, for example, negatively affects soil properties. In most cases this leads to reduced land productivity due to land degradation (Fischer and Sun, 2001; Houghton, 1990; Schoorl and Veldkamp, 2001). The conversion of forest to grasslands and permanent crops usually leads to less degradation (Schoorl and Veldkamp, 2001). But conversion from forest or grassland to arable lands can have strong negative impact in terms of soil productivity (Priess *et al.*, 2001; Schoorl and Veldkamp, 2001).

Land use is a dynamic process, which changes over time due to some factors, such as increasing population, income, changes in farming system, technology and the general structure of the overall economy (Onchan, 1993). Although population is certainly one factor that acts to influence land use change, it does so in association with two other variables: technological capacity and levels of consumption (Sage, 1994). In developing countries population growth, the major obstacle to development is found to be the major driving force on land use change. As population increases so does the demand for food and this results in more land under cultivation. As the country gradually advances towards development consumption per capita also increases and thereby increases the need for more production that ultimately results in more agricultural land and thereby land use changes. Technology results in more production per unit of land and thereby in lower use of farmland. In view of this,

Farmed area = Population x food consumption per person x area per unit of food production

It is clear that if technology and food consumption do not change, population growth translates directly into land conversion for agriculture. Yet there are other pressures on land besides its use as a resource for food production. In the North pressures for land conversion derive from qualitative changes as well as quantitative increases in consumption (Sage, 1994). On the other

hand, in the South this pressure comes mainly form the demand for basic requirements, such as food, shelter and clothing. So, the effect of land use change can be considered as a combined effect of social, political and economic conditions of a region or a country.

2.4. Land Use Models.

Models are essentially hypotheses about systems, usually expressed in mathematical form (Jones, 2000). Again, modelling is an important tool for studying land use change due to its ability to integrate measurements of changes in land cover and the associated drivers (Lambin *et al.*, 1999). Land use modelling, especially if done in a spatially-explicit, integrated and multi-scale manner, is an important technique for the projection of alternative pathways into the future, for conducting experiments that test our understanding of key processes in land use changes (Serneels and Lambin, 2001; Veldkamp and Lambin, 2001). Land use models are a means of exploring alternative land uses in a defined area, experimenting with likely management schemes and policies (Smith and Budd, 1982). Their main advantages are to initiate planning discussions creating ideas and proposals for future land use strategies. All models are a simplification of the real world situation and an awareness of their limitations is critical to their successful application and use in planning. When modelling appropriate land uses most authors are concerned about the economic benefits of a piece of land for production purposes.

Understanding the role of land use in global environmental change requires historical reconstruction of past land cover conversions and/or projection of likely future changes (Stéphenne and Lambin, 2001). Questions of land use/land cover change have attracted interest among a wide variety of researchers concerned with modelling the spatial and temporal patterns of land conversion and understanding the causes and consequences of these changes. Among these, geographers and natural scientists have taken the lead in developing spatially explicit models of land use change at highly disaggregate scales (i.e. individual land parcels or cells of the landscape) (Irwin and Geoghegan, 2001). Land use change models are often used to assess the impact of land cover on biophysical processes, e.g. climate variability, land degradation, ecosystem stability and diversity (Veldkamp and Lambin, 2001). Models of land use change can

address two separate questions: where are land use changes likely to take place (location of change) and at what rates are changes likely to progress (quantity of change) (Serneels and Lambin, 2001; Veldkamp and Lambin, 2001). The first question is often much easier to deal with through models, as it mostly requires identification of the natural and cultural landscape attributes which are the spatial determinants of change, i.e. local proximate causes directly linked to land use changes (Serneels and Lambin, 2001; Veldkamp and Lambin, 2001). The projection of future rates of land use change is a more difficult task, as it requires a good understanding of the underlying driving forces of the change (Riebsame *et al.*, 1994 as cited in Serneels and Lambin, 2001; Stéphenne and Lambin, 2001; Veldkamp and Lambin, 2001). Land use change modelling is a highly dynamic field of research with many new developments (Veldkamp and Lambin, 2001). So far many different modelling approaches have been adopted in the study of land use and land cover change (Serneels and Lambin, 2001). A brief overview of some of the land use models constructed by different scientists/authors is given below.

2.4.1. Examples of Land Use Models.

Land use changes are the result of complex interaction between human and biological driving forces that act over a wide range of temporal and spatial scales (Dale, 1997; Veldkamp and Fresco, 1996; Verburg *et al.*, 1999). Computer simulation models can best deal with some of the complexities of the vegetation and climate systems (Dale, 1997). A large number of research groups have developed models to simulate and explore land use changes (Verburg, *et al.*, 1999). Differences in modelling techniques often relate to differences in the purpose of the study and the scale of study. Explorative models are developed to design alternatives for present land use (Veldkamp and Fresco, 1997; Verburg *et al.*, 1999). Derived land use patterns represent optimisations of land use based on biophysical potentials, sometimes including socio-economic estimates of inputs and goals (Verburg *et al.*, 1999). Another group of land use change models is developed to explore possible changes in land use in the near future as a function of driving forces. These models provide information about the scope and impact of land use change, and can be used by resource planners or policy makers to identify areas that require priority attention. The CLUE (Conversion of Land Use and its Effects) modelling framework is such a dynamic land use change model that establishes formal linkages between biophysical and human drivers

of land use (Veldkamp and Fresco, 1996, 1996a, 1997; Verburg et al., 1999). CLUE modelling approach integrates environmental modelling and a geographical information system (GIS) (Veldkamp and Fresco, 1996a). A number of researchers have used this modelling framework at different spatial and temporal scales for various countries, such as Ecuador (De Koning *et al.*, 1999; Priess *et al.*, 2001; Verburg *et al.*, 1999), Costa Rica (Veldkamp and Fresco, 1996a, 1997; Kok *et al.*, 2001), Honduras (Kok *et al.*, 2001), China (Verburg *et al.*, 1999b cited in Kok *et al.*, 2001). It uses a (statistical) description of land use patterns and their dependency on a set of socio-economic and biophysical variables at a number of spatial resolutions (Kok *et al.*, 2001). This model usually consists of two main modules: the demand module and the allocation module (Figure 2.2).

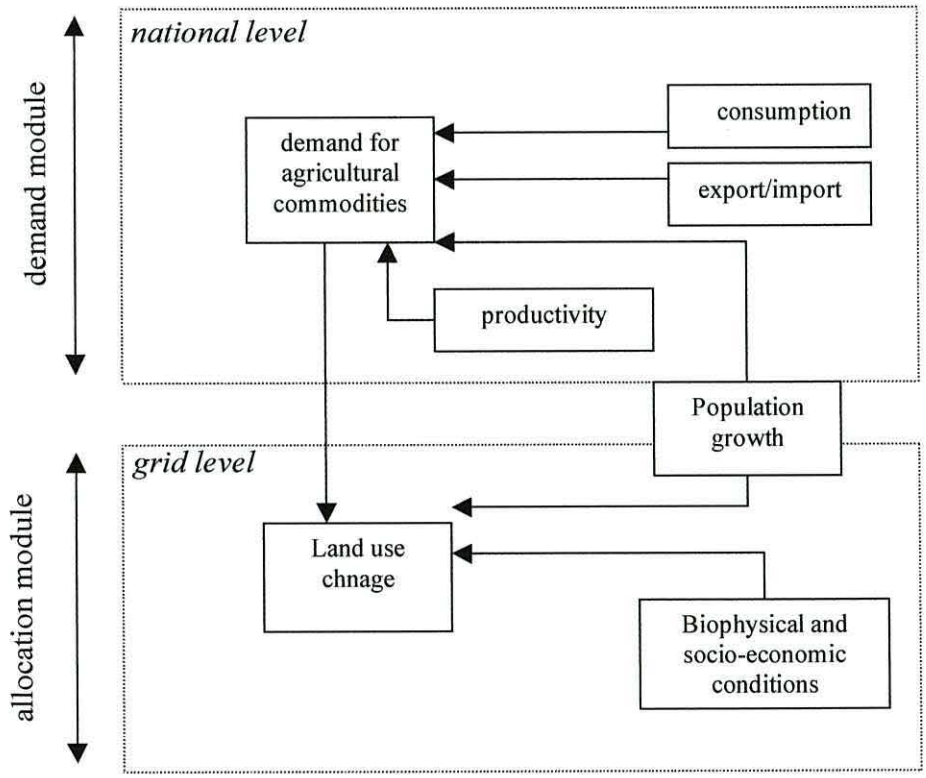


Figure 2.2. General structure of the CLUE modelling framework (Source: De Koning *et al.*, 1999).

Stéphenne and Lambin, (2001) developed a model considering the competition between different land uses taking place within the national space, which is finite as follows:

U= Veg + Past + Crop

where *U* is the used area, *Veg* the fuelwood extraction area, *Past* the pastoral land and *Crop* the cropland, all quantities being in ha.

Land use models could be based on linear programming that looks at future land use given a set of objectives, which included high agricultural and/or forestry production and the maintenance of rural employment. The potential productivity of different land classes can be assessed under a number of land uses, and defined objectives (Smith and Budd, 1982). According to them land use model can be:

$$Z = \sum_i \sum_j C_{ij} X_{ij}$$

where, X_{ij} = land areas, i = land type, j = land use, C = commodity and Z = output.

Thornton and Jones (1998) developed a set of models to handle more agricultural land use options, and initial household wealth and land-holding distributions which can be summarised as: the landscape is made up of a set of plots of land, or facets, which may have any one of a number of agricultural land uses. Households within the landscape operate a number of these facets. In any time period t, the household makes a choice concerning the land use of all its facets during the season (time t). Choice is based on (1) expected gross margins of each competing land use alternative, based on past performance, and (2) household preferences for each alternative that vary according to the household's past experience and are sampled randomly.

Expected gross margins of each competing land use alternative:

For each land use, the expected gross margin for period t is calculated from:

$$GM_{ijt} = Y_{ijt}.P_{it} - I_{ijt} - L_{ijt}$$

where for the ith land use on the jth facet, *GM* is the gross margin in arbitrary monetary units per hectare (mu ha^{-1}), *Y* is the quantity of product (t ha^{-1}), *P* the product price (mu t^{-1}), I the costs

(mu ha^{-1}), and *L* the location costs (mu ha^{-1}). Yield or production, *Y*, for any land use on any facet is defined to be a function of land use in the previous time period and land quality,

$$Y_t = f(Y_{t-1}, LQ)$$

Household preferences for each alternative:

The model tracks all households in the landscape through time, and updates a proxy for wealth:

$$W_t = W_{t-1} + \sum_{j=1}^{N} GM_j a_j$$

where *W* is wealth in period t (mu), *GM* is the gross margin (mu ha^{-1}) of the jth plot of the household's total of n plots in its chosen land use, and *a* is its area (ha). The model assumes that each household has a certain predilection for utilising a facet in a particular land use. This preference changes, depending on the household's perception of its performance over time. An above-average gross margin will have a positive effect on the household's preference for that particular land use in that particular facet. In the model, these preferences are expressed as numbers between 0 and 1, and for manipulation they are transformed to normal probabilities. For choosing between land uses in a particular time period, the current preferences are assembled into a cumulative distribution function and sampled randomly. A check is made to ensure that the household has enough wealth to purchase the necessary inputs. If not, then the choice is disallowed, and the process is repeated until the inputs for the land use of choice can be afforded for that particular facet.

Sarker and Mckillop (1991) formulated a domestic demand relationship with quantity of timber demanded as a function of real price of timber, real GNP, population and a time trend to represent changing tastes and technology in consuming sectors of Bangladesh using two-stage least squares and annual data in logarithmic form for 1960 to 1983 which can be shown as follows:

$$\text{Log } Q = 4.58 - 0.05 \log P + 0.249 \log N + 0.07 \log T$$
$$\qquad\quad (0.22) \qquad (0.01) \qquad (0.06) \qquad (0.01)$$

$R^2 = 0.97$ and Durbin-Watson D = 1.68

where Q is the quantity of timber demanded in million cubic feet, P is the weighted average price in Taka (1 Taka = US$0.028) per cubic foot of timber, N is the population in million, and T is the time trend.

It is clear that land use and land use change models aimed at describing human impacts on land use and land use changes. These models help land use planners and policy makers to solve land use related problems and decide on future land use to cope with the growing needs of the population and the economy at local, national, regional or even global level. This study also aims to decide on future land use in Bangladesh at local as well as national level.

2.5. Land Use Policies.

Land use policy is based on the premise that land is a limited resource, that it does not have the same value or the same capacities everywhere and that its use should therefore be managed rationally. Its purpose consists in determining how the various types of land making up some region can best be allocated among the different possible uses and in seeing that this is done, in accordance with a number of criteria related to social and economic needs and more recently environmental protection (OECD, 1976).

Land use policy concepts are still often vague and go on changing, sometimes even the implementing measures have reached an advanced stage. Whatever a country's general policy may be with regard to the extent of State intervention, it is found that people are taking more interest in land use questions and that this issue is being increasingly included in general economic development policy (OECD, 1976)

The purpose of land use planning is 'to produce the best use of land' (Harrison, 1977). This definition might be taken to involve finding the best spatial arrangement of activities and the most suitable intensity of use for each parcel of land within the area being planned.

Land is a vital resource and one that is characterised, in economic theory, by being in finite supply. A comprehensive planning model for national development would be one that would attempt to maximise long-run output from all resources. In order to do this national planners should be aware of the output potential of all resources, at a given level of technology, and should attempt to ensure that output maximising resource combinations are effected (Boddington, 1978). In this context, national planners are all those in the public sector concerned with resource allocation. Planning should therefore be regarded as the formulation and implementation of policies that will provide the greatest social benefit in the long term. The division of our land resource as between one demand and another is a legitimate area of activity for such national planners.

Schickele (1950) reported that land policies are social control measures designed to improve the use of land resources and the conditions of property rights under which people work and live on the land. The objectives of land policy are governed by what people desire, and what the functions of government are conceived to be in bringing about better land use and tenure. But changes in land use and tenure are desired only when people do not like existing conditions or when people visualise better use and tenure of land.

Van Ittersum *et al.* (1998) pointed out the problems with food security, the maintenance of a social infrastructure, unequal distribution of regional income and the depletion of natural resources are some of the reasons for a government to initiate active land use policies. Policies aimed at changing land use in a predefined direction form strong instruments to alleviate all these problems. However, land use policy should focus on the purpose of land use as this depends on the natural and socio-economic conditions of a region that change over time (Kitamura and Kobayashi, 1993). In developing countries, where the level of economic development is relatively low, the basic purpose of land use is agricultural production and land use policy is focused on creating a land use system with highly productive and sustainable agricultural output

to meet food demands. In some regions with a rather high level of development, the focus of land use shifts toward natural environment conservation and/or provision of amenities. For example, McKillop and Sarkar (1992) recommended that net economic benefit could be maximised by releasing less productive forestlands for low-intensity agriculture or for environmental production assessing current and alternative forest policies for the special case of Bangladesh in terms of economic efficiency of forest management and land allocation. Countries that are more developed have more comprehensive and well-ordered land use, providing a balanced nature and human society.

2.6. History of Land Use Change in Different Countries.

Humans have been altering the earth's surface to produce food through agricultural activities for centuries (Reid *et al.*, 2000) and increasingly contributing towards modification of global environment (Ojima *et al.*, 1994). The growing scarcity of agricultural land has led to both planned and unplanned migration into tropical forests areas. Usually, land conversion due to unplanned agricultural colonization substantially exceeds the land subject to government-induced migration programmes, such as "Grow More Food" campaign in India, "Land for the Landless" program in the Philippines (Amelung and Diehl, 1992). The rehabilitation schemes of the Bangladesh government starting from 1957 have contributed considerably to deforestation, as under these schemes 1.6 to 2.4 ha of forestland has been allotted to each settled cultivator who cleared the forests for agricultural uses (Salam, *et al.*, 1999). A sizable number of Bengali people along with indigenous people have settled in the Hill Forests under these programmes. But most of the programmes failed because of settlers' inadequate motivation and education, lack of infrastructure and marketing facilities, and lack of financial incentives. Consequently, transmigrants with no other source of income have depended directly on the land and forest for survival resulting in large scale forest loss (Salam *et al.*, 1999).

Wolman and Fournier (1987) pointed out that population change, war, technological revolutions, and a variety of social changes throughout history have resulted in profound transformations of the land. The magnitudes of the changes, as well as the rates of transformation, are clearly

demonstrated in the history of agricultural development from earliest man through the industrial revolution. Whether one refers to these as lessons or not, history provides examples of continuing change, changes mirroring those of today and certain to occur tomorrow. This does not imply that future transformations will be like those of the past or present, but that a myriad of influences will alter how the land is used, what it is used for, and the imprint that such uses will have on the land and soil.

Increasing number of people, and the encroachment of urban, industrial and transportation activities on the agricultural landscape, and the modern techniques of agriculture, are all properly viewed as exerting real or potential pressure on the availability of good land required for future agricultural production (Buringh and Dudal, 1987; Wolman and Fournier, 1987). For the past twenty years, it has been argued that a combination of rapid population growth and the lack of sophisticated agriculture in the South have caused a steadily escalating spiral of food shortages, malnutrition and famine (Dudley 1992). The twin responses to the problem of insufficient food supply have therefore been widely seen as 'controlling' population growth and improving the productivity of agriculture. Programmes aimed at achieving this have become a major concern of the Northern governments and international aid agencies.

From an economic point of view there is a difference in development of land use between densely populated countries (e.g. Western Europe) and those with much sparser populations (e.g. the USA), because of available labour and consequently labour costs. In Europe production per hectare is important, but in USA it is production per man. In less than one century these countries, which once were agricultural, have been transformed into industrialized countries, where agriculture has become a less important sector of the economy (Buringh and Dudal, 1987).

The subject of land transformation is interesting not only historically or from an economics standpoint, but also from the point of view of land use, because it is evident that all changes in social, cultural, economic and political conditions have influenced the way land is being used. Many developments are hardly possible without the help of a government, particularly in the fields of research, education and extension in agriculture. Moreover, the governments of many countries interfere in the way land is used by land use planning, although this is not always done

in favour of agriculture: in many countries this type of planning is done to guide the non-agricultural use of land. In some countries it is now realized that planning of land use should include the protection of valuable, productive agricultural land, called 'prime land'. Another important factor is the regulation of prices of the main agricultural products by governments. If, for example, more sugar is needed, an increase in the price of sugar will stimulate the cultivation of sugar cane or beet. The price of the basic food crops is often rather low because governments want cheap food for the many poor people (developing countries) or for the labourers in industry (industrial countries) in order to promote the export of industrial products. In the USA the government provides incentives to farmers not to grow cereal crops, because of high surpluses of cereal grains (Buringh and Dudal, 1987).

2.6.1. Agrarian Transformations.

Transformation of a pre-capitalist agrarian social structure to a capitalist mode of production assumes diverse forms and processes depending on historical and spatial circumstances (Ullah, 1996). As civilization progressed in different parts of the world the demand for agricultural commodities increased leading to agricultural revolution and with further progress in technology to industrial revolution. All these developments played an important role in transforming global ecosystems through land use and land cover change. A brief description of these transformations in different countries below shows the uniqueness of each development path.

English Path: England being the first home of industrial revolution, whose prelude is often traced in its successful agrarian transformation, displays a long and eventful course of change. The whole process is marked by complex interactions of events and dramatic twists and turns. Demise of serfdom, disintegration of feudalism and the emergence of capitalist landlords along with consolidation of holdings that form large farming units are the three major stages in this development (Ullah, 1996). The transformation assumed a form wherein the capitalist landlord got their land cultivated by the large tenant farmers who got the job done by hired labour.

French Path: France, like England, also saw the disintegration of serfdom at the close of the fifteenth century but with different results. In England, the dominant tendencies were consolidation of holdings into larger units, the emergence of capitalist relations and innovations in agricultural. On the other hand, in France, holdings became fragmented, rents increased, and the productivity declined. As a result, the capitalist transformation was obstructed and France became a land of small peasant proprietors. These peasants, however, had the right to transfer their property or pass it on to their descendants (Ullah, 1996).

American Path: The American path of agrarian transformation is the best example of the development of capitalism from below. It is so identified, as it was predominantly from the peasantry that capitalism emerged. The American path differed fundamentally from English path, as there was no presence of a landlord class in an effective manner. Another important feature of agrarian transformation in North America was the absence of wage labour. Agrarian transformation in the United States assumed the unique form as independent family farmers with a high commercial orientation who had ties with the world market settled it. These farmers had access to a vast stretch of land free from any feudal bondage. As a result, a proliferation of the family farm system in the United States occurred during the 19th century as millions of settlers established their farms over this land (Ullah, 1996).

Japanese Path: Japan is the most dynamic capitalist economy in the contemporary world and the transformation of its economy into a capitalist social formation is unique. Here an agrarian transition enabled the modern industrial sector to secure a vast amount of surplus from the agricultural sector. There was also a parallel capitalist transformation that took place without the development of capitalist relations of production in the countryside. The Japanese experience shows that the agrarian question can be resolved bypassing the development of capitalist relations in agriculture (Ullah, 1996). Japanese agriculture was characterised by remarkably small average size of holdings (2.45 acres) with no sharp differentiation. However, there was inequality in the distribution of operated holdings. Most of the holdings were so small that the family labourers predominantly worked them. Consequently, wage labourers as a group remained small and their number did not exceed 30,000 before the Second World War period. In contrast, the total number of agricultural workers was 14 million. Immediately after the Second World War, Japan

experienced a land reform that opened up possibilities for the development of capitalism in Japanese agriculture (Ullah, 1996).

Korean and Taiwanese Paths: In the development literature, South Korea and Taiwan are the most cited examples of successful capitalist development (Ullah, 1996). Poor nations of Asia are often advised to adopt their model. In both South Korea and Taiwan, a labour intensive industrialisation took place that radically changed the economic structure from agriculture to industry. The agricultural growth achieved in these countries has also been very impressive and that too was through the use of labour intensive methods. Income distribution also remained reasonably egalitarian. The adoption of free market policies, a liberal trade regime and minimal state interventions were key to their successes. However, there is a dissenting view and it claims that the root of their success lies in the 'guided market economy' policy, which allowed protection (if necessary), and pervasive government intervention (Ullah, 1996).

Bangladesh Scenario: Before the British rule, rights of ownership in land were neither in the hands of the State nor in the hands of the fiscal agents known as 'Zamindars' but in the hands of cultivating masses. The British rulers wanted to bring in an agrarian transformation in Bengal in the fashion of the English path enforcing the 'Permanent Settlement Act' of 1793 that reversed the scenario. The Zamindars became the owners and the cultivators became the tenants. The British created a landlord class in Bengal whose annual revenue obligations to the government would remain fixed and unchanged for all times to come. It was expected that the new landlord class would behave like the improving landlords of England and a capitalist agriculture would eventually emerge. However, this was never fulfilled. The Zamindars degenerated into a class of largely parasitic and absentee landlords and created a system of sub-infeudation that left the peasantry rack-rented and in a pauperised state. Agricultural production stagnated and the peasants became highly indebted. Some attempts were made to redress the sufferings of the tenants but their conditions failed to improve (Ullah, 1996). After partition of colonial India in 1947, Eastern Bengal became part of Pakistan. One of the most important reform measures adopted by the government of East Bengal was the abolition of the Zamindari system through the 'East Bengal State Acquisition and Tenancy Act' of 1950 in the light of the recommendation of 'Land Revenue Commission (1938)' headed by Sir Francis Floud. However with the abolition of

Zamindari system, a 'Jotedar', rich land owners who rented-out land for cultivation emerged and dominated peasant agriculture. Between the State Acquisition Act of 1950 and 1955 some minor reforms in the form of 'Bargadar Rights' (sharecroppers' rights), fixation of ceilings on land holdings and reforms in the tenurial structure were attempted but with very little success.

Today, Bangladesh's rural society is characterised by inequalities in land ownership. Tremendous demographic pressure has also reduced the per capita land owned. The largest land holding group have also experienced a decline in their average quantity of landholdings. At the same time there has been an emergence of a huge mass of marginal and landless rural households.

2.7. Land Use in Bangladesh.

Bangladesh mostly lies within the broad delta formed by the Ganges and Brahmaputra rivers and is exceedingly flat, low-lying, and subject to annual flooding. Much fertile, alluvial soil is deposited by the floodwaters that made it extremely suitable for agriculture. The only significant area of hilly terrain, constituting less than one-tenth of the nation's territory, is the Chittagong Hill Tracts in the narrow south-eastern panhandle of the country having the country's highest peak (1000 m). Small, scattered hills lie along or near the eastern and northern borders with India (NDB, 2001). Forests usually dominate these hilly areas. There also exist eroded remnants of two old alluvial terraces, the Madhupur Tract, in the north central part of the country, and the Barind, straddling the north-western boundary with India. These attain elevation of about 30 m where the soils are less fertile than the annually replenished alluvium of the surrounding floodplain.

Bangladesh is one of the most densely populated countries in the world. As a result the competition for land among different land users is very intense. In Bangladesh 60% of the land is under cultivation (Hasan and Mulamoottil, 1993, 1994). Only 5% of the land is cultivated three times a year, while double cropped land is only 25% (Hasan and Mulamoottil, 1993). Eighty- five percent of the cropped area is under cereal, mainly rice, cultivation. Commercial crops like jute and tea are cultivated on only 0.81 mha or 6% of total cropped area and contributes 32% of the total export earnings. Average size of land ownership per farm household in Bangladesh is 0.81

ha, while cultivable land per agricultural worker is only 0.49 ha. These holdings are subdivided into an average of ten fragments. A huge portion of land is kept from production to divide land into different holdings. Because of the smallness of the holdings scientific agricultural measures are very hard to be implemented (Hasan and Mulamoottil, 1993). Gain *et al.* (1998) estimated that there are about 75 million plots of cultivated area in the country and a raised land locally known as *Ail* marks their divisions. This is increasing gradually in successive generations and occupying a huge amount of land kept from production. However, *Ails* are not a total waste as they are sometimes used to hold water particularly where the lands are slightly elevated. They also protect surface soil erosion during flood runoff. But the fragmentation of holding is more wasting. Sometimes, a farmer holds several lands apart from each other and plots belonged to other owners exist in between. This wastes time and energy of the farmers as well as affecting proper crop planning.

Most of the land in the rural areas is used for agricultural purposes. The other predominant uses are homestead, water bodies (ponds), orchards, etc. People generally live in small communities locally known as *para* or settlement nodes (Gain *et al.*, 1998). Only 13% land is under forest cover. But there is controversy about the total amount of land under forest cover. Giri and Shrestha (1996) showed it as 14.66%.

The rural and urban elites who do not cultivate the land own most of the land in Bangladesh. Of the total land area, 23% is cultivated by tenants or owner-cum-tenants. Paid labourers cultivate another 45% of arable land. The most common form of tenancy relationship in Bangladesh is sharecropping (bargadari), which gives the landowner half of the production, while the sharecropper, after providing all the input and labour, receives the other half. In a few areas the tin-bagha (three-share) system has been introduced. The production is divided into three shares against land, labour, and input (Hasan and Mulamoottil, 1994). In rural areas the land is tilled and cropped for the benefit of the individual farmer and/or for the financial benefit of the landowner. If a potato or onion crop provides a good return in one year, in the following year the farmers are encouraged by themselves or sometimes by the landowners to intensify cultivation of the same crops. When this pattern occurs in parallel on all farms there is a price drop. This type of agricultural practice is a natural consequence of short term profit seeking.

2.7.1. Land Use Changes in Bangladesh.

Land use and land cover change can happen in a number of different ways. The amount, the rate and the intensity of land use and land cover change are very high in developing countries (Rao and Pant, 2001). Islam (1995) identified a number of processes for land use change in Bangladesh, namely (a) conversions of forests to cropland, the intentional and inadvertent burning of forests, and the removal of wood for fuel (deforestation); (b) the conversion of wetlands to agricultural and urban uses; (c) losses of productive cropland through erosion, natural hazards and human activities involving natural processes; and (d) the conversion of other types of land to uses associated with urbanization, development of infrastructures for transportation, energy production and irrigation structures. All of these processes bring about changes in biogeochemical cycles, in biodiversity, and in the climate system at scales from local (through changes in land use characteristics) to the global (through the emission of greenhouse gases).

2.8. Research Priorities.

Indiscriminate use of land in Bangladesh has become the major concern among foresters, agriculturists, economists and environmentalists. Unwise use and in some cases over use have resulted in land degradation and depletion of soil fertility. For these reasons, much more research is needed to better understand the future consequences of the inappropriate use of land in Bangladesh and try to find out best possible land use mix.

Based on a review of previous studies some research priorities can be identified. These include widespread assessment of potential lands for different competing land uses, considering ecological and socio-economic importance of each parcel of land all over the country; prepare a future land use plan at least for 20 years based on the future demand of food items, forest products, recreation, industrial development and urbanization; impact of present land tenure system on productivity and decision about land use and work out appropriate systems for the future.

However before developing a policy that has the potential to manage land use efficiently it is necessary to understand the drivers of past land use change, and then consider the future impact of these drivers. The rest of the study will explore the present land use in Bangladesh from national to regional scale and formulate some land use models to guide future land use systems and finally discuss the need for a national land use policy and recommend some policy measures. The next chapter will discuss existing related national policies.

CHAPTER 3

NATIONAL POLICIES RELATED TO FORESTRY, AGRICULTURE AND LAND USE

3.1. Introduction.

Bangladesh is faced with high levels of poverty, high population density and an increasing population, recurring natural disasters and a dwindling natural resource base (Rahman *et al.*, 1994). The social and economic viability of Bangladesh to a great extent depends upon its ability to generate a food surplus and to provide adequate nutrition for its population. These requirements are important today and will continue to be so in the future (RTF, 1991c). Human modification of the environment takes place at increasingly larger scales and usually involves progressively more complex technologies. It is very likely that in the future there will be more large-scale modifications of environment in an attempt to develop the country's economic and social conditions (Islam, 1995). In view of these, policies related to natural resources, such as environment, forestry, agriculture, and land use have become imperative.

This chapter describes current policies related to land use in Bangladesh. Bangladesh is yet to formulate a national land use policy. So it is wise to analyse the following policies, which address land use, as a step in recommending some policy measures for land use in Bangladesh.

The policies described here are:

1) National Environment Policy 1992.
2) National Forestry Policy 1994.
3) National Agriculture Policy 1999.

3.2. National Environment Policy 1992.

3.2.1. Proposal and Context.

The survival of animal and plant kingdoms is dependent on nature and environment. Recently degradation of the natural environment has been recognized as an alarming problem for the survival of a range of living things and the development of human civilization. Due to adverse effects on the environment the Bangladesh Government have given special attention on environmental conservation and development. Natural calamities such as continuous floods, droughts, tornados, cyclones, initial signs of desertification in the northern region, expansion of salinity in rivers, rapid forest destruction, climate and weather unrest are some of the environmental problems that exist in the country. In view of these issues the Ministry of Environment and Forests and Department of Environment were established to coordinate activities related to environmental preservation, development and problems related to environmental pollution and depletion. In order to do this it is necessary to solve different socio-economic problems such as population explosion, poverty, illiteracy, ill health, general lack of mass awareness, as these have emerged as very large obstacles in environmental conservation. It should be possible to solve all related problems under well-defined national policies. The details of the policy described here have been drawn from official sources (MOEF, 1992).

3.2.2. Objectives.

The objectives of the National Environment Policy are:

- Sustenance of the ecological balance and overall progress of the country through protection and improvement of the environment.
- Protection of the country against natural disasters.
- Identification and control of activities that pollute and degrade the environment.

- Ensuring environmentally sound development in all sectors.
- Ensuring sustainable, long term and environmentally sound utilization of all resources.
- Active association with environment related international initiatives to the extent possible.

3.2.3. Policy Statements.

The National Environment Policy embodies environmental policies for 15 sectors namely, (i) Agriculture, (ii) Industry, (iii) Health and Sanitation, (iv) Energy and Fuel, (v) Water Development, Flood Control and Irrigation, (vi) Land, (vii) Forest, Wildlife and Biodiversity, (viii) Fisheries and Livestock, (ix) Food, (x) Coastal and Marine Environment, (xi) Transport and Communication, (xii) Housing and Urbanization, (xiii) Population, (xiv) Education and Public Awareness, and (xv) Science, Technology and Research.

Environment policy statements for some of the important sectors are given below:

3.2.3.1. Environment policies: Agriculture

- Make all efforts and technology environmentally sound for the purpose of agricultural development and food security.
- Conserve agricultural resource bases in development works and guarantee their environmental friendly and long lasting use.
- Control the use of chemicals and artificial inputs that destroy soil fertility and organic materials as well as exert bad effects on human and other animals and secure use of safety measures for agricultural labour while using those inputs. At the same time encourage the use of natural manure and insecticides.

- Help develop environmentally sound development through necessary changes for the purpose of environmental conservation and development and enduring use of resources for production management and production relationships in agricultural sector.
- Increase use of environmentally friendly natural fibres, such as jute and jute products

3.2.3.2. Environment policies: Forest, Wildlife and Biodiversity

- Conserve, expand and develop forest to sustain the ecological balance and meet the socio-economic needs and realities;
- Include tree plantation programmes in all relevant development schemes;
- Stop shrinkage and depletion of forestland and forest resources;
- Conserve wildlife and biodiversity and strengthen related research and help dissemination and exchange of knowledge in the concerned area; and
- Conserve and develop wetlands and protect migratory birds.

3.2.3.3. Environment policies: Land

- Formulate a balanced and environmentally sound national land-use policy and plan.
- Prevent land erosion, preserve and increase soil fertility, and expand activities for conservation and environmentally sound management of newly accreted land.
- Encourage a land-use system compatible with various ecosystems.
- Prevent spread of salinity and alkalinity on land.

3.2.3.4. Environment policies: Fisheries and Livestock

- Ascertain appropriate environment for conservation and development of fisheries and livestock resources.
- Prevent shrinkage of marshlands that are considered as source of fish resources and encourage activities to improve the situation.
- Ascertain all the attempts to develop fishery and livestock in order not to create any adverse effect on mangrove forest and other ecosystems.
- Re-evaluation of water development, flood control and irrigation projects that are detrimental to fish resources and provision of alternative ways for fish culture by improving the environment.

3.2.4. Legal Framework.

- Timely amendment of all current laws related to conservation of environment and resources and control of pollution and devastation.
- Formulation of new laws in every aspect necessary to control environmental pollution and devastation.
- Ascertain implementation of all regulations of relevant laws and creation of mass awareness in this respect.
- Approve all international laws/conventions/protocols that are approvable by Bangladesh and amend/improve existing laws in accordance with those laws/conventions/protocols.

3.2.5. Institutional Framework.

- Ministry of Environment and Forests will coordinate the implementation of this policy.
- Formation of a National Environment Committee with the Head of the Government as its President to oversee and give directions to implement this policy.
- Ministry of Environment and Forests will take timely and appropriate action to amend/improve this policy in future with respect to environmental condition and socio-economic and other necessities.
- Department of Environment will finally examine and approve all Environmental Impact Assessments (EIA).

3.2.6. Comment on National Environment Policy 1992.

Bangladesh experiences an almost unique environmental situation being located on the delta of two of the world's largest rivers and in one of the great flood and storm hazard zones of the earth. While physical environmental problems merge imperceptibly into development problems, the socio-economic development of the country has been constrained owing to unintentional manipulation of the environment bringing in disharmony between resource development and utilization so vital for the economy (Islam, 1995). The National Environment Policy 1992 successfully covers policy statements for all related sectors to help and maintain a better environment for the socio-economic development of Bangladesh highlighting the need to maintain ecological balance and overall development through protection and improvement of the environment. However formulation of a national policy is not enough until and unless all the related government and nongovernmental organisations coordinate all their activities for the successful implementation of the policy directives and create mass awareness among the general public about their responsibility for a sound environment. Although agriculture is the main production sector in the economy, the population explosion made it so difficult to support the whole nation and as a result Bangladesh is now relying

more and more on industrialization for its economic development for its ever growing population. In this situation it is really difficult to successfully implement all the policy directives given the overall poverty and low infrastructure and other development. Again bureaucracy sometimes makes it so complicated that long time frames are required for implementation of any environmentally feasible project. This in turn encourages investors to set up industries that are not even environmentally sound with the help of corrupt government officials. However, the Government of Bangladesh has taken a positive step in preparing a National Environment Management Action Plan (NEMAP), with the objective of identifying key environmental issues and improving the quality of human life for the period 1995-2005 (MOEF, 1995). NEMAP is being considered as the basis for programmes and interventions aimed at promoting better resource management, making people aware of environmental problems and reversing the present trend towards environmental degradation. This is certainly a good attempt by the government to follow up the National Environment Policy 1992.

3.3. National Forestry Policy 1994.

The Bangladesh Government formulated a National Forestry Policy for the first time on July 8, 1979 after the independence of the country. It was a vague, manifesto type statement. Several crucial aspects did not get any (or adequate) mention in the policy. These included functional classification and use of forest land, community participation in forestry, role of private sector/small holders/homesteads, role of non government organizations, organisation of the forest-based growth centres, enterprise development, fuelwood and rural energy, involvement of voluntary organisations, importance of non timber forest products, need for forestry extension, measures for sustainable development linked to pattern of production, utilization and consumption etc. (FMP,1993). In the meantime, initiatives have been taken to orient the policies to meet demands of the time, particularly in consideration of the task of tackling the natural and undesired hindrances arising out of abnormal and quick depletion of forest resources owing to numerous socio-economic factors. As part of this attempt the Government of Bangladesh has undertaken the formulation of a National Forestry Master Plan covering a period of 20 years that suggested amending the National Forestry Policy, 1979 (ADB, 1995).

The Government of Bangladesh launched the Forestry Master Plan Project in October 1991 with technical assistance from the Asian Development Bank (ADB) and the United Nations Development Program (UNDP) and ended in September 1993 with the objectives to optimise the contribution of forest resources for environmental stability and economic and social development (ADB, 1995; Gain, 1998; Gain *et al.* 1998). In view of the recommendations put forth to amend the National Forestry Policy 1979 by the Forestry Master Plan Project the current National Forestry Policy 1994 has been formulated and was officially announced on 31st May 1995 (Bangladesh Gazette, July 6, 1995, pp 241-244).

In the formulation of the Forestry Policy 1994 the following issues were brought into special consideration:

- People's welfare principles inscribed in the constitution of the People's Republic of Bangladesh;
- Long term and specific roles of the forest sector in the overall socio-economic development of the country including the environment;
- National policies for the development of agriculture, cottage industries and other sectors;
- Decisions and recommendations taken in different international conferences and conventions particularly Agenda 21 of the Earth Summit in Brazil in 1992.

In the interest of the total development and ecological balance of the country facilitating afforestation, tree plantation, nursery establishment, development, maintenance and preservation through involving, encouraging and extending cooperation to the people of different sections of the society, the government has expressed its desire to adopt the following as a part of National Forestry Policy, 1994 upon the amendment of the forestry policy, 1979. The details of the policy have been drawn from ADB (1995).

3.3.1. Preconditions for the Development of the Forestry Sector

- The forestry sector provides several commodities and services, which are essential for the fulfilment of the basic needs of the people.
- Benefits of forestry sector development will be equitably distributed among the people, especially those whose livelihood depends on trees and forests.
- Scope for the people's participation in afforestation programmes required for the development of forestry sector will be created and the opinions and suggestions of the planters, users of forests and those whose livelihood depends on forestry resources and forest lands will be incorporated in the planning and decision making processes.
- Long-term political commitment of the government will be continued in the development of the forestry sector since afforestation is a long-term programme.
- Attempts will be made to ensure the effective use and conservation of bio-ecology and biodiversity by installing sound management of forest resources and conserving the production capacity of these resources so as to ensure their contribution in the rural and national development.

3.3.2. Objectives of the National Forestry Policy.

- To meet the basic needs of the present and future generations and also to ensure greater contribution of the forestry sector in the economic development, about 20% of the total area of the country will be afforested by taking up various afforestation programmes in forest lands, fallow lands, lands not useful for agriculture, hinterlands and other possible areas. Government sponsored afforestation programmes will be implemented. Moreover, appropriate measures will be taken to encourage afforestation on private land, and technical support and services regarding the production of forest crops has to be ensured.

- By creating employment opportunities, strengthening the rural and national economy, the scope for poverty alleviation and trees and forest based rural development sectors will be extended and consolidated.
- The biodiversity of the existing degraded forests will be enriched by conserving the remaining natural habitat of birds and animals.
- The Agriculture sector will be strengthened by extending assistance to the sectors related with forest development, especially by conserving the land and the water resources.
- National responsibilities and commitments will be fulfilled by implementing various efforts and government ratified agreements relating to global warming, desertification and control of trade and commerce of wild birds and animals.
- Through the participation of the local people, illegal occupation of the forestlands, illegal tree felling and hunting of the wild animals will be prevented.
- Effective use and utilization of the forest goods at various stages of processing will be encouraged, and
- Implementation of the afforestation programmes on both public and private lands will be provided with encouragement and assistance.

3.3.3. Statements of the National Forestry Policy 1994

- Attempts will be made to bring about 20% of the country under the afforestation programmes of the government and private sector by year 2015 by accelerating the pace of the programme through the coordinated efforts of the government and NGOs and active participation of the people in order to achieve self reliance in forest products and maintenance of ecological balance.
- Because of the limited amount of forestland, effective measures will be taken for afforestation in rural areas, in the newly accreted char in the coastal areas and in the denuded

Unclassed State Forest areas of Chittagong Hill Tract and northern zone of the country including the Barind tract.

- Private initiatives will be encouraged to implement programmes of tree plantation and afforestation on fallow and hinterland, the banks of the ponds and homestead lands which are under private ownership. Technical and other support services will be extended for introducing agroforestry on privately owned fallow and hinterlands to keep intact the production of grass and herb which is grown on government and privately owned forests and fallow lands.
- Tree plantation on the courtyards of rural organizations such as Union Parishad, School, Eidgah, Mosque-Moktab, Temple, Club, Orphanage home, Madrassa, etc. and other fallow lands around will be initiated. The government will encourage this type of initiative and extend technical and other supports.
- Massive plantation on either side of land surrounding road, rail, dam and khas tank through the partnership of the local people and NGOs will be commenced. Side by side, rubber plantation will be encouraged in all suitable areas of the country including Chittagong Hill Tract, Sylhet and Modhupur.
- Special afforestation programmes will take place in every city of the country under the auspices of the government in order to prevent pollution of environment in the densely populated areas. Municipal, town and other relevant authorities will make concerted efforts in implementing this program. Attempts will also be made to ensure tree plantation/afforestation while plans are made in respect of residential areas.
- Massive afforestation programmes in the denuded hilly areas of Unclassed State Forests of Rangamati, Khagrachari and Bandarban will be undertaken under the auspices of the government and private initiatives. The participation and rehabilitation of the local jhum cultivators will be ensured while implementing this program. This will be done under the auspices of the Ministry of Land in cooperation with the local government by keeping the land ownership rights intact.
- The priority protection areas are the habitats, which encompass representative samples of flora and fauna in the core area of National Parks, Wildlife Sanctuaries and Game Reserves.

Attempts will be made to increase the amount of this protected area by 10 per cent of the reserved forestland by the year 2015.

- Multiple use of forest, water and fish of Sundarbans through sustained management will be ensured keeping the bio-environment of the area intact.
- All state owned forests of natural origin and the plantations of the Hills and Sal forest will be used for producing forest resources keeping aside the areas earmarked for conserving soil and water resources, and maintaining the biodiversity. Keeping in view the ecology, the management of forestlands will be brought under profit-oriented business.
- Inaccessible areas such as slopes of the hills, fragile watersheds, swamps, etc. will be identified and kept as protected areas.
- The areas under the reserved forest, which have been denuded or encroached, will be identified. Afforestation in these lands will be done through people's participation. In this regard, the use of agro-forestry will be encouraged. NGOs will have opportunities to participate in this program. Side by side, the lands in Chittagong and Sylhet, which were allocated to different persons and institutions for developing the tea gardens and still remain unutilised and uncultivated will be identified and used for tree plantations and afforestation.
- Initiatives will be taken to reduce wastage by using modern and appropriate technology at all stages of extraction and processing forest products.
- Emphasis will be imparted on modernization of forest-based industries to ensure effective utilization of the forest raw materials.
- Steps will be taken to bring state owned forest based industries to competitive and profit-oriented management system under the free market economy.
- Forest resource based labour-intensive small and cottage scale industries will be encouraged in the rural areas.
- Rules and procedures regarding transportation of forest produce in the country will be simplified and made up-to-date.
- Export of logs will remain banned given the scarcity of wood in the country. But processed forest products can be exported. Import policy on wood and wood-based products will be

liberalized, but import tariffs for wood products that are abundant in the country, will be levied appropriately.

- Because of the scarcity of forestland, state-owned reserved forest cannot be used for non-forest purposes without the permission of the Head of the Government.
- A large number of tribal people live around a few forest zones. Since the ownership of land under their disposal is not determined, they procure the forestland at will. They will be imparted ownership of certain amount of land through the forest settlement process. The rest of the forestland will be brought under permanent protection.
- Funds from different donors including international aid organizations will be used to promote private forestry organizations and tree farming, and for such programmes like training and financial support will be imparted at an increasing rate.
- Women will be encouraged to participate in homestead and farm forestry, and participatory afforestation programmes.
- Ecotourism, related to forest and wildlife, is recognized as forestry related activity, which will be promoted taking into consideration the carrying capacity of nature.
- There will be a massive campaign through the government and non-government media for raising consciousness among the people regarding afforestation and conservation, and use of forest resources.
- Encouragement will be extended to grow fruit trees for producing more fruits along with the production of timber, fuel wood and non-wood forest products under the afforestation program.
- Initiatives will be taken to reduce wastage by increasing efficiency and modernizing the technology for extracting forest resources.
- The Forest Department will be strengthened in order to achieve the goals and objectives of National Forestry Policy. A new department called "Department of Social Forestry" will be established.

- The implementation of National Forestry Policy will be supported by strengthening educational, training and research organizations. This will contribute to forestry sector development.
- Laws, rules and regulations relating to the forestry sector will be amended and if necessary, new laws and rules will be promulgated in consonance with goals and objectives of National Forestry Policy.

3.3.4. Comment on National Forestry Policy 1994.

The National Forestry Policy 1994 is virtually the policy of economic growth that covers acceleration of economic growth, alleviation of poverty, generation of employment opportunities through massive afforestation programmes and encouragement of forest resource based labour-intensive small and cottage industries in the rural areas, self reliance in forest products and maintenance of ecological balance. The policy also aims to attain 20 per cent of country's total area under afforestation programmes of the government and private sector by 2015. Special emphasis is placed on programmes for new charlands, denuded state forest, the Barind tract, fallow lands in general and on the sides of road, rail and flood embankments. A multiple use policy is adopted for the Sundarbans, covering forest, water and fish. The policy also recognises the international commitments Bangladesh has made on global warming, desertification and control of trade in wild birds and animals (WARPO, 2000). It successfully addresses all the major problems/issues related to forestry development in Bangladesh. However proper implementation of the forestry policy requires successful coordination of several government and nongovernmental organizations but due to bureaucracy, corruption and lack of firm political commitment the success of the policy is still in question. Again, law enforcement is the most important factor for successful implementation of any policy. The basis of the present Forest Law is the Forest Act of 1927, which is inadequate to meet the present conditions (FMP, 1992b). The changes made in the form of amendments (The Forest Act (Amendment) Ordinance 1989) have only been cosmetic (FMP, 1993). National Forestry Policy 1994 also addressed the requirement of new laws and regulations relating to the forestry sector. So it

is imperative to amend current forest law in consonance with the forestry policy. On the other hand, the lack of a National Land Use Policy has resulted in serious land use conflicts. Lands ideally suited for forestry production have often been settled in favour of less productive purposes (RTF, 1991c).

The new forestry policy seems very ambitious especially to attain a 20 per cent tree cover of the total land area, which is at the moment only 6 to 8 per cent. Under the Forestry Master Plan the Bangladesh Government aims to invest US$ 2 billion over 20 years (1995-2000). The reforestation would be extended to all the lands recorded as forestlands at the time of the Forest Act 1927 (Gain, 1998). The plan will face a tremendous challenge to reforest huge amount of land – degraded, encroached and converted to agricultural production for long time. If implemented the reforestation programmes would reduce food production on one hand and would militate against the forest communities on the other hand. The new forestry policy successfully includes participatory forestry through government and non-government organizations for these areas securing ownership of land and tree resources but fails to dictate appropriate measures about the agricultural production, which is very much needed for a country like Bangladesh. So far there has been no attempt to monitor the success of the new forestry policy. However the success of the policy depends mainly on the honesty of the concerned officials and willingness of the political leaders as well as the concerned beneficiaries.

3.4. National Agriculture Policy 1999.

3.4.1. Introduction.

The economy of Bangladesh is primarily dependent on agriculture. About 84 percent of the total population live in rural areas and are directly or indirectly engaged in a wide range of agricultural activities. Agriculture contributes about 32 per cent to the country's GDP, about 23 per cent of which is contributed by the crop sector alone. About 63 percent of the labour force is employed in agriculture with about 57 per cent being employed in the crop sector. The scope of modern agriculture has been widened significantly. Although agriculture used to be originally defined as

the cultivation of land for producing crops only, now-a-days, any applied activity through proper utilization of natural resources which relates to the production, development, preservation, processing, marketing and extension of not only crops but also other agricultural commodities such as fish, meat, eggs, forest products, etc. is universally accepted within the purview of agriculture.

Although overall agriculture encompasses the development of crops, livestock, fishery, environment and forestry, separate policies on fisheries, livestock as well as environment and forestry have already been formulated by the respective ministries.

In Bangladesh, it is possible to reduce poverty and raise the living standard of common people by establishing agriculture as a profitable sector. It is, therefore, necessary to reorganize and develop the agricultural production system into a more dynamic and commercially profitable sector. In this perspective, Ministry of Agriculture, Government of the People's Republic of Bangladesh, has formulated a policy document entitled the "National Agriculture Policy" in order to provide proper guidelines for various development activities relating to crops, which is the largest sector of agriculture. The primary goal of the National Agriculture Policy is to modernize and diversify the crop sector, through initiation and implementation of a well-organized and well-coordinated development plan. The National Agriculture Policy 1999 as described below has been drawn from official sources (MOA, 1999).

3.4.2. Objectives of the National Agriculture Policy.

The overall objective of the National Agriculture Policy is to make the nation self-sufficient in food through increasing production of all crops including cereals and to ensure a dependable food security system for all. The specific objectives are:

- Ensure a profitable and sustainable agricultural production system and raise the purchasing power by increasing real income of the farmers;

- Preserve and develop land productivity;
- Reduce excessive dependence on any single crop to minimize the risk;
- Increase production and supplies of more nutritious food crops and thereby ensuring food security and improving nutritional status;
- Preserve existing bio-diversity of different crops;
- Take up programmes for the introduction, utilization and extension of bio-technology;
- Take necessary steps to ensure environmental protection as well as 'environmentally-friendly sustainable agriculture' through increased use of organic manure and strengthening of the Integrated Pest Management (IPM) programmes.
- Take appropriate steps to develop an efficient irrigation system and encourage farmers in providing supplementary irrigation during drought with a view to increasing cropping intensity and yield;
- Establish agriculture as a diversified and sustainable income generating sector through strengthening of 'Farming System' based agricultural production and agro-forestry programmes;
- Take effective steps to ensure input supplies to the farmers at fair prices in a competitive market and remove difficulties at the farmers' level which have arisen out of the privatization of input distribution system;
- Develop marketing system to ensure fair prices of agricultural commodities;
- Introduce an appropriate institutional system of providing credit to ensure the availability of agricultural credit in time;
- Produce and supply agricultural commodities as required by the industrial sector;
- Reduce imports of agricultural commodities and find out newer opportunities for increasing exports as well;
- Create opportunities for establishing agro-processing and agro-based industries;
- Protect interests of the small, marginal and tenant farmers;

- Update the agricultural system in the light of the Agreement on Agriculture under WTO, SAFTA and other international treaties by protecting the national interests; and
- Develop contingency management system to combat natural disasters.

3.4.3. Policy Statements.

The National Agriculture Policy embodies policy statements for (i) Crop Production, (ii) Seeds, (iii) Fertilizers, (iv) Minor Irrigation, (v) Pest Management, (vi) Agricultural Mechanization, (vii) Agriculture Research, (viii) Agriculture Extension, (ix) Agriculture Marketing, (x) Land Use, (xi) Agriculture Education and Training, (xii) Agriculture Credit, (xiii) Government Support for Agricultural Production and Contingency Plan, (xiv) Food-based Nutrition, (xv) Environmental Protection in Agriculture, (xvi) Women in Agriculture, (xvii) Coordination among the Government, NGOs and Private Sector, (xviii) Reliable Database, and (xix) Conclusion.

Some important policy statements are as follows:

3.4.3.1. Agriculture Policy: Crop Production

Although the intensification of food grain production, especially rice-based production system, is apparently profitable from the farmers' point of view, this approach has appeared to be harmful to land productivity. At present, rice covers about 75 per cent of the cultivated land in Bangladesh. The area coverage of other crops is as follows: pulses (4.64%), wheat (3.92%), oilseeds (3.77%), jute (3.71%), sugarcane (1.23%), potato (1.11%), fruits (0.84%) and vegetables (1.39%). The production system dominated by a single crop (i.e. rice) is neither scientifically nor economically acceptable. It is, therefore, necessary to increase the cultivation and production of the other crops. However, considering the increasing demand for food grains and with a view to ensuring food security, production of rice will continue to get priority in the food grain production programmes. In order to increase rice production, supportive programmes will be taken to raise per hectare yield through the

use of modern technology and improved cultural practices along with the increased use of high yielding variety (HYV) seeds.

In Bangladesh, only 4.14 per cent of net cultivated land remains currently fallow, which means that there is hardly any scope for increasing cultivable land. Currently, cropping intensity is around 185 per cent. Thus, the only possible option for increasing agricultural production is to increase both the cropping intensity and yields simultaneously. In this respect, policies adopted by the government are to:

- Take supportive programmes for inter-cropping in a field instead of single cropping; and
- Take appropriate measures in reducing the gap between potential yield and farmers' realized yield of different crops to raise the present level of production significantly.

Crop diversification is one of the major components of crop production policy. For the overall development of crop sector, special emphasis will be given to crop diversification program under the crop production policy. The government policies in this respect are as follows:

- The area under wheat has reached 0.8 million hectares. Given the potential for expanding wheat areas, efforts will continue to encourage farmers to grow more wheat.
- The production of maize has shown promising results in last two years. Maize has also gained popularity as human food side by side with the poultry feed. Public sector procurement of maize has been introduced like rice and wheat in order to encourage farmers into maize cultivation. The efforts for increasing area and production of maize will be strengthened.
- The program for increasing area and production of other crops, e.g., potato, pulses, oilseeds, vegetables, fruits and spices will gradually be extended under the crop diversification program.
- Production of different cash crops including jute, cotton will be increased and efforts will be made to expand their multiple uses.

- Special development programmes will be taken with a view to increasing production of potential crops suitable for the coastal areas and the hill tracts.

Increased crop production depends on good quality of seeds, efficient irrigation management, use of balanced fertilizers and availability of credit in time. In accordance with the free market economy, the important task of agricultural input distribution has largely been shifted to the private sector. Despite its beneficial effects in general, the privatization process has given rise to considerable inefficiency in some cases, such as, marketing and distribution of minor irrigation equipments and fertilizers. It is alleged that the privatization process has also been accompanied by non-availability, price rise, smuggling and quality degradation of fertilizers. Under this situation the government will seek to:

- Establish and consolidate the distribution system for irrigation equipment, fertilizers, seeds and credit in the light of farmers' need; and
- Ensure responsibility and accountability of the private sector through strengthening of the relevant legal framework and its enforcement.

The production of crops, especially *aman* crop, is heavily damaged every year due to the inadequate soil moisture regime prevailing in drought-affected areas. To combat this situation government has adopted the following policies:

- Supplementary irrigation will be ensured in severe and extremely severe drought affected areas.
- Location specific (including hill tracts) suitable crops will be identified with respect to technological and economic parameters and appropriate strategies will be pursued for cultivating those crops.
- Measures will be taken to minimise post-harvest losses by introducing appropriate technologies.

Since agricultural production is very expensive and risky, often it is not possible for the farmers to grow crops profitably at the individual level due to the shortage of required labour and capital. Therefore, government will encourage the formation of self-motivated cooperatives for producing and marketing agricultural commodities, which should ideally succeed in mobilizing adequate resources (including labour and capital) for more production, income and equity.

3.4.3.2. Agriculture Policy: Land Use

Government has the primary responsibility of ensuring optimum use of land. Although land is a private owned property in general, its use has to be compatible with the overall social goals. Moreover, it is important to consider that the interests of small and marginal farmers and the sharecroppers are protected, as they constitute the majority of farmers.

The following steps will be taken to ensure planned utilization of land for crop production:

- Land zoning program will be taken up by the Soil Resources Development Institute (SRDI) on a priority basis. The integrated approach of SRDI will be further strengthened for this purpose.
- To ensure maximum utilization of land, bottom up planning through people's participation and its implementation will be started from the mouza or village level.
- In most areas the same land is suitable for more than one crop. Therefore, farmers will be encouraged to grow other profitable crops as an alternative to the rice-rice cropping pattern.
- Fertile agricultural land is going out of cultivation due to its use for non-agricultural purposes such as private construction, house building, brickfield, etc. Appropriate measures will be taken to stop this trend in the light of the Land Policy of the government.
- Maximum utilization of land will be ensured through promotion of inter-cropping with the main crops.

- Acquisition of land in excess of requirement for non-agricultural purposes will be discouraged.
- Programmes will be taken up to motivate the landowners not to keep their land unused without any acceptable reason.
- Appropriate measures will be taken in the light of the Land Policy so that the interests of small and marginal farmers and the sharecroppers are protected and that the agricultural land is not kept fallow for a long period.

3.4.3.3. Agriculture Policy: Environmental Protection in Agriculture

One of the objectives of the National Agriculture Policy is to create awareness so that the chemical fertilizers and pesticides used for increased crop production do not turn out to be responsible for environmental pollution.

Water logging and salinity are appearing to be a serious problem in some parts of the country including the coastal areas which is not only a threat to the agricultural activities in those areas but also can cause a great damage to the overall environment. The steps to be taken by the government in this respect are:

- Measures will be taken to resist water logging and the farmers will be motivated to follow appropriate crop rotation as well as to practise crop and fish culture by turns.
- Salt tolerant crop varieties will be developed and extended along with possible measures to resist salinity.
- Considering the environmental hazards associated with the implementation of crop production policy, necessary steps will be taken to protect the environment in the light of the approved National Environment and Water Policies.
- Although earning of foreign exchange is largely attributed to the shrimp culture in the southern saline areas, saline water together with shrimp disposals in shrimp enclosures and

adjacent areas have been appearing as a source of environmental pollution. In this respect, realistic steps will be taken in the light of the already formulated Fisheries Policy.

3.4.3.4. Agriculture Policy: Conclusion

The proper implementation of the National Agriculture Policy will transform the crop production system, and for that matter the overall agriculture into dynamic sector over time, which is expected to bring about significant positive changes in the economy of the country. In respect of time, the National Agriculture Policy will be evaluated and reviewed in the context of overall economic condition of the country and the changing agricultural production system, and, accordingly measures will be taken to update this policy.

3.4.4. Comment on National Agriculture Policy 1999.

The National Agriculture Policy 1999 is still very new and hence it is difficult to judge its success. However the policy comprises some positive measures for the development of the agriculture sector and the economy of the country highlighting the interests of the marginal and small farmers, supplying them with improved input and credit. Land use, environmental protection, increased production and coordination among government, non-government and private sectors are well addressed by the policy. Flexibility to update the policy in the context of the overall economic condition of the country and the changing agricultural production system has given the policy better opportunity to take appropriate and timely measures to bring about significant positive changes in the economy of the country. No plan for monitoring successful implementation of the policy has been designed so far. However if implemented successfully there will be significant improvement on the country's total food production and the journey towards its economic development.

3.5. Discussion.

Formulation of policy is not enough for either sectoral development or the country as a whole. The effectiveness of a policy depends on political commitment, financial and legal support. Policy related to natural resources requires collaboration and coordination among different government and nongovernmental organisations. Without this no fruitful result can be achieved. Due to high population pressure land in Bangladesh has become a scarce resource. At present there is no national land use policy to guide wise use of this scarce resource. Although land use forms a part of all national policies related to natural resources, such as forestry, agriculture and environment, these policies do not address detailed land use problems prevailing in Bangladesh nor do they present a coordinated effort to solve these problems. Most of the population are poor and illiterate in Bangladesh where agriculture is their main occupation. The government is still trying to attain self-sufficiency in food production. As the population increases every year they need more land for settlement and food production. As a result more and more forestlands and protected areas are encroached and converted to agriculture by the growing population. Hence, there are growing conflicts among forestry, agriculture and environmental protection. Population growth, land use conflicts and development needs can be considered as common issues for the sound economic and environmental development of Bangladesh. But all national policies related to natural resources, such as forestry, agriculture and environment, fail to relate these issues and guide appropriate measures to solve problems related to these. At present Bangladesh needs more food to feed its growing population more than forest products and amenities. So it needs more agricultural land. Again a larger population demands more land for settlement. As the country is slowly advancing towards economic development the demand for such commodities other than food increases encouraging urbanization and industrialization throughout the country. This may lead to environmental degradation and in turn may be demanded more land for environmental conservation and forest production. Hence the need for agriculture, forestry and environmental protection in Bangladesh can never be neglected. But no coordinated efforts are mentioned in the existing policies related to natural resources. There will be enormous conflicts for land among forestry, environmental protection, agriculture and urban development. Wise use and allocation of land among different competing land uses based on the principle of multiple land use could be the best option to solve these conflicts. A separate body could be formed for this under the Ministry of Land

to coordinate among concerned agencies. In view of this Bangladesh urgently needs a national land use policy indicating appropriate measures to solve problems related to natural resources and to guide the country towards sound economic and environmental development. The following chapters aim to identify problems relating to land use and finally recommend some policy measures to achieve this aim.

CHAPTER 4

NATIONAL LAND USE ANALYSIS

4.1. Introduction.

Agriculture, forestry and human settlements are the three major land uses in Bangladesh. Rapid population growth has already pushed human settlements to marginal and hazard-prone areas. In addition, due to rapid growth of urbanization and industrialization in recent years, the demand for land for non-agricultural purposes and urban uses has increased sharply (Choudhury, 1987). Urban centres also appear to offer the chance of prosperity to large sections of the rural population that expedites migration from rural to urban areas. However to cope with the population pressure and steady progress, although very slow, towards economic development Bangladesh has been facing changes in its land use for centuries. These changes accelerated in the post-independence period. This chapter aims to summarize land use changes over time at national scale to help inform decisions related to rational land uses to cope with the overall development needs of Bangladesh.

In this chapter the history of land use in Bangladesh especially forest and agriculture has been given prominence in order to describe how changes have occurred through the ages. Population and land use characteristics are examined as key drivers of the overall changes in land use. Some simple land use models are established in order to understand future land use change in Bangladesh.

4.2. Data and Methods.

This study was conducted mainly using secondary data sources. Annually updated statistical yearbooks (BBS, 1997a, 1997b, 1999a, 1999c, 1999d; FAO, various years) and worldwide websites (NDB, 2001) were used as sources of data on land use. However data from population and agricultural censuses (BBS, 1999b), published books and reports (ADB, 1995; Farooque, 1997; FMP, 1992a; Gain *et al.*, 1998; Khan, 1972; Khan, 1998) and journal articles and in some cases unpublished data from some government (Forest Department, WARPO) and non-

government organizations were also used to find out the past and present land uses and the changes that have occurred over the last century. First the data were compiled to meet the requirements of this study using SPSS. A land use map was also reproduced from SRDI (1996) digitising first using Cartalinx and then converting it into IDRISI image file to show the general land uses in Bangladesh. Updated summary data were then critically analysed using SPSS and some regression models were established in order to understand how historical land use change related to key variables.

4.3. Historical Land Use.

In ancient times, India, Burma and Ceylon were densely covered with jungles because these areas had been situated within monsoon-belts endowed with seasonal rains and damp heat. In the early periods Bengal, Assam and the eastern part of Bihar were all covered with dense forests (Farooque, 1997). This forest had started to disappear early in the development of agriculture. Bangladesh had always been a part of another country before it had emerged as an independent state in 1971. From ancient times it was the part of India ruled by people mostly from outside India, such as Mughals from the sixteenth to eighteenth century and the British from mid-eighteenth to mid-twentieth century. After independence from British rule, Bangladesh became a part of Pakistan and named as East Pakistan. With this historical background it would be wise to look back to history of ancient India while studying land use history of Bangladesh.

The land of Bangladesh is highly suitable for agricultural purposes. This has attracted people into the region for the last thousand years (Gain *et al.*, 1998). Lee and Barrett (2001) indicated that sedentary agriculture developed on the fertile banks of Ganges, Tigris and Nile Rivers some 10,000 years ago. Flint and Richards (1991) described some evidence of historical change in land use in Northern India, Bangladesh and Burma.

A vegetation map of south Asia constructed from historical sources (Banerjee, 1966 cited in Flint and Richards, 1991) indicates that cropland had displaced forest in the core areas of settlement in the Gangetic Plain before A.D. 650. Records of the Mughal period indicate a further expansion of

agriculture in the Gangetic Plain at the expense of tropical forest before A.D. 1600 (Moosvi, 1987 cited in Flint and Richards, 1991). Maps reconstructed from the Ain-i-Akbari (ca. 1561-1595) indicate that at this time the extent of deforestation was considerably greater in the relatively dry upper Gangetic Plain than downriver (Banerjee, 1966 cited in Flint and Richards, 1991). Rice cultivation was well established at this time in the lower Gangetic Plain (corresponding to modern Bihar, West Bengal and Bangladesh) but had not yet completely displaced the tropical moist forest vegetation (Flint and Richards, 1991).

Geological evidence of forestry during 350 million to 225 million years ago shows superabundant vegetation in India (Banerjee, 1966 cited in Ghosh, 1993). The history of forestry in ancient India is, perhaps, more of deforestation or destruction caused by human agencies and the natural phenomena (Farooque, 1997). Forest destruction started as far back as in Chalcolithic period extending from 300-3500 BC. Forests disappeared, with the invasion of people from Sumerian region contributing towards the settled cultivation and pasturage (Ghosh, 1993). But it was the migration of Aryans between 2000 and 1000 BC that began the history of clearing forests for human habitation and agricultural and pastoral activities (Agarwala, 1990; Farooque, 1997; Ghosh, 1993; Khan, 1998). Aryans carried on almost a systematic deforestation to meet the requirements of their settlements. As population increased more forests were cleared. They used wood for their vehicles, such as carts and chariots and also for house building materials as doors, windows, posts, rafters, ridges and bottoms (Agarwala, 1990).

The Aryans however did not leave any evidence of forest management (Ghosh, 1993). During the Mauryan period (321 to 247 BC), the forests came under the supervision of the State more effectively and a number of rules were framed. The *Arthashastra* of Kautilya (321 BC), the Prime Minister of Emperor Chandra Gupta Maurya, *Indika* of Megasthenes (305 BC), a Greek Ambassador in the court of Emperor Chandra Gupta Maurya, showed evidence of forest management in ancient India. In the administration of Chandra Gupta Maurya, there was a regular forest department headed by *Kupyadhyaksha* (Superintendant of Forest Products) and assisted by a number of *Vanapalas* or Forest Guards (Agarwala, 1990; Ghosh, 1993; Khan, 1998; Padhi, 1982). The fall of Mauryan regime was followed by Khusans and then by Guptas (240-673). Guptas also had organised structure for forest management (Khan, 1998).

The next important phase in the history of forestry was the rule by Mughals (1526-1700). Bengal (of which present Bangladesh is a part) formed a major *Suba* (province) during this time (Khan, 1998). During this period reclamation of land for agriculture took place. Their invasion pushed a part of the agricultural population into the forests, hills and mountains where these people adopted shifting cultivation. The Mughals used forests as game reserves for sports, gardening and avenue planting (Farooque, 1997; Khan, 1998). The Mughals' aesthetic perspective on forest management was evident by the works of the great Emperor Akbar who showed interest in canal-side planting "so as to make it [look] like the canals under the tree in Paradise" (FRI, 1961 as cited in Khan, 1998). There are some particular information on forest use in the Dhaka-Mymensingh *Sal* forest tracts during the Mughal period, which show that the dense forests of the area served as ideal refuge for 'outlaws' and 'squatters'. The Mughal emperor Jahangir granted a patch of forests from this tract (called the Atia Pargana) to his 'physical-training instructor' Munayem Khan. Similarly, another patch, called Bhowal belonged to a family of proprietors locally known as Gazies (Ahmad, 1938 as cited in Khna, 1998).

Between the eighteenth and mid nineteenth century, different parts of Indian forests were subjected to exploitation on a huge scale under the British East India Company and later the British rule. Colonial administrators of this period tended to perceive Indian forests as being inexhaustible (Agarwala, 1990; Sivaramakrishnan, 1997). Extraction for shipbuilding and railway sleeper production went on heavily without preservation consideration (Agarwala, 1990; Farooque, 1997; Ghosh, 1993; Khan, 1998). The extension of agriculture, which entailed considerable clearance of forests, received priority over forestry and was encouraged by the government during British rule (Farooque, 1997; Khan, 1998) as they viewed forests chiefly as limiting agriculture (Sivaramakrishnan, 1997).

According to Khattak (1979) Bengal, until the close of the nineteenth century, had paid little attention to forest conservancy. Only in 1864 was Dr. T.A. Anderson, Superintendent of the Botanic Gardens Calcutta, appointed as Conservator of Forests Lower Provinces in addition to his own duties (Agarwala, 1990; Farooque, 1997; Padhi, 1982; Sivaramakrinshnan, 1997). Large forested tracts were at this time being cleared for cultivation. Although the British Government assumed the ownership of Sundarban forest in 1828, no attempt was made to introduce forest

conservancy for another half a century and in fact large leases were given during this period for clearing the forest and reclaiming land for cultivation (Choudhury, 1968 cited in Khattak, 1979).

4.3.1. Population and Land Use History in Bangladesh.

A summary history of land use in Bangladesh is shown in Table 4.1. It is seen that land under cultivation and settlement increased at the expense of forest, wetland and other areas over the time period 1880-1980. The total human population over this time has tripled.

Table 4.1. Population and Land use history in Bangladesh from 1880-1980 (compiled from Flint and Richards, 1991).

	1880	1920	1950	1980
Population (millions)	24.89	33.43	41.88	86.97
Population density (persons/Sq. Km)	168	226	283	588
Total forest-woodland area (10^6 ha)	1.61 (11)	1.47 (10)	1.41 (10)	1.01 (7)
Total Cultivated+Settled area (10^6 ha)	7.50 (51)	7.82 (53)	8.89 (60)	9.24 (62)
Total wetland area (10^6 ha)	3.25 (21)	3.38 (23)	2.88 (19)	2.65 (18)
Other area (10^6 ha)	2.44 (16)	2.13 (14)	1.62 (11)	1.90 (13)
Total	14.80 (100)	14.80 (100)	14.80 (100)	14.80 (100)

- Values in the parentheses show the percentage to total area.

4.4. Human Population.

Bangladesh is predominantly a rural country and the majority of the population are directly or indirectly dependent on agriculture. Despite fertile soil and abundant water reserves, the performance in the agricultural sector continues to be low due to constraints on resources for irrigation and fertilizers needed for the high-yield crops as well as institutional bottlenecks affecting access to such inputs among the poor. The low rate of growth in the agricultural sector, and indeed, the economy as a whole coupled with a doubling of the rural population over the past three decades has resulted in increased unemployment and underemployment, widespread fragmentation and subdivision of land, increased distress sale of land, and a sharp rise in landlessness (RTF, 1991a). These factors have forced rural people to migrate to rapidly growing urban areas for a better chance of employment. This migration has been confined mostly to 5 major cities (Dhaka, Chittagong, Khulna, Rajshahi and Narayanganj), which together account for 50 per cent of the total urban population (Das, 1993). As a result the urban population increased from as low as 5 per cent of the total population in 1961 to 21 per cent in 2000 and it is expected to be 60 per cent by the year 2050 (Table 4.2). The trend of population projection has been shown graphically in Figure 4.1.

Table 4.2. Population characteristics and projections to year 2050 (compiled from BBS, 1999a; Ittefaq, 2001a; Prothomalo, 2001; WARPO, 2000; World Bank, 1998).

Year	Urban		Rural		Population	Density
	(millions)	(%)	(millions)	(%)	(millions)	(Persons/Sq.Km)
1961	3	5	48	95	51	356
1974	6	9	65	91	71	497
1981	13	15	74	85	87	590
1991	21	20	85	80	106	720
2001	30	23	99	77	129	834
2010	43	29	107	71	150	1016
2020	62	36	108	64	170	1152
2025	73	40	108	60	181	1227
2050	137	60	90	40	227	1538

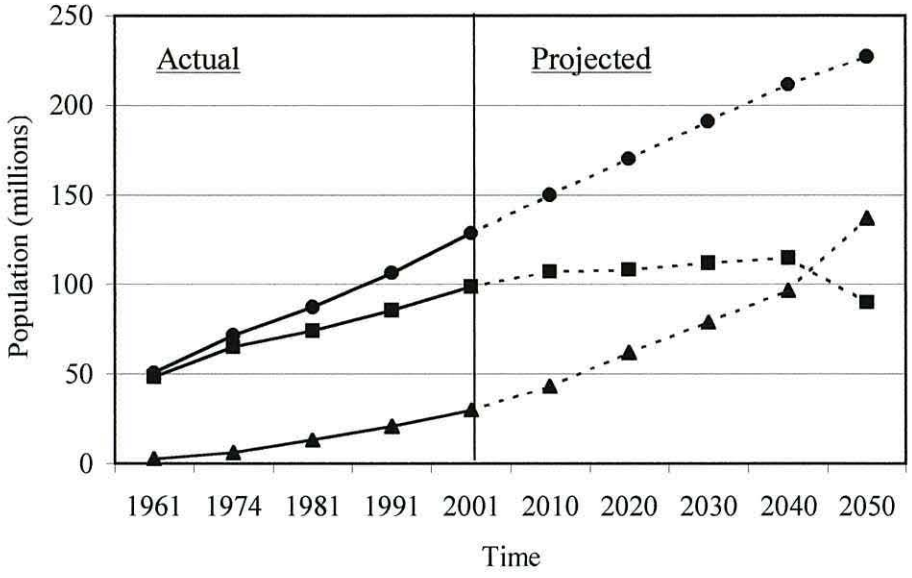


Figure 4.1. Population Characteristics and Projection to Year 2050 [● Total population, ■ Rural Population and ▲ Urban population] (complied from BBS, 1999a; Ittefaq, 2001a; Prothomalo, 2001; WARPO, 2000; World Bank, 1998).

The general trend in population migration from 1993-1997 is shown in Table 4.3. It is evident that migration can be of several different natures, rural to rural, rural to urban, urban to rural and urban to urban. The degree of migration was also found different among different types of migration. Urban to urban migration was observed to dominate with 61 per cent of the total population migrating in a year. This migration usually takes place due to change of job or transfer from one place to another. Very few people were found to migrate from urban to rural areas. However migration from rural to urban (16 per cent) is very important as it substantially increases the urban population every year. As a result the rural population is gradually decreasing leaving fewer people engaged in agriculture every year. An estimate shows that the agricultural population has decreased more than 15 per cent from 1965 to 1995 (Figure 4.2).

Table 4.3. Population characteristics from 1993-1997 (compiled from NDB, 2001)

	Year				
	1993	1994	1995	1996	1997
Population (Million)	115.5	117.7	119.9	122.1	124.3
Density (sq. Km)	783	798	812	827	842
Population Growth Rate	1.88	1.88	1.8	1.74	1.73
Urban population (% of total population)	20.58	20.85	21.13	21.38	21.67
Population Migration ('000)	46.59	49.91	51.28	51.48	53.04
	(100)	(100)	(100)	(100)	(100)
Rural to Rural	10.25	11	11.32	10.72	11.25
	(22)	(22)	(22)	(21)	(21)
Rural to Urban	6.89	7.76	7.80	8.30	8.35
	(15)	(15)	(15)	(16)	(16)
Urban to Rural	0.93	0.90	0.87	0.83	0.92
	(2)	(2)	(2)	(2)	(2)
Urban to Urban	28.52	30.25	31.29	31.63	32.52
	(61)	(61)	(61)	(61)	(61)

- Values in the parentheses show the percentages to total population migration.

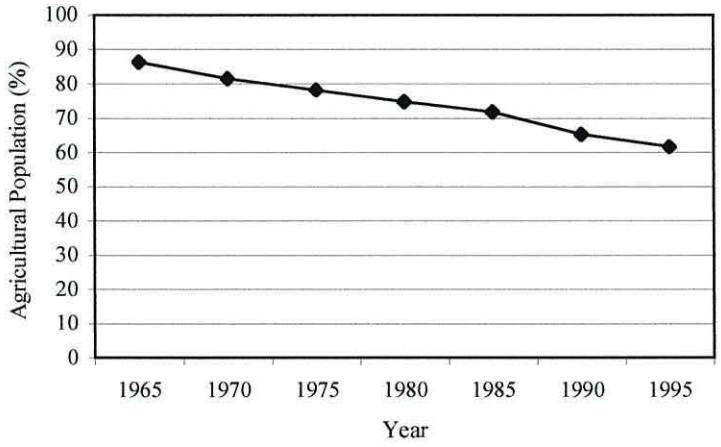


Figure 4.2. Size of Agricultural Population from 1965-1995 expressed as a percentage of total population (compiled from FAO, various years).

4.4.1. Religious Composition.

Bangladesh is predominantly a Muslim country, and Muslims constituted 88.3 per cent of its total population according to last population census in 1991. Historical analysis from 1901 to 1991 also shows this dominance, which has showed gradual increase over time (Table 4.4). As at present about 90 per cent of the population in Bangladesh are Muslims so we can consider their socio-economic characteristics to represent the overall country's situation.

Table 4.4. Percentage distribution of population by religious communities (1901 – 1991) (Source: NDB, 2001).

Census Year	Muslim	Hindu	Buddhist	Christian	Others	Total
1901	66.1	33.0	-	-	0.9	100
1911	67.2	31.5	-	-	1.3	100
1921	68.1	30.6	-	-	1.3	100
1931	69.5	29.4	-	0.2	1.0	100
1941	70.3	28.0	-	0.1	1.6	100
1951	76.9	22.0	0.7	0.3	0.1	100
1961	80.4	18.5	0.7	0.3	0.1	100
1974	85.4	13.5	0.6	0.3	0.2	100
1981	86.7	12.1	0.6	0.3	0.3	100
1991	88.3	10.5	0.6	0.3	0.3	100

4.5. Land Use.

Most of the land in Bangladesh is owned by rural and urban elites who do not cultivate the land. Of the total land area, 23 per cent is cultivated by tenants or owner-cum-tenants (Januzzi and Peach, 1980 cited in Hasan and Mulamoottil, 1994). Another 45 per cent of arable land is cultivated by paid labourers (Hasan and Mulamoottil, 1994). The most common form of tenancy relationship in Bangladesh is sharecropping (*bargadari*), which gives the landowner half of the production, while the sharecropper after providing all the input and labour, receives the other half. This system is usually known as *adhi barga*, which represents half of the share. In some areas landowners receives a predetermined amount of money for a specific time period or crop(s) from the tenants known as *tendar* in northern part of Bangladesh. In a few areas the *tin-bagha* (three-share) system has been introduced, where the production is divided into three shares against land, labour and input.

Land is not only a determinant of status but is also a basic factor of production. Unfortunately, the land distribution in Bangladesh is very skewed. It is evident that, while the population is concentrated in the lower farm size groups, land is concentrated in the higher size groups (Rahman, 1984). Data from the agriculture and livestock census 1996 shows that majority of the households (53%) are in the small farm size group and operates about 23 per cent of the country's total area. Non-farm households comprising 34 per cent of the total households operate only 1 per cent of the country's total area (Table 4.5).

Comparisons of data from agriculture and livestock censuses suggest that the average land holding is decreasing although total households have doubled in the three decades from 1960 to 1996 (Table 4.6). There was also a substantial increase in the number of small farm households from 52 per cent to 80 per cent between these time periods. As a consequence medium and large farm households decreased. There has been a remarkable increase in the total number of farm holdings from 1960 to 1996 although the total operated area has decreased, causing average farm sizes to shrink to less than half their 1960 value (Table 4.7).

Table 4.5. Basic characteristics of different household groups from the Agriculture and Livestock Census, 1996 (compiled from BBS, 1999b).

Items	Non-farm Households (<0.02 ha)	Small Farm Households (0.02-1.01 ha)	Medium Farm Households (1.01-3.03 ha)	Large Farm Households (>3.03 ha)	Total Households
No. of Holdings	6029945	9422793	2077784	297665	17828187
Percentage (%)	33.82	52.85	11.67	1.67	100
Operated area (ha)	213438	3326094	3351505	1398778	8289815
% of total area	1.45	22.54	22.71	9.48	56.18
% of operated area	2.58	40.12	40.43	16.87	100
Owned area (ha)	528295	3319552	3034358	1346411	8228615
% of operated area	3.58	22.49	20.56	9.12	55.76
Homestead Area (ha)	119477	278045	109596	26426	533544
% of operated area	56	8	3	2	6
Net-cropped area (ha)	8857	2868217	3049964	1264774	7191812
% of operated area	4.15	86.23	91.00	90.42	86.75
Area under permanent crop (ha)	6771	251217	165950	63111	487049
Net temporary cropped area (ha)	1521	2598553	2864560	1192665	6657298
% of net-cropped area	17	91	94	94	93
Holding reporting irrigation	48442	5794788	1511921	215151	7570302
Net area irrigated (ha)	503	1500706	1419084	554432	3474724
% of cultivated area	6	52	47	44	48
Holding reporting use of fertilizer	70890	7529783	1908704	273308	9782685
Net area fertilized (ha)	752	2264584	2368150	950728	5584213
% of cultivated area	8	79	78	75	78

Table 4.6. The distribution of farm households by size group according to different nationwide agricultural censuses (compiled from BBS, 1999a; FMP, 1992a; NDB, 2001; RTF, 1991b).

Category	Agriculture and Livestock Census Year			
	1960	1977	1983-84	1996
Total Households	9603000	13690000	13817646	17828187
Non-farm Households (<0.02 ha)	3464000	6581000	3772347	6029945
% Of Total Households	36.07	48.07	27.30	33.82
Small farm Households (0.02-1.01 ha)	3169566	3533173	7065863	9423256
% Of Total Households	33.01	25.81	51.14	52.86
Medium Farm Households (1.01-3.03 ha)	2313175	2907581	2483198	2077670
% Of Total Households	24.09	21.24	17.97	11.65
Large farm Households (>3.03 ha)	656259	668246	496238	297316
% Of Total Households	6.83	4.88	3.59	1.67
Total Farm Households	6139000	7109000	10045299	11798242
% Of Total Households	63.93	51.93	72.70	66.18
Agriculture Labour Households	-	-	5495300	6725319
% Of Total Households	-	-	39.77	37.72

Table 4.7. Distribution of farm holdings in Bangladesh from different agricultural and livestock censuses (compiled from BBS, 1999a; Rahman and Ali, 1984).

Farm Size	Number of farms ('000)			% Of farm			Operated Area ('000 ha)			% Of total farm area			Average farm size (ha)		
(ha)	1960	1983-84	1996	1960	1983-84	1996	1960	1983-84	1996	1960	1983-84	1996	1960	1983-84	1996
Total farms	6140	10045	11798	100	100	100	8792	9177	8076	100	100	100	1.43	0.91	0.68
Small farms	3171	7066	9422	51.64	70.34	79.86	1428	2660	3326	16.24	28.98	41.18	0.45	0.38	0.35
<0.20	804	2417	3356	13.09	24.06	28.45	83	252	362	0.94	2.74	4.48	0.10	0.10	0.11
00.20-0.40	690	1644	2437	11.24	16.37	20.66	202	466	687	2.30	5.08	8.51	0.29	0.28	0.28
0.40-1.01	1677	3005	3629	27.31	29.92	30.76	1144	1942	2277	13.01	21.16	28.19	0.68	0.65	0.63
Medium farms	2313	2483	2078	37.67	24.72	17.61	4018	4138	3351	45.70	45.09	41.49	1.74	1.67	1.61
1.01-2.02	1615	1806	1577	26.30	17.98	13.37	2321	2520	2163	26.40	27.45	26.78	1.44	1.40	1.37
2.02-3.03	698	677	501	11.37	6.74	4.25	1697	1619	1188	19.30	17.64	14.71	2.43	2.39	2.37
Large farms	656	496	298	10.68	4.94	2.53	3346	2379	1399	38.06	25.92	17.32	5.10	4.80	4.69
3.04-10.11	630	479	288	10.26	4.77	2.44	2924	2131	1256	33.26	23.22	15.55	4.64	4.45	4.36
>10.12	26	17	10	0.42	0.17	0.08	422	248	143	4.80	2.70	1.77	16.23	14.59	14.29

Rahman and Ali (1984) suggest that an extremely skewed distribution of land ownership will lead to the rise of landless peasants in society. Table 4.8 clearly shows an unequal distribution of operated area among the farm holdings and indicates a high degree of inequality. About 13.09 per cent of farm holdings belonged to the lowest size class (<0.20 ha) and together this comprised only 0.94 per cent of the total operated land in 1960, having a relative mean inequality of 0.1215, an inequality measure expressed as a proportionate difference between the percentage of farm households and percentage of operated area. This situation gradually worsened over time, and by 1996 28.45 per cent of total farm households (Table 4.8) were in the lowest class with a relative mean inequality 0.2396. Maximum relative mean inequality was observed in the size class 0.40-1.01 ha which again increased from 0.3539 in 1960 to 0.3868 in 1996. The Gini-coefficient, an aggregate inequality measure that can vary anywhere from 0 (perfect equality) to 1 (perfect inequality), also increased from 0.4974 in 1960 to 0.5288 in 1996 showing a farther rise in inequality in the distribution of operational land in Bangladesh. However, comparisons between 1983-84 and 1996 show decline in inequality in distribution from 0.5394 to 0.5288.

This inequality in distribution of operational land in Bangladesh among different household types can also be presented by a Lorenz curve, where cumulative percentage of households is plotted against the cumulative percentage of land operated by households. The more the Lorenz line curves away from the diagonal (perfect equality), the greater the degree of inequality represented (Todaro, 1994). In short, the greater the curvature of the Lorenz line the greater the relative degree of inequality. As seen in Figure 4.3 this inequality in the distribution of operational land among different households types has increased from 1960 to 1996.

Table 4.8. Concentration of operational land holdings in Bangladesh from 1960-1996 (compiled from BBS, 1999a; Rahman and Ali, 1984.)

Farm Size Class (ha)	1960			1883-84			1996		
	Cumulative Percentage		Relative mean	Cumulative Percentage		Relative mean	Cumulative Percentage		Relative mean
	Households (a)	Operated area (b)	Inequality (a-b)/100	Households (a)	Operated area (b)	Inequality (a-b)/100	Households (a)	Operated area (b)	Inequality (a-b)/100
<0.20	13.09	0.94	0.1215	24.06	2.74	0.2132	28.45	4.48	0.2396
0.20-0.40	24.33	3.24	0.2109	40.43	7.82	0.3261	49.10	12.99	0.3611
0.40-1.01	51.64	16.25	0.3539*	70.34	28.98	0.4136*	79.86	41.18	0.3868*
1.01-2.02	77.94	42.64	0.3530	88.32	56.44	0.3188	93.23	67.97	0.2526
2.02-3.03	89.31	61.94	0.2737	95.06	74.08	0.2099	97.47	82.68	0.1480
3.04-10.11	99.57	95.20	0.0437	99.83	97.30	0.0253	99.92	98.23	0.0168
>10.12	100	100	-	100	100	-	100	100	-
Gini ratio			0.4974			0.5394			0.5288

* Maximum relative mean inequality.

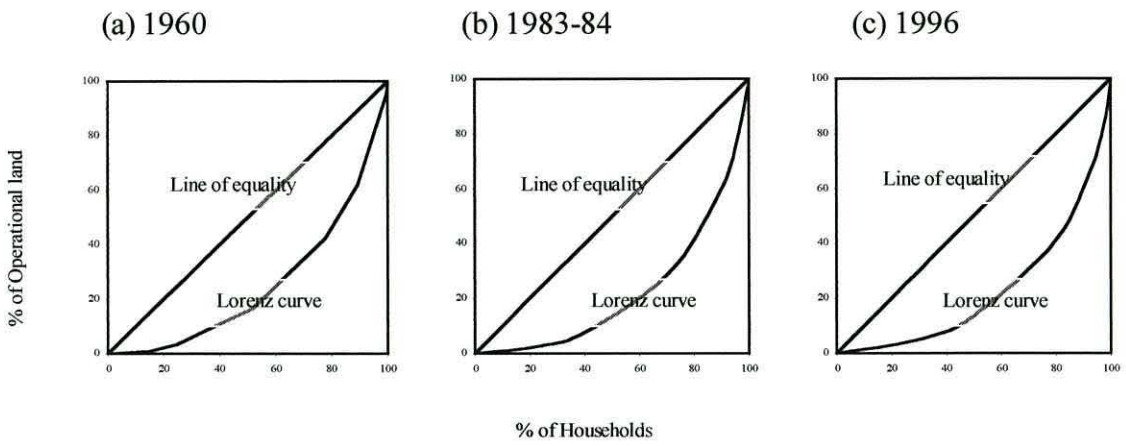


Figure 4.3. Quantitative relationships between different household types and distribution of operational land in Bangladesh according to different agricultural and livestock censuses.

4.5.1. Agricultural Land Use.

Bangladesh is predominantly an agricultural country with about 64 per cent of its area under cultivation. Agriculture plays a vital role in the growth and stability of the country's economy as indicated by its share of GDP. Once contributing about 65 per cent of the total GDP share in 1950, agriculture now faces lots of competition from other sectors as development progresses. At present it accounts for about one-third of GDP showing decreasing trends whereas other sectors like services, construction/development and industry show increasing trends in their share of GDP (Figure 4.4). Cropping represented 72 per cent of agricultural GDP and about 23 per cent in total GDP during 1997/98 showing a gradual decreasing trend from 1994/95 to 1997/98. Although the forestry sub-sector contributed more or less the same share in agricultural as well as total GDP, the livestock and fisheries sub-sectors showed increasing contributions towards GDP during this time period (Table 4.9).

Table 4.9. GDP share of different agricultural sub-sectors in different financial years (compiled from BBS, 1999a).

	1994-95	1995-96	1996-97	1997-98
Crops	74.10	73.47	73.29	72.18
	(24.30)	(23.66)	(23.75)	(22.81)
Forestry	7.36	7.41	7.25	7.34
	(2.41)	(2.38)	(2.35)	(2.32)
Livestock	9.13	9.51	9.65	10.13
	(2.91)	(3.06)	(3.13)	(3.20)
Fisheries	9.41	9.61	9.81	10.35
	(3.09)	(3.10)	(3.18)	(3.27)
Agriculture (Total)	100	100	100	100
	(32.80)	(32.2)	(32.4)	(31.6)

- Values in parentheses show the percentage share in GDP.

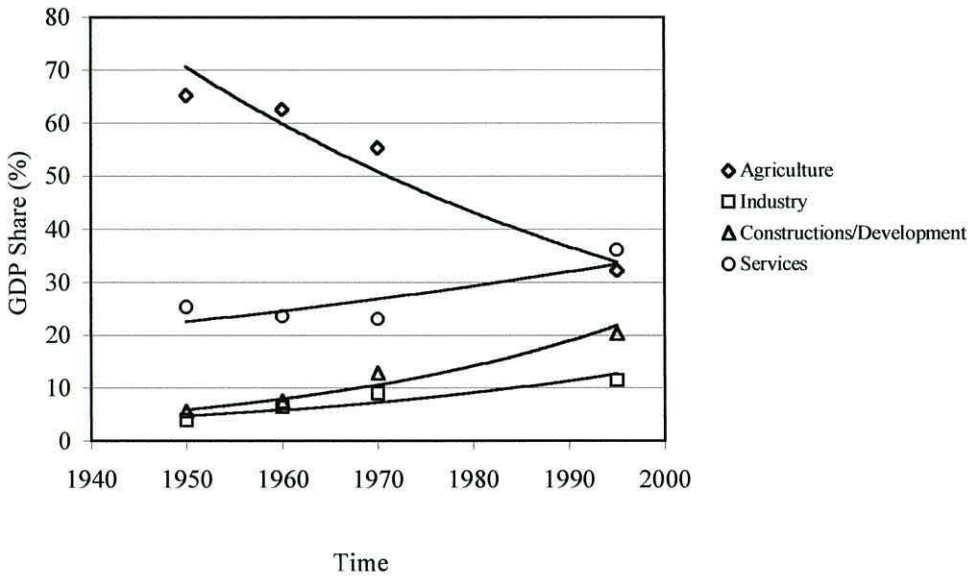


Figure 4.4. Sectoral GDP share (%) in different years (compiled from BBS, 1999a; Khan, 1972).

Agriculture occupies about 64 percent of the total land area where as forests comprise only 18 per cent. Other areas consisting of urban development, water areas and settlement account for the rest of the land, about 18 per cent (Table 4.10).

Table 4.10. General land use in Bangladesh (Source: FMP, 1992a; ADB, 1995)

Land use Category	Land Area	
	Million ha (mha)	%
Agriculture	9.25	64.2
State Forest	2.22	15.4
Classified	1.49	10.3
Unclassified	0.73	5.1
Private Forest	0.34	2.4
Village	0.27	1.9
Tea/Rubber Garden	0.07	0.5
Total Forest	2.56	17.8
Urban	1.16	8.1
Water	0.94	6.5
Other	0.49	3.4
Total Other Areas	2.59	18.0
Grand Total	14.40	100

General land utilization from 1971-72 to 1996-97 in Bangladesh shows an increasing amount of the area not being available for cultivation (Table 4.11). This is mainly due to increased demand for more land for urban and other development like industrial sites, roads and infrastructures, etc. This is very important as the population is increasing every year and demand for land other than agriculture or forest is increasing as well. Land use planners should keep this in mind while planning for future land use.

It is interesting to see that although total cropped area generally increased from 1971-1996, net-cropped area reached a maximum point of 8.85 mha during 1986-87 and then started declining. By the year 1996-97 it had decreased to a level below its 1971-72 value. This is due to the fact that there was a substantial increase in the area sown more than once, i.e. increased cropping intensity, over that time period. There was also a gradual increasing trend of culturable watse land that can easily be brought under cultivation. On the other hand current fallow land, which at first increased up to a maximum point in 1988-89, is now decreasing every year to compensate for loss of net-cropped area to other uses. Although forest areas have tended to decrease over time reaching a low point in 1993-94, there has been an increasing trend since that time period. This may be due to the increased social and participatory forestry programme by the government's Forest Department and other non-government organisations.

Table 4.11. Land Utilization in Bangladesh (compiled from BBS, 1999c; Rahman *et al.*, 1994).

(areas in mha)

Year	Forest	Not available for cultivation	Culturable waste	Current fallow	Net-cropped area	Area sown more than once	Total cropped area
1971-72	2.23	2.66	0.30	0.85	8.24	3.16	11.40
1972-73	2.23	2.66	0.28	0.68	8.43	3.32	11.75
1973-74	2.23	2.66	0.27	0.63	8.49	3.42	11.91
1974-75	2.21	2.66	0.27	0.81	8.32	3.27	11.59
1975-76	2.20	2.68	0.27	0.64	8.49	3.53	12.01
1976-77	2.21	2.68	0.27	0.85	8.27	3.45	11.73
1977-78	2.20	2.70	0.27	0.74	8.35	3.67	12.02
1978-79	2.19	2.70	0.25	0.71	8.42	4.47	12.89
1979-80	2.20	2.71	0.25	0.69	8.45	4.49	12.94
1980-81	2.19	2.72	0.25	0.57	8.56	4.60	13.16
1981-82	2.14	2.77	0.25	0.55	8.58	4.62	13.21
1982-83	2.14	2.78	0.23	0.48	8.65	4.76	13.41
1983-84	2.11	2.90	0.33	0.45	8.68	4.68	13.36
1984-85	2.14	2.91	0.29	0.49	8.64	4.51	13.15
1985-86	2.12	2.92	0.27	0.40	8.77	4.77	13.54
1986-87	1.99	3.29	0.26	0.39	8.85	5.26	14.12
1987-88	1.90	3.11	0.36	1.18	8.29	5.53	13.82
1988-89	1.90	3.09	0.36	1.33	8.15	5.56	13.71
1989-90	1.90	3.15	0.35	1.09	8.35	5.71	14.06
1990-91	1.90	3.22	0.58	0.96	8.17	5.86	14.03
1991-92	1.89	3.86	0.48	0.63	7.98	5.83	13.81
1992-93	1.89	4.19	0.44	0.66	7.65	6.06	13.70
1993-94	1.89	4.19	0.63	0.40	7.73	5.76	13.48
1994-95	1.97	4.10	0.63	0.40	7.74	5.78	13.52
1995-96	2.15	3.96	0.53	0.39	7.80	5.71	13.51
1996-97	2.16	3.92	0.52	0.39	7.85	5.94	13.80

- Culturable waste is the area suitable for cultivation but lying fallow for more than one year.
- Current fallow is the area already brought under cultivation, but not cultivated during the year.
- Total cropped area is the sum of the net-cropped area and the area sown more than once.

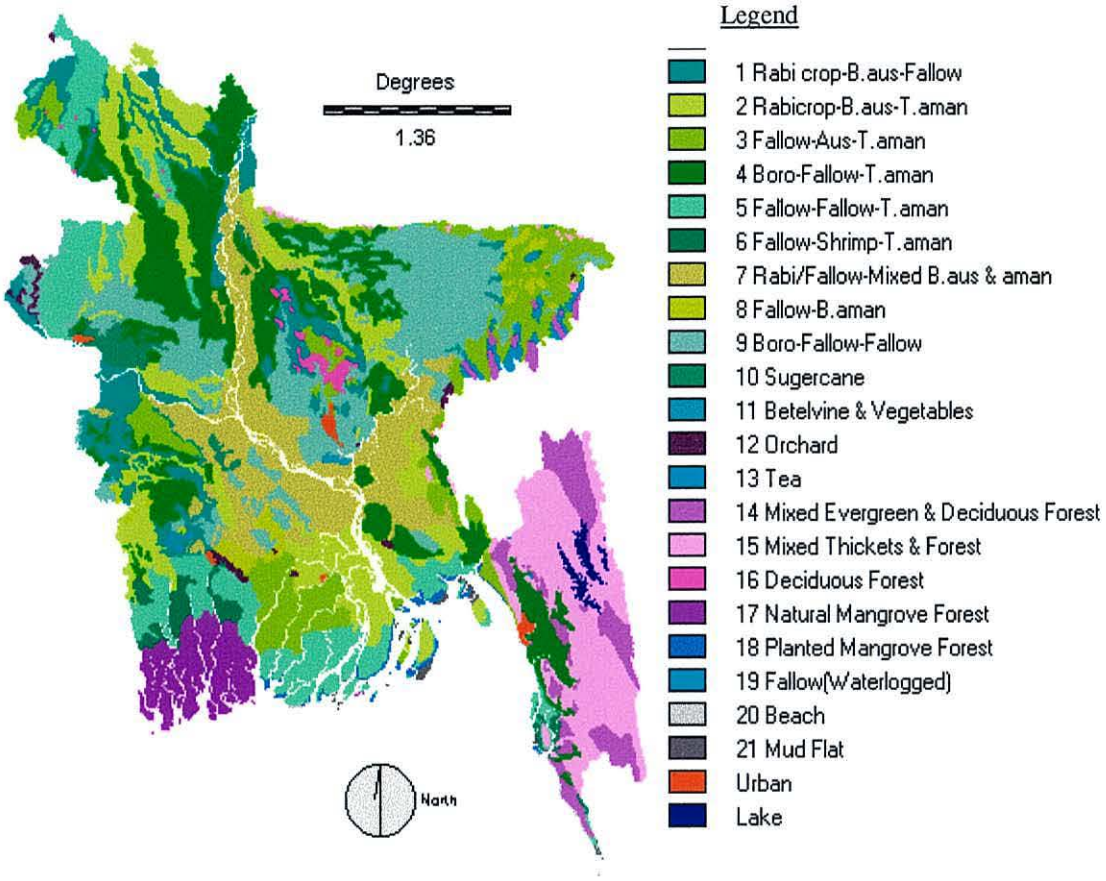


Figure 4.5. Detailed land use in Bangladesh (1996).

4.5.1.1. Secondary Land Use.

Detailed analysis of the secondary land use in Bangladesh is shown in Figure 4.5. This map was developed from data held by SRDI (1996). It is evident that most of the lands are devoted to rice cultivation. Forest areas are generally concentrated in the south-eastern and south-western parts of the country. A few patches of forest areas are also found in central, northern and north-eastern parts. According to this analysis 77 per cent of the total land areas are used for agricultural purposes mostly for different rice varieties and some *rabi* crops and vegetables. Forest areas also cover about 14 per cent of the total area (Table 4.12). Both these figures differ from those in

Table 4.10 as homestead and other areas were not separated from agricultural areas and homestead forests were not considered when calculating total forest areas in Table 4.12.

Table 4.12. Detailed Land Use in Bangladesh (compiled from SRDI, 1996).

Secondary Land Uses	AREA (sq. Km)	Percentage (%)
Agriculture	113720	77.06
Rabi crop-B. Aus-Fallow	10086	6.83
Rabi crop- Aus-T. Aman	17888	12.12
Fallow-Aus-T.aman	12735	8.63
Boro-Fallow-T.aman	20305	13.76
Fallow-Fallow-T.aman	13367	9.06
Fallow-Shrimp-T.aman	1752	1.19
Rabicrop/Fallow-Mixed B.aus & aman	14937	10.12
Fallow-B. Aman	1667	1.13
Boro-Fallow-Fallow	19272	13.06
Sugarcane	1574	1.07
Betel vine & Vegetables	137	0.09
Orchard	666	0.45
Tea	1003	0.68
Forest	21036	14.25
Mixed Evergreen & Deciduous Forest	5226	3.54
Mixed Thickets & Forest	9941	6.74
Deciduous Forest (Sal)	794	0.54
Natural Mangrove Forest	4498	3.05
Planted Mangrove Forest	577	0.39
Wetland	9951	6.74
Fallow (Waterlogged)	121	0.08
Beach	114	0.08
Mud Flat	337	0.23
River	9379	6.36
Other land	1194	0.81
Water bodies	705	0.48
Urban	489	0.33
TOTAL	147570	100

4.5.1.2. Crop Production Potential.

The potential for increasing agricultural production by bringing more land into cultivation is extremely limited in Bangladesh. Net cultivated land hardly increased during the 1950s, experienced moderate growth during the 1960s and 1970s but started to decrease in the 1980s

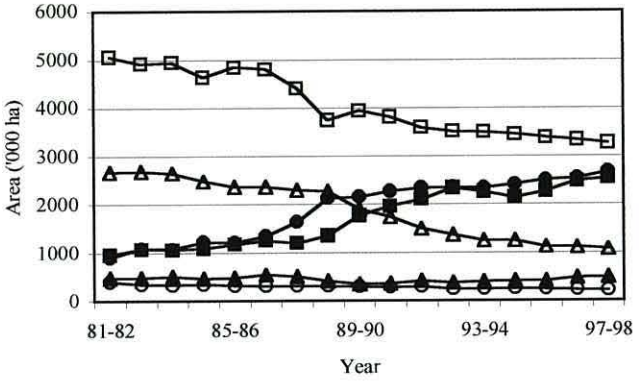
due to increased transfer of land to other uses. Bangladesh made steady progress in cropping agriculture in the post-independence period, and the political leaders are now seeking to be self sufficient in food production during 1998-2000 time period (unofficial sources). The cropping intensity increased from 128 per cent in 1950 to 176 per cent in 1996 (Table 4.14). Rice is the dominant crop covering about 72 per cent of the total cropped area (TCA). The technological breakthrough in Bangladesh agriculture has been primarily in the food grain sector, and relates to the introduction of rice based 'Green Revolution' technology followed by a gradual introduction of wheat-based technology (Rahman and Thapa, 1999).

In 1970 modern rice varieties only covered 1.5 per cent, now they cover 54 per cent of the total rice area. Figure 4.6 clearly shows the development in rice production from 1981-82 to 1997-98. High yielding varieties (HYV) are now becoming more and more important to the farmers due to their increased production. As a result their cultivation is being intensified at the expense of local rice varieties every year. The most remarkable success was achieved for *boro* (HYV) where both area and production has trebled between 1981-82 and 1997-98 (Table 4.13). Bangladesh made tremendous success in agricultural sectors for three consecutive years which eventually increased GDP growth rate, stabilized money inflation and had a positive impact on country's foreign exchange reserves (Dipu, 2000). As a result 8 per cent of people crossed the poverty line. Alam (2001) reported that agricultural scientists in Bangladesh Rice Research Institute (BRRI) have had tremendous success breeding HYV rice and have a worldwide reputation. To date they have invented 41 types of HYV rice where the best known one is 'BRRI-29' producing a huge yields up to 10 tons per hectare with an average of 6 to 8 tons per hectare. These rice varieties are playing a great role in attaining self-sufficiency in the country's total rice production and also in overall food production. Alam (2001) also reports that 78 per cent of the country's total rice is now produced by HYV rice. Very recently BRRI has developed another variety named as 'HYV Super Rice', which is capable of producing 14 tons per ha. The effort to develop this particular rice started in 1997 and it will need another 2-3 years before it reaches the farmers for mass production. Once this particular rice variety is put under full production it is hoped that the country will make strong progress in eradicating poverty.

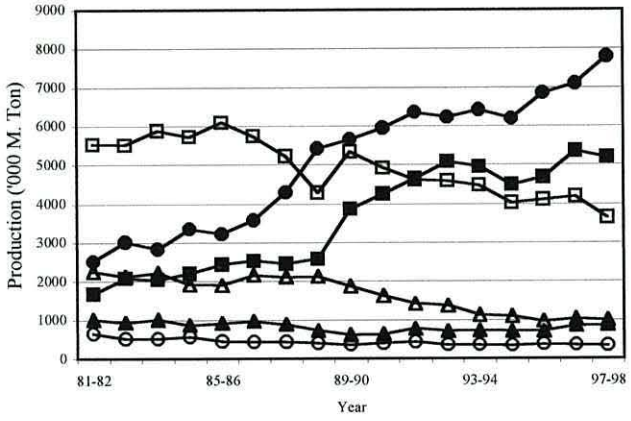
Table 4.13. Area and production of different rice varieties in 1981-82 and 1997-98 (compiled from BBS, 1999c).

	1981-82					1997-98				
	Area		Production		Yield	Area		Production		Yield
Varieties	('000 ha)	%	('000 M.Ton)	%	(M.Ton/ha)	('000 ha)	%	('000 M.Ton)	%	(M.Ton/ha)
Aman (Local)	5056	48.33	5542	40.66	1.10	3261	31.78	3644	19.32	1.12
Aman (HYV)	955	9.13	1667	12.23	1.74	2547	24.82	5206	27.60	2.04
Aman (Total)	6011	57.47	7209	52.89	1.20	5808	56.60	8850	46.92	1.52
Aus (Local)	2674	25.57	2248	16.49	0.84	1075	10.48	1003	5.32	0.93
Aus (HYV)	472	4.51	1022	7.50	2.17	490	4.78	871	4.62	1.78
Aus (Total)	3146	30.08	3270	23.99	1.04	1565	15.25	1874	9.94	1.20
Boro (Local)	405	3.87	637	4.67	1.57	218	2.13	341	1.81	1.56
Boro (HYV)	898	8.58	2515	18.45	2.80	2671	26.02	7796	41.33	2.92
Boro (Total)	1303	12.45	3152	23.12	2.42	2889	28.15	8137	43.14	2.82
Total Rice	10460	100	13631	100	1.30	10262	100	18861	100	1.84

(a) Rice area ('000 ha)



(b) Total rice production ('000 M. Ton)



(c) Rice production per ha (M. Ton/ha)

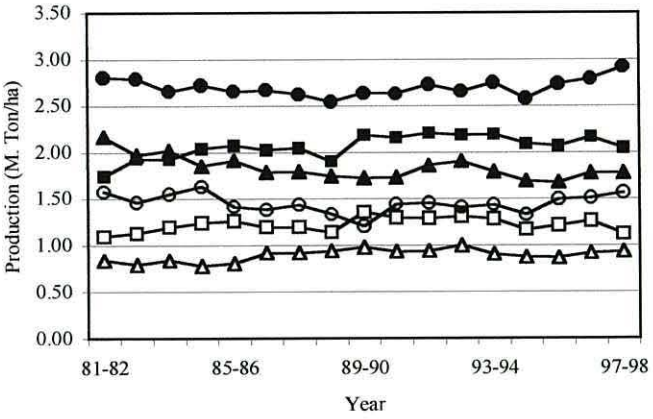


Figure 4.6. Variation in different rice varieties with area and production in different years.
[□ Aman (Local), ■ Aman (HYV), △ Aus (Local), ▲ Aus (HYV), ○ Boro (Local), ● Boro (HYV)]
(Source: Data from BBS, 1999c).

Table 4.14. Selected indicators of technological change in Bangladesh agriculture, 1950-1996 (compiled from BBS, 1999a; BBS, 1999b; FAO, 1977; Hossain, 1987; Rahman and Thapa, 1999).

Indicators	1950	1960	1970	1982	1992	1996
Total cropped area (TCA) (mha)	10.61	10.99	12.73	13.26	13.75	13.8
Net-cropped area (NCA) (mha)	8.28	8.41	8.73	8.60	7.81	7.85
Cropping intensity (%)	128	131	146	154	176	176
Cereal area (mha)	8.11	9.11 [a]	10.11	11.06	10.90	10.70
Cereal as % of TCA	76.4	82.8	79.4	83.4	79.2	77.5
Total rice area (mha)	8.07	8.96 [a]	10.05	10.31	10.14	9.95
Rice as percent of TCA (%)	76.0	81.5	79.0	77.7	73.7	72.1
Rice as % of Cereal area	99.5	98.4	99.4	93.2	93.0	93.0
Modern rice as percent of total rice area (%)	nil	na	1.5	20.3	49.0	54.0
Total wheat area ('000 ha)	39	60 [a]	105	520	609	616
Wheat area as % of Cereal area	0.37	0.55	0.82	3.92	4.43	4.46
Wheat area as % of Cereal area	0.48	0.66	1.04	4.70	5.59	5.76
Modern wheat as percent of total wheat (%)	nil	na	6.1	96.2	98.0	66.6
Total irrigated area (IA) ('000 ha)	<1	na	1057	1865	3257	3475
Irrigated area as percent of TCA (%)	na	na	8.3	14.1	23.7	25.2
Foodgrain irrigated area as percent of IA (%)	na	na	85.8	78.4	91.2	90.5
Irrgation by methods : *Modern* (%)	na	na	31.5	67.2	70.9	90.2
Traditional (%)	na	na	68.5	32.8	29.1	9.8
Total fertilizer used ('000 M. Ton of nutrients)	<1	na	113.1	380.8	664.8	na
Fertilizer use rate per TCA (kg of nutrients/ha)	na	na	8.8	29.1	48.3	na
Pesticide use ('000 M. Ton)	na	na	na	2.2	6.5	na
Rice production ('000 M. Ton)	7367	15048[a]	11504	13417	18211	18882
Rice yield (M. Ton/ha): *Total*	0.91	1.68 [a]	1.14	1.30	1.80	1.90
Modern variety	nil	na	3.81	2.30	2.41	2.42
Local variety	0.91	na	1.10	1.05	1.21	1.19
Wheat production ('000 M. Ton)	22	37 [a]	86	932	1124	1454
Wheat yield (M. Ton/ha)	0.56	0.62 [a]	0.82	1.79	1.85	2.36

[a] - Figures for the period 1961-65.
na - Data not available.

4.5.2. Forest Land Use.

Officially forestry was one of the sub-sectors of agriculture in Bangladesh but now operates separately under the Ministry of Environment and Forests (although Bangladesh Bureau of Statistics still considers it as one of the sub-sectors of agriculture when calculating its share of national income). Once covered with dense forests, Bangladesh is now almost devoid of forests as a result of overexploitation and mismanagement over large areas of the country. The remaining forests are situated mainly in remote areas in the east, southeast and southwest of the country (Giri and Shrestha, 1996). A small tract of evergreen and semi-evergreen forest in Chittagong and Sylhet area, deciduous or *sal* forests in the central plains and mangrove forests in the Sundarban area are the major relic forest type. According to recent estimates, total forestland in Bangladesh is about 2.56 mha or 17.8 per cent of the land surface of the country. The forest land of Bangladesh is broadly categorized as State forestland (2.22 mha) and private forestland (0.34 mha) (Table 4.10). State forestland usually consists of two categories. One is classified forest (1.49 mha) controlled by the Forest Department and the other one is unclassified State forest (0.73 mha) also known as USF and administered by the Ministry of Land through local authorities.

However not all of these forests are covered by trees. Inventories show that an overall depletion has taken place in all major forest areas. For example in the Chittagong Hill Tracts, Cox's Bazar and *sal* forest areas about half of the land area controlled by Forest Department lacks tree cover (Anon, 1991; Gain *et al.*, 1998). Some evidence also suggests that only about 6 percent of the country has actual tree cover (Collins *et al.*, 1991 cited in Giri and Shrestha, 1996; Gain, 1998; Salam, *et. al.*, 2000). Bose (1998) also reported that almost half of the forest lands are unproductive with poor stock in most cases and in the worst cases they are covered by scattered trees or lying barren as is the case in unclassed state forests. The condition is very bad in *sal* forests with only 25 percent tree cover (Table 4.15) where as Gain (1998) reported only 10 percent of the *sal* forests are truly covered with the *sal* trees. Interestingly homestead forests are highly productive and efficiently managed compared to the low productivity and under-utilization of reserve forests and other government controlled forestlands. In general homestead forests provide the country as a whole with about 70-80 per cent of timber, 90 per cent of fuel

wood and 90 percent of total bamboo consumption (Khan 1998; Gain, 1998). Homestead forest groves are an integral part of the traditional land use system in Bangladesh. Trees, shrubs, bushes and herbs surround each house. A pond is a common feature of the gardens and various kinds of fish are fed with vegetable and household waste. This system has developed over centuries as a result of long-term adaptation of cultural techniques to local ecological conditions (Mahtab and Karim, 1992).

Table 4.15. Forest types and area in Bangladesh (compiled from Hashem, 1998; Khan, 1998).

Forest Type	Location	Area (mha)	% Of Country's Total Area	Estimated Tree Cover (%)
i) Mangrove Forest (Tropical Evergreen)		0.67	4.58	75
a) Sundarbans	Khulna, Satkhira areas	0.57	3.90	
b) Coastal	Cox's Bazar, Chittagong, Noakhali, Barisal, Patuakhali, & adjacent coastal areas	0.10	0.68	
ii) Hill Forest (Tropical Moist Evergreen)		1.40	9.59	50
a) Hill Forest	Chittagong, Sylhet, Comilla	0.67	4.59	
b) Unclassified State Forest	Rangamati, Bandarban & Khagrachari	0.73	5.00	
iii) Plain Land Sal Forest	Dhaka, Tangail, Mymensingh, Dinajpur & other North Western Part	0.12	0.82	25
iv) Village Forest	All over the country in homesteads	0.27	1.85	80
TOTAL		2.46	16.84	-

The distribution and use of State forestland are shown in Table 4.16. There are about 32 per cent of natural forest areas of which more than 20 per cent are considered good stocked forest. About 50 per cent of the state forests are unproductive with 5 per cent of land assigned to parks and sanctuaries.

Table 4.16. State forestland use in Bangladesh (compiled from ADB, 1995).

Land Cover Type	Area (ha)	Area (%)
Natural Forest	710000	31.7
Medium-Good Density	460700	20.5
Poor Density	82200	3.7
Bamboo	71200	3.2
Scattered Trees/barren	95900	4.3
Plantations	303100	13.5
Jhummed/Encroached	111000	5.0
Total Productive	1124100	50.1
Unproductive	12900	0.6
Parks/Sanctuaries	116700	5.2
Water	90	0.0
Other*	988510	44.1
Total Unproductive	1118200	49.9
Grand Total	2242300	100

* Predominantly Unclassified state Forest (USF)

4.5.2.1. Loss of Forest Cover.

Massive deforestation has been taking place in the Third World, resulting in environmental deterioration and a greater scarcity of forest resources, such as firewood, fodder and timber. Cleared land is generally used for cultivation to feed growing populations, which suggests that the most fundamental cause of deforestation is the expansion of cropland (Otsuka and Place, 2001). Cropper and Griffiths (1994) identified three reasons for tropical deforestation: the desire to convert forest and woodland areas to pasture and cropland, the harvesting of logs, and the gathering of fuel wood. Population pressures are emphasized as an underlying cause of all three sources of deforestation.

Deforestation in Bangladesh is also very alarming with an average annual rate of 3.3 per cent against only 0.8 per cent in tropical developing countries from 1981 to 1990 (Tole, 1998). The multilateral development banks (MDBs), the Forest Department and other authorities generally blame growing population, wide-spread poverty, migration of landless people in the forest areas, shifting cultivation and inappropriate exploitation of forest resources for depletion and degradation of forests in Bangladesh (Gain, 1998). Grazing, illegal felling, fuelwood collection,

uncontrolled and wasteful commercial exploitations are also causes of depletion of forest resources. Table 4.11 presents some statistics on forest cover loss in Bangladesh. Reassuringly forest reached its lowest point during 1991-94 periods has since increased due to positive attempts made by Forest Department, with the help of the Forestry Master Plan (1995-2015). However this does not mean that trees cover all the forest areas. The Forest Department is now concentrating on increasing tree cover intensifying reforestation and afforestation programs on forest lands and other marginal lands like sides of roads, railway lines, embankment and other khas lands. According to Amelung and Diehl (1992) the agriculture sector is one of the main sources of deforestation. Most of the forest loss occurred due to the expansion of agriculture in Bangladesh as in other tropical developing countries. Comparing conversion of forest areas in the past two decades it is clear that rate of conversion to agriculture has decreased from 93 per cent in 1971-80 to 53 per cent in 1980-90 as demand for other uses increasing. Other reasons behind this may be the technological development in agricultural production systems, which require less land and labour input for production (Table 4.17). Demand for other areas is increasing as the country is moving towards development requiring more and more developed areas such as urban areas, industrial sites, roads and infrastructural development etc. This fact is clear from Table 4.18 that shows the changes happening to different land uses. Both forests and agricultural land area decreased between 1992-1998 whereas other land uses increased. This change is probably due to the increase in population of the country and conversion of forest and agricultural land to urban and other developed areas.

Table 4.17. Characteristics of forest conversion to other land uses from 1971-1990 (Source: Amelung and Diehl, 1992).

	1971-80		1980-90	
	(Sq.Km)	(%)	(Sq.Km)	(%)
Conversion to agriculture	500	93	1140	53
Conversion to other land uses	40	7	1010	47
Total forest conversion	540	100	2150	100

Table 4.18. Land use characteristics (compiled from ADB, 1995; FMP, 1992a; NDB, 2001).

Land use type	1992		1998	
	Area (million ha)	(%)	Area (million ha)	(%)
Forests	2.56	17	1.88	13
Agriculture	9.25	63	8.54	58
Other area	2.95	20	4.34	29
Total Area	14.76	100	14.76	100

4.6. Land Use Models.

Land use change is a continuous process and many authors have attempted to describe the underlying causes. Dale *et al.* (2000) suggested that human population can be considered an ultimate cause for many land use changes (although population expansion is affected by many factors, such as political dynamics and policy decisions that influence local and regional trends in suburbanization, urbanization and colonization). The present study also aimed to investigate the major driving forces that affect land use changes, with the hope of establishing some useful land use models for Bangladesh. FAO Production Yearbooks were used as data sources to establish these models. National land use data from 1970 to 1995 were compiled and modelled using SPSS. A number of regression models were tried and models that best fitted the data were chosen to predict future land use changes at the national scale.

Data analysis suggests that land use changes in Bangladesh were related to time and population at the national level (Figures 4.7 & 4.8). However it is apparent that population increases with time (Figure 4.7c). Regression analysis suggested a relationship between forests and time, which was found to be highly significant ($P = <0.001$) whereas the relationship between net-cropped area and time was not significant even at the 0.05 level. This suggests that net-cropped area did not decline over time while forests did (Figure 4.7). However, when so few data points are plotted the overall regression can be affected by one data point. This may have occurred here, as the data point for 1985 seems to be greater than may be expected. As population increases over time so does the demand for more land for settlement, urban and industrial sites, and other development works collectively named here as 'other land uses'. These have significantly increased with the increase of population (Figure 4.8) over this time period (although 'other land uses' also include river

areas that represent a substantial amount of land throughout the country). The statistical significance of the relationship between forests and population and forests and 'other land uses' suggests that forests may be cleared directly by a growing population for 'living space' or alternatively are cleared through secondary causes such as collection of fuelwood. Again, net-cropped area and forests also showed a significant decrease with population increases (Figure 4.8). 'Other land uses' on the other hand was observed to have significant negative correlation with net-cropped area (P value <0.01) and forests (P value <0.05) supporting the fact that net-cropped area and forests decrease with the increase of other land uses (Figure 4.9) that have a strong positive correlation with population (P value <0.001). This is logically inevitable as the total area of the country is constant. To explore this further both forests and net-cropped area were plotted against 'all other land use' separately (Figures 4.10 & 4.11). It was observed that each land use declined with the increase of 'all other land use' but did not produce the expected line of slope –1 (Figures 4.10a & 4.11 a), which may be due to an anomaly in total land area in 1970. This anomaly in total land area may be due to re-arrangement of Bangladesh borders after independence from Pakistan in 1971. To overcome the situation 1970 data were excluded from the database and same relationships were plotted again (Figures 4.10b & 4.11b). It was then observed that the slopes became not significantly different from –1, as expected.

However it was the rural population that significantly described the changes in land use in Bangladesh from 1970 to 1995. It was found that rural population was negatively related to net-cropped area and forests, while it was positively related to other land uses (Figure 4.12).

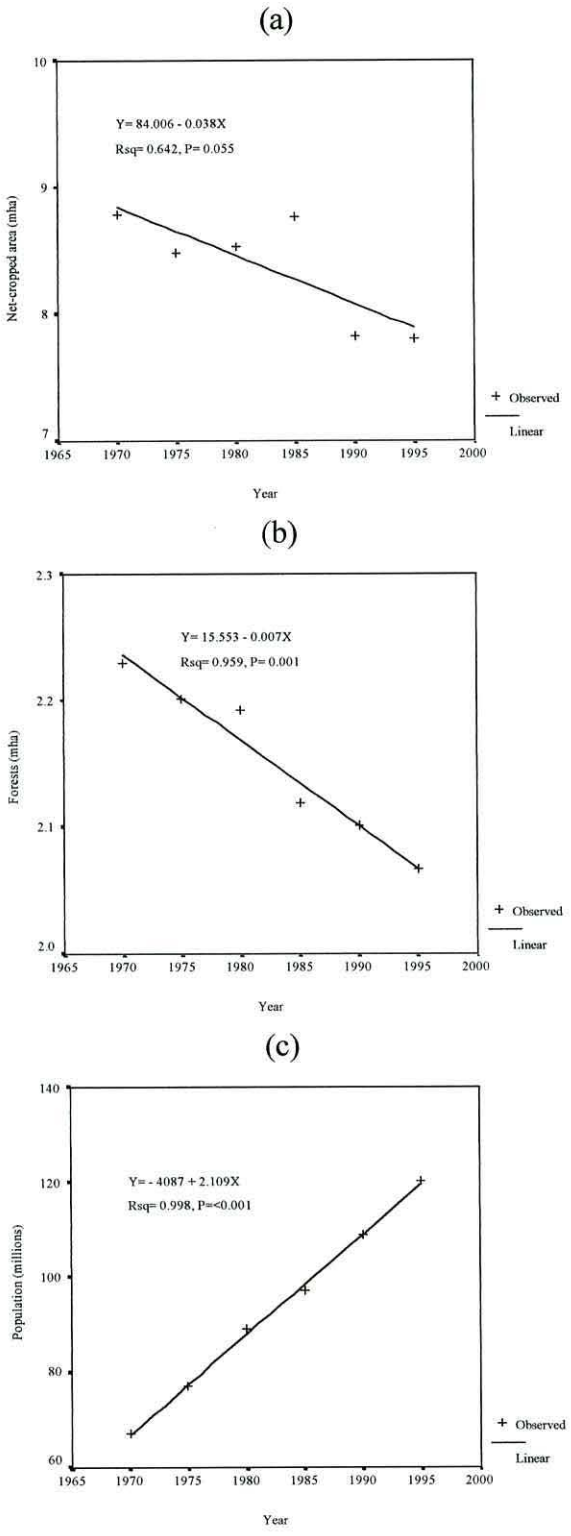
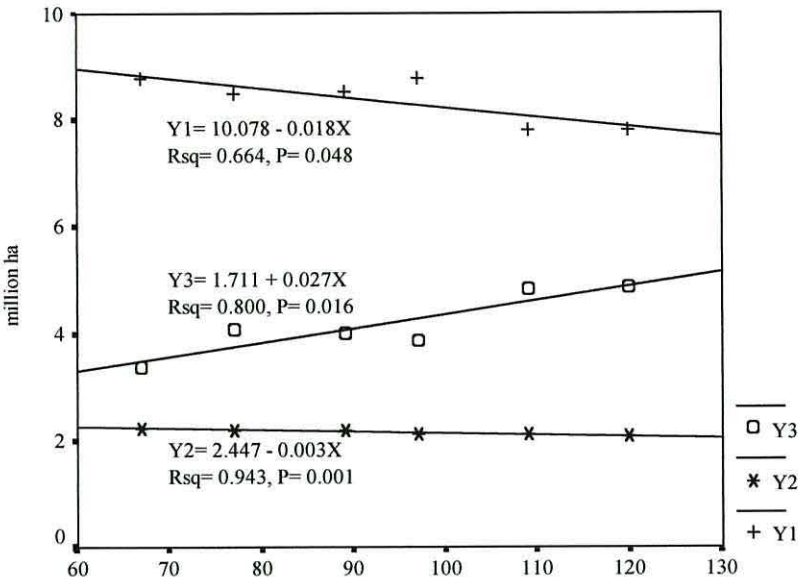
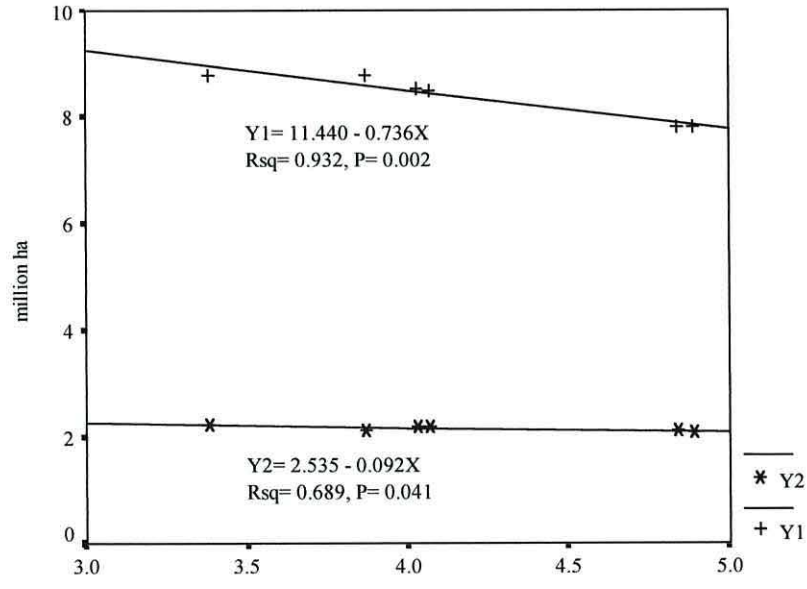


Figure 4.7. Regression models between time and (a) net-cropped area, (b) forests, and (c) population.



Y1= Net-cropped area; Y2= Forests; Y3= Other land uses

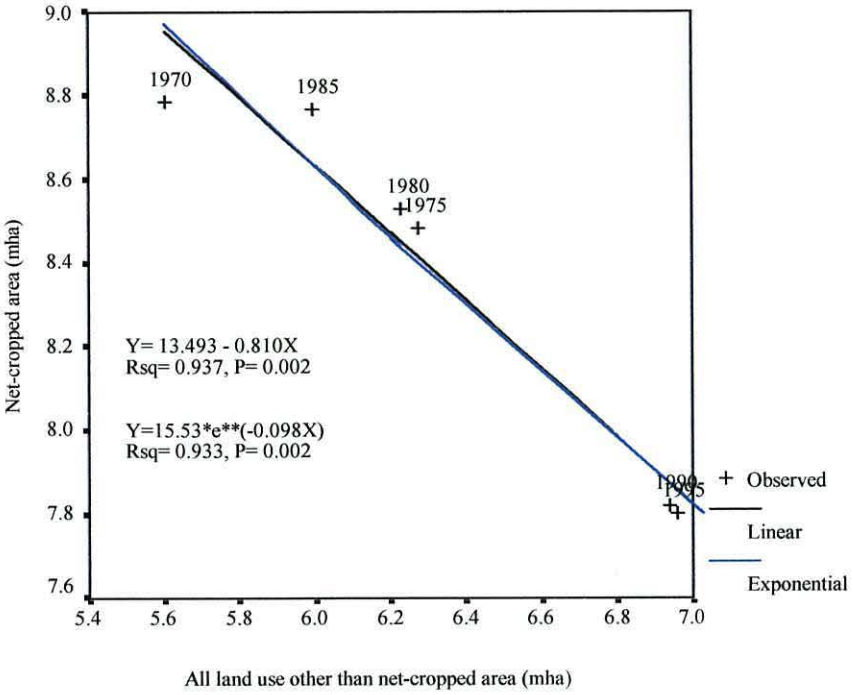
Figure 4.8. Regression models between net-cropped area (mha) (Y1), forests (mha) (Y2), and 'other land uses'(mha) (Y3) against population (millions) (1970-1995).



Y1= Net-cropped area; Y2= Forests

Figure 4.9. Regression models between net-cropped area (Y1) and forests (Y2) against 'other land uses'.

(a)



(b)

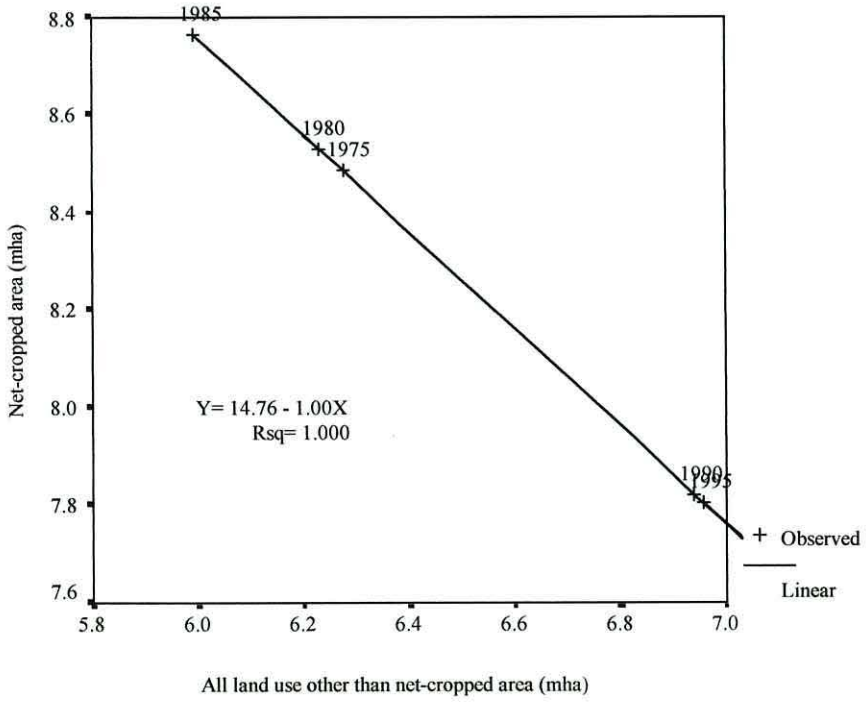
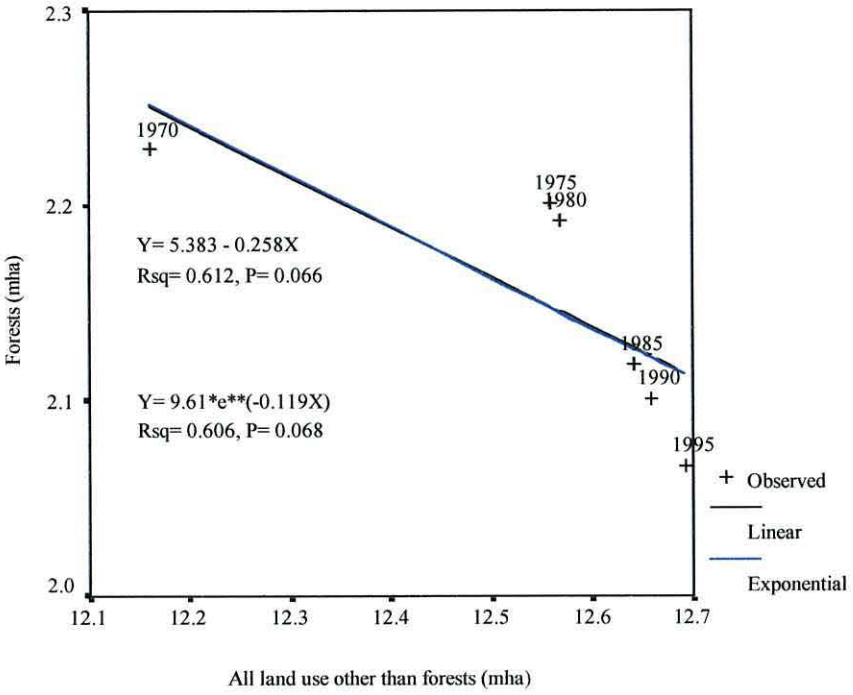


Figure 4.10. Regression models between net-cropped area and 'all land use other than net-cropped area' ((a) using data from 1970-1995, (b) using data from 1975-1995).

(a)



(b)

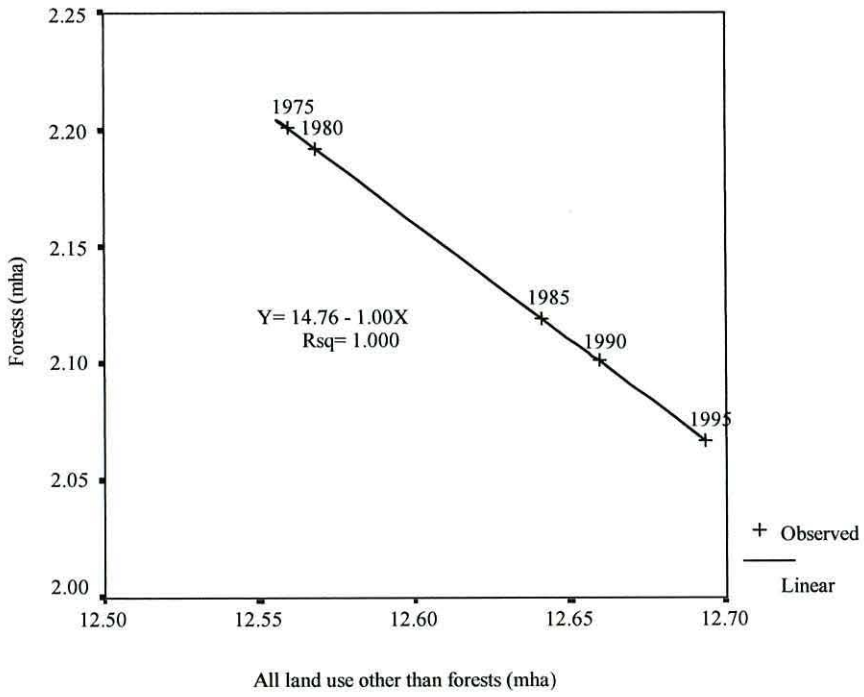


Figure 4.11. Regression models between forests and 'all land use other than forests' ((a) using data from 1970-1995, (b) using data from 1975-1995).

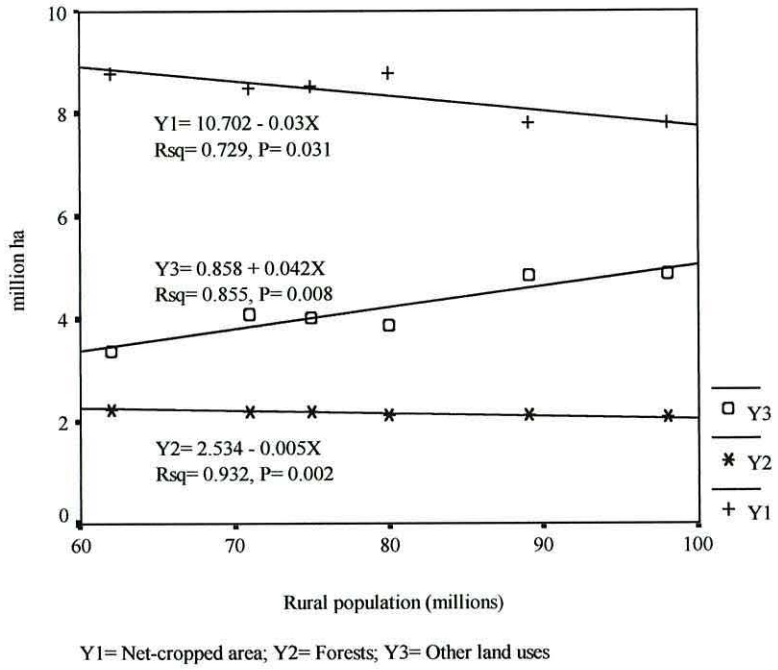


Figure 4.12. Regression models between net-cropped area (mha) (Y1), forests (mha) (Y2), and 'other land uses' (mha) (Y3) against rural population.

4.6.1. Multiple Regression Models.

Major land use changes in Bangladesh were related to time, population and 'other land uses'. Population was found to have a strong positive correlation with time (P value <0.001) that causes 'other land uses' to increase significantly (R^2= 0.80, P <0.05). As a result net-cropped area and forests decreased (Figure 4.9). Based on these relationships the following multiple regression models were established to describe the changes happening to net-cropped area and forests in Bangladesh with respect to population and other land uses at national scale from 1970 to 1995:

NCA = -230.235 - 0.830*OLU+ 0.125*T - 0.055*P (R^2= 0.955, P >0.05).....(Equation 4.1)
(0.571) (0.094) (0.553) (0.588)

NCA = 11.44 – 0.736*OLU (R^2= 0.932, P= <0.01).....(Equation 4.2)
(<0.001) (0.002)

FO = 67.732 - 0.034*T + 0.002*OLU + 0.013*P (R^2= 0.989 ; P= <0.05).....(Equation 4.3)
(0.113) (0.120) (0.944) (0.181)

$$FO = 15.553 - 0.007*T \quad (R^2 = 0.959;\ P = <0.001) \quad \text{(Equation 4.4)}$$
$$(<0.001) \quad (0.001)$$

where, NCA= Net-cropped area (mha), FO= Forests (mha), OLU= Other land uses (mha) and T= Time (year), P= Population (millions) (values in the parentheses express significance value for the respective explanatory variable).

Both stepwise and enter mode were used to conduct the multiple regression analysis using SPSS. Several models were developed but only those models having higher R^2 value are shown here. Stepwise regression analysis showed that 'other land uses' were the significant cause predicting net-cropped area, having lower collinearity with other explanatory variables, time and population (Equation 4.2). Again, forests were found to be negatively related to time but positively related to total population and 'other land uses' but not significantly so (Equation 4.3). However, forests were found to be negatively related to both total population and 'other land uses' separately (Figures 4.8 & 4.9). Stepwise regression revealed that the time trend was a significant cause in predicting forests having a significant negative effect on forests (Equation 4.4) due to deforestation and encroachment. However, more population and 'other land uses' tend to increase forests in the form of homestead plantations and afforestation programmes on other land areas. However this increase of forests cannot substantially overcome yearly deforestation, and has a very small collinearity with time. So both the time trend and population of the country should be considered when predicting future land uses in Bangladesh.

4.7. Discussion.

Time and population pressure were found to be the major driving forces of land use changes in Bangladesh, as in many other developing countries. Historical analysis shows that there was a greater competition between forests and agriculture as population increased. Most of the forests were cleared for cultivation and settlement. But with the introduction of 'the Green Revolution' this competition for land was reduced, as greater production was possible from less land and labour input using high technology, fertilizers and high yielding food grain varieties. As a result the country was put on a development path and other competing land uses come forward such as urbanization, industrialization, roads and infrastructures development. Both forests and

agricultural land uses are facing tremendous pressures from human settlement, industrialization, infrastructure development, road construction and other land uses collectively defined here as 'other land uses' (Figure 4.9). Net-cropped area has decreased as in some places land is being converted to housing, industrial sites, road constructions and other infrastructure development like schools, government or non government office premises, hospitals, business centres and urban development. However in some places forests are under continuous conversion to settlement and agricultural land through encroachment or illegal occupation of forestlands as in *Sal* forests of Modhupur and shifting cultivation as practised in Chittagong Hill Tracts by indigenous population (Gain, 1998) to cope with the population pressure.

This chapter tried to describe the land use and its changes at national scale, which is very difficult as the whole country is not homogeneous in topography or land suitability for different land uses on the one hand and not equally important from the urban development point of view on the other hand. To better understand these changes it is necessary to analyse the whole system at a smaller scale such as divisional, district or village level. The following chapters aim to analyse land use and its changes more elaborately at these different scales.

CHAPTER 5

DIVISIONAL LAND USE ANALYSIS

5.1. Introduction.

There are six administrative divisions in Bangladesh. Each and every division has got its own distinct physical and geographical characteristics. Use of land in different divisions is not the same. Although agriculture is the dominant land use for all the divisions, as for the country as a whole, forests are important land uses from the environmental point of view and there is distinct variability among the divisions. Variability also exists in demographic and socio-economic characteristics among different divisions. This chapter analyses overall land use differences among the divisions and seeks to develop some land use models to understand past land use change and predict future land use change at divisional scale. This is a follow up from the previous chapter but at a rather smaller scale. Considering land use change at different scales may bring different perspectives to understanding past changes, and thereby aid develop more robust and efficient policies for the future.

In this chapter population and land use characteristics have been analysed with respect to divisional scale. Attempts were made to find out the changes happening in the socio-economic and demographic characteristics of the population and as a result the changes in land uses in different divisions.

5.2. Data and Methods.

There is no organised database related to population and land use in national, divisional or district level that could serve the purpose of this study. However different government (BBS, WARPO) and non-government organisations have prepared some databases. But there is no link between these databases. So it became essential for this study to develop a database at divisional scale. As such a divisional database was prepared based on different official data sources like BBS (1999a, 1999b); NDB (2001) and WARPO (2000). The database consists of various data related to population and land use from different dates covering a period of 1996 to 2000. All the data

used in the database assumed unchanged within this 4 year time period, as it was difficult to integrate all the data in one year collected from different sources. All the analysis presented here is based on this database. First the data were compiled to meet the requirements of this study using SPSS. A land use map was also reproduced from SRDI (1996) and was digitised first using Cartalinx and then converted into an IDRISI image file to show the major land uses in different divisions. Updated summary data were then critically analysed using SPSS and some regression models were developed in order to understand how land uses change related to certain key variables. Both linear and quadratic regression models were developed and are discussed. Finally, multiple regression equations were developed to predict the forest and net-cropped area at a divisional scale. Numerous regression models were developed during the work, but only those providing the best fits are presented here.

5.3. Demographic Characteristics.

There exists great variability in area and population characteristics of different divisions (Table 5.1). Divisional area ranges from as low as 9 per cent of the country's total area (Barisal and Sylhet) to as high as 23 per cent (Chittagong and Rajshahi). Dhaka is the most densely populated division with 1365 people per square kilometre with a greater percentage of urban population (30 per cent) due to the capital city being situated in this division (Figure 5.1). The majority of the population are rural ranging from 88 per cent in Sylhet to 70 per cent in Dhaka with a national average of 79 per cent. Most of the households live in Rajshahi and Dhaka divisions consisting of 29 and 28 per cent of the total respectively. Sylhet on the other hand comprises only 6 per cent of total households. On average 66 per cent of total households are farm households and the rest are non-farm households. Again most of the farm households are in the smallest farm size class (range: 86 per cent in Chittagong, 73 per cent in Sylhet).

Table 5.1. Demographic characteristics of different divisions (source: divisional database compiled from BBS, 1999a, 1999b; NDB, 2001; WARPO, 2000).

Characteristics	Barisal	Chittagong	Dhaka	Khulna	Rajshahi	Sylhet	Total
Area ('000 ha)	1330	3377	3112	2227	3451	1260	14757
% of country's total area	9	23	21	15	23	9	100
Population (millions)	8.44	23.89	37.77	14.52	30.13	7.82	122.57
% of country's total	7	19	31	12	25	6	100
Rural (millions)	7.27	18.63	26.32	11.56	25.68	6.9	96.36
% of division total	86	78	70	80	85	88	79
Share of country's total	0.08	0.19	0.27	0.12	0.27	0.07	1.00
Urban (millions)	1.18	5.27	11.45	2.96	4.45	0.92	26.23
% of division total	14	22	30	20	15	12	21
Share of country's total	0.04	0.20	0.44	0.11	0.17	0.04	1.00
Population Density (sq. km)	723	909	1385	751	889	638	883
Total Households	1352016	3174243	4938633	2174009	5083762	1105524	17828187
% of country's total	8	18	28	12	29	6	100
Non-Farm Households	325879	1047617	1719733	655218	1879341	402157	6029945
% of total households	24	33	35	30	37	36	34
Farm Households	1026137	2126626	3218900	1518791	3204421	703367	11798242
% of total households	76	67	65	70	63	64	66
Small (0.02-1.01 ha)	812650	1831982	2629376	1170815	2465629	512341	9422793
% of farm households	79	86	82	77	77	73	80
Medium (1.01-3.03 ha)	184758	264668	527686	305058	637924	157690	2077784
% of farm households	18	12	16	20	20	22	18
Large (>3.03 ha)	28729	29976	61838	42918	100868	33336	297665
% of farm households	3	1	2	3	3	5	3

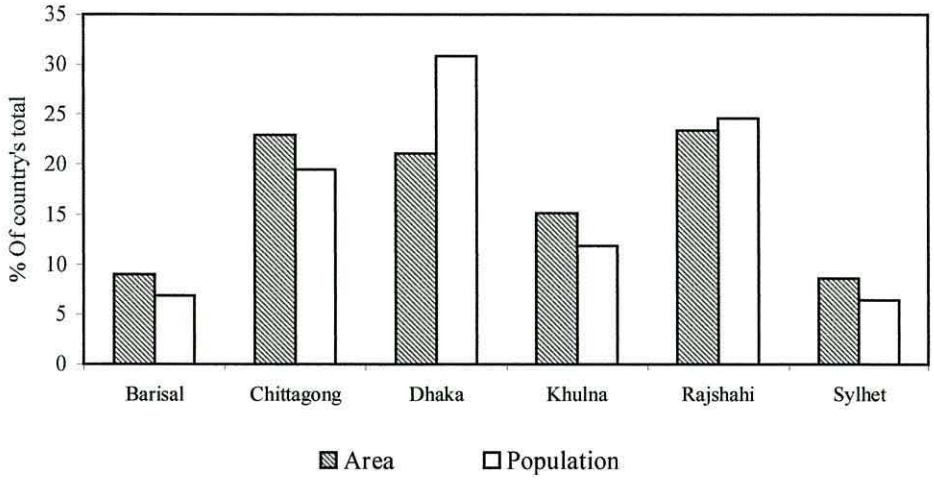


Figure 5.1. Percentage of country's total area and population by division.

The relationship between divisional shares of country's total population and area were plotted and a linear regression line was fitted (Figure 5.2). Dhaka, Chittagong and Khulna were the major outliers from the fitted line (Figure 5.2). This may be due to specific reasons in different divisions. Dhaka, being the capital city, is the centre of all activities and has a denser population than other divisions. As a result Dhaka possesses a greater share of total population than area (Figure 5.3). On the contrary Chittagong and Khulna contain most of the forest areas in Bangladesh and, these two divisions also possess a lower share of total population than area (Figure 5.4). Variability also exists in land distribution per head in the different divisions (Figure 5.5). Barisal had the greatest population per cultivated area and Chittagong the greatest per capita forest area. Although other areas have got influence in proportion of cultivated area or forest area as in Sylhet, as a general rule we can presuppose that cultivated area has got a negative relationship with forest area. Official data sources also show some variability in the distribution of general land types based on elevation in different divisions (Table 5.2) that may have influence on the type of general land use. It is interesting to see that Chittagong comprises more highlands (10.51 per cent) than any other division and contains most of the forestlands in Bangladesh (60.19 per cent). Again, Rajshahi comprises more medium highlands and consists of more net-cropped area (30.18 per cent) than any other division in Bangladesh (Table 5.3).

Table 5.2. Percentage distribution of different land types by divisions (BBS, 1999c).

Division	Highland	Medium Highland	Medium Lowland	Lowland	Very Lowland	Total
Barisal	0.15	5.24	0.46	0.06	0.00	5.91
Chittagong	10.51	4.59	2.40	0.83	0.18	18.51
Dhaka	3.61	7.38	4.19	2.72	0.69	18.59
Khulna	3.09	8.38	1.76	0.39	0.00	13.62
Rajshahi	4.40	13.40	1.96	1.30	0.11	21.16
Sylhet	1.30	2.03	1.43	2.31	0.52	7.59
Total	23.07	41.02	12.18	7.61	1.50	85.39
			Miscellaneous Land Types			
				Homestead	7.53	
				Urban	0.55	
				Rivers, beels, etc.	6.53	
				Total		14.61
Grand Total						100.00

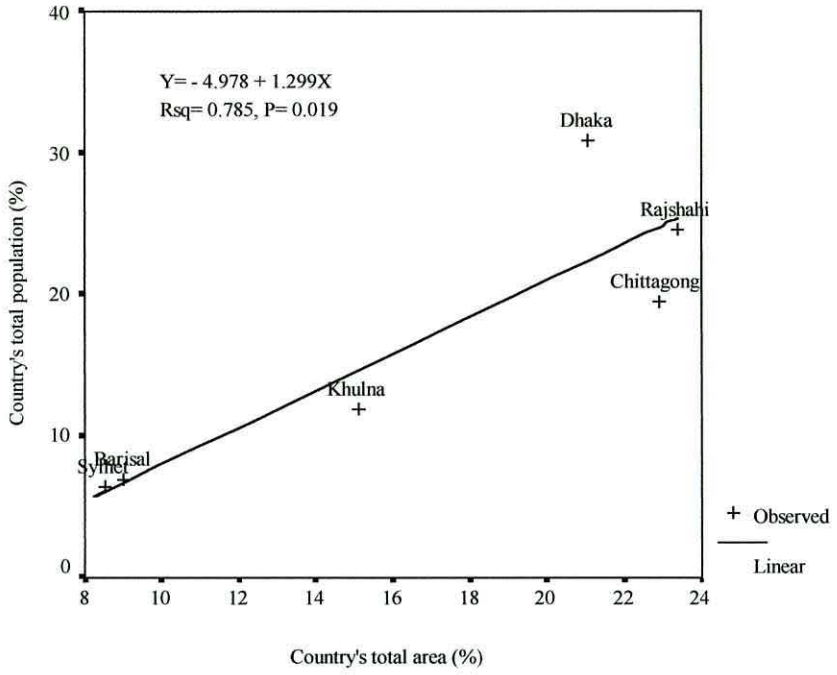


Figure 5.2. Relationship between divisional share of country's total population and area.

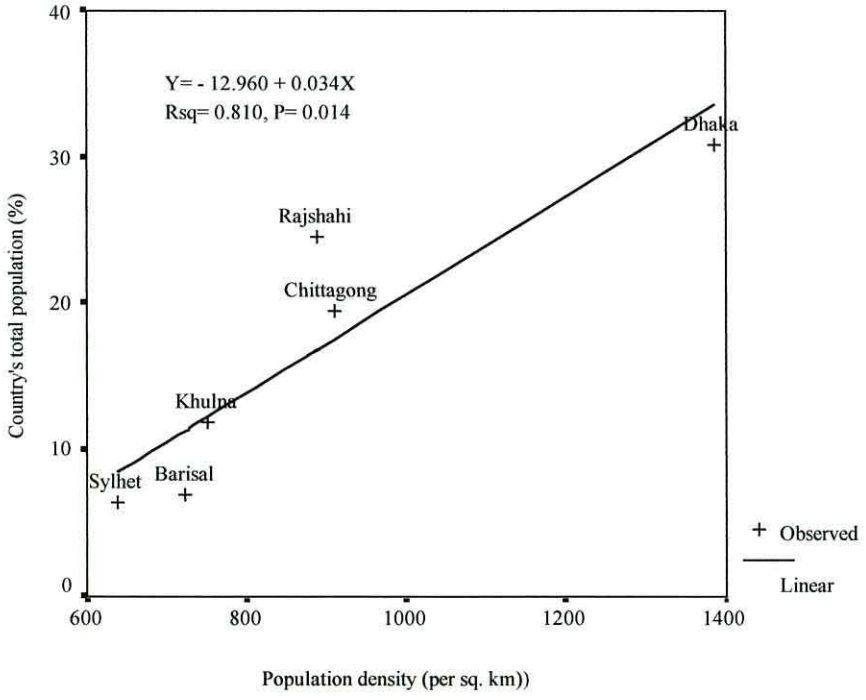


Figure 5.3. Relationship between divisional share of country's total population (%) and population density (per sq. km).

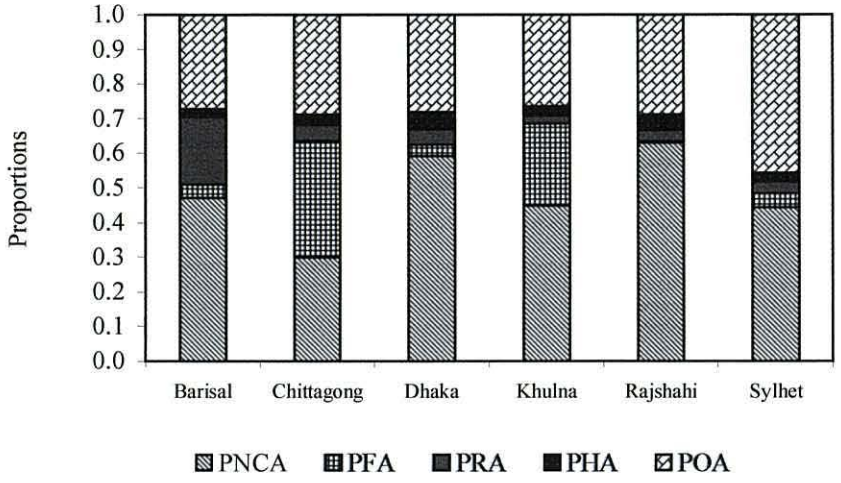


Figure 5.4. Proportional distribution of different land uses by divisions (PNCA= Proportion of Net-cropped Area; PFA= Proportion of Forest Area; PRA= Proportion of River Area; PHA= Proportion of Homestead Area; POA= Proportion of Other Area) (Source: divisional database).

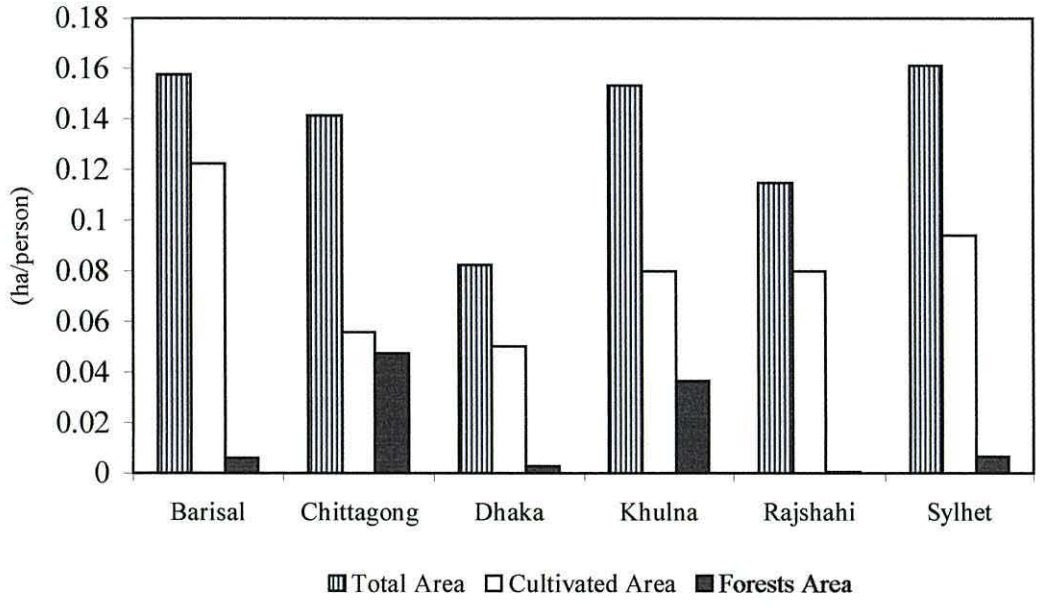


Figure 5.5. Distribution of area per person by divisions (Source: divisional database).

5.4. Land Use Characteristics.

Land use characteristics in different divisions are also different from each other as shown in Table 5.3. Despite some greater variability in Chittagong and Khulna general land use is more or less the same in different divisions with agriculture being the major land use (Figure 5.6). Operated area, (the area owned by a farm holding plus the area rented from others minus the owned area given to others for operation (BBS, 1999b)), by the farm households varies from 72 per cent in Rahshahi to 36 per cent in Chittagong related to divisional area. This also suggests that the greater the operated area the less will be the forest area and vice versa. Net-cropped area

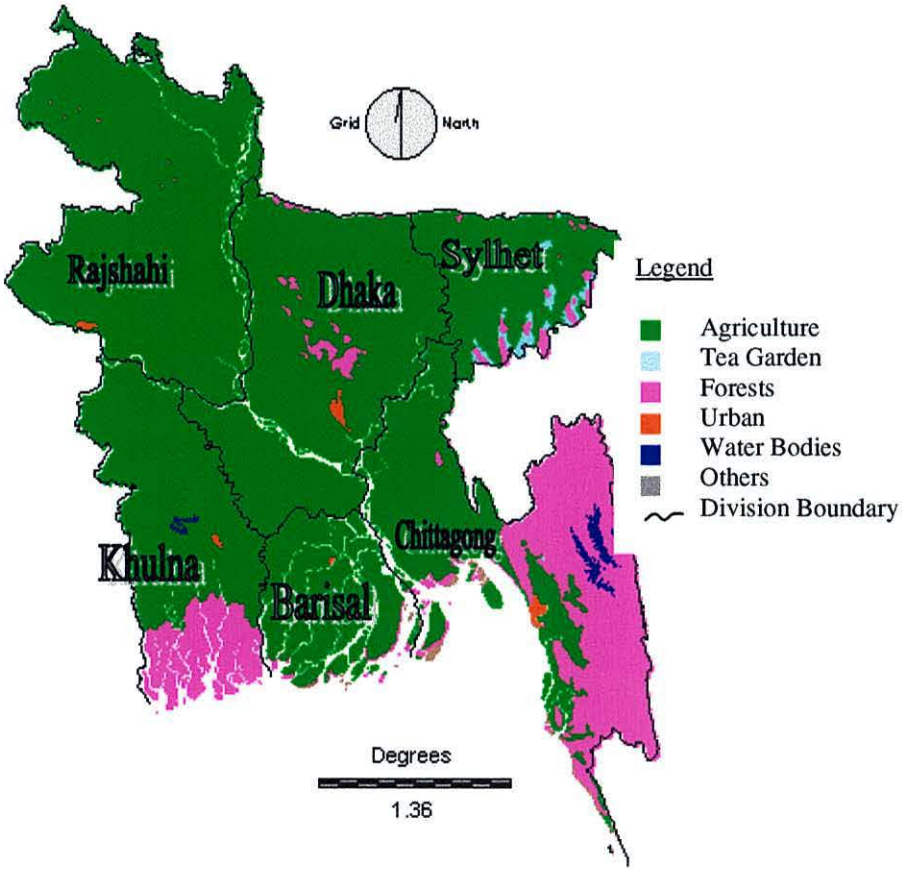


Figure 5.6. Major land uses by division (1996).

ranges from 83 to 90 per cent in different divisions. Homestead area per household is more or less the same in all the divisions (0.03 ha) but net-cropped area varies between 0.50 ha per household in Sylhet and 0.32 ha in Chittagong. Technological innovations adopted by each division are also different. For example Rajshahi has 66 per cent of its net-cropped area under irrigation and 91 per cent under fertilizer, where as the values for Barisal are 9 and 55 respectively.

Table 5.3. Land use characteristics of different divisions (source: divisional database compiled from BBS, 1999a, 1999b; NDB, 2001; WARPO, 2001).

Characteristics	Barisal	Chittagong	Dhaka	Khulna	Rajshahi	Sylhet
Total area ('000 ha)	1330	3377	3112	2227	3451	1260
Operated area ('000 ha)	694	1218	2122	1147	2478	631
% of divisional area	52.18	36.06	68.19	51.48	71.81	50.09
Operated area per household (ha)	0.51	0.38	0.43	0.53	0.49	0.57
Homestead area ('000 ha)	33	99	154	66	149	33
Homestead area per household (ha)	0.02	0.03	0.03	0.03	0.03	0.03
Net-cropped area ('000 ha)	626	1007	1835	995	2171	558
% of operated area	90	83	86	87	88	88
% of divisional area	47.09	29.81	58.97	44.67	62.90	44.29
% of country's total area	4.24	6.82	12.44	6.74	14.71	3.78
% of country's net-cropped area	8.71	14.00	25.52	13.84	30.18	7.76
Net-cropped area per household (ha)	0.46	0.32	0.37	0.46	0.43	0.50
Net irrigated area ('000 ha)	57	404	928	461	1424	201
% of net-cropped area	9.13	40.13	50.56	46.29	65.60	36.03
Net area under fertilizer ('000 ha)	343	767	1504	686	1966	317
% of net-cropped area	54.84	76.20	81.97	68.92	90.58	56.90
Fallow land ('000 ha)	38	131	176	44	129	105
% of divisional area	2.83	3.87	5.65	1.98	3.74	8.37
Forest area ('000 ha)	50	1134	106	530	14	50
% of divisional area	3.79	33.57	3.39	23.79	0.41	3.95
% of country's total area	0.34	7.68	0.72	3.59	0.10	0.34
% of country's forest area	2.67	60.19	5.61	28.13	0.75	2.64
River area ('000 ha)	258	162	139	50	121	43
% of divisional area	19.39	4.81	4.46	2.23	3.49	3.43
% of country's total area	1.75	1.10	0.94	0.34	0.82	0.29
% of country's river area	33.38	21.03	17.98	6.42	15.61	5.59

Rice is the dominant crop in each division composing up to 94 per cent of gross cropped area in Sylhet, and only 66 per cent in Khulna, the lowest for any division (Table 5.4). Rice also composes more than 90 per cent of total cereal area in different divisions. Rice cropping intensity varies from 126 in Chittagong to 99 in Khulna. Cropping intensity is also found different in different divisions varying from 135 per cent in Sylhet to 181 per cent in Chittagong. It is interesting to see that cropping intensity also varies among farm types. Small farms tend to have more intensive cropping than medium and large farms (Table 5.4). This is probably because small farmers want to get as much crop as they can from their limited amount of land.

Table 5.4. Agricultural land use by divisions (source: database compiled from BBS, 1999a, 1999b; NDB, 2001; WARPO, 2001).

Items	Barisal	Chittagong	Dhaka	Khulna	Rajshahi	Sylhet
Net-cropped Area (ha)	626092	1006864	1835142	995010	2170821	557883
Gross Cropped Area (ha)	952285	1616820	3109695	1482990	3739509	679378
Net Temporary Cropped Area (ha)	542347	885693	1717047	903782	2089563	518866
Area under permanent crops (ha)	79415	112313	106971	84690	69953	33709
Cereal (ha)	750578	1328343	2318389	1086691	2944777	641329
% of gross cropped area	79	82	75	73	79	94
Rice (ha)	740445	1269989	2156186	984827	2643286	636122
% of cereal area	99	96	93	91	90	99
% of gross cropped area	78	79	69	66	71	94
Rice intensity (%)	118	126	117	99	122	114
Wheat (ha)	9967	53841	159048	101067	287020	4985
% of cereal area	1	4	7	9	10	1
% of gross cropped area	1	3	5	7	8	1
Minor Cereal (ha)	166	4512	3156	797	14471	222
Pulses (ha)	122766	44589	152984	111378	102467	1842
% of gross cropped area	13	3	5	8	3	0
Oilseeds (ha)	9680	59683	181691	63709	156193	8788
% of gross cropped area	1	4	6	4	4	1
Cash Crops (ha)	7949	36117	238891	150052	293254	3180
% of gross cropped area	1	2	8	10	8	0
Vegetables (ha)	18694	86848	102836	36772	148403	17658
% of gross cropped area	2	5	3	2	4	3
Spices (ha)	42452	61042	113876	34285	93323	6581
% of gross cropped area	4	4	4	2	2	1
Others (ha)	167	198	1028	103	1093	0
Cropping Intensity (%)	173	181	179	167	180	135
Small Farms (0.02-1.01 ha)	187	191	192	177	191	145
Medium Farms (1.01-3.03 ha)	177	179	177	162	175	131
Large Farms (>3.03 ha)	158	159	159	145	164	118
Total Farms	176	183	181	164	179	131

The distribution of state forestlands also varied greatly in different divisions. Most of the forestlands are concentrated in Chittagong (63 %) and Khulna (26 %). The remaining divisions have got very little forestlands comprising only 1 per cent in Rajshahi to 5 per cent in Dhaka of the country's total forestlands (Table 5.5).

Table 5.5. Area and distribution of forest types in Bangladesh (compiled from Appendix 6.1).

Division	Reserved Forest (ha)	Protected Forest (ha)	Acquired Forest (ha)	Vested Forest (ha)	Unclassed State Forest (ha)	KhasLand (ha)	Total Forest Land	
							(ha)	(%)
Barisal	34402.53	0.00	0.00	0.00	0.00	7714.72	42117.25	2
Chittagong	668930.80	36074.71	4010.69	2635.29	658945.51	0.00	1370597.00	63
Dhaka	104277.16	0.00	238.79	86.66	0.00	1075.94	105678.55	5
Khulna	577039.74	0.00	0.00	0.00	0.00	49.98	577089.73	26
Rajshahi	6419.52	2424.76	960.54	5812.60	0.00	1226.54	16843.96	1
Sylhet	70451.83	0.00	4424.03	0.00	1727.32	0.00	76603.18	3
Total	1461521.59	38499.47	9634.04	8534.56	660672.82	10067.18	2188929.66	100

5.5. Land Use Models.

An attempt has been made to analyse land use and its changes at divisional scale. Due to a lack of time series data these analyses were conducted on cross-sectional data. Attempts were made to fit some land use models to predict future land uses at divisional scale. However modelling land uses at divisional scale is difficult as they are an administrative structure that does not reflect natural boundaries of environmental or social system and are generally too large to be homogeneous. A number of models were developed for this purpose and the models that best fit the data are shown. Although there are many factors that can affect land use, population was found to be the most important variable in every case. The proportion of forest area was found negatively related to number of households per square kilometre whereas proportion of net-cropped area was found to be significantly positively related to number of households per square kilometre (Figure 5.7). In the case of forests the fitted linear model was non-significant at the 0.05 level, and both Chittagong and Khulna divisions lie well above the fitted line. These divisions are naturally forest rich (Table 5.5) and it may be said that the geographical location determines the amount of forests in different divisions.

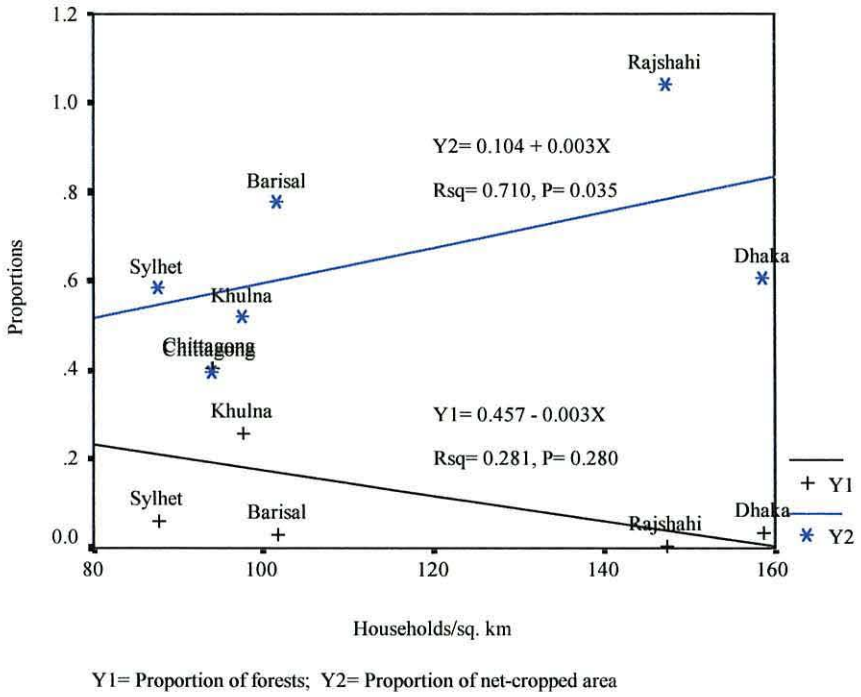


Figure 5.7. Relationship between forests and net-cropped area against number of households per square kilometre by divisions (1996-2000).

The relationship between forests and net-cropped area is portrayed in Figure 5.8. Here it is clear that forest area decreases as net-cropped area increases. Both negative exponential and linear regression models are significant at <0.05 level (Figure 5.8). However the negative exponential model seems a better fit to the data set explaining more variation than the linear one. It also has a more sensible interpretation than the linear model, as forests can never be zero or negative in practical terms. Again, the proportion of forest area was found to be negatively related to 'settlement & other area'; an area calculated from settlement area and all other areas except forests, net-cropped area and river area (Figure 5.9). Here as well, the negative exponential model shows a more sensible relationship between forests and 'settlement and other area' than the linear model although the relationship is not significant in either case. Net-cropped area on the other hand had a positive relationship with 'settlement and other area' (Figure 5.10), which was again found to be non-significant for both linear and negative exponential models at the 0.05 level.

Net-cropped area per household decreased with the increase of population density and households per hectare (Figure 5.11). This may be because more population means more households and as a result net-cropped area per household decreases. Again, an increase in the number of household per square kilometre also increases net-cropped area and decreases forest area (Figure 5.7) supporting the fact that forests and net-cropped area are both negatively related to each other (Figure 5.8).

As rice is the dominant crop in all the divisions, and in Bangladesh as a whole, it can be considered as the country's major item of food production. Increase of net-cropped area per square kilometre certainly increases total food production in terms of rice production and rice yield as well (although both these relationships are non significant at <0.05 level)(Figure 5.12). However this increase in net-cropped area is not the only solution to increasing the country's total food production. Bangladesh is the most densely populated country in the world and slowly progressing towards development, and there is certainly a point to come beyond which there is no way to increase net-cropped area as other forms of land use will compete with this, such as human settlement and urbanization, industrialization, development works etc. Increasing the cropping intensity and adopting technological development are acceptable alternatives to this problem. Bangladesh has already made good progress in developing its cropping sector adopting new technology and increasing cropping intensity known as 'Green Revolution'. Increasing cropping intensity reduces rice yield per ha but it certainly increases total rice production (Figure 5.13) irrespective of divisional area (although both the relationship are non significant at <0.05 level).

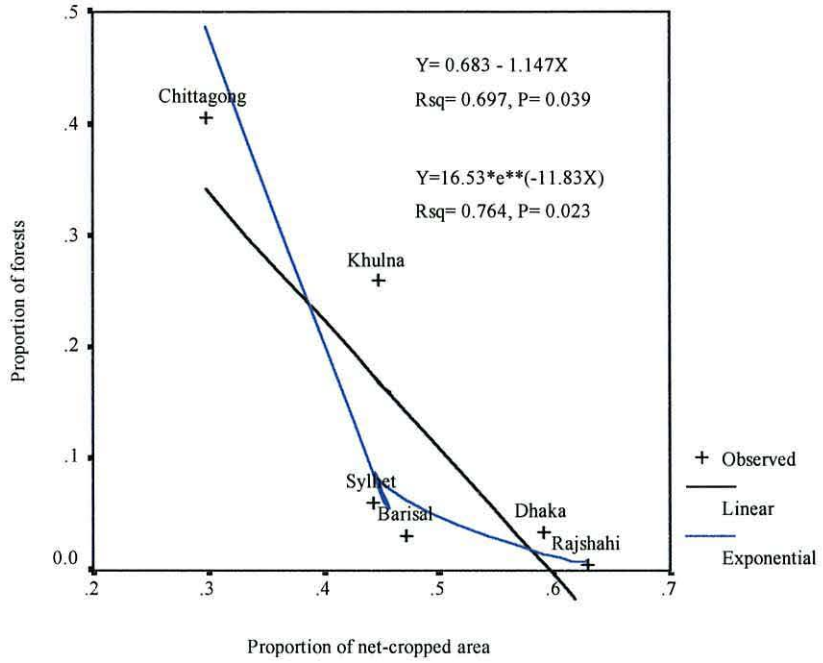


Figure 5.8. Relationship between forests and net-cropped area by divisions.

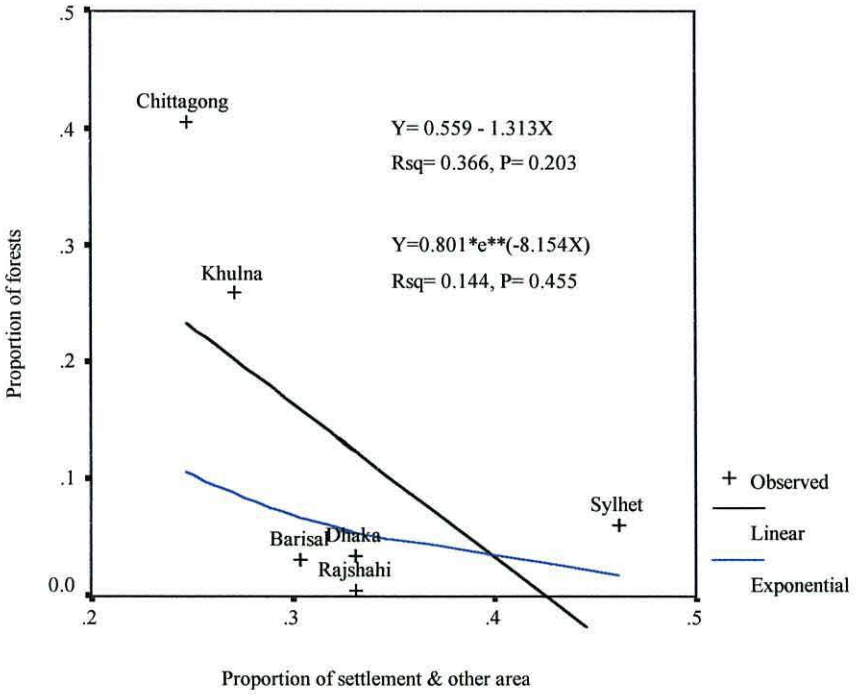


Figure 5.9. Relationship between forests and 'settlement & other area' by divisions.

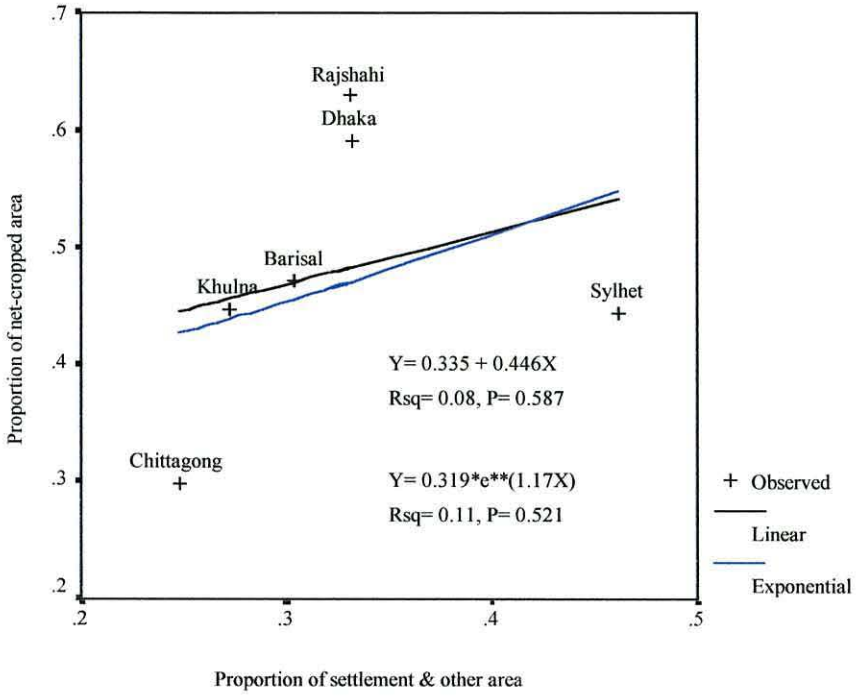


Figure 5.10. Relationship between net-cropped area and 'settlement & other area' by divisions.

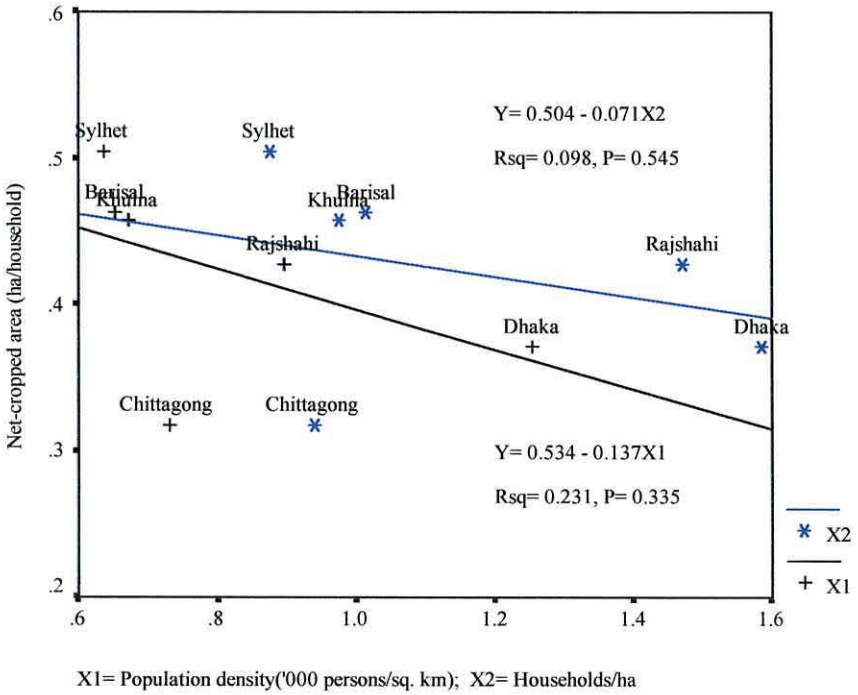
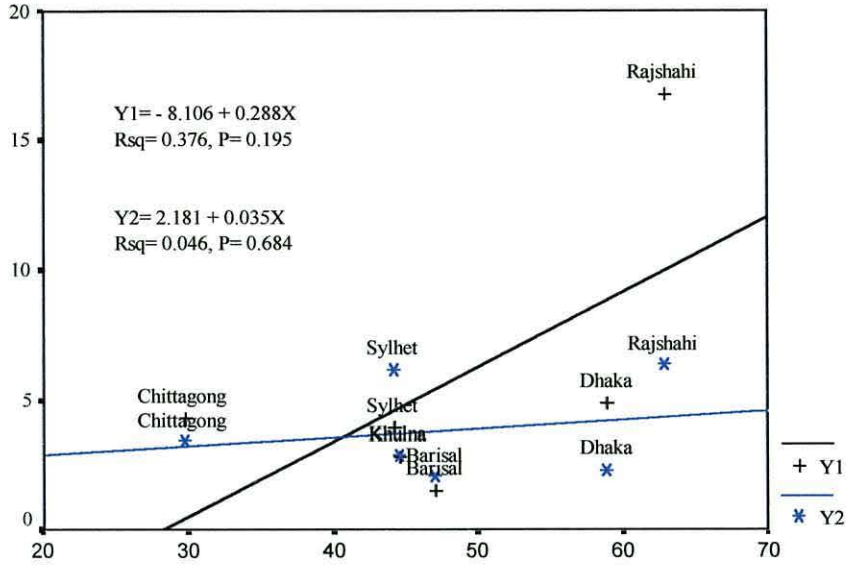
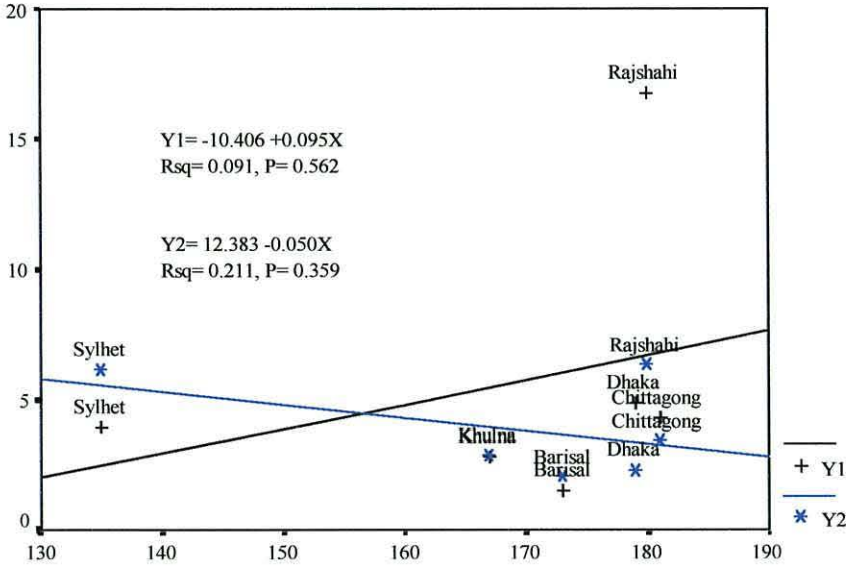


Figure 5.11. Relationship between net-cropped area (ha/household) against population density ('000 person/ha) and households (households/ha) by divisions.



Y1= Rice production (million ton); Y2= Rice yield (M.ton/ha)

Figure 5.12. Relationship between rice production (million ton) and rice yield (M.ton/ha) against net-cropped area (ha/sq. km) by divisions.



Y1= Rice production (million ton); Y2= Rice yield (M.ton/ha)

Figure 5.13. Relationship between rice production (million ton) and rice yield (M.ton/ha) against cropping intensity (%) by divisions.

5.5.1. Multiple Regression Models.

Based on the above discussion several multiple regression models were developed in order to describe the relationship between net-cropped area and forests in Bangladesh at a divisional scale. Models that explained more variation and having higher R^2 were considered first. However, non-significant models were also considered to show the possible relationship between forests and net-cropped area with the explanatory variables indicating their relative significance value (P value). Stepwise regression analysis was conducted in every case. Forests had a significant negative relationship with net-cropped area (Equation 5.2). On the other hand net-cropped area was found to have significant positive relationship with total households per square kilometre (Equation 5.4), which is significantly positively related with population density (Figure 5.5).

PFA = 0.826 – 1.379*PNCA + 0.002*TH – 0.674*PSOA (R^2= 0.864, P= >0.05).....(Equation 5.1)
(0.084) (0.234) (0.647) (0.435)

PFA = 0.683 – 1.147*PNCA (R^2= 0.697, P= <0.05).....(Equation 5.2)
(0.021) (0.039)

PNCA = - 0.093 + 0.005*TH + 0.384*PSOA– 0.0005*UP (R^2= 0.895, P= >0.05).....(Equation 5.3)
(0.626) (0.074) (0.411) (0.328)

PNCA= 0.104 + 0.003*TH (R^2= 0.710, P= <0.05).....(Equation 5.4)
(0.447) (0.035)

TH= 20.898 + 0.116*PD (R^2= 0.833, P= 0.011).....(Equation 5.5)
(0.391) (0.011)

where, PFA= Proportions of forest area; PNCA= Proportions of net-cropped area; PSOA= Proportion of settlement and other area; TH= Total households per sq. km; UP= Urban population per sq. km, PD= Population density per sq. km (values in the parentheses express significance value for the respective explanatory variable).

This implies that as population increases, total households also increase requiring more land for settlement and other uses and this ultimately increases net-cropped area to produce more food and to employ the growing labour force. Again, urban population per square kilometre has a negative relationship with the net-cropped area meaning increases in the urban population will decrease net-cropped area (Equation 5.3). This is probably due to the fact that more and more agricultural land will be converted to urbanization, industrial sites and other development works.

As a general rule population growth encourages deforestation in the form of encroachment or illegal occupation for agriculture or settlement. This means more population will require more agricultural land and settlement area causing forest area to decrease. It is interesting to see here that forest area increases with the increase of total households per square kilometre and decreases with the increase of settlement and other area (Equation 5.1) although there exists a negative relationship between forests and number of households per square kilometre (Figure 5.7).

5.6. Discussion.

Due to lack of time series data at divisional scale this study relied on cross-sectional data to understand the actual situation regarding land use and its characteristics. Based on the cross-sectional data analysis it is observed that population and demographic characteristics are the major causes of land use differences at the division level. The two major land uses considered here are forests and agriculture. Net-cropped areas were found to increase with the increase of total households, and settlement and other area that are positively related to population. Forest area decreases with the increase of net-cropped area as population pressure pushes some people to encroach and convert forestlands to settlement and agriculture. Variation was also observed between the land use characteristics (Table 5.3), especially agricultural land use (Table 5.4) among different divisions. However at this scale it is not possible to identify some specific reasons behind different land uses at different locations. Chittagong and Khulna divisions comprise most of the forests in Bangladesh and this may be explained by the geographical locations and presence of distinct environmental conditions, which support forests such as hill forests in Chittagong division and mangroves in Khulna division. Again not all the districts in different divisions are equally rich in forest areas. Topography and physiography make it so complicated at this larger scale that it is hard to find specific reasons to explain land use change at divisional scale. Administrative boundaries on the other hand do not show any homogeneity in land use among the divisions. A lack of temporal data related to land use at divisional scale also restricts proper understanding of the land use and land use changes in different divisions. Proper understanding of the land use and land use changes can help policy makers to decide rational land use among competing land uses to meet the demand of the growing population and at the same time meet the country's development needs. This work has tried to develop some land use models

at divisional scale. But due to small number of sample data (n= 6) and lack of homogeneity in land uses among different divisions it was not possible to understand clearly the land use and land use change at this larger scale. So it may be better to investigate this question at a rather smaller scale to better understand the exact land uses of each region in Bangladesh. Chapter 6 describes such an investigation at district level.

CHAPTER 6

DISTRICT LAND USE ANALYSIS

6.1. Introduction.

Each division in Bangladesh is further divided into districts for ease of administration, each headed by a Deputy Commissioner (DC). There are at the moment 64 districts in Bangladesh. Each and every district has got its own distinct physical and geographical characteristics. Use of land in the different districts is not the same. Agriculture is the dominant land use for all the districts, as for divisions and the country as a whole. Forests that contribute to the economic and ecological stability are mostly located in specific districts with some distinct physical and geographical characteristics. Only 40 districts have got public forestlands (Appendix 6.1). The rest have no forest at all (here forests meant state owned forests only). But there also exist small tree/fruit gardens, known as village forests in and around the homesteads in every household in Bangladesh, and these play a substantial role in meeting the demands of forest products. Tea gardens in some places also contribute to forest products in Bangladesh. This chapter analyses overall land use differences among the districts and tries to develop some land use models to help understand current land use and to predict future land use change at this scale.

In this chapter population and land use characteristics has been analysed with respect to district scale. Attempts were made to discover the changes happening in the socio-economic and demographic characteristics of the population and as a result all the changes to its land uses in different districts.

6.2. Data and Methods.

There is no organised database related to population and land use in national, divisional or district level that could serve the purpose of this study. However different government (BBS, WARPO) and non-government organisations have prepared some databases. But there is no link between these databases. So it became essential for this study to develop a database at district scale. As such a district database, like the divisional one, is prepared based on different official data

sources like BBS (1999a, 1999b; NDB (2001) and WARPO (2000). The database consists of various data related to population and land use from different dates covering a period of 1996 to 2000. All the data used in the database were assumed unchanged within this 4 year time period, as it was difficult to integrate all the data in one year collected from different sources. All the analysis presented here is based on this database. First the data were compiled to meet the requirements of this study using SPSS. A land use map was reproduced from SRDI (1996) and was digitised first using Cartalinx and then converted into an IDRISI image file to show the major land uses in different districts. In addition to this a district map (ARC View shape file showing 64 districts from WARPO) was also reproduced to show and redefine each district with inundation land types considering only the major unit in each district from MOA (1985). This inundation land type map was used to analyse the database in order to see if there is any difference in land use among different districts. Updated summary data were then critically analysed using SPSS and some regression models were developed in order to understand how land uses change related to certain key variables. Both linear and negative exponential regression models were developed and are discussed. While modelling land uses regression lines that better fit the data were considered. Finally, multiple regression equations were developed to predict the forest and net-cropped area at district scale. Numerous regression models were developed during the work, but only those providing the best fits are presented here.

6.3. Demographic Characteristics.

There exists great variability in demographic as well as socio-economic characteristics of different districts. Population density may be an important characteristic in determining land use and demand for development works. Population density varies from as low as 62 persons per sq. km in Bandarban to as high as 5367 in Dhaka, which is also the capital city of Bangladesh, with an average of 972 for the country as a whole (Table 6.1). The annual rate of population growth was found to be greater in urban areas compared to rural areas. Average annual population growth rate for the country was 2.05 per cent with 1.73 in rural areas and 3.31 in urban areas (Table 6.1). Literacy, another important criterion in describing the overall development of a country, is far below the expected level of total literacy. Less than half of the population are currently literate. Literacy rates range from 79.3 to 37.7 per cent in different districts. But the

literacy rate is increasing with an annual growth rate of 6.66 per cent for the country as a whole. If this growth rate continues than 100 per cent population will be literate by 2010 assuming a constant rate of literacy.

Table 6.1. Demographic characteristics of different districts (source: district database compiled from BBS, 1999a, 199b; NDB, 2001; WARPO, 2000).

District Name	Total Area (sq. km)	Population Density (per sq. km)	Population Growth Rate (%)			Literacy (%)	Literacy Growth Rate (%)
			Rural	Urban	Total		
Barguna	1832	492	1.57	4.27	1.82	56.1	4.91
Barisal	2791	919	1.51	3.14	1.76	60.1	4.90
Bhola	3403	511	1.77	3.30	1.98	38.7	7.13
Jhalakati	758	1023	1.54	3.53	1.80	70.6	4.70
Patuakhali	3205	457	1.40	3.63	1.65	50.3	4.73
Pirojpur	1308	935	1.44	3.05	1.65	67.7	4.85
Bandarban	4479	62	2.38	2.24	2.33	41.6	8.30
Brahmanbaria	1927	1327	1.91	4.05	2.18	45.5	7.97
Chandpur	1704	1415	2.53	-2.49	2.13	51.3	4.46
Chittagong	5283	1219	1.60	3.02	2.26	61.9	5.27
Comilla	3085	1560	1.89	4.87	2.18	42.6	3.67
Cox's Bazar	2492	687	2.05	3.96	2.33	40.6	9.22
Feni	928	1412	1.92	5.01	2.21	58.1	5.22
Khagrachari	2700	153	2.36	2.00	2.24	43.5	7.45
Lakshmipur	1456	1071	1.80	3.75	2.09	53.2	6.47
Noakhali	3601	1015	1.93	4.05	2.16	58.1	6.62
Rangamati	6116	77	2.33	1.03	1.87	58.1	6.87
Dhaka	1464	5367	0.08	3.92	3.51	79.3	5.67
Faridpur	2073	843	1.56	3.59	1.78	46.4	7.59
Gazipur	1741	1116	1.97	2.27	2.09	60.9	7.55
Gopalganj	1490	818	1.41	4.66	1.66	51.3	4.30
Jamalpur	2032	1081	1.68	3.66	1.92	37.7	8.35
Kishorganj	2689	995	1.55	3.21	1.77	40.6	8.26
Madaripur	1145	1080	1.50	4.28	1.74	49.3	6.09
Manikganj	1379	978	1.37	4.36	1.62	43.5	7.11
Munshiganj	955	1429	1.40	3.75	1.63	51.3	5.27
Mymensingh	4363	1056	1.99	0.65	1.83	42.6	7.61
Narayanganj	759	2561	1.59	0.22	0.90	61.9	6.51
Narsingdi	1141	1694	1.69	2.75	1.86	46.4	6.63
Netrakona	2810	719	1.65	4.29	1.87	42.6	7.31
Rajbari	1119	875	1.68	3.88	1.92	44.5	7.74
Shariatpur	1181	930	1.44	4.68	1.69	42.6	8.29
Sherpur	1364	978	1.70	3.94	1.92	37.9	9.96
Tangail	3414	1029	1.66	4.02	1.90	42.6	5.44
Bagerhat	3959	423	1.63	3.44	1.88	57.1	3.69
Chuadanga	1158	820	1.65	2.61	1.90	39.7	6.71
Jessore	2567	967	1.73	3.52	1.98	51.3	6.32
Jhenaidah	1961	817	1.68	3.82	1.97	41.6	7.00
Khulna	4395	559	1.26	3.30	2.31	68.7	6.61
Khustia	1621	1086	1.66	3.90	1.92	42.6	7.43
Magura	1049	809	1.64	5.32	1.94	44.5	6.73
Meherpur	716	807	1.70	4.41	1.97	38.7	7.65

Table 6.1. continued.

Narail	990	742	0.97	3.68	1.26	51.3	5.32
Satkhira	3858	481	1.53	4.53	1.80	48.4	6.82
Bogra	2920	1088	1.91	3.96	2.15	50.3	8.51
Dinajpur	3438	781	1.88	3.59	2.11	45.5	6.23
Gaibandha	2179	1062	1.87	5.19	2.12	37.7	6.48
Joypurhat	965	940	1.84	4.09	2.09	55.2	9.00
Kurigram	2296	823	1.92	2.40	1.99	37.7	7.79
Lalmonirhat	1242	861	1.05	3.00	1.28	43.5	9.00
Naogaon	3436	741	1.85	4.83	2.11	51.3	8.81
Natore	1896	824	1.09	3.04	1.33	46.4	8.04
Nawabganj	1702	820	2.23	1.64	2.12	37.7	6.79
Nilphamari	1641	966	2.05	1.29	1.95	40.6	6.99
Pabna	2371	952	2.06	1.37	1.94	50.3	9.41
Panchagarh	1405	568	1.05	3.82	1.29	45.5	5.83
Rajshahi	2407	963	1.72	4.08	2.48	55.2	8.79
Rangpur	2308	1114	1.89	3.11	2.10	39.7	5.83
Siranjganj	2498	1071	1.80	3.80	2.04	43.5	7.05
Thakurgaon	1809	657	1.75	3.96	1.97	43.5	6.88
Habiganj	2637	684	1.77	4.99	2.04	41.6	7.86
Moulvibazar	2799	579	1.72	4.97	2.00	49.3	6.95
Sunamganj	3670	552	1.85	5.26	2.11	42.6	9.69
Sylhet	3490	736	1.89	3.57	2.16	51.3	6.14
Total	147570	972	1.73	3.31	2.05	48.6	6.66

District households' characteristics are presented in Table 6.2. It is observed that 66 per cent of the total households belong to farm category and rest 34 per cent to non-farm category. Pirojpur had the highest per cent of farm households (81.22) and Dhaka was lowest (48.98) which is even lower than the non-farm households, the only exception being the capital city. Among the farm category the majority of the households are found to be 'small farm households', comprising 53 per cent of total households ranging from 32 per cent to 68 per cent in different districts. Medium and large farms comprised only 12 and 2 per cent of the total households and operating about 40 and 17 per cent of the total operated area by the households respectively (Table 4.5). Operated area can be defined as an area owned by farm holding plus the area rented from others minus the owned area given to others for operation (BBS, 1999b). Medium and large farms collectively comprised only 13 per cent of the households but operated a total of 57 per cent of the total operated area (Table 4.5). Conversly small farms comprised 87 per cent of the households but only operated 43 per cent of the total operated land area.

Table 6.2. District household characteristics (TH= Total households; NFH= Non farm households; SFH= Small farm households; MFH= Medium farm households; LFH= Large farm households; TFH= Total farm households) (compiled from BBS, 1999b).

Districts	TH	NFH (%)	SFH (%)	MFH (%)	LFH (%)	TFH (%)
Barguna	146470	20.61	56.92	18.79	3.68	79.39
Barisal	366421	21.27	67.77	10.16	0.80	78.73
Bhola	268680	33.69	52.05	12.16	2.11	66.31
Jhalakati	110635	24.67	59.78	14.19	1.36	75.33
Patuakhali	243330	24.37	54.46	17.16	4.00	75.63
Pirojpur	216480	18.78	65.81	13.80	1.62	81.22
Bandarban	45705	24.54	35.79	33.77	5.90	75.46
Brahmanbaria	353335	36.50	54.26	8.60	0.65	63.50
Chandpur	359978	29.45	65.96	4.41	0.18	70.55
Chittagong	565703	47.45	45.22	6.82	0.51	52.55
Comilla	674004	28.12	65.23	6.35	0.30	71.88
Cox's Bazar	237095	42.53	48.83	7.81	0.82	57.47
Feni	185093	31.40	62.10	6.24	0.26	68.60
Khagrachari	72855	27.32	44.53	24.95	3.20	72.68
Lakshmipur	237715	22.96	68.36	7.51	1.17	77.04
Noakhali	373120	24.75	65.06	8.38	1.81	75.25
Rangamati	69640	25.38	32.38	34.91	7.33	74.62
Dhaka	140147	51.02	39.76	8.28	0.93	48.98
Faridpur	275892	34.59	49.80	13.99	1.62	65.41
Gazipur	217939	26.49	60.66	11.85	1.00	73.51
Gopalganj	183500	25.07	55.50	17.64	1.80	74.93
Jamalpur	380720	37.89	51.79	9.38	0.94	62.11
Kishorganj	419011	39.45	49.14	9.58	1.84	60.55
Madaripur	193480	27.12	60.27	11.52	1.09	72.88
Manikganj	221547	40.94	48.08	10.01	0.98	59.06
Munshiganj	197703	48.05	44.49	6.64	0.82	51.95
Mymensingh	781534	32.38	55.31	11.22	1.09	67.62
Narayanganj	151714	45.30	49.34	4.95	0.40	54.70
Narsingdi	295272	36.30	57.31	6.03	0.35	63.70
Netrakona	340187	37.34	45.24	14.46	2.96	62.66
Rajbari	147842	33.57	51.01	13.99	1.43	66.43
Shariatpur	189055	22.67	65.57	10.66	1.10	77.33
Sherpur	236010	34.50	53.07	11.05	1.38	65.50
Tangail	567080	30.23	58.76	10.01	1.00	69.77
Bagerhat	251455	23.38	58.84	15.08	2.70	76.62
Chuadanga	151744	28.47	54.32	14.97	2.23	71.53
Jessore	390717	28.67	56.56	13.10	1.66	71.33
Jhenaidah	242913	26.59	54.85	16.46	2.10	73.41
Khulna	211197	31.42	50.01	15.67	2.90	68.58
Khustia	283110	40.19	48.87	9.70	1.23	59.81
Magura	124534	25.48	54.86	18.06	1.60	74.52
Meherpur	105088	31.03	54.92	12.34	1.71	68.97
Narail	106379	26.35	51.00	20.79	1.86	73.65
Satkhira	306872	33.93	52.77	11.44	1.87	66.07
Bogra	541686	37.48	52.20	9.17	1.14	62.52
Dinajpur	456216	39.99	40.89	15.86	3.25	60.01
Gaibandha	410280	37.49	52.74	8.85	0.92	62.51
Joypurhat	161655	32.89	53.27	12.37	1.47	67.11
Kurigram	318270	36.15	51.38	10.88	1.59	63.85

Table 6.2. continued.

Lalmonirhat	196060	30.83	54.69	13.01	1.47	69.17
Naogaon	440979	33.04	48.57	15.41	2.99	66.96
Natore	269750	34.96	50.14	12.32	2.57	65.04
Nawabganj	199725	42.35	37.97	16.59	3.10	57.65
Nilphamari	270805	36.89	48.55	12.89	1.67	63.11
Pabna	324786	42.20	43.48	12.45	1.86	57.80
Panchagarh	146400	32.18	46.05	18.10	3.67	67.82
Rajshahi	296536	32.71	53.70	12.02	1.57	67.29
Rangpur	440235	37.70	50.48	10.54	1.28	62.30
Siranjganj	400036	42.60	45.84	10.17	1.40	57.40
Thakurgaon	210343	32.96	44.11	19.28	3.65	67.04
Habiganj	266930	37.87	45.60	13.80	2.73	62.13
Moulvibazar	233054	36.08	50.03	12.13	1.76	63.92
Sunamganj	286880	38.10	40.50	16.64	4.76	61.90
Sylhet	318660	33.79	49.53	14.07	2.61	66.21
Total	17828187	33.82	52.85	11.65	1.67	66.18

6.4. Land Use Characteristics.

A general picture of major land use by districts is presented in Figure 6.1. Here it is clear that most of the districts are dominated by agriculture except some districts in southeast and southwest region of the country where forests dominate general land use. Table 6.3 summarizes general household land utilization by farm households in different districts. It is evident that between 74 per cent and 92 per cent of lands are devoted to cultivation (average of 87 per cent). Homesteads comprise about 6 per cent of the total land ranging from 12 in Chittagong to 4 in Rangamati. There still exists 7 per cent of the total area denoted here as 'other area', these are areas which farm households do not usually use for productive purposes. These lands are mainly fallow lands and can easily be converted to cultivated land. Table 6.4 and 6.5 review agricultural land use by districts. Rice (73 per cent of the gross cultivated area) dominates the land use pattern in almost every district. Cropping intensity indicates how intensively land is used. Overall intensity was found to be 174 per cent, which means that on average each parcel of land is cultivated 1.74 times a year. However it is observed to be even more than twice in some districts. As Bangladesh has very limited scope to increase the land under cultivation it may be worth increasing the cropping intensity in order to increase total food production and thereby meet the ever-increasing food demands of the growing population.

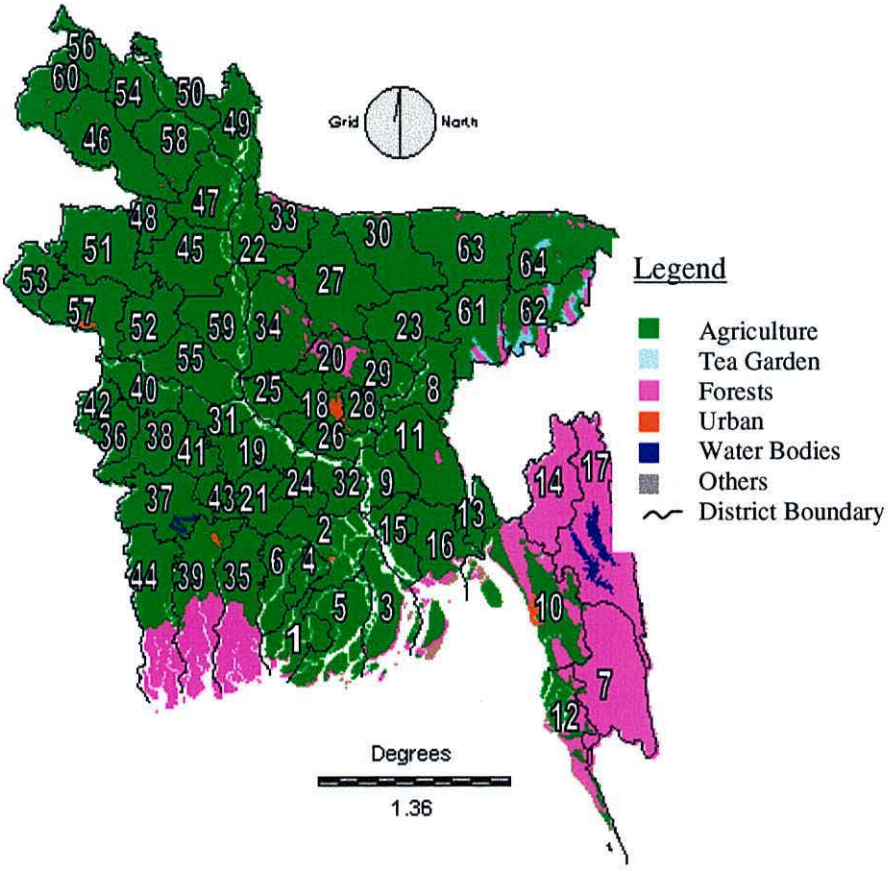


Figure 6.1. Major land use by districts (1996) (1= Barguna, 2= Barisal, 3= Bhola, 4= Jhalakati, 5= Patuakhali, 6= Pirojpur, 7= Bandarban, 8= Brahmanbaria, 9= Chandpur, 10= Chittagong, 11= Comilla, 12= Cox's Bazar, 13= Feni, 14= Khagrachari, 15= Lakshmipur, 16= Noakhali, 17= Rangamati, 18= Dhaka, 19= Faridpur, 20= Gazipur, 21= Gopalganj, 22= Jamalpur, 23= Kishorganj, 24= Madaripur, 25= Manikganj, 26= Munshiganj, 27= Mymensingh, 28= Narayanganj, 29= Narshingdi, 30= Netrokona, 31= Rajbari, 32= Shariatpur, 33= Sherpur, 34= Tangail, 35= Bagerhat, 36= Chuadanga, 37= Jessore, 38= Jhenaidah, 39= Khulna, 40= Khustia, 41= Magura, 42= Meherpur, 43= Narail, 44= Satkhira, 45= Bogra, 46= Dinajpur, 47= Gaibandha, 48= Joypurhat, 49= Kurigram, 50= Lalmonirhat, 51= Naogaon, 52= Natore, 53= Nawabganj, 54= Nilphamari, 55= Pabna, 56= Panchagarh, 57= Rajshahi, 58= Rangpur, 59= Sirajganj, 60= Thakurgaon, 61= Habiganj, 62= Moulvibazar, 63=Sunamganj, 64= Sylhet).

Table 6.3. Household area utilization by districts (compiled from BBS, 1999b).

District	Total Operated Area	Homestead Area		Net Cropped Area		Other Area	
	(ha)	(ha)	(%)	(ha)	(%)	(ha)	(%)
Barguna	98065	4331	4.42	88864	90.62	4870	4.97
Barisal	151883	8923	5.88	133166	87.68	9794	6.45
Bhola	129993	5982	4.60	117410	90.32	6602	5.08
Jhalakati	52237	2698	5.17	46413	88.85	3126	5.98
Patuakhali	156042	5965	3.82	143976	92.27	6101	3.91
Pirojpur	105661	4609	4.36	96264	91.11	4789	4.53
Bandarban	50464	2489	4.93	37130	73.58	10846	21.49
Brahmanbaria	132932	9700	7.30	119612	89.98	3620	2.72
Chandpur	98930	9860	9.97	81434	82.31	7636	7.72
Chittagong	172903	19994	11.56	142756	82.56	10153	5.87
Comilla	227644	20527	9.02	195009	85.66	12107	5.32
Cox's Bazar	82976	8889	10.71	64560	77.81	9527	11.48
Feni	60019	5559	9.26	49137	81.87	5323	8.87
Khagrachari	60495	2853	4.72	38554	63.73	19088	31.55
Lakshmipur	89525	6110	6.82	79102	88.36	4314	4.82
Noakhali	163056	10325	6.33	144457	88.59	8273	5.07
Rangamati	78758	2903	3.69	55113	69.98	20743	26.34
Dhaka	46417	4812	10.37	37342	80.45	4263	9.18
Faridpur	139983	10064	7.19	116687	83.36	13232	9.45
Gazipur	101730	8030	7.89	87472	85.98	6229	6.12
Gopalganj	109187	6421	5.88	97973	89.73	4793	4.39
Jamalpur	145441	11474	7.89	125512	86.30	8455	5.81
Kishorganj	181566	10279	5.66	166046	91.45	5241	2.89
Madaripur	89749	6579	7.33	77004	85.80	6165	6.87
Manikganj	89603	9001	10.05	71614	79.92	8988	10.03
Munshiganj	59885	5216	8.71	49608	82.84	5061	8.45
Mymensingh	338058	23558	6.97	295473	87.40	19028	5.63
Narayanganj	38922	3653	9.38	33393	85.79	1877	4.82
Narsingdi	89575	9263	10.34	77034	86.00	3278	3.66
Netrakona	194620	9863	5.07	175655	90.26	9101	4.68
Rajbari	72814	4509	6.19	62356	85.64	5948	8.17
Shariatpur	84842	4560	5.37	74252	87.52	6030	7.11
Sherpur	100159	6232	6.22	89004	88.86	4923	4.91
Tangail	239548	20700	8.64	198718	82.96	20130	8.40
Bagerhat	142965	6142	4.30	130628	91.37	6195	4.33
Chuadanga	85259	4271	5.01	77170	90.51	3818	4.48
Jessore	193706	12207	6.30	169451	87.48	12048	6.22
Jhenaidah	144887	8875	6.13	125731	86.78	10281	7.10
Khulna	124182	5853	4.71	109835	88.45	8494	6.84
Khustia	113060	8258	7.30	90977	80.47	13824	12.23
Magura	74559	4338	5.82	65704	88.12	4517	6.06
Meherpur	51388	3010	5.86	46692	90.86	1687	3.28
Narail	67403	3911	5.80	59130	87.73	4362	6.47
Satkhira	149336	8670	5.81	119693	80.15	20973	14.04
Bogra	216454	14432	6.67	182994	84.54	19028	8.79
Dinajpur	268652	12846	4.78	243959	90.81	11847	4.41
Gaibandha	152363	11331	7.44	132846	87.19	8186	5.37
Joypurhat	77261	4051	5.24	69859	90.42	3351	4.34
Kurigram	141856	9728	6.86	113546	80.04	18582	13.10
Lalmonirhat	91622	4878	5.32	78852	86.06	7891	8.61
Naogaon	260452	10791	4.14	237621	91.23	12040	4.62
Natore	138792	8251	5.94	127203	91.65	3337	2.40
Nawabganj	116610	5537	4.75	102781	88.14	8292	7.11
Nilphamari	128561	7409	5.76	113164	88.02	7988	6.21
Pabna	153049	12811	8.37	134746	88.04	5492	3.59
Panchagarh	99037	4840	4.89	89852	90.73	4346	4.39
Rajshahi	136375	7119	5.22	120507	88.36	8749	6.42
Rangpur	180088	11449	6.36	159704	88.68	8934	4.96
Siranjganj	175280	16199	9.24	132281	75.47	26800	15.29
Thakurgaon	141944	7158	5.04	130905	92.22	3880	2.73
Habiganj	146605	7220	4.92	132828	90.60	6557	4.47
Moulvibazar	109871	7797	7.10	91918	83.66	10155	9.24
Sunamganj	202787	7618	3.76	185571	91.51	9599	4.73
Sylhet	171730	10610	6.18	147565	85.93	13554	7.89
Total	8289815	533544	6.44	7191812	86.75	564459	6.81

Table 6.4. Agricultural land use by farm households (TFH= Total farm households; NCA= Net cropped area; GCA= Gross cropped area; CI= Cropping intensity; MC= Minor cereal such as oat, barley, millet, etc. Percent of different crops was calculated from GCA) (compiled from BBS, 1999b).

District	TFH	NCA	GCA	CI	Rice		Wheat		MC	
		(ha)	(ha)	(%)	(ha)	(%)	(ha)	(%)	(ha)	(%)
Barguna	1035	80087	123661	154	103919	84.04	40	0.03	21	0.02
Barisal	76645	115140	210030	182	158133	75.29	3148	1.50	49	0.02
Bhola	38367	99877	208837	209	150225	71.93	6572	3.15	70	0.03
Jhalakati	5037	39669	65520	165	55106	84.11	32	0.05	8	0.01
Patuakhali	2302	133006	231350	174	175734	75.96	117	0.05	11	0.00
Pirojpur	18515	74460	112887	152	97328	86.22	57	0.05	7	0.01
Bandarban	13416	26886	40997	152	28200	68.79	4	0.01	857	2.09
Brahmanbaria	184006	115169	174565	152	122766	70.33	12728	7.29	95	0.05
Chandpur	97712	71857	142588	198	101026	70.85	10408	7.30	70	0.05
Chittagong	112035	130783	237987	182	216254	90.87	178	0.07	74	0.03
Comilla	231779	185291	377123	204	289806	76.85	27456	7.28	264	0.07
Cox's Bazar	63905	58673	91476	156	83744	91.55	15	0.02	36	0.04
Feni	38158	45016	85846	191	79363	92.45	256	0.30	23	0.03
Khagrachari	16124	24174	37966	157	31642	83.34	27	0.07	19	0.05
Lakshmipur	35721	63251	128375	203	101174	78.81	2482	1.93	80	0.06
Noakhali	64741	129285	218787	169	180599	82.55	240	0.11	58	0.03
Rangamati	30056	35060	81111	231	35416	43.66	48	0.06	2935	3.62
Dhaka	52858	35891	58837	164	30878	52.48	4872	8.28	40	0.07
Faridpur	101203	111505	212497	191	93925	44.20	23635	11.12	65	0.03
Gazipur	92713	66047	96606	146	78253	81.00	1214	1.26	148	0.15
Gopalganj	87624	94145	151467	161	107523	70.99	4474	2.95	40	0.03
Jamalpur	209535	122565	238060	194	156646	65.80	18175	7.63	1017	0.43
Kishorganj	312196	160721	237908	148	190123	79.91	9491	3.99	89	0.04
Madaripur	67539	72102	138214	192	69450	50.25	8557	6.19	32	0.02
Manikganj	65469	69218	140455	203	73491	52.32	9827	7.00	183	0.13
Munshiganj	39060	47205	78567	166	32901	41.88	2758	3.51	12	0.02
Mymensingh	379137	277572	545715	197	465949	85.38	18321	3.36	222	0.04
Narayanganj	49480	31440	45562	145	28341	62.20	2611	5.73	51	0.11
Narsingdi	115354	66572	117416	176	81833	69.70	4312	3.67	44	0.04
Netrakona	278898	171486	280262	163	247526	88.32	4571	1.63	106	0.04
Rajbari	45040	59441	120617	203	58060	48.14	12569	10.42	103	0.09
Shariatpur	52007	67209	144024	214	79024	54.87	11497	7.98	17	0.01
Sherpur	132319	85960	166113	193	141885	85.41	5407	3.26	87	0.05
Tangail	291517	177539	337374	190	220380	65.32	16758	4.97	898	0.27
Bagerhat	23781	108885	131086	120	118105	90.10	222	0.17	18	0.01
Chuadanga	78613	70797	118409	167	56163	47.43	18444	15.58	55	0.05
Jessore	184556	147643	270046	183	187259	69.34	15160	5.61	72	0.03
Jhenaidah	133687	116224	215214	185	135302	62.87	16320	7.58	255	0.12
Khulna	10416	103197	128103	124	112138	87.54	299	0.23	10	0.01
Khustia	74701	84429	157816	187	80989	51.32	20373	12.91	245	0.16
Magura	54692	62578	125069	200	72164	57.70	8051	6.44	17	0.01
Meherpur	52553	43316	78828	182	34692	44.01	14332	18.18	15	0.02
Narail	25426	54885	100203	183	62399	62.27	4393	4.38	46	0.05
Satkhira	85293	111677	158215	142	125616	79.40	3473	2.19	65	0.04
Bogra	362622	178477	361249	202	289906	80.25	9647	2.67	270	0.07
Dinajpur	370226	237984	418462	176	330851	79.06	41182	9.84	524	0.13
Gaibandha	235970	127412	248914	195	182062	73.14	18027	7.24	2189	0.88

Table 6.4. continued.

Joypurhat	137833	66917	139434	208	110549	79.28	4155	2.98	46	0.03
Kurigram	183134	108052	216621	200	145844	67.33	22443	10.36	2334	1.08
Lalmonirhat	69694	74854	133770	179	90322	67.52	10615	7.94	652	0.49
Naogaon	316155	232036	364144	157	313140	85.99	16741	4.60	169	0.05
Natore	152505	121466	200791	165	123053	61.28	17717	8.82	146	0.07
Nawabganj	85514	94428	141702	150	95468	67.37	13249	9.35	735	0.52
Nilphamari	116092	111126	213069	192	144417	67.78	13725	6.44	700	0.33
Pabna	120646	128136	230830	180	120764	52.32	21310	9.23	405	0.18
Panchagarh	59638	86333	142248	165	89023	62.58	12552	8.82	2356	1.66
Rajshahi	116683	109682	173126	158	103697	59.90	19257	11.12	391	0.23
Rangpur	229763	154607	302723	196	216392	71.48	22691	7.50	503	0.17
Siranjganj	235966	129493	240810	186	135718	56.36	16104	6.69	905	0.38
Thakurgaon	182610	128120	211618	165	152079	71.87	27606	13.05	2146	1.01
Habiganj	179691	128115	178115	139	163184	91.62	2928	1.64	44	0.02
Moulvibazar	39217	79585	121492	153	115033	94.68	306	0.25	17	0.01
Sunamganj	307452	179767	200205	111	187258	93.53	1284	0.64	122	0.06
Sylhet	89810	131251	179565	137	170648	95.03	467	0.26	39	0.02
Total	7716442	6655777	11580677	174	8430855	72.80	615928	5.32	23324	0.20

Table 6.5. Agricultural land use continued (Cash crops include jute, sugarcane, cotton, tobacco, etc. Percent of different crops was calculated from GCA.) (compiled from BBS, 1999b).

District	Pulses		Oilseeds		Cash Crops		Vegetables		Spices	
	(ha)	(%)	(ha)	(%)	(ha)	(%)	(ha)	(%)	(ha)	(%)
Barguna	14344	11.60	572	0.46	247	0.20	1511	1.22	2983	2.41
Barisal	30584	14.56	2237	1.07	5210	2.48	3169	1.51	7469	3.56
Bhola	23731	11.36	3694	1.77	520	0.25	5333	2.55	18691	8.95
Jhalakati	6351	9.69	415	0.63	475	0.72	1413	2.16	1716	2.62
Patuakhali	40076	17.32	2507	1.08	311	0.13	3348	1.45	9141	3.95
Pirojpur	7680	6.80	254	0.22	1186	1.05	3921	3.47	2452	2.17
Bandarban	120	0.29	1291	3.15	3481	8.49	3968	9.68	3074	7.50
Brahmanbaria	4999	2.86	17142	9.82	7924	4.54	4739	2.71	4144	2.37
Chandpur	3557	2.49	4730	3.32	6194	4.34	10546	7.40	6035	4.23
Chittagong	3565	1.50	1146	0.48	742	0.31	10020	4.21	6006	2.52
Comilla	7359	1.95	12527	3.32	8409	2.23	22800	6.05	8464	2.24
Cox's Bazar	367	0.40	431	0.47	823	0.90	3392	3.71	2666	2.91
Feni	2157	2.51	515	0.60	78	0.09	2050	2.39	1403	1.63
Khagrachari	82	0.22	503	1.32	463	1.22	3043	8.02	2093	5.51
Lakshmipur	6650	5.18	4927	3.84	826	0.64	2310	1.80	9922	7.73
Noakhali	15437	7.06	9516	4.35	900	0.41	4539	2.07	7497	3.43
Rangamati	295	0.36	6954	8.57	6277	7.74	19440	23.97	9736	12.00
Dhaka	4856	8.25	7479	12.71	5017	8.53	3434	5.84	1927	3.28
Faridpur	32829	15.45	9273	4.36	35992	16.94	1758	0.83	15020	7.07
Gazipur	1220	1.26	2530	2.62	7941	8.22	2914	3.02	2382	2.47
Gopalganj	21462	14.17	6019	3.97	8668	5.72	960	0.63	2314	1.53
Jamalpur	2055	0.86	16642	6.99	25025	10.51	6961	2.92	11531	4.84
Kishorganj	3139	1.32	9524	4.00	12761	5.36	6970	2.93	5796	2.44
Madaripur	22091	15.98	12960	9.38	16945	12.26	1469	1.06	6705	4.85
Manikganj	14559	10.37	18974	13.51	8267	5.89	5485	3.91	9655	6.87
Munshiganj	1101	1.40	4804	6.11	9105	11.59	23659	30.11	4015	5.11

Table 6.5. continued.

Mymensingh	6617	1.21	8622	1.58	25086	4.60	10894	2.00	9962	1.83
Narayanganj	1732	3.80	5447	11.96	2699	5.92	2743	6.02	1821	4.00
Narsingdi	749	0.64	7130	6.07	9006	7.67	10320	8.79	3996	3.40
Netrakona	1233	0.44	6559	2.34	12181	4.35	4382	1.56	3701	1.32
Rajbari	14831	12.30	3604	2.99	18081	14.99	2779	2.30	10585	8.78
Shariatpur	14126	9.81	9369	6.51	11082	7.69	3283	2.28	15426	10.71
Sherpur	543	0.33	4556	2.74	5274	3.18	5023	3.02	3339	2.01
Tangail	9843	2.92	48199	14.29	25761	7.64	9802	2.91	5703	1.69
Bagerhat	5397	4.12	1676	1.28	1457	1.11	2628	2.00	1582	1.21
Chuadanga	13835	11.68	4800	4.05	19573	16.53	3179	2.68	2340	1.98
Jessore	16186	5.99	16227	6.01	23061	8.54	7787	2.88	4288	1.59
Jhenaidah	19223	8.93	7613	3.54	25132	11.68	3835	1.78	7514	3.49
Khulna	1348	1.05	5836	4.56	2879	2.25	4433	3.46	1158	0.90
Khustia	16266	10.31	4492	2.85	27214	17.24	2576	1.63	5630	3.57
Magura	16221	12.97	7419	5.93	14810	11.84	1083	0.87	5304	4.24
Meherpur	4146	5.26	3970	5.04	17705	22.46	2062	2.62	1893	2.40
Narail	15221	15.19	5564	5.55	9294	9.28	1116	1.11	2163	2.16
Satkhira	3536	2.23	6112	3.86	8927	5.64	8073	5.10	2412	1.52
Bogra	592	0.16	15440	4.27	13904	3.85	21083	5.84	10402	2.88
Dinajpur	2419	0.58	6967	1.67	14709	3.52	14184	3.39	7544	1.80
Gaibandha	1626	0.65	9966	4.00	19086	7.67	10371	4.17	5571	2.24
Joypurhat	521	0.37	5322	3.82	3786	2.72	13286	9.53	1769	1.27
Kurigram	3471	1.60	6732	3.11	25742	11.88	5730	2.65	4318	1.99
Lalmonirhat	377	0.28	1995	1.49	22708	16.98	4802	3.59	2283	1.71
Naogaon	1795	0.49	7938	2.18	8010	2.20	11442	3.14	4904	1.35
Natore	14679	7.31	10241	5.10	24866	12.38	4275	2.13	5788	2.88
Nawabganj	14115	9.96	4530	3.20	8000	5.65	2890	2.04	2715	1.92
Nilphamari	320	0.15	552	0.26	38658	18.14	9670	4.54	5010	2.35
Pabna	35976	15.59	11522	4.99	17543	7.60	4707	2.04	17988	7.79
Panchagarh	1099	0.77	11583	8.14	14909	10.48	5931	4.17	4790	3.37
Rajshahi	9693	5.60	6871	3.97	16240	9.38	10043	5.80	6845	3.95
Rangpur	1497	0.49	5354	1.77	34241	11.31	17620	5.82	4416	1.46
Sirajganj	11593	4.81	45800	19.02	19892	8.26	4821	2.00	5783	2.40
Thakurgaon	2695	1.27	5380	2.54	10959	5.18	7547	3.57	3196	1.51
Habiganj	1105	0.62	3196	1.79	1360	0.76	4688	2.63	1500	0.84
Moulvibazar	146	0.12	226	0.19	293	0.24	4513	3.72	958	0.79
Sunamganj	476	0.24	3811	1.90	1256	0.63	3496	1.75	2503	1.25
Sylhet	116	0.06	1555	0.87	271	0.15	4850	2.70	1620	0.90
Total	536026	4.63	479743	4.14	729442	6.30	411101	3.55	351558	3.04

District data were further classified by population density, literacy rate and forest availability in order to analyse the differential characteristics in land use in different districts (Appendix 6.2) with the assumption that these variables have significant influence on the district land use characteristics. Population density (per sq. km) was considered as it was found the major determinant for land use (Chapter 5), literacy rate (%) was considered with the assumption that higher literacy rate may lead to development of service sector decreasing the pressure on agriculture and on land use, and forest availability (%) was considered as there exists greater

variability regarding proportion of forest area in different divisions and districts (Figure 5.9) with the assumption that this may have significant effect on district land use characteristics. The frequency distributions of different districts into different grouping variables are shown in Table 6.6. Most of the districts were found to be in the medium population density class (55%) and the medium literacy rate class (45%). It is interesting to see that Bangladesh has got some interesting features in its land use especially for the forests. Although agriculture dominates most of the districts (Figure 6.1 & 6.2b) the availability of forests is not the same in every district, and there are some districts like Rangamati, Khagrachari, Bandarban and Bagerhat where forests dominate overall land use (Figure 6.1 & 6.2a). Only 12 districts can be considered as forest rich (10 per cent or more area under forests). 28 districts have got few or very few forests (less than 10 per cent) but the rest, 24 districts, have no forests at all (Table 6.6).

Table 6.6. District frequency distribution by different grouping variables.

Population density (persons/sq. km)			Literacy rate (%)			Forest availability (%)		
Category	Frequency	(%)	Category	Frequency	(%)	Category	Frequency	(%)
Low (<500)	7	11	Low (<40)	9	14	No forest (0 %)	24	37
Medium (501-1000)	35	55	Medium (40-50)	29	45	Very low forest (<1 %)	16	25
High (1001-1500)	18	28	High (50-60)	18	28	Low forest (1-10 %)	12	19
Very High (>1500)	4	6	Very High (>60)	8	13	Rich forest (10-25 %)	5	8
						Very rich forest (>25 %)	7	11
Total	64	100	Total	64	100	Total	64	100

Based on the above classification, agricultural land uses were analysed to see the differences among different grouping variables. First the distribution of district agricultural land uses (%) was checked for normality and then homogeneity in variances. If the land use data were found both normal and homogeneous in variances then one-way ANOVA test was conducted to see if there were any significant differences among the district agricultural land uses. Otherwise Kruskal-Wallis, a non-parametric test, was conducted to see the difference among the grouping variables. It is observed that rice area (%) was highly significant among different forest availability classes but not for population density and literacy classes, and not significant among

population density and literacy rate classes (Table 6.7). However rice area (%) was found to decrease with the increase of population density and increase with the increase of literacy rate and forest availability class (Table 6.8). This may be due to greater competition with agriculture from non-agricultural land uses with the increase of population density and question of more benefit from agriculture, which is clear from the increase of wheat, cash crops and oilseed with denser population. Wheat area (%) was found to be highly significant for all the three grouping variables (Table 6.7). It is interesting to see that wheat area shows a decreasing tendency with increasing literacy rate and forest availability class (Table 6.8). This is probably due to more competition from rice and less suitability of wheat in forest rich areas. Again, as literacy rate increases agricultural sector loses potential labour force to other employment opportunities and as result the smaller labour force cannot grow more crops other than rice. Cash crop areas were also found significantly different among literacy and forest availability classes. Forest availability class was found to influence pulses (%) significantly showing decreasing tendency with increasing forest availability class (Tables 6.7 & 6.8). So it can be said that population density, literacy rate and forest availability class have significant influence on agricultural land uses in different districts.

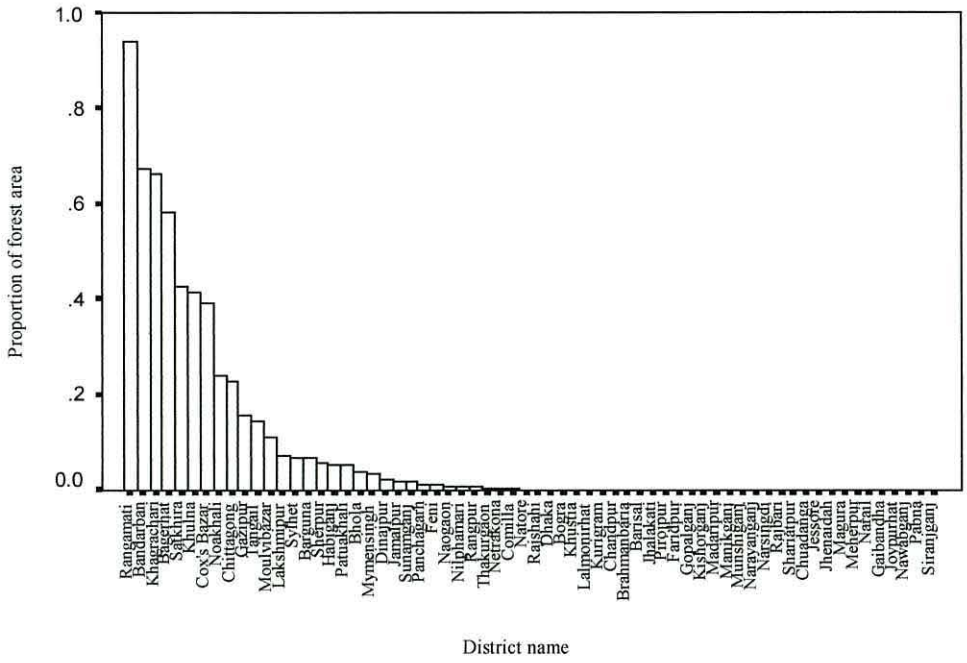
Table 6.7. Agricultural land use characteristics showing relative significance by different grouping variables (GCA= Gross cropped area, NS= Not significant, *= Significant at 0.05 level, **= Significant at 0.01 level, ***= Significant at 0.001 level) (All the variables were first tested for normality and if normal homogeneity of variances were also tested based on the grouping variables. One-way ANOVA was used where data were both normal and homogeneous in variances otherwise Kruskal-Wallis test option was used).

Grouping variables	Land use (% of GCA)	Test Option	n	df	Test Statistics	P-value
Population density	Rice	One Way ANOVA	64	3	F = 0.38	0.768 ^{NS}
Literacy rate		One Way ANOVA	64	3	F = 1.036	0.383 ^{NS}
Forest availability		One Way ANOVA	64	4	F = 6.194	0.000 ***
Population density	Wheat	Kruskal-Wallis	64	3	H = 15.144	0.002 **
Literacy rate		One Way ANOVA	64	3	F = 6.664	0.001 ***
Forest availability		One Way ANOVA	64	4	F = 7.283	0.000 ***
Population density	Minor cereal	Kruskal-Wallis	64	3	H = 0.996	0.802 ^{NS}
Literacy rate		Kruskal-Wallis	64	3	H = 7.476	0.058 ^{NS}
Forest availability		Kruskal-Wallis	64	4	H = 7.280	0.122 ^{NS}
Population density	Cash crops	One Way ANOVA	64	3	F = 1.034	0.384 ^{NS}
Literacy rate		One Way ANOVA	64	3	F = 4.069	0.011 *
Forest availability		One Way ANOVA	64	4	F = 4.314	0.004 **
Population density	Pulses	Kruskal-Wallis	64	3	H = 0.206	0.977 ^{NS}
Literacy rate		Kruskal-Wallis	64	3	H = 1.992	0.574 ^{NS}
Forest availability		Kruskal-Wallis	64	4	H = 18.245	0.001 ***
Population density	Oilseeds	Kruskal-Wallis	64	3	H = 6.787	0.079 ^{NS}
Literacy rate		Kruskal-Wallis	64	3	H = 0.885	0.829 ^{NS}
Forest availability		Kruskal-Wallis	64	4	H = 9.329	0.053 ^{NS}
Population density	Vegetables	Kruskal-Wallis	64	3	H = 8.761	0.033 *
Literacy rate		Kruskal-Wallis	64	3	H = 0.931	0.818 ^{NS}
Forest availability		Kruskal-Wallis	64	4	H = 11.291	0.023 *
Population density	Spices	Kruskal-Wallis	64	3	H = 3.484	0.323 ^{NS}
Literacy rate		Kruskal-Wallis	64	3	H = 0.261	0.967 ^{NS}
Forest availability		Kruskal-Wallis	64	4	H = 4.372	0.358 ^{NS}

Table 6.8. Agricultural land use characteristics expressed as % of gross cropped area by different grouping variables (MC= Minor cereal, CC= Cash crops, OS= Oilseeds, Veg= Vegetables) (source: database compiled from BBS 1999a, 1999b; NDB, 2001; WARPO, 2000).

Grouping variables		Rice	Wheat	MC	CC	Pulses	OS	Veg	Spices
Population density (per sq. km)	<500	75.04	0.37	0.83	3.50	5.16	2.82	7.35	4.87
	501-1000	70.78	6.18	0.19	7.41	5.81	3.54	2.90	3.16
	1001-1500	71.79	4.50	0.16	6.34	3.96	5.33	4.68	3.22
	>1500	65.31	6.24	0.07	6.09	3.66	8.52	6.68	3.23
Literacy class	<40 %	65.99	9.14	0.36	9.94	4.69	3.63	3.16	3.09
	40-50 %	69.89	5.80	0.26	7.85	4.37	4.88	3.43	3.49
	50-60 %	73.09	3.18	0.25	4.21	6.09	3.62	5.89	3.62
	>60 %	77.46	2.15	0.05	3.69	5.86	4.28	3.71	2.69
Forest availability class	0 %	62.17	6.56	0.12	8.77	8.65	5.66	4.07	3.94
	<1 %	71.00	7.34	0.25	8.29	2.89	3.73	4.04	2.42
	1-10 %	80.76	3.38	0.21	2.92	4.18	2.74	2.47	3.32
	10-25 %	82.88	1.33	0.10	3.36	2.57	4.39	3.19	2.18
	>25 %	77.77	0.39	0.84	3.91	1.24	3.32	7.99	4.51

(a)



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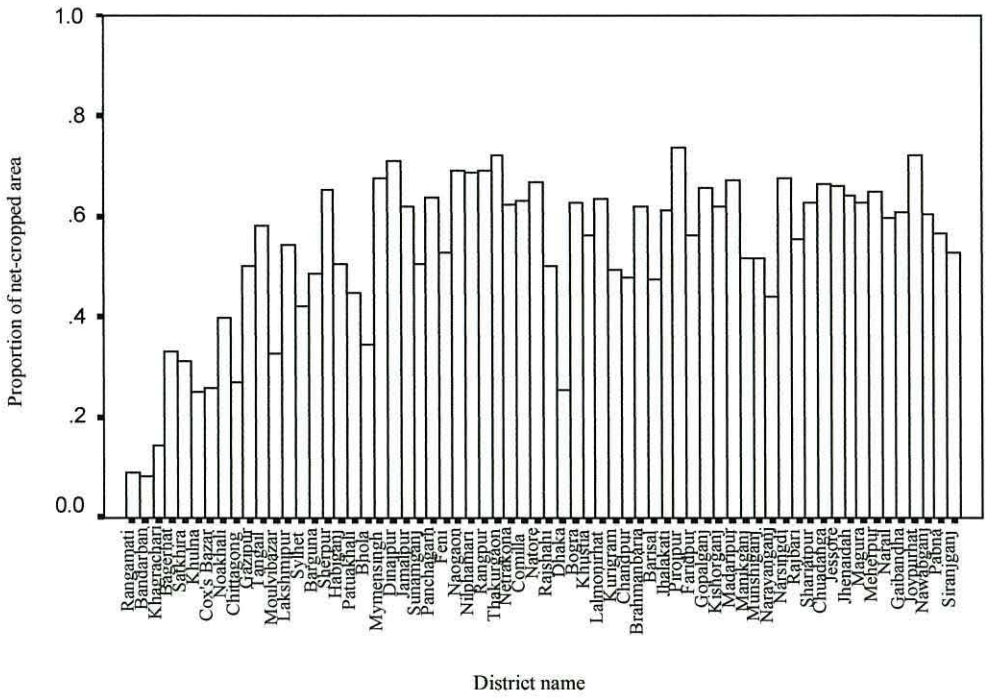


Figure 6.2. Proportions of (a) forests and (b) net-cropped area by districts in Bangladesh (districts were arranged with descending forest areas).

6.5. Land Use Models.

Forests show a greater anomaly than agricultural land use in their distribution among different districts with very little or no forests in most of the districts and abnormally high density of forests in some districts (Figure 6.2). A critical analysis was attempted to find out the reason behind this anomaly in the distribution of forests in Bangladesh. For convenience, every district was classified based on inundation land types, a land classification system in relation to flood depth (MOA, 1985). Inundation land type defines different land units with relative elevation to be inundated by normal flood. As the elevation declines so the land unit is more susceptible to inundation by floodwater. In the absence of any other land classification system, inundation land type was taken as an indicator of land suitability for different land uses. Flooding depth relates to elevation, proximity to waterways and suitability for cropping. The exception is Sundarbans in Khulna division, which is regularly inundated by saline water from the Bay of Bengal and is generally suitable for mangrove forests. Again lowlands and very lowlands are not suitable for crops, as these remain submerged under water most of the year. Medium highlands to lowlands are generally suitable for crops due to easy access to irrigation facilities and fertile sediment deposits after each flood. So inundation land type reflects potential for cropping. Only the major land type was considered to redefine each district (although other land types may exist in each district) (Figure 6.3; Table 6.9). From this classification it is clear that inundation land type has some impacts on the general land use of each district.

It is observed that as the elevation decreases the amount of forests also decreases and conversely net-cropped area increases (Figure 6.4). However a significant negative relationship was observed between the proportion of forest area and net-cropped area (Figure 6.5). In this case, a negative exponential model could not be used, as some districts possess non-positive values (zero proportion) (note that linear model can not be sensible as practically forest areas can never be negative). Again, net-cropped area per household was also found positively related to population density in each district where both linear and exponential regression models were significant at the 0.001 level (Figure 6.6). Here the negative exponential model gives a sensible understanding of the real situation, as practically net-cropped area per household can never be negative. Again,

the growing population needs more space in which to live and also for development works, so there will definitely be a negative relationship between population and net cultivated area.

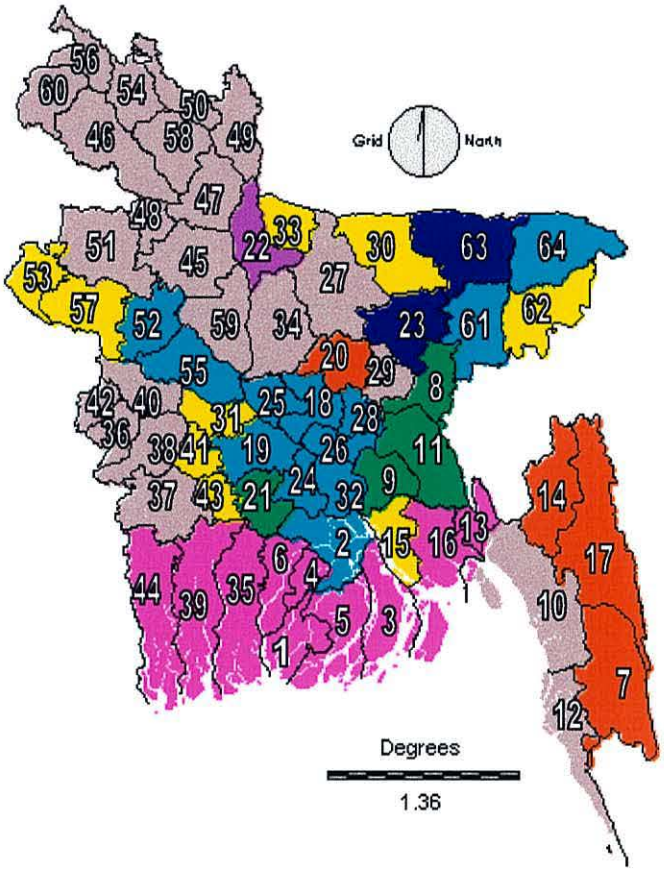


Figure 6.3. Inundation land types by districts (1= Barguna, 2= Barisal, 3= Bhola, 4= Jhalakati, 5= Patuakhali, 6= Pirojpur, 7= Bandarban, 8= Brahmanbaria, 9= Chandpur, 10= Chittagong, 11= Comilla, 12= Cox's Bazar, 13= Feni, 14= Khagrachari, 15= Lakshmipur, 16= Noakhali, 17= Rangamati, 18= Dhaka, 19= Faridpur, 20= Gazipur, 21= Gopalganj, 22= Jamalpur, 23= Kishorganj, 24= Madaripur, 25= Manikganj, 26= Munshiganj, 27= Mymensingh, 28= Narayanganj, 29= Narshingdi, 30= Netrokona, 31= Rajbari, 32= Shariatpur, 33= Sherpur, 34= Tangail, 35= Bagerhat, 36= Chuadanga, 37= Jessore, 38= Jhenaidah, 39= Khulna, 40= Khustia, 41= Magura, 42= Meherpur, 43= Narail, 44= Satkhira, 45= Bogra, 46= Dinajpur, 47= Gaibandha, 48= Joypurhat, 49= Kurigram, 50= Lalmonirhat, 51= Naogaon, 52= Natore, 53= Nawabganj, 54= Nilphamari, 55= Pabna, 56= Panchagarh, 57= Rajshahi, 58= Rangpur, 59= Sirajganj, 60= Thakurgaon, 61= Habiganj, 62= Moulvibazar, 63=Sunamganj, 64= Sylhet) (Mainly Highland, Medium Highland, Highland to Medium Lowland, Medium Highland and Highland, Medium Highland and Medium Lowland, Medium Highland to Lowland, Medium Lowland to Lowland, Lowland to Very Lowland).

Table 6.9. Distribution of inundation land types and corresponding forest and net cultivated area (PFA= Proportion of forest area, PNCA= Proportion of net cultivated area) (compiled from MOA, 1985).

District	Inundation land type	Flood depth (cm)	PFA	PNCA
Barguna	Medium Highland	<30	0.069	0.485
Barisal	Medium Highland to Lowland	30-240	0.000	0.477
Bhola	Medium Highland	<30	0.038	0.345
Jhalakati	Medium Highland	<30	0.000	0.612
Patuakhali	Medium Highland	<30	0.052	0.449
Pirojpur	Medium Highland	<30	0.000	0.736
Bandarban	Mainly Highland	0	0.671	0.083
Brahmanbaria	Medium Lowland to Lowland	135-240	0.000	0.621
Chandpur	Medium Lowland to Lowland	135-240	0.000	0.478
Chittagong	Medium highland and Highland	0-30	0.228	0.270
Comilla	Medium Lowland to Lowland	135-240	0.002	0.632
Cox's Bazar	Medium highland and Highland	0-30	0.391	0.259
Feni	Medium Highland	<30	0.010	0.529
Khagrachari	Mainly Highland	0	0.661	0.143
Lakshmipur	Highland to Medium Lowland	0-135	0.074	0.543
Noakhali	Medium Highland	<30	0.240	0.401
Rangamati	Mainly Highland	0	0.940	0.090
Dhaka	Medium Highland to Lowland	30-240	0.001	0.255
Faridpur	Medium Highland to Lowland	30-240	0.000	0.563
Gazipur	Mainly Highland	0	0.156	0.502
Gopalganj	Medium Lowland to Lowland	135-240	0.000	0.658
Jamalpur	Medium Highland and Medium Lowland	30-135	0.021	0.618
Kishorganj	Lowland to Very Lowland	>240	0.000	0.618
Madaripur	Medium Highland to Lowland	30-240	0.000	0.673
Manikganj	Medium Highland to Lowland	30-240	0.000	0.519
Munshiganj	Medium Highland to Lowland	30-240	0.000	0.519
Mymensingh	Medium highland and Highland	0-30	0.036	0.677
Narayanganj	Medium Highland to Lowland	30-240	0.000	0.440
Narsingdi	Medium highland and Highland	0-30	0.000	0.675
Netrakona	Highland to Medium Lowland	0-135	0.003	0.625
Rajbari	Highland to Medium Lowland	0-135	0.000	0.557
Shariatpur	Medium Highland to Lowland	30-240	0.000	0.629
Sherpur	Highland to Medium Lowland	0-135	0.058	0.653
Tangail	Medium highland and Highland	0-30	0.146	0.582
Bagerhat	Medium Highland	<30	0.583	0.330
Chuadanga	Medium highland and Highland	0-30	0.000	0.666
Jessore	Medium highland and Highland	0-30	0.000	0.660
Jhenaidah	Medium highland and Highland	0-30	0.000	0.641
Khulna	Medium Highland	<30	0.413	0.250
Khustia	Medium highland and Highland	0-30	0.000	0.561
Magura	Highland to Medium Lowland	0-135	0.000	0.626
Meherpur	Medium highland and Highland	0-30	0.000	0.652
Narail	Highland to Medium Lowland	0-135	0.000	0.597
Satkhira	Medium Highland	<30	0.426	0.310
Bogra	Medium highland and Highland	0-30	0.001	0.627
Dinajpur	Medium highland and Highland	0-30	0.022	0.710
Gaibandha	Medium highland and Highland	0-30	0.000	0.610
Joypurhat	Medium highland and Highland	0-30	0.000	0.724
Kurigram	Medium highland and Highland	0-30	0.000	0.495
Lalmonirhat	Medium highland and Highland	0-30	0.000	0.635
Naogaon	Medium highland and Highland	0-30	0.008	0.692
Natore	Medium Highland to Lowland	30-240	0.001	0.671
Nawabganj	Highland to Medium Lowland	0-135	0.000	0.604
Nilphamari	Medium highland and Highland	0-30	0.007	0.690
Pabna	Medium Highland to Lowland	30-240	0.000	0.568
Panchagarh	Medium highland and Highland	0-30	0.013	0.640
Rajshahi	Highland to Medium Lowland	0-135	0.001	0.501
Rangpur	Medium highland and Highland	0-30	0.007	0.692
Sirajganj	Medium highland and Highland	0-30	0.000	0.530
Thakurgaon	Medium highland and Highland	0-30	0.005	0.724
Habiganj	Medium Highland to Lowland	30-240	0.055	0.504
Moulvibazar	Highland to Medium Lowland	0-135	0.111	0.328
Sunamganj	Lowland to Very Lowland	>240	0.019	0.506
Sylhet	Medium Highland to Lowland	30-240	0.069	0.423

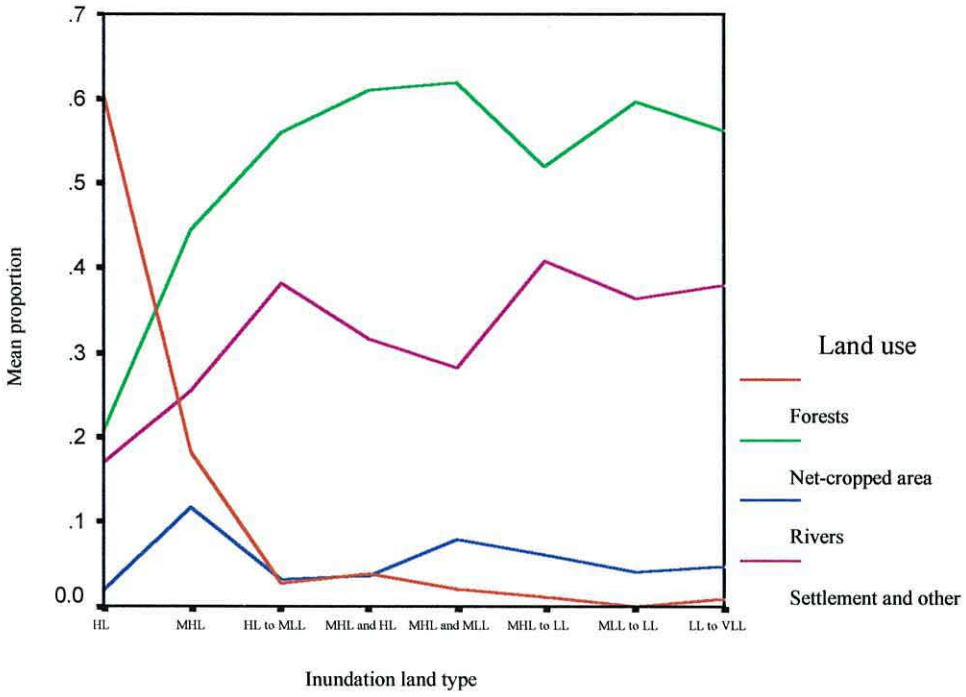


Figure 6.4. Proportions of different land uses by inundation land types at district scale (HL= Highland; HL to MLL= Highland to Medium Lowland; MHL= Mainly Medium Highland; MHL and HL= Medium Highland and Highland; MHL and MLL= Medium Highland and Medium Lowland; MHL to LL= Medium highland to Lowland; MLL to LL= Medium Highland to Lowland; LL to VLL= Lowland to Very Lowland).

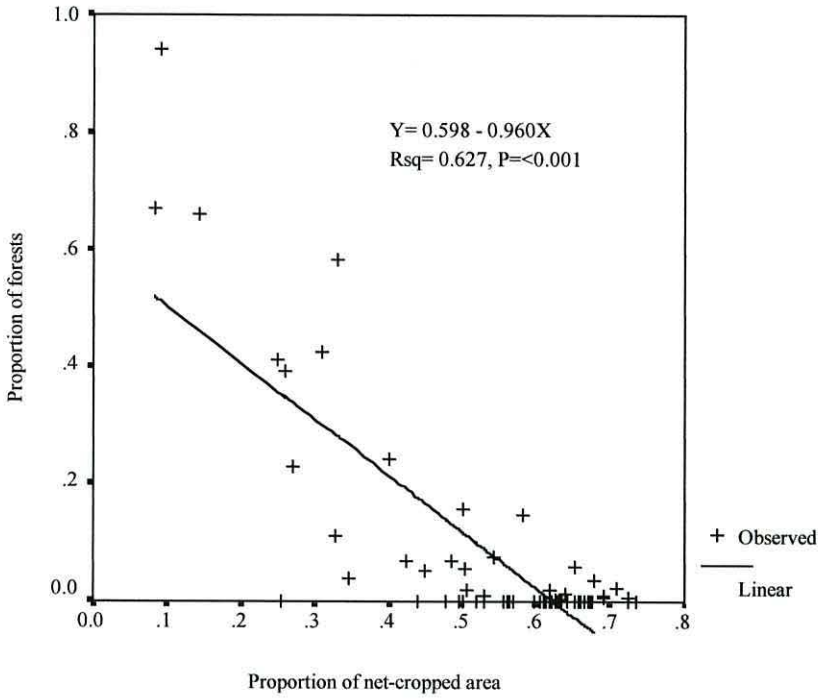


Figure 6.5. Relationship between proportion of net-cropped area and forests by districts.

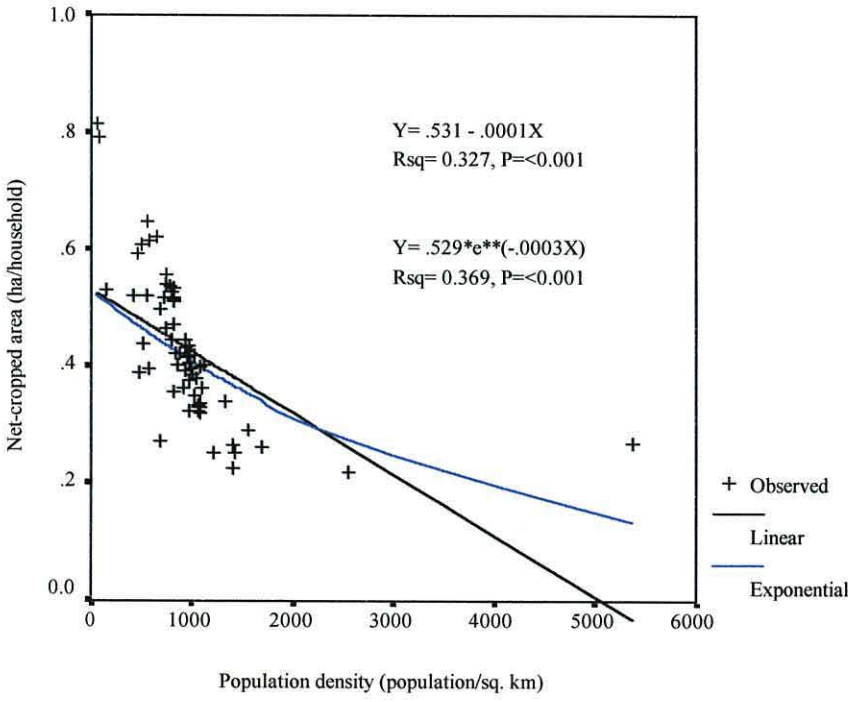
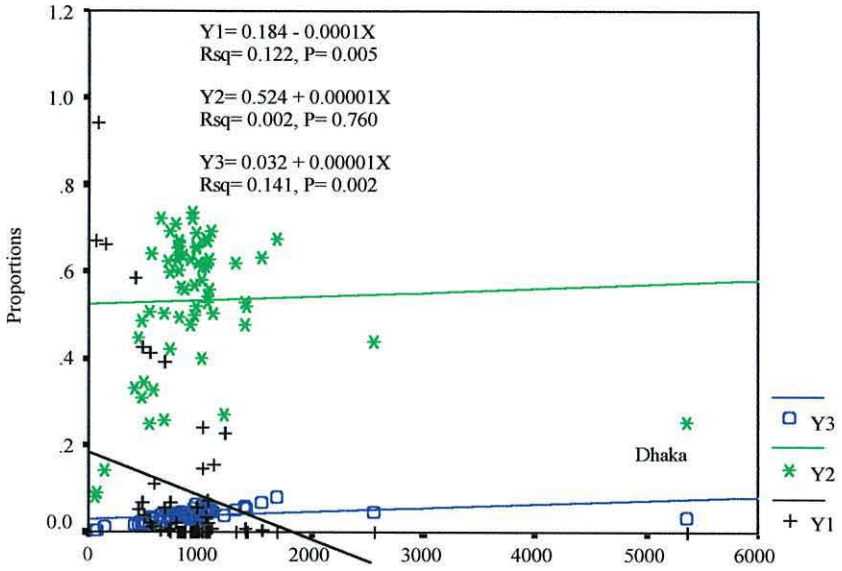


Figure 6.6. Relationship between population density (population/sq. km) and net-cropped area (ha/household) by districts.

Figure 6.7 portrays the relationships between population density and major land uses, such as forests, net-cropped area and homestead area. If population increases forest decreases and on the other hand net-cropped area and homestead area increases. Forests and homestead area were found significantly related to population density at the 0.01 level although R^2 values were smaller whereas net-cropped area had a non-significant relationship. In every case Dhaka was an outlier, lying far away from the average data value. This is due to the presence of capital city of Bangladesh in the district where most of the population is concentrated (Figure 6.7a). This may be due to 'other land uses' that occupy the large proportion of Dhaka consisting of urban areas. As Dhaka is clearly not typical of the other districts due to the presence of a large urban population, an attempt was made to correct the situation by excluding Dhaka from the data set and refitting the same models. This resulted in a better fit of the models and in every case improved R^2 and P values were obtained (Figure 6.7b).

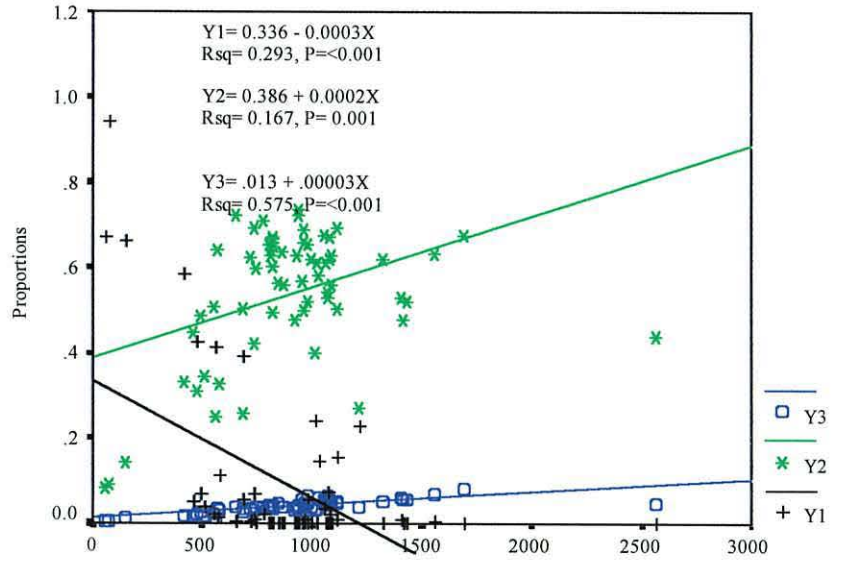
Homestead area was positively related to population density (Figure 6.7) and was found to have influence on forests and net-cropped area in each district. Figure 6.8 portrays the relationship between forests and net-cropped area against homestead area. Both forests and net-cropped area were found significantly related to homestead area. A significant negative exponential relationship was observed between the proportion of net-cropped area and homestead area (Figure 6.8b), but it was impossible to fit a negative exponential model between the proportion of forests and homestead area (Figure 6.8a) as some districts possess non-positive values (zero proportion). If population increases more people will encroach more forests to build their homestead and establish cultivated areas. As a result the forest area will decrease. In Bangladesh this is a great threat to forests, as the growing population will be left with no room for the living space for future generations. This situation may not be overcome, as the decision is more political then any other consideration. No political parties/government will take the risk to withdraw those people who have already occupied forest areas or can exercise laws to prevent further occupation of government forests. In this regard there is a need to find out some useful ways to prevent encroachment and help these people to satisfy their basic needs.

(a)



Y1= Forests; Y2= Net-cropped area; Y3= Homestead area

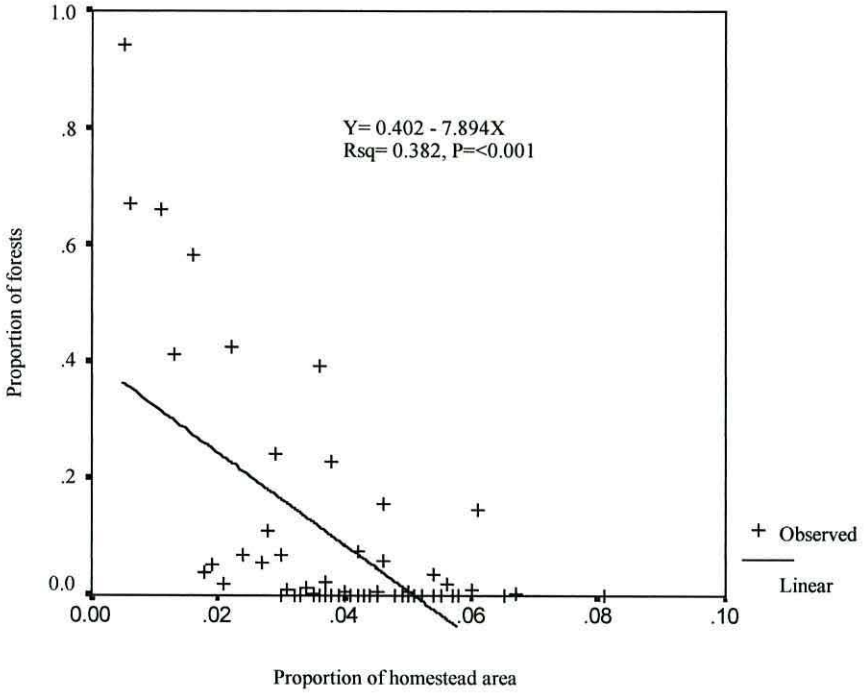
(b)



Y1= Forests; Y2= Net-cropped area; Y3= homestead area

Figure 6.7. Relationship between proportion of forests, net-cropped area and homestead area against population density by districts ((a) includes all districts (n=64) and (b) includes all districts except Dhaka (n=63))

(a)



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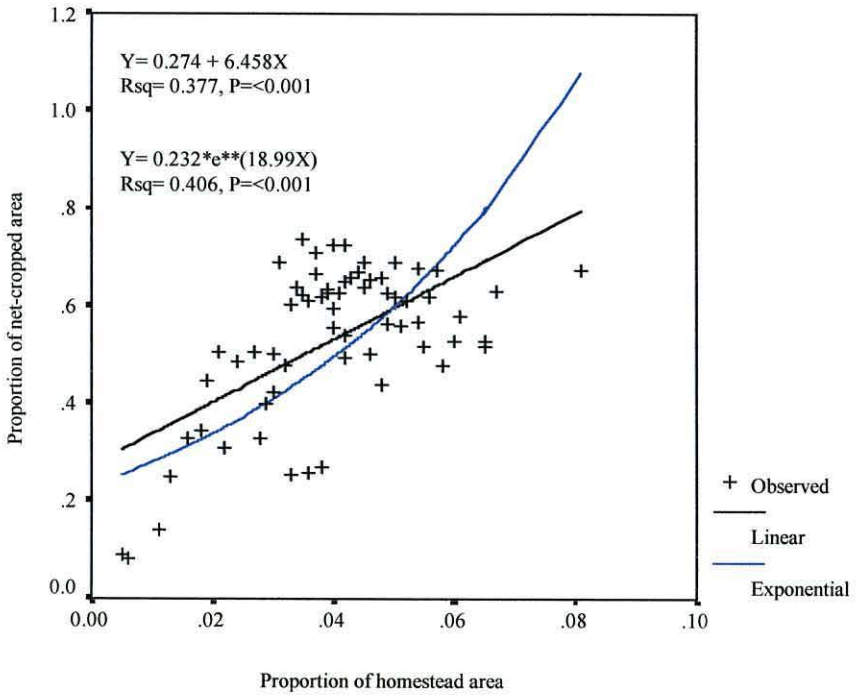

Figure 6.8. Relationship between proportion of homestead area and (a) proportion of forests and (b) proportion of net-cropped area by districts.

6.5.1. Multiple Regression Models.

The previous analyses show a relationship between population density and changing land use at the district level. Inundation land type also explained some anomaly in land uses at the district scale. The main interest of this study was focused on agriculture and forest land uses and possible changes happening to these land uses with the increase of population and development needs in Bangladesh. To this end several multiple regression models were developed to explain variation in net-cropped area and forests in Bangladesh at district scale using stepwise regression analysis. The models that explained the most variation are presented below:

PFA= 0.598 – 0.960*PNCA (R^2= 0.627, P= <0.001).....(Equation 6.1)
(<0.001) (<0.001)

PFA= 0.678 – 0.945*PNCA – 0.009*PD (R^2= 0.728, P= <0.001).....(Equation 6.2)
(<0.001) (<0.001) (<0.001)

PFA= 0.700 – 0.875*PNCA – 0.007*PD – 0.018*ILT (R^2= 0.751, P= <0.001).....(Equation 6.3)
(<0.001) (<0.001) (<0.001) (0.024)

PNCA= 0.274 + 6.458*PHA (R^2= 0.377, P= <0.001).....(Equation 6.4)
(<0.001) (<0.001)

PNCA= 0.311 + 7.031*PHA – 0.031*TP (R^2= 0.377, P= <0.001).....(Equation 6.5)
(<0.001) (<0.001) (0.018)

PNCA= 0.288 + 6.322*PHA – 0.036*TP + 0.015*ILT (R^2= 0.453, P= <0.001).....(Equation 6.6)
(<0.001) (<0.001) (0.007) (0.133)

where, PFA= Proportion of forest area, PNCA= Proportion of net cultivated area, PHA= Proportion of homestead area, ILT= Inundation land type, PD= Population density (persons/ha), TP= Total population (millions).

Here, it is seen that forest area of a district is significantly negatively related to its net-cropped area, population density and major inundation land types of the district (Equations 6.1, 6.2 & 6.3). On the other hand net-cropped area is significantly positively related to homestead area, inundation land types and negatively to total population of the district (Equations 6.4, 6.5 & 6.6). This implies that population growth has negative influence on proportion of both forests and net-cropped area of a district. Inundation land type was found to influence forests negatively and net-cropped area positively as the average elevation of the district decreases. This also supports the existence of a negative relationship between forests and net-cropped area (Figure 6.6). It may be

noted here that districts free of flood hazard are generally suitable for forests and conversely those susceptible to flood are more suitable for agriculture.

6.6. Discussion.

Due to lack of temporal data this study also relied on cross-sectional data regarding land use and its characteristics at district scale. Analysis of these data revealed relationships between population density and land use, as was found at national and divisional level. District data set was developed from cross-sectional data from different districts in Bangladesh due to lack of time series data at district level. So while these relationships seem strong, in the absence of time series data it is not possible to conclude that population was the major cause of most land use changes in Bangladesh as other time-related variables may also have had a significant effect on land use and its changes. However considering present findings, population pressure was found to determine both forests and net-cropped area at district scale. Population growth increases demand for both food and living space thereby increasing homestead area and net-cropped area. This ultimately encourages deforestation and encroachment of forestlands and finally decreases forests. There were some anomalies in the distribution of forests at district level. In Bangladesh only 19 per cent of the districts can be considered as forest rich areas (Table 6.6) and 37 per cent of all districts have no forest at all. The rest of the districts have low or very low proportion of forest. Inundation land type classification was found useful to understand this irregular distribution of forests at district level. It is seen that availability of forests at district level is largely dependent on the general elevation of the district expressed as the flood depth. The higher the elevation the more will be the forests in that particular district (Figure 6.4). So hilly and elevated areas are found to have more forest than low areas. Unlike forests net-cropped areas were found to increase as the flood depth increases from highland to lowland. This implies that lowlands are generally suitable for agriculture. This may be due to the opportunity to have access to easy irrigation facilities that the lowlands offer. The exception is the Sundarbans suitable for mangrove forests in south-western part of Bangladesh. This mangrove forest is not suitable for crops (although it is regularly inundated). Again low elevation areas contain more rivers and thereby help practice of agriculture more than the forests. For this reason Barisal division

possesses more net-cropped area and less forests having more river areas (Chapter 5). Variations were also observed among agricultural land use characteristics in different districts (Tables 6.4 & 6.5). Population density, literacy rate and forest availability class showed some interesting characteristics of agricultural land use in district level (Tables 6.7 & 6.8). Population growth showed a decrease in rice area but an increase in wheat, cash crops, oilseeds areas. This may be due to more economic benefits farmers might get from such crops other than rice while due to improved varieties and increased cropping intensity rice production has increased tremendously (Chapter 4). Increasing literacy rate on the other hand was related to an increased rice area but a decrease in 'other crops' area. This is probably due to a shortage of agricultural labourers as a greater literacy rate encourages people to engage themselves in better employment opportunities than agriculture. Again literacy is also related to overall development of a nation. As the country advances towards development after satisfying its basic requirements other demands increase, such as the demand for luxury items, leisure activities requiring more land for this purposes. So land use decisions should be based on the population pressure and development needs of the country. Careful land allocation at district level to competing land uses and coordinated efforts from concerned government and non-government organisations might help the whole nation towards development.

So far this work has concentrated on aggregate statistics. However, these aggregate statistics are the result of millions of individual land use decisions made by farmers and landowners. Policy also acts on farmers and landowners, and for this reason understanding land use decision-making at the individual farm level is an important step in developing practical land use policy. The next chapter looks into land use at village level to find out farmers' perception about land use and its changes.

CHAPTER 7

SOCIO-ECONOMIC STUDY AND VILLAGE LAND USE

7.1. Introduction.

Bangladesh is predominantly a rural society and about 80 per cent of its population live in the rural areas (Table 4.2). Agriculture is the major land use in Bangladesh covering about 64 per cent of its total area (Table 4.10) and employing about 64 per cent of the total labour force in the country (BBS, 1999b). There are about 17.8 million households in the rural areas of which 64 per cent are considered as farm households (BBS, 1999b) depending directly or indirectly on agriculture. However agricultural land uses show a great variability between different divisions and districts (Chapters 5 & 6). It would be wise to further analyse this variability at rather smaller scale such as at village level to find out the actual land uses and their variations among different households in different divisions, districts and thanas in Bangladesh. This chapter aimed at analysing land uses at household level to identify land use by each individual household in the village areas as well as their socio-economic characteristics at different divisions, districts and thanas in Bangladesh.

This chapter presents the survey results, analysis and a discussion of the results. It is structured in the following sections: a description of the study area, respondents, their attitudes towards land cultivation, relationship between socio-economic aspects and land holding types, respondents' perceptions about cropping pattern and other types of land uses and a discussion of the results and analyses.

7.2. Objective.

The survey was conducted to find out the general socio-economic and land use characteristics of the rural households and to model some socio-economic and land use patterns in rural Bangladesh.

7.3. Research Methods.

A comprehensive socio-economic survey was conducted using a questionnaire format as described in Appendix- 7.1 in order to find out the socio-economic condition and rural land use systems used by the farm households in different sample villages of Bangladesh. A survey was conducted from May to September 1999. The survey was conducted in Bengali and in some cases in local languages with the help of a local guide chosen by the author, and subsequently trained in the importance of the study.

The village household survey was carried out to get the real picture about land use, needs and demand for sample households at micro level. There are six divisions in Bangladesh of which three were selected based on availability of forests, namely,

- Rajshahi as very little forest area,
- Dhaka as moderate forest area and
- Chittagong as forest rich area.

In each division two districts were selected randomly from where two thanas were selected from each district. Then in each thana one village was randomly selected (Appendix 7.2). Sample households were selected from three categories based on the amount of land they operate:

- Small Household (<1.01 ha)
- Medium Household (1.01-3.033 ha)
- Large Household (>3.033 ha)

Rajshahi: Rajshahi is an area poor in forest resources situated on the northwestern part of Bangladesh occupying 23 per cent of total land area (Table 5.1) but having only 1 per cent of total forest area (Table 5.5) of Bangladesh. From this division two districts were randomly selected as Rajshahi and Bogra. Four thanas, Paba and Puthia from Rajshahi and Sonatala and Bogra Sadar were randomly selected, two from each district, from which four villages were selected randomly, one from each thana.

Dhaka: Dhaka is a moderate forest resource zone with a very high population density (1385 persons per sq. km) situated on the central part of Bangladesh occupying 21 per cent of land area (Table 5.1) and containing 5 per cent of the total forest area (Table 5.5) of Bangladesh. Two districts were randomly selected as Tangail and Gazipur, and from within these four thanas, Tangail Sadar and Modhupur from Tangail and Gazipur Sadar and Sripur from Gazipur district were randomly selected. Finally from each thana one village was selected randomly for the survey.

Chittagong: Chittagong is a zone rich in forest resource with comparatively low population density (909 persons per sq. km) situated on the southeastern part of Bangladesh occupying 23 per cent of total land area (Table 5.1) and having a huge 63 per cent of total forest area (Table 5.5) of Bangladesh. From this division two districts were randomly selected as Chittagong and Cox's Bazar. Four thanas were randomly selected, Hathazari and Lohagara from Chittagong and Cox's Bazar Sadar and Ramu from Cox's Bazar district from which four villages were selected randomly, one from each thana.

Then from each household category 4 sample households were selected randomly. After selection of households the head of the household was interviewed with a pre-structured questionnaire (Appendix 7.1) in order to ascertain the demographic and socio-economic conditions of the particular household. Particular emphases were placed on the general history of land use and the causes of land use change in the families' own land.

The survey sought information on respondents' socio-economic situation, and their attitudes towards land use systems. Data on the socio-economic situation revealed characteristics of respondents, whereas attitudes towards land use systems included respondents' perceptions of land use and its changes.

Finally, the survey data were analysed using Microsoft Excel, SPSS and Minitab. The statistical analysis included one-way ANOVA, nested ANOVA, Kruskal-Wallis test, chi-square (χ^2) test, Pearson and Spearman correlation, and regression models. Survey data were first coded and tabulated to prepare a 'village survey database' in order to store all the survey data and

information in SPSS. Survey data were then tested for normality separately for each variable prior to statistical analysis. If data was normal and variances were homogeneous then parametric tests, like one-way ANOVA or nested ANOVA were utilised during data analysis. If the data were not normal log transformations were also conducted to check if it is normal using SPSS otherwise non-parametric tests like Kruskal-Wallis or chi-square tests were performed. While modelling using regression analysis, models of best fit were sought and presented.

7.4. Respondents' Demographic Characteristics.

7.4.1. *Age.*

The head of the family was considered to be the respondent for this study. Most of the respondents' were found to be in 40-49 years class (31.3%) and 50-59 years class (36.8%) ranging from a minimum of 22 years to a maximum of 80 years (Figure 7.1). The mean age of respondents' was found to be 49 years (Table 7.1).

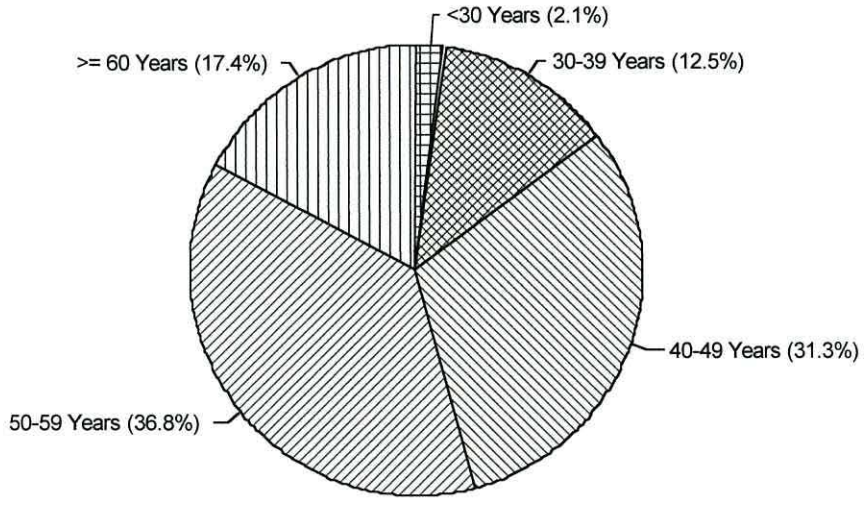

Figure 7.1. Respondents' age class distribution in the study villages.

Respondents' age was found to be significantly different between districts and household types. But it was not significantly different between divisions or thanas (Table 7.2). A nested ANOVA shows that respondents' age distribution is significant in different districts under different divisions such as, Rajshahi and Bogra in Rajshahi division and Chittagong and Cox's Bazar in Chittagong division are significantly different from each other in respondents' mean age (Table 7.1).

7.4.2. Education.

From the survey it was revealed that most of the respondents' have at least primary level education (40%) and only 19% have got no education (Table 7.3). The rest have got secondary (31%) and graduate (9%) level education. For this study those with secondary or higher education were considered as educated. Hence 40% of respondents were found to be educated that ranges from 35 per cent to 46 percent in different divisions and 21 per cent to 62 per cent in different household types. Chi-square test shows that respondents' educational level did not differ significantly between different divisions, districts and thanas but it was found to differ significantly between different household types (Table 7.2). This implies that access to education is dependent on the type of household, that is, the larger the households the greater the percentage of respondents' education level. This is because larger households are better off than the smaller households with more family income and access to basic needs, such as, food, shelter, clothing, health, and other luxury needs and as a result access to more education. Again considering the whole family in all the divisions 59% of family members were found to be educated (Table 7.1), where family members educated (FME) were calculated from family members with secondary or higher education plus schooling family members. The percentage of family members educated did not differ significantly between different divisions and districts but it was found to differ significantly between different thanas and household types (Table 7.2). This implies that access to education is dependent on locality itself and household types. Some thanas in Bangladesh have got more facilities than others, which affect access to education in these thanas and villages.

7.4.3. Family Size.

Average family size was found to be 7 ranging from a minimum of 3 to a maximum of 19 (Table 7.1). It is found to vary significantly between divisions, districts, thanas and household types (Table 7.2). Family size was found to differ significantly with household types. It could be that the larger the household the greater is the family size, as it can support more people than a small household does. Alternatively, it could be that those households with more land needed a larger family in order to manage that land.

Table 7.1. Characteristics of respondents in socio-economic survey grouped by division, district, thana and household type (FS= Family size, FME (%)= Percentage family members educated, FLA= Family labours in agriculture, NS= Not significant, a= Test Statistics are given in Table 7.2. Values in bold denotes significant difference) (nested ANOVA was used showing LSD values for variables having normal distribution).

Grouping variables				Variables			
Division	District	Thana	Household	Respondents' mean age	Family size	Family members educated (%)	Family labours in agriculture
Rajshahi				48	7	59	1
	Rajshahi			**45**	7	63	2
		Paba		44	8	58	2
			Small	40	5	61	1
			Medium	45	8	60	2
			Large	48	11	51	2
		Puthia		45	7	68	1
			Small	40	6	70	1
			Medium	42	7	68	1
			Large	53	9	68	2
	Bogra			**52**	6	54	1
		Sonatala		52	6	51	1
			Small	49	5	36	1
			Medium	55	7	47	2
			Large	53	6	71	1
		Bogra Sadar		51	6	57	1
			Small	51	5	42	2
			Medium	52	5	51	1
			Large	50	8	78	1
Dhaka				49	6	60	1
	Tangail			49	6	58	2
		Tangail Sadar		52	7	58	1
			Small	50	6	64	1
			Medium	52	8	40	2
			Large	54	7	71	1
		Modhupur		46	6	57	2
			Small	40	5	37	3
			Medium	42	6	66	3
			Large	55	7	69	1

Table 7.1. continued.

Gazipur		50	6	63	1
	Gazipur	48	5	51	1
	Small	45	5	25	0
	Medium	49	5	48	1
	Large	50	6	80	1
	Sripur	52	8	74	1
	Small	56	6	59	1
	Medium	46	6	84	1
	Large	55	8	80	2
Chittagong		49	7	58	1
Chittagong		**52**	7	58	1
	Hathazari	50	8	44	1
	Small	50	6	40	1
	Medium	51	9	33	2
	Large	48	8	59	0
	Lohagara	55	6	71	1
	Small	49	6	57	2
	Medium	57	6	67	1
	Large	59	6	89	0
Cox's Bazar		**45**	8	59	1
	Cox's Bazar Sadar	45	8	71	1
	Small	37	7	65	1
	Medium	51	7	75	1
	Large	47	11	72	1
	Ramu	46	8	47	2
	Small	41	7	25	2
	Medium	42	7	43	3
	Large	53	10	72	1
Total		49	7	59	1
LSD Division		NS	a	a	a
LSD District (Division)		5.23	a	a	a
LSD Thana (Division District)		NS	a	a	a
LSD Household (Division District Thana)		NS	a	a	a

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Table 7.2. Respondents' demographic characteristics (HHT= Household Types; a = More than 20% cells have expected count less than 5; NS= Not significant, *= Significant at 0.05 level, **= Significant at 0.01 level, ***= Significant at 0.001 level) (All the variables were first tested for normality and if normal homogeneity of variances were also tested based on the grouping variables. One-way ANOVA was used where data were both normal and homogeneous in variances otherwise Kruskal-Wallis test option was used, and for categorical data Chi-square test was used).

Grouping Factors	Variable	Test Option	n	df	Test Statistics	P-value
Division	Respondents' Age	One Way ANOVA	144	2	$F = 0.191$	0.826^{NS}
District		One Way ANOVA	144	5	$F = 2.712$	0.023^{*}
Thana		Kruskal-Wallis	144	11	$H = 15.936$	0.144^{NS}
HHT		Kruskal-Wallis	144	2	$H = 15.334$	0.000^{***}
Division	Respondents' Education Level	Chi-Square	144	2	$\chi^2 = 2.58$	0.631^{NS}
District		Chi-Square	144	5	$\chi^2 = 7.51$ [a]	0.677^{NS}
Thana		Chi-Square	144	11	$\chi^2 = 16.91$ [a]	0.769^{NS}
HHT		Chi-Square	144	2	$\chi^2 = 23.64$	0.000^{***}
Division	Family Size	Kruskal-Wallis	144	2	$H = 8.53$	0.014^{*}
District		Kruskal-Wallis	144	5	$H = 18.14$	0.003^{**}
Thana		Kruskal-Wallis	144	11	$H = 26.56$	0.005^{**}
HHT		Kruskal-Wallis	144	2	$H = 25.67$	0.000^{***}
Division	Family Members Educated (%)	Kruskal-Wallis	144	2	$H = 0.15$	0.927^{NS}
District		Kruskal-Wallis	144	5	$H = 3.40$	0.638^{NS}
Thana		Kruskal-Wallis	144	11	$H = 22.43$	0.021^{*}
HHT		Kruskal-Wallis	144	2	$H = 25.45$	0.000^{***}
Division	Primary Occupation	Chi-Square	144	2	$\chi^2 = 0.21$	0.900^{NS}
District		Chi-Square	144	5	$\chi^2 = 2.85$	0.723^{NS}
Thana		Chi-Square	144	11	$\chi^2 = 6.86$ [a]	0.811^{NS}
HHT		Chi-Square	144	2	$\chi^2 = 9.07$ [a]	0.011^{*}
Division	Secondary Occupation	Chi-Square	144	2	$\chi^2 = 5.60$	0.231^{NS}
District		Chi-Square	144	5	$\chi^2 = 6.50$ [a]	0.772^{NS}
Thana		Chi-Square	144	11	$\chi^2 = 11.50$ [a]	0.967^{NS}
HHT		Chi-Square	144	2	$\chi^2 = 8.50$	0.075^{NS}
Division	Family Labour in Agriculture	Kruskal-Wallis	144	2	$H = 2.97$	0.226^{NS}
District		Kruskal-Wallis	144	5	$H = 16.11$	0.007^{**}
Thana		Kruskal-Wallis	144	11	$H = 28.02$	0.003^{**}
HHT		Kruskal-Wallis	144	2	$H = 6.29$	0.043^{*}
Division	Family Type	Chi-Square	144	2	$\chi^2 = 1.75$	0.418^{NS}
District		Chi-Square	144	5	$\chi^2 = 3.01$	0.699^{NS}
Thana		Chi-Square	144	11	$\chi^2 = 14.84$ [a]	0.190^{NS}
HHT		Chi-Square	144	2	$\chi^2 = 21.53$	0.000^{***}

Table 7.3. Educational characteristics of respondents grouped by division and household type.

Division	Household Type	Respondents' education level				
		No education	Primary level	Secondary level	Graduate level	Total
Rajshahi	Small (n= 16)	31.3	37.5	25.0	6.3	100
	Medium (n= 16)	31.3	31.3	37.5	0.0	100
	Large (n= 16)	6.3	43.8	43.8	6.3	100
	Total (n= 48)	22.9	37.5	35.4	4.2	100
Dhaka	Small (n= 16)	50.0	37.5	12.5	0.0	100
	Medium (n= 16)	18.8	43.8	25.0	12.5	100
	Large (n= 16)	0.0	43.8	50.0	6.3	100
	Total (n= 48)	22.9	41.7	29.2	6.3	100
Chittagong	Small (n= 16)	18.8	62.5	6.3	12.5	100
	Medium (n= 16)	18.8	43.8	37.5	0.0	100
	Large (n= 16)	0.0	18.8	43.8	37.5	100
	Total (n= 48)	12.5	41.7	29.2	16.7	100
Overall	Small (n= 48)	33.3	45.8	14.6	6.3	100
	Medium (n= 48)	22.9	39.6	33.3	4.2	100
	Large (n= 48)	2.1	35.4	45.8	16.7	100
	Total (n= 144)	19.4	40.3	31.3	9.0	100

7.4.4. *Occupation.*

Most of the families were found to depend directly or indirectly on agriculture in the village areas. Result shows that 27 per cent of the families depended purely on agriculture and the majority (46 per cent) stated agriculture was their primary occupation with business, services or other as secondary occupations. A further 15 per cent had agriculture as a secondary occupation with business, services or other as the primary occupation. Not surprisingly, only 12 per cent of the families engaged themselves in occupations other than agriculture (Table 7.4) that is only 4.2 per cent for the medium households. This implies that medium households are more dependent on agriculture compared to a smaller or larger household. Variation in occupation is also observed in divisions. Rajshahi division showed more dependency on agriculture with all the households (100%) engaged directly or indirectly in agriculture compared to Dhaka (81%) and Chittagong (83%) (Table 7.4).

Table 7.4. Occupational characteristics of respondent households grouped by division and household type (A&B= Agriculture & business; A&S= Agriculture & service; A&O= Agriculture and others; B&A= Business & agriculture; S&A= Service & agriculture; O7A= Others & agriculture).

Division	Household Type	Pure Agriculture	Primary agriculture				Secondary agriculture				Non-agriculture				Total
			A&B	A&S	A&O	Total	B&A	S&A	O&A	Total	Business	Service	Others	Total	
Rajshahi	Small (n= 16)	18.8	18.8	0.0	18.8	37.5	6.3	12.5	25.0	43.8	0.0	0.0	0.0	0.0	100
	Medium (n= 16)	31.3	25.0	6.3	18.8	50.0	6.3	12.5	0.0	18.8	0.0	0.0	0.0	0.0	100
	Large (n= 16)	50.0	18.8	18.8	0.0	37.5	6.3	6.3	0.0	12.5	0.0	0.0	0.0	0.0	100
	Total (n= 48)	33.3	20.8	8.3	12.5	41.7	6.3	10.4	8.3	25.0	0.0	0.0	0.0	0.0	100
Dhaka	Small (n= 16)	12.5	6.3	12.5	25.0	43.8	6.3	0.0	0.0	6.3	18.8	6.3	12.5	37.5	100
	Medium (n= 16)	43.8	25.0	0.0	18.8	43.8	0.0	6.3	0.0	6.3	0.0	6.3	0.0	6.3	100
	Large (n= 16)	12.5	25.0	37.5	0.0	62.5	12.5	0.0	0.0	12.5	6.3	6.3	0.0	12.5	100
	Total (n= 48)	22.9	18.8	16.7	14.6	50.0	6.3	2.1	0.0	8.3	8.3	6.3	4.2	18.8	100
Chittagong	Small (n= 16)	6.3	12.5	18.8	25.0	56.3	0.0	12.5	12.5	25.0	0.0	0.0	12.5	12.5	100
	Medium (n= 16)	56.3	6.3	25.0	0.0	31.3	0.0	6.3	0.0	6.3	0.0	6.3	0.0	6.3	100
	Large (n= 16)	12.5	31.3	18.8	0.0	50.0	0.0	6.3	0.0	6.3	25.0	6.3	0.0	31.3	100
	Total (n= 48)	25.0	16.7	20.8	8.3	45.8	0.0	4.2	8.3	12.5	8.3	4.2	4.2	16.7	100
Overall	Small (n= 48)	12.5	12.5	10.4	22.9	45.8	4.2	8.3	12.5	25.0	6.3	2.1	8.3	16.7	100
	Medium (n= 48)	43.8	18.8	10.4	12.5	41.7	2.1	8.3	0.0	10.4	0.0	4.2	0.0	4.2	100
	Large (n= 48)	25.0	25.0	25.0	0.0	50.0	6.3	4.2	0.0	10.5	10.4	4.2	0.0	14.5	100
	Total (n= 144)	27.1	18.8	15.3	11.8	45.8	4.2	6.9	4.2	15.3	5.6	3.5	2.8	11.9	100

7.5. Village Land Use Pattern.

In village areas most of the land is used for agricultural purposes. It was found that on average 80 per cent of total land was used for this purpose of which 59 per cent was used by the farmer himself and the rest was let to others for cultivation (Table 7.5). A second major land use is the homestead, covering 17 per cent of land. A homestead is an area for the household to live and generally comprised a dwelling unit (4.2 per cent of total land), pond (3.6 per cent of total land), trees (6.2 per cent of total land), yard (1.9 per cent of total land) and animal sheds (0.8 per cent of total land) (Table 7.5). A strong positive relationship (with P value <0.001) was found between household types and homestead area in all the divisions (Table 7.10). This implies that the larger the household type the greater the homestead area irrespective of locality. Smaller households use a greater proportion of their total land for homestead purpose (28 per cent) compared to 13 per cent and 10 per cent for medium and large households respectively (Table 7.5). Significant variation was also observed in the use of homestead land as percentage of total land between household types but not for divisions, districts or thanas (Table 7.9). This implies that the smaller the household greater is the percentage of total land used for homestead irrespective of locality. Larger households were found to use more of their land for agricultural purpose (86 per cent of total land) than medium (83 per cent of total land) and small households (70 per cent of total land) (Table 7.5). It was the medium households who used more of their land for cropping purposes (74 per cent) compared to 65 per cent by small households and only 37 per cent by large households (Table 7.5). However larger households let more of their land to others for cultivation (49 per cent of total land) compared to only 6 per cent for small households and 9 per cent for medium households (Table 7.5). The farm households also used the cropped area for different crops. The majority of households cultivated rice (80 per cent of total respondents) and vegetables (72 per cent of total respondents) (Table 7.6). Cropped area was found to have strong significant positive correlation with household types except in Chittagong division (Table 7.10). Strong significant variations were observed in the cultivation of wheat, jute and potato in different locations (division, district or thana) (Tables 7.6 & 7.9). Wheat and jute were not cultivated in Chittagong division at all (Table 7.6). The survey revealed that farm households use 8 per cent of their total land resources for growing trees and bamboos (Table 7.5), known as homestead forests that supply majority of the forest products' demand of the country (Chapter 4).

Table 7.5. Land use characteristics of respondent households grouped by division and household type (land use expressed as the percentage of total land resources of respondent households).

Division	Household Type	Homestead (%)						Agriculture (%)			Trees & bamboos (%)	Fishing (%)	Other land (%)	Total land (%)	Total trees (%)
		Dwelling unit	Pond	Trees	Yard	Animal shed	Total	Cropped area	Land let to others	Total					
Rajshahi	Small	7.3	3.7	2.7	3.1	1.4	18.2	79.8	0.0	79.8	0.0	2.0	0.0	100	2.7
	Medium	2.2	3.3	2.1	1.4	0.6	9.5	74.2	7.6	81.8	3.9	4.7	0.1	100	6.0
	Large	2.1	3.7	2.6	1.4	0.6	10.4	48.7	33.9	82.6	4.0	2.9	0.0	100	6.7
	Total	3.8	3.6	2.5	1.9	0.9	12.7	67.6	13.8	81.4	2.6	3.2	0.0	100	5.1
Dhaka	Small	10.1	0.8	22.2	3.8	1.7	38.6	45.5	12.9	58.4	1.9	0.4	0.6	100	24.1
	Medium	2.7	3.0	5.4	1.3	0.7	13.0	74.2	9.4	83.6	1.9	1.5	0.0	100	7.3
	Large	1.6	3.1	2.7	0.7	0.4	8.6	40.6	47.7	88.3	1.2	1.8	0.0	100	3.9
	Total	4.8	2.3	10.1	1.9	0.9	20.0	53.5	23.4	76.9	1.7	1.3	0.2	100	11.8
Chittagong	Small	7.4	7.9	6.3	3.3	1.3	26.2	68.3	4.2	72.5	0.0	1.3	0.0	100	6.3
	Medium	2.8	4.0	6.8	1.2	0.6	15.5	72.6	10.5	83.1	1.4	0.0	0.0	100	8.2
	Large	1.3	2.9	4.6	0.9	0.3	10.0	22.4	65.2	87.6	1.3	0.7	0.3	100	6.0
	Total	3.8	4.9	5.9	1.8	0.7	17.2	54.4	26.6	81.0	0.9	0.7	0.2	100	6.8
Overall	Small	8.3	4.1	10.4	3.4	1.5	27.6	64.5	5.7	70.2	0.6	1.2	0.3	100	11.0
	Medium	2.6	3.4	4.8	1.3	0.6	12.7	73.7	9.2	82.9	2.4	2.1	0.0	100	7.2
	Large	1.7	3.2	3.3	1.0	0.4	9.7	37.3	48.9	86.2	2.2	1.8	0.1	100	5.5
	Total	4.2	3.6	6.2	1.9	0.8	16.7	58.5	21.3	79.8	1.7	1.7	0.1	100	7.9

Smaller households were observed to use a greater proportion (11 per cent) of their land resources for trees (Table 7.5). This may be due to less proportion of their land used for agriculture compared to larger households. Dhaka division used a greater proportion of their land trees (12 per cent) compared to 5 per cent in Rajshahi and 6 per cent in Chittagong. However it was the smaller households in Dhaka division that used a greater proportion of their land for trees (24 per cent) compared to larger households. This may be due to more dependence of smaller households on fruit trees especially the jack fruits (*Artocarpus heteropyllus*) as a source of their family income in Modhupur thana. A significant variation was also observed in tree areas as percentage of total land resources between thanas but not for divisions, districts or household types (Table 7.9).

Table 7.6. Agricultural land use characteristics of respondent households grouped by division and household type (cropping pattern expressed as the percentage of the respondents cultivating that particular crop).

Division	Household Type	Cropping pattern (% of total respondents)					
		Rice	Wheat	Jute	Potato	Vegetables	Others
Rajshahi	Small (n= 16)	100.0	25.0	0.0	25.0	81.3	25.0
	Medium (n= 16)	93.8	31.3	43.8	56.3	81.3	43.8
	Large (n= 16)	87.5	37.5	18.8	56.3	81.3	56.3
	Total (n= 48)	93.8	31.3	20.8	45.8	81.3	41.7
Dhaka	Small (n= 16)	43.8	0.0	12.5	0.0	25.0	25.0
	Medium (n= 16)	81.3	18.8	25.0	6.3	68.8	50.0
	Large (n= 16)	75.0	12.5	18.8	6.3	68.8	37.5
	Total (n= 48)	66.7	10.4	18.8	4.2	54.2	37.5
Chittagong	Small (n= 16)	87.5	0.0	0.0	25.0	81.3	31.3
	Medium (n= 16)	87.5	0.0	0.0	43.8	93.8	50.0
	Large (n= 16)	62.5	0.0	0.0	43.8	62.5	43.8
	Total (n= 48)	79.2	0.0	0.0	37.5	79.2	41.7
Overall	Small (n= 48)	77.1	8.3	4.2	16.7	62.5	27.1
	Medium (n= 48)	87.5	16.7	22.9	35.4	81.3	47.9
	Large (n= 48)	75.0	16.7	12.5	35.4	70.8	45.8
	Total (n= 144)	79.9	13.9	13.2	29.2	71.5	40.3

7.5.1. *Homestead.*

The distribution of land within the homestead in the different divisions and household types is presented in Table 7.7. It is observed that there exists great variability in the composition of different land utilizations in the homestead among divisions and household types. Tree areas in and around the homestead were the major land use in the homestead comprising an overall average of 36 per cent of the homestead area. Ponds (30 per cent) were the next major land use followed by dwelling unit (19 per cent), yard (11 per cent) and animal shed (5 per cent). Among the divisions Rajshahi showed different results from the overall average, where ponds were the major land use comprising 35 per cent of the homestead area.

Table 7.7. Homestead land utilization of respondent households grouped by division and household type.

Division	Household Type	Dwelling unit		Pond		Trees		Yard		Animal shed		Homestead	
		(ha)	(%)	(ha)	(%)	(ha)	(%)	(ha)	(%)	(ha)	(%)	(ha)	(%)
Rajshahi	Small	0.028	37	0.018	24	0.010	14	0.013	17	0.006	8	0.076	100
	Medium	0.037	23	0.057	35	0.037	22	0.023	14	0.010	6	0.163	100
	Large	0.082	19	0.156	37	0.106	25	0.059	14	0.025	6	0.428	100
	Total	0.049	22	0.077	35	0.051	23	0.032	14	0.014	6	0.222	100
Dhaka	Small	0.033	22	0.007	4	0.090	60	0.013	9	0.007	5	0.149	100
	Medium	0.047	20	0.060	26	0.092	40	0.021	9	0.012	5	0.232	100
	Large	0.063	19	0.120	37	0.101	31	0.027	8	0.015	5	0.326	100
	Total	0.048	20	0.062	26	0.094	40	0.020	9	0.011	5	0.236	100
Chittagong	Small	0.030	25	0.033	27	0.038	31	0.013	11	0.007	6	0.121	100
	Medium	0.051	19	0.074	27	0.113	42	0.020	8	0.011	4	0.270	100
	Large	0.062	12	0.144	29	0.230	46	0.050	10	0.013	3	0.498	100
	Total	0.047	16	0.084	28	0.127	43	0.028	9	0.010	3	0.296	100
Overall	Small	0.030	26	0.019	17	0.046	40	0.013	11	0.007	6	0.116	100
	Medium	0.045	20	0.064	29	0.081	36	0.021	10	0.011	5	0.222	100
	Large	0.069	17	0.140	34	0.146	35	0.045	11	0.017	4	0.418	100
	Total	0.048	19	0.074	30	0.091	36	0.027	11	0.012	5	0.252	100

7.5.2. *Agriculture.*

Variability was also observed in the agricultural land utilization in the village areas. Household land use distributions and their differences between different grouping variables are presented in Tables 7.8 and 7.9. It is observed that total land resources differ significantly between different

household types, but not between different divisions, districts or thanas. Homestead area was also found to be highly significant among different household types. Cropped area differed significantly between districts and household types. Cropping intensity, an indication of how intensively cropped area is used for different crops, also differed significantly between divisions, districts, thanas and household types. Chittagong division had the more intensive cropping (223 per cent) then other divisions (Table 7.8). However household type also affected cropping intensity significantly. The smaller households tended to crop more intensively, perhaps due to a desire to get more production from their limited land resources.

As rice was the major crop grown in the village areas an attempt has been made to analyse rice production according to different grouping variables such as, divisions, districts, thanas and household types. The results of this analysis are presented in Tables 7.11 and 7.12. Rice production varied significantly between different thanas/villages, with an average value of 547.12 US$/ha (1 US$= 54 TK.). Net rice production also varied significantly between different thanas/villages, but not between other grouping variables. Rice production per capita (Kg/Year) differed significantly between different households. This is because large and medium families produce more rice, as they tend to have more rice area.

Table 7.8. Village land use characteristics grouped by division, district, thana and household type (TLR= Total Land Resources (ha), HSA= Homestead Area (ha), CA= Cropped Area (ha), GCA= Gross Cropped Area (ha), RA= Rice Area (ha), CI= Cropping Intensity (%), NS= Not significant, a= Test Statistics are given in Table 7.9) (nested ANOVA was used showing LSD values for variables having normal distribution).

Grouping variables				Variables					
Division	District	Thana	Household	TLR	HSA	CA	GCA	CI	RA
Rajshahi				2.109	0.222	1.205	2.068	184	0.685
	Rajshahi			2.042	0.225	1.450	2.275	167	0.647
		Paba		2.067	0.252	1.380	2.034	158	0.587
			Small	0.450	0.083	0.369	0.628	173	0.259
			Medium	1.725	0.268	1.335	2.170	163	0.668
			Large	4.025	0.405	2.437	3.304	139	0.835
		Puthia		2.017	0.198	1.519	2.515	175	0.707
			Small	0.700	0.080	0.618	1.252	206	0.451
			Medium	1.700	0.115	1.402	2.221	158	0.634
			Large	3.650	0.400	2.537	4.073	160	1.035
	Bogra			2.176	0.219	0.960	1.862	201	0.724
		Sonatala		2.282	0.262	0.944	1.902	193	0.816

Table 7.8. continued.

		Small	0.545	0.075	0.394	0.866	194	0.394
		Medium	1.725	0.140	1.170	2.370	204	0.985
		Large	4.575	0.570	1.269	2.471	180	1.068
	Bogra Sadar		2.070	0.177	0.976	1.822	209	0.631
		Small	0.385	0.063	0.325	0.774	275	0.258
		Medium	1.850	0.130	1.269	2.037	147	0.735
		Large	3.975	0.338	1.335	2.654	207	0.901
Dhaka			2.064	0.235	1.054	1.919	175	0.751
	Tangail		2.022	0.230	1.238	2.409	191	0.737
		Tangail Sadar	2.118	0.178	1.192	3.163	263	1.003
		Small	0.828	0.095	0.601	1.688	281	0.601
		Medium	1.950	0.170	1.739	4.295	261	1.439
		Large	3.575	0.268	1.235	3.506	248	0.968
		Modhupur	1.927	0.283	1.284	1.655	119	0.471
		Small	0.480	0.260	0.219	0.219	100	0.000
		Medium	1.550	0.255	1.306	1.407	107	0.302
		Large	3.750	0.335	2.327	3.339	148	1.113
	Gazipur		2.105	0.240	0.870	1.429	160	0.765
		Gazipur	2.052	0.211	0.768	0.959	115	0.691
		Small	0.355	0.100	0.134	0.134	100	0.100
		Medium	1.900	0.230	1.202	1.440	123	1.139
		Large	3.900	0.303	0.968	1.302	122	0.835
		Sripur	2.159	0.269	0.972	1.900	205	0.839
		Small	0.578	0.138	0.313	0.725	220	0.313
		Medium	1.875	0.268	1.002	2.104	213	0.935
		Large	4.025	0.403	1.602	2.872	182	1.269
Chittagong			2.593	0.296	0.968	2.066	223	0.868
	Chittagong		2.559	0.267	0.679	1.463	226	0.645
		Hathazari	2.626	0.163	0.602	1.301	228	0.575
		Small	0.403	0.093	0.310	0.706	218	0.310
		Medium	1.500	0.088	1.417	2.995	217	1.336
		Large	5.975	0.308	0.081	0.202	250	0.081
		Lohagara	2.493	0.371	0.755	1.626	224	0.715
		Small	0.553	0.185	0.364	0.931	261	0.364
		Medium	1.950	0.380	1.214	2.570	214	1.174
		Large	4.975	0.548	0.688	1.376	196	0.607
	Cox's Bazar		2.626	0.325	1.257	2.670	220	1.091
		Cox's Bazar Sadar	2.676	0.344	1.145	2.598	222	1.124
		Small	0.778	0.098	0.421	0.994	242	0.724
		Medium	2.050	0.283	1.402	2.788	175	1.035
		Large	5.200	0.653	1.613	4.012	249	1.613
		Ramu	2.576	0.306	1.369	2.742	218	1.059
		Small	0.678	0.108	0.567	1.442	257	0.567
		Medium	1.875	0.323	1.437	3.071	216	1.315
		Large	5.175	0.488	2.104	3.713	181	1.295
Total			2.255	0.251	1.076	2.018	194	0.768
LSD Division			a	a	NS	NS	NS	NS
LSD District (Division)			a	a	0.216	NS	NS	NS
LSD Thana (Division District)			a	a	NS	NS	47	NS
LSD Household (Division District Thana)			a	a	0.840	1.692	58	0.742

Table 7.9. Village land use characteristics (HHT= Household Types; NS= Not significant, *= Significant at 0.05 level, **= Significant at 0.01 level, ***= Significant at 0.001 level) (All the variables were first tested for normality and if normal homogeneity of variances were also tested based on the grouping variables. One-way ANOVA was used where data were both normal and homogeneous in variances otherwise Kruskal-Wallis test option was used).

Grouping Factors	Variable	Test Option	n	df	Test Statistics	P-value
Division	Total Land Resources (ha)	Kruskal-Wallis	144	2	H= 0.52	0.771 NS
District		Kruskal-Wallis	144	5	H= 0.89	0.971 NS
Thana		Kruskal-Wallis	144	11	H= 1.34	1.000 NS
HHT		Kruskal-Wallis	144	2	H= 126.97	0.000 ***
Division	Homestead Area (ha)	Kruskal-Wallis	144	2	H= 4.01	0.134 NS
District		Kruskal-Wallis	144	5	H= 5.46	0.362 NS
Thana		Kruskal-Wallis	144	11	H= 16.09	0.138 NS
HHT		Kruskal-Wallis	144	2	H= 66.58	0.000 ***
Division	Homestead Area (% of total land)	Kruskal-Wallis	144	2	H= 1.58	0.455 NS
District		Kruskal-Wallis	144	5	H= 2.68	0.749 NS
Thana		Kruskal-Wallis	144	11	H= 15.78	0.149 NS
HHT		Kruskal-Wallis	144	2	H= 28.78	0.000 ***
Division	Cropped Area (ha)	One Way ANOVA	144	2	F= 0.98	0.380 NS
District		One Way ANOVA	144	5	F= 2.99	0.013 *
Thana		One Way ANOVA	144	11	F= 1.43	0.167 NS
HHT		Kruskal-Wallis	144	2	H= 50.09	0.000 ***
Division	Gross Cropped Area (ha)	One Way ANOVA	144	2	F= 0.14	0.870 NS
District		One Way ANOVA	144	5	F= 2.70	0.023 *
Thana		One Way ANOVA	144	11	F= 2.09	0.025 *
HHT		Kruskal-Wallis	144	2	H= 40.126	0.000 ***
Division	Cropped area (% of total land)	Kruskal-Wallis	144	2	H= 2.21	0.332 NS
District		Kruskal-Wallis	144	5	H= 12.98	0.024 *
Thana		Kruskal-Wallis	144	11	H= 17.65	0.090 NS
HHT		Kruskal-Wallis	144	2	H= 36.38	0.000 ***
Division	Cropping Intensity (%)	Kruskal-Wallis	144	2	H= 15.538	0.000 ***
District		Kruskal-Wallis	144	5	H= 23.241	0.000 ***
Thana		Kruskal-Wallis	144	11	H= 58.299	0.000 ***
HHT		One Way ANOVA	144	2	F= 5.06	0.008 **
Division	Rice Area	Kruskal-Wallis	144	2	H= 0.895	0.639 NS
District		Kruskal-Wallis	144	5	H= 6.790	0.237 NS
Thana		Kruskal-Wallis	144	11	H= 14.015	0.232 NS
HHT		Kruskal-Wallis	144	2	H= 31.326	0.000 ***
Division	Wheat Area (ha)	Kruskal-Wallis	144	2	H= 19.873	0.000 ***
District		Kruskal-Wallis	144	5	H= 62.647	0.000 ***
Thana		Kruskal-Wallis	144	11	H= 87.672	0.000 ***
HHT		Kruskal-Wallis	144	2	H= 2.294	0.318 NS
Division	Jute Area (ha)	Kruskal-Wallis	144	2	H= 10.825	0.004 **
District		Kruskal-Wallis	144	5	H= 28.769	0.000 ***
Thana		Kruskal-Wallis	144	11	H= 79.143	0.000 ***
HHT		Kruskal-Wallis	144	2	H= 7.448	0.024 *

Table 7.9. continued.

Division	Potato Area (ha)	Kruskal-Wallis	144	2	H= 22.167	0.000 ***
District		Kruskal-Wallis	144	5	H= 65.686	0.000 ***
Thana		Kruskal-Wallis	144	11	H= 70.328	0.000 ***
HHT		Kruskal-Wallis	144	2	H= 8.052	0.018 *
Division	Vegetable Area (ha)	Kruskal-Wallis	144	2	H= 5.536	0.063 NS
District		Kruskal-Wallis	144	5	H= 18.845	0.002 **
Thana		Kruskal-Wallis	144	11	H= 34.33	0.000 ***
HHT		Kruskal-Wallis	144	2	H= 20.008	0.000 ***
Division	Other Crop Area (ha)	Kruskal-Wallis	144	2	H= 0.712	0.701 NS
District		Kruskal-Wallis	144	5	H= 66.798	0.000 ***
Thana		Kruskal-Wallis	144	11	H= 76.462	0.000 ***
HHT		Kruskal-Wallis	144	2	H= 8.722	0.013 *
Division	Other Areas	Kruskal-Wallis	144	2	H= 7.23	0.027 *
District		Kruskal-Wallis	144	5	H= 10.74	0.057 NS
Thana		Kruskal-Wallis	144	11	H= 18.73	0.066 NS
HHT		Kruskal-Wallis	144	2	H= 19.25	0.000 ***
Division	Total tree areas (% of total land)	Kruskal-Wallis	144	2	H= 1.45	0.485 NS
District		Kruskal-Wallis	144	5	H= 9.86	0.079 NS
Thana		Kruskal-Wallis	144	11	H= 30.33	0.001 ***
HHT		Kruskal-Wallis	144	2	H= 0.48	0.788 NS

Table 7.10. Correlation between different variables (a) all divisions, (b) Rajshahi division, (c) Dhaka division and (d) Chittagong division. (HHT= Household Type, FS= Family Size, TLR= Total Land Resources (ha), HSA= Homestead Area (ha), CA= Cultivated Area (ha), RA= Rice Area (ha), WA= Wheat Area (ha), JA= Jute Area (ha), PA= Potato Area (ha), VA= Vegetable Area (ha), OCA= Other Crop Area (ha), TR= Tree Resources (nos.), TFI= Total Family Income (US$), ***= Significant at 0.001 level, **= Significant at 0.01 level, *= Significant at 0.05 level, NS= Not significant. Pearson's correlation coefficients are used except for HHT vs other factors where Spearman's rho are used. Values in parenthesis show P-value).

(a)

	HHT	*FS*	*TLR*	*HSA*	*CA*	*RA*	*WA*	*JA*	*PA*	*VA*	*OCA*	*TR*
FS	.424***	-	-	-	-	-	-	-	-	-	-	-
	(.000)											
TLR	.942***	.423***	-	-	-	-	-	-	-	-	-	-
	(.000)	(.000)										
HSA	.681***	.237**	.672***	-	-	-	-	-	-	-	-	-
	(.000)	(.004)	(.000)									
CA	.525***	.454***	.448***	.273**	-	-	-	-	-	-	-	-
	(.000)	(.000)	(.000)	(.001)								
RA	.387***	.351***	.360***	.218**	.787***	-	-	-	-	-	-	-
	(.000)	(.000)	(.000)	(.009)	(.000)							
WA	.115NS	.270***	.101NS	-.031NS	.409***	.120NS	-	-	-	-	-	-
	(.170)	(.001)	(.227)	(.710)	(.000)	(.153)						
JA	.104NS	.081NS	.050NS	-.054NS	.248**	.203*	.391***	-	-	-	-	-
	(.215)	(.334)	(.556)	(.518)	(.003)	(.015)	(.000)					
PA	.223**	.310***	.354***	.256**	.448***	.373***	.162NS	.130NS	-	-	-	-
	(.007)	(.000)	(.000)	(.002)	(.000)	(.000)	(.053)	(.121)				
VA	.330***	.386***	.273***	.116NS	.601***	.495***	.347***	.172*	.304***	-	-	-
	(.000)	(.000)	(.001)	(.167)	(.000)	(.000)	(.000)	(.039)	(.000)			
OCA	.230**	.234**	.207*	.142NS	.609***	.228**	.482***	.215**	.175*	.068NS	-	-
	(.006)	(.005)	(.013)	(.090)	(.000)	(.006)	(.000)	(.010)	(.036)	(.417)		
TR	.291***	.177*	.234**	.310***	.193*	.254**	-.127NS	-.109NS	.324***	.038NS	.132NS	-
	(.000)	(.034)	(.005)	(.000)	(.021)	(.002)	(.130)	(.195)	(.000)	(.648)	(.115)	
TFI	.688***	.424***	.665***	.513***	.140NS	.144NS	.032NS	-.009NS	.071NS	.043NS	.117NS	.192*
	(.000)	(.000)	(.000)	(.000)	(.094)	(.086)	(.699)	(.912)	(.397)	(.609)	(.163)	(.021)

(b)

	HHT	*FS*	*TLR*	*HSA*	*CA*	*RA*	*WA*	*JA*	*PA*	*VA*	*OCA*	*TR*
FS	.526***	-	-	-	-	-	-	-	-	-	-	-
	(.000)											
TLR	.943***	.470***	-	-	-	-	-	-	-	-	-	-
	(.000)	(.001)										
HSA	.808***	.177NS	.801***	-	-	-	-	-	-	-	-	-
	(.000)	(.229)	(.000)									
CA	.715***	.657***	.646***	.398**	-	-	-	-	-	-	-	-
	(.000)	(.000)	(.000)	(.005)								
RA	.601***	.286*	.621***	.482***	.719***	-	-	-	-	-	-	-
	(.000)	(.049)	(.000)	(.001)	(.000)							
WA	.178NS	.566***	.189NS	.024NS	.583***	.077NS	-	-	-	-	-	-
	(.225)	(.000)	(.198)	(.873)	(.000)	(.604)						
JA	.186NS	.222NS	.072NS	.075NS	.298*	.220NS	.002NS	-	-	-	-	-
	(.206)	(.129)	(.627)	(.613)	(.039)	(.134)	(.987)					
PA	.359*	.351*	.466***	.223**	.480***	.528***	.026NS	.213NS	-	-	-	-
	(.012)	(.014)	(.001)	(.128)	(.001)	(.000)	(.863)	(.147)				
VA	.464***	.640***	.436**	.240NS	.705***	.253NS	.503***	.308*	.293*	-	-	-
	(.001)	(.000)	(.002)	(.101)	(.000)	(.082)	(.000)	(.033)	(.043)			
OCA	.349*	.438**	.348*	.165NS	.692***	.297*	.730***	-.131NS	.056NS	.389**	-	-
	(.015)	(.002)	(.016)	(.263)	(.000)	(.041)	(.000)	(.373)	(.707)	(.006)		
TR	.590***	.062NS	.442**	.496***	.201NS	.237NS	-.131NS	.030NS	.078NS	.053NS	-.003NS	-
	(.000)	(.675)	(.002)	(.000)	(.171)	(.105)	(.375)	(.841)	(.599)	(.718)	(.984)	
TFI	.761***	.359*	.795***	.687***	.414**	.403**	.239NS	-.105NS	.213NS	.161NS	.356*	.476***
	(.000)	(.012)	(.000)	(.000)	(.003)	(.005)	(.101)	(.479)	(.147)	(.276)	(.013)	(.001)

Table 7.10. continued.

(c)

	HHT	*FS*	*TLR*	*HSA*	*CA*	*RA*	*WA*	*JA*	*PA*	*VA*	*OCA*	*TR*
FS	.425*** (.000)	-	-	-	-	-	-	-	-	-	-	-
TLR	.942*** (.000)	.477*** (.001)	-	-	-	-	-	-	-	-	-	-
HSA	.528*** (.000)	.325* (.024)	.546*** (.000)	-	-	-	-	-	-	-	-	-
CA	.607*** (.000)	.303* (.037)	.569*** (.000)	.243NS (.096)	-	-	-	-	-	-	-	-
RA	.479*** (.001)	.260NS (.075)	.483*** (.001)	.112NS (.450)	.834*** (.000)	-	-	-	-	-	-	-
WA	.172NS (.242)	.130NS (.379)	.234NS (.110)	.014NS (.924)	.341* (.018)	.395** (.006)	-	-	-	-	-	-
JA	.085NS (.565)	.225NS (.125)	.166NS (.261)	-.111NS (.451)	.305* (.035)	.359* (.012)	.752*** (.000)	-	-	-	-	-
PA	.130NS (.377)	-.011NS (.940)	.160NS (.277)	.010** (.945)	.167NS (.256)	.203NS (.166)	.612*** (.000)	.413** (.004)	-	-	-	-
VA	.448*** (.001)	.399** (.005)	.497*** (.000)	.251NS (.085)	.373** (.009)	.614*** (.000)	.249NS (.088)	.222NS (.129)	.184NS (.211)	-	-	-
OCA	.195NS (.184)	.085NS (.566)	.174NS (.238)	.060NS (.683)	.577*** (.000)	.173NS (.239)	.311* (.031)	.347* (.016)	.249NS (.088)	-.243NS (.096)	-	-
TR	.061NS (.681)	-.185NS (.208)	-.112NS (.450)	.071NS (.631)	.055NS (.711)	-.178NS (.226)	-.130NS (.370)	-.143NS (.333)	-.080NS (.591)	-.260NS (.074)	.263NS (.074)	-
TFI	.666*** (.000)	.535*** (.000)	.629*** (.000)	.480*** (.001)	.269NS (.065)	.261NS (.074)	.156NS (.289)	.129NS (.381)	.140NS (.343)	.424** (.003)	.084NS (.568)	.029NS (.843)

(d)

	HHT	*FS*	*TLR*	*HSA*	*CA*	*RA*	*WA*	*JA*	*PA*	*VA*	*OCA*	*TR*
FS	.363* (.011)	-	-	-	-	-	-	-	-	-	-	-
TLR	.943*** (.000)	.352* (.014)	-	-	-	-	-	-	-	-	-	-
HSA	.715*** (.000)	.202NS (.168)	.640*** (.000)	-	-	-	-	-	-	-	-	-
CA	.256NS (.079)	.450*** (.001)	.295* (.042)	.249NS (.088)	-	-	-	-	-	-	-	-
RA	.183NS (.212)	.469*** (.001)	.171NS (.244)	.120NS (.417)	.899*** (.000)	-	-	-	-	-	-	-
WA	-	-	-	-	-	-	-	-	-	-	-	-
JA	-	-	-	-	-	-	-	-	-	-	-	-
PA	.245NS (.093)	.319* (.027)	.395** (.006)	.441** (.002)	.660*** (.000)	.522*** (.000)	-	-	-	-	-	-
VA	.083NS (.573)	.057NS (.700)	.014NS (.927)	-.093NS (.528)	.732*** (.000)	.660*** (.000)	-	-	.282NS (.053)	-	-	-
OCA	.188NS (.200)	.431** (.002)	.287* (.048)	.399** (.005)	.641*** (.000)	.427** (.002)	-	-	.717*** (.000)	.183NS (.212)	-	-
TR	.361* (.012)	.191NS (.193)	.285* (.050)	.384** (.007)	.444** (.002)	.372** (.009)	-	-	.650*** (.000)	.129NS (.383)	.515*** (.000)	-
TFI	.708*** (.000)	.435** (.002)	.642*** (.000)	.447*** (.001)	.010NS (.946)	-.044NS (.764)	-	-	.061NS (.679)	-.219NS (.135)	.148NS (.315)	.134NS (.364)

Table 7.11. Rice production variables grouped by division, district, thana and household type (RP= Rice production (US$/ha), RPC= Rice production cost (US$/ha), NRP= Net rice production (US$/ha), PCRP= Per capita rice production (Kg/Year), PCRD= Per capita rice demand (Kg/Year), PCRB= Per capita rice balance (Kg/Year), NS= Not significant, a= Test Statistics are given in Table 7.12)(nested ANOVA was used showing LSD values for variables having normal distribution).

Grouping variables				Variables					
Division	District	Thana	Household	RP	RPC	NRP	PCRP	PCRD	PCRB
Rajshahi				618.44	303.60	314.84	707.0	430.6	276.4
	Rajshahi			678.59	336.14	342.45	588.3	408.5	179.8
		Paba		757.24	350.37	406.87	558.7	423.0	135.7
			Small	783.82	309.23	474.59	400.7	423.4	-22.7
			Medium	788.38	360.54	427.84	678.7	427.8	250.9
			Large	699.53	381.34	318.19	596.7	417.7	179.0
		Puthia		599.93	321.92	278.01	617.9	394.1	223.8
			Small	576.05	299.00	277.05	427.1	346.2	80.8
			Medium	551.20	256.54	294.66	567.2	365.6	201.6
			Large	672.54	410.22	262.31	859.4	470.3	389.1
	Bogra			558.29	271.06	287.23	825.9	452.7	373.1
		Sonatala		532.55	295.25	237.30	716.2	456.6	259.6
			Small	650.01	289.47	360.54	359.4	361.9	-2.5
			Medium	495.24	294.67	200.57	726.6	459.4	267.2
			Large	452.40	301.60	150.80	1062.5	548.4	514.1
		Bogra Sadar		584.02	246.87	337.15	935.4	448.8	486.6
			Small	559.55	171.14	388.41	609.4	392.2	217.2
			Medium	432.68	176.80	255.88	1029.1	411.5	617.6
			Large	759.85	392.66	367.19	1167.7	542.7	625.0
Dhaka				488.37	199.43	288.94	652.2	423.2	229.0
	Tangail			424.22	195.96	228.26	676.2	420.7	255.5
		Tangail Sadar		621.65	252.17	369.48	998.6	465.9	532.7
			Small	491.12	201.07	290.05	669.6	436.2	233.4
			Medium	834.20	278.12	556.08	1367.6	404.2	963.4
			Large	539.65	277.34	262.31	958.7	557.4	401.3
		Modhupur		226.78	139.74	87.04	354.0	375.6	-21.7
			Small	0.00	0.00	0.00	0.00	268.8	-268.8
			Medium	322.84	173.27	149.57	316.4	424.6	-108.2
			Large	357.50	245.96	111.54	745.5	433.5	311.9
	Gazipur			552.52	202.91	349.61	628.1	425.7	202.4
		Gazipur		282.77	92.08	190.69	440.9	404.2	36.7
			Small	138.67	41.60	97.07	93.8	275.0	-181.5
			Medium	453.10	153.75	299.35	746.9	506.2	240.6
			Large	256.54	80.89	175.35	482.1	431.3	50.9
		Sripur		822.27	313.73	508.54	815.3	447.2	368.2
			Small	749.50	284.27	465.23	328.6	324.1	4.5
			Medium	780.00	294.67	485.33	1038.0	462.1	575.9
			Large	937.30	362.27	575.03	1079.5	555.4	524.1
Chittagong				534.56	228.62	305.94	651.5	347.3	311.9
	Chittagong			604.45	252.69	351.76	796.2	352.8	443.4
		Hathazari		654.05	268.84	385.21	706.8	313.5	393.3
			Small	772.20	300.30	471.90	515.0	283.1	231.9
			Medium	596.03	263.12	332.91	687.5	343.2	344.3
			Large	593.93	243.10	350.83	918.0	314.3	603.6

Table 7.11. continued.

	Lohagara	554.85	236.54	318.31	885.6	392.1	493.5
	Small	546.44	198.12	348.32	474.8	247.6	227.2
	Medium	482.56	241.11	241.45	771.3	540.3	231.0
	Large	635.56	270.40	365.16	1410.7	388.4	1022.3
Cox's Bazar		464.68	204.56	260.12	506.9	341.9	180.4
	Cox's Bazar Sadar	532.69	228.71	303.98	470.5	337.9	132.6
	Small	665.08	312.43	352.65	298.5	264.5	34.0
	Medium	171.60	85.80	85.80	156.3	390.6	-234.4
	Large	761.39	287.90	473.49	956.7	358.5	598.2
	Ramu	396.66	180.40	216.26	543.2	345.8	228.2
	Small	471.90	185.90	286.00	335.9	291.7	156.3
	Medium	274.56	171.60	102.96	421.9	433.6	-31.4
	Large	443.52	183.70	259.82	871.9	312.2	559.7
Total		547.12	243.88	303.24	670.2	400.4	272.4
LSD Division		a	a	a	NS	36.9	NS
LSD District (Division)		a	a	a	NS	NS	NS
LSD Thana (Division District)		a	a	a	NS	NS	NS
LSD Household Type (Division District Thana)		a	a	a	690.2	134.2	NS

Table 7.12. Rice production variables (HHT= Household Types; NS= Not significant, *= Significant at 0.05 level, **= Significant at 0.01 level, ***= Significant at 0.001 level) (All the variables were first tested for normality and if normal homogeneity of variances were also tested based on the grouping variables. One-way ANOVA was used where data were both normal and homogeneous in variances otherwise Kruskal-Wallis test option was used).

Grouping Factors	Variable	Test Option	n	df	Test Statistics	P-value
Division	Rice production (US$/ha)	Kruskal-Wallis	144	2	H= 4.03	0.133^{NS}
District		Kruskal-Wallis	144	5	H= 8.91	0.113^{NS}
Thana		Kruskal-Wallis	144	11	H= 39.76	0.000^{***}
HHT		Kruskal-Wallis	144	2	H= 0.95	0.623^{NS}
Division	Rice production cost (US$/ha)	Kruskal-Wallis	144	2	H= 13.73	0.001^{***}
District		Kruskal-Wallis	144	5	H= 16.74	0.005^{**}
Thana		Kruskal-Wallis	144	11	H= 38.44	0.000^{***}
HHT		Kruskal-Wallis	144	2	H= 7.46	0.024^{*}
Division	Net rice production (US$/ha)	Kruskal-Wallis	144	2	H= 0.78	0.677^{NS}
District		Kruskal-Wallis	144	5	H= 7.33	0.197^{NS}
Thana		Kruskal-Wallis	144	11	H= 34.62	0.000^{***}
HHT		Kruskal-Wallis	144	2	H= 0.90	0.637^{NS}
Division	Per capita rice production (Kg/Year)	One Way ANOVA	144	2	F= 0.16	0.852^{NS}
District		Kruskal-Wallis	144	5	H= 5.768	0.329^{NS}
Thana		Kruskal-Wallis	144	11	H= 18.26	0.076^{NS}
HHT		Kruskal-Wallis	144	2	H= 23.245	0.000^{***}
Division	Per capita rice demand (Kg/Year)	One Way ANOVA	144	2	F= 7.633	0.001^{***}
District		One Way ANOVA	144	5	F= 3.392	0.006^{**}
Thana		One Way ANOVA	144	11	F= 2.182	0.019^{*}
HHT		One Way ANOVA	144	2	F= 16.755	0.000^{***}
Division	Per capita rice balance (Kg/Year)	One Way ANOVA	144	2	F= 0.256	0.775^{NS}
District		Kruskal-Wallis	144	5	H= 5.104	0.403^{NS}
Thana		Kruskal-Wallis	144	11	H= 15.951	0.143^{NS}
HHT		Kruskal-Wallis	144	2	H= 17.747	0.000^{***}

7.6. Family Income.

Family income is an important criterion in determining the socio-economic condition of a household. Access to daily necessities and demand for more food, better health, good sanitation, luxury goods and activities all depend on family income. Households with low family income live in a very poor condition. Their living and health conditions reveals their economic position (Plate 7.1). Family income was found to be significantly different between household types (Table 7.14) having significant (P value <0.001) positive correlation with household type (Table 7.10). This means that large households earn more income and as a result they live better lives. Family size also has a significant positive correlation with family income. This is probably because of more members of family earning income contributes to greater wealth. Total land resources and homestead area were also found to be significantly correlated with family income. However agricultural land uses do not have any significant correlation with family income (Table 7.10). Survey results show that on average 49 per cent of the total family income is derived from agricultural sources (Table 7.13) although about 89 per cent of families in the village areas are directly or indirectly dependent on agriculture (Table 7.4). This implies that agriculture is the major source of livelihood in the village areas but it is not a profitable business. However farmers have no choice except to continue like this due to shortage of alternative means of income. Table 7.15 also supports this finding showing family income against different occupations and household types in different districts. It is clear that occupation also plays an important role along with household types for family income. Generally as family occupations move away from agriculture their total family income increases.

Plate 7.1. Photographs showing typical crop fields and homesteads in Bangladesh. (a) & (b) Crop field in Rajshahi; (c) Backyard tree garden and crop field in Bogra; (d) Banana cultivation in Bogra; (e) Large homestead in Cox's Bazar; (f) Large homestead in Bogra; (g) Medium homestead in Chittagong and (h) Small homestead in Bogra.

Table 7.13. Household income characteristics grouped by division, district, thana and household type (TFI= Total Family Income, AI= Agricultural Income, NAI= Non-Agricultural Income, JOI= Jobs and Other Income, NS= Not significant, a= Test Statistics are given in Table 7.14) (nested ANOVA was used showing LSD values for variables having normal distribution).

Grouping variables				Variables						
Division	District	Thana	Household	TFI	AI		NAI		JOI	
				US$	US$	(%)	US$	(%)	US$	(%)
Rajshahi				1270	797	63	114	9	359	28
	Rajshahi			1244	880	71	48	4	316	25
		Paba		1098	691	63	77	7	330	30
			Small	662	236	36	0	0	426	64
			Medium	976	613	63	86	9	278	28
			Large	1656	1223	74	146	9	287	17
		Puthia		1390	1068	77	19	1	302	22
			Small	851	319	37	0	0	533	63
			Medium	1436	1142	80	11	1	282	20
			Large	1883	1745	93	46	2	93	5
	Bogra			1295	715	55	179	14	401	31
		Sonatala		1528	632	41	250	16	372	24
			Small	557	214	38	130	23	213	38
			Medium	1021	540	53	204	20	278	27
			Large	2184	1143	52	416	19	625	29
		Bogra Sadar		1337	798	60	108	8	431	32
			Small	523	272	52	0	0	251	48
			Medium	1131	683	60	102	9	346	31
			Large	2356	1438	61	223	9	695	29
Dhaka				1638	829	51	136	8	674	41
	Tangail			1528	883	58	140	9	505	33
		Tangail Sadar		1711	1017	59	114	7	580	34
			Small	869	323	37	9	1	537	62
			Medium	2246	1288	57	255	11	704	31
			Large	2019	1440	71	79	4	500	25
		Modhupur		1344	750	56	165	12	430	32
			Small	885	101	11	79	9	706	80
			Medium	1229	794	65	334	27	102	8
			Large	1918	1353	71	83	4	481	25
	Gazipur			1749	775	44	132	8	842	48
		Gazipur		1366	569	42	129	9	668	49
			Small	912	105	11	261	29	545	60
			Medium	1084	519	48	56	5	509	47
			Large	2102	1084	52	70	3	949	45
		Sripur		2133	981	46	135	6	1016	48
			Small	1155	219	19	68	6	869	75
			Medium	1872	974	52	83	4	815	44
			Large	3372	1751	52	255	8	1366	41
Chittagong				2015	802	40	161	8	1052	52
	Chittagong			2215	657	30	53	2	1505	68
		Hathazari		2545	680	27	64	3	1801	71
			Small	1019	183	18	17	2	819	80
			Medium	1834	649	35	9	1	1176	64
			Large	4781	1207	25	167	3	3408	71

Table 7.13. continued.

	Lohagara	1886	635	34	42	2	1209	64
	Small	999	241	24	46	5	711	71
	Medium	1660	715	43	74	4	871	52
	Large	3000	949	32	5	0	2046	68
Cox's Bazar		1815	946	52	269	15	600	33
	Cox's Bazar Sadar	1836	906	49	165	9	764	42
	Small	1088	323	30	28	3	737	68
	Medium	1550	921	59	185	12	444	29
	Large	2869	1476	51	283	10	1111	39
	Ramu	1794	986	55	373	21	435	24
	Small	1009	464	46	88	9	457	45
	Medium	1259	818	65	408	32	33	3
	Large	3114	1676	54	624	20	815	26
Total		1641	809	49	137	8	695	42
LSD Division		a	NS	NS	a	a	a	a
LSD District (Division)		a	NS	10	a	a	a	a
LSD Thana (Division District)		a	NS	NS	a	a	a	a
LSD Household Type (Division District Thana)		a	540	40	a	a	a	a

Table 7.14. Household income characteristics (HHT= Household Types; NS= Not significant, *= Significant at 0.05 level, **= Significant at 0.01 level, ***= Significant at 0.001 level) (All the variables were first tested for normality and if normal homogeneity of variances were also tested based on the grouping variables. One-way ANOVA was used where data were both normal and homogeneous in variances otherwise Kruskal-Wallis test option was used).

Grouping Factors	Variable	Test Option	n	df	Test Statistics	P-value
Division	Total Family Income (US$)	Kruskal-Wallis	144	2	H= 7.64	0.022^{*}
District		Kruskal-Wallis	144	5	H= 7.95	0.159^{NS}
Thana		Kruskal-Wallis	144	11	H= 12.31	0.341^{NS}
HHT		Kruskal-Wallis	144	2	H= 68.32	0.000^{***}
Division	Agricultural Income (US$)	One Way ANOVA	144	2	F= 0.039	0.962^{NS}
District		One Way ANOVA	144	5	F= 0.81	0.544^{NS}
Thana		One Way ANOVA	144	11	F= 0.996	0.454^{NS}
HHT		Kruskal-Wallis	144	2	H= 95.594	0.000^{***}
Division	Agricultural Income as Percentage of Total Family Income (%)	One Way ANOVA	144	2	F= 2.933	0.057^{NS}
District		One Way ANOVA	144	5	F= 2.645	0.025^{*}
Thana		One Way ANOVA	144	11	F= 1.334	0.213^{NS}
HHT		One Way ANOVA	144	2	F= 16.953	0.000^{***}
Division	Non-Agricultural Income (US$)	Kruskal-Wallis	144	2	H= 2.17	0.337^{NS}
District		Kruskal-Wallis	144	5	H= 16.64	0.005^{**}
Thana		Kruskal-Wallis	144	11	H= 23.56	0.015^{*}
HHT		Kruskal-Wallis	144	2	H= 10.73	0.005^{**}
Division	Non-Agricultural Income as Percentage of Total Family Income (%)	Kruskal-Wallis	144	2	H= 1.30	0.521^{NS}
District		Kruskal-Wallis	144	5	H= 16.81	0.005^{**}
Thana		Kruskal-Wallis	144	11	H= 27.32	0.004^{**}
HHT		Kruskal-Wallis	144	2	H= 5.97	0.051^{NS}
Division	Jobs and Other Income (US$)	Kruskal-Wallis	144	2	H= 9.98	0.007^{**}
District		Kruskal-Wallis	144	5	H= 15.83	0.007^{**}
Thana		Kruskal-Wallis	144	11	H= 16.88	0.111^{NS}
HHT		Kruskal-Wallis	144	2	H= 8.53	0.014^{*}
Division	Jobs and Other Income as Percentage of Total Family Income (%)	Kruskal-Wallis	144	2	H= 4.06	0.131^{NS}
District		Kruskal-Wallis	144	5	H= 12.56	0.028^{*}
Thana		Kruskal-Wallis	144	11	H= 14.09	0.228^{NS}
HHT		Kruskal-Wallis	144	2	H= 29.57	0.000^{***}

Table 7.15. Total family income (US$) of respondent households grouped by districts, occupation and household type.

Districts	Pure Agriculture			Primary Agriculture			Secondary Agriculture			Non-Agriculture			Total
	Small	Medium	Large	Small	Medium	Large	Small	Medium	Large	Small	Medium	Large	
Rajshahi	613	816	1501	478	1223	2233	1176	1764	2185	-	-	-	1244
Bogra	664	558	1678	734	1147	2638	381	1759	2574	-	-	-	1295
Tangail	713	1431	1835	979	2073	2015	-	1958	2000	769	-	-	1528
Gazipur	537	1002	-	988	1440	2899	1306	-	2704	1153	3056	2347	1749
Chittagong	-	818	1124	1129	2957	2333	1051	-	-	400	1830	5750	2215
Cox's Bazar	619	1366	1491	1053	1278	3302	356	1852	3241	2148	-	2689	1815
Total	635	1066	1569	911	1640	2629	822	1819	2541	1050	2443	4340	1641

7.6.1. *Household demand.*

Survey data was analysed to find out household demand and possible sources to meet their demand. Table 7.16 shows household demand and per capita demand for different daily necessities in different districts and household types. Table 7.17 shows the significance of these daily necessities with different grouping variables. Per capita rice demand and per capita meat demand was found to vary significantly with all the grouping variables. Per capita rice demand was found to be highly significant in different household types irrespective of division, districts or thanas. This is obvious household size determines demand for daily necessities. So as the household size increases both total family demand and per capita demand characteristics increases.

Table 7.16. Household and per capita demand characteristics of respondent households grouped by division and household type (Vege= Vegetables, Fuel= Fuel wood and others).

Districts	Household	Household demand (Kg)					Per capita demand (Kg)				
		Rice	Vege	Fuel	Meat	Fish	Rice	Vege	Fuel	Meat	Fish
Rajshahi	Small	2091	1136	2496	60	151	385	223	520	12	29
	Medium	2906	1547	3084	98	285	397	215	426	14	40
	Large	3938	1889	3853	145	310	444	214	417	15	36
	Total	2978	1541	3173	103	253	409	217	451	14	35
Bogra	Small	1833	919	2175	42	133	377	180	428	9	27
	Medium	2897	1177	2334	110	219	546	234	440	21	45
	Large	3056	1238	2503	134	248	435	168	375	22	38
	Total	2595	1128	2361	100	206	453	195	412	18	38
Tangail	Small	2036	900	1710	88	210	364	181	335	16	39
	Medium	2700	975	2250	132	340	414	141	321	19	47
	Large	3225	1388	2409	143	255	495	212	372	22	40
	Total	2680	1147	2148	123	257	427	186	355	19	41
Gazipur	Small	1603	1313	2250	130	150	300	188	321	19	21
	Medium	2588	1479	2132	145	257	484	247	365	26	44
	Large	3619	1791	2344	198	303	493	253	331	27	44
	Total	2603	1606	2245	168	266	426	243	346	25	41
Chittagong	Small	1647	1607	2089	102	186	276	278	360	17	31
	Medium	2672	1650	2875	130	252	335	209	389	18	35
	Large	2930	1007	3000	356	343	412	144	448	46	51
	Total	2450	1397	2644	203	261	344	210	400	28	40
Cox's Bazar	Small	1922	1211	2661	73	130	265	172	370	11	23
	Medium	2416	1228	2606	88	214	351	174	391	14	31
	Large	4500	2079	3654	143	301	442	213	359	15	31
	Total	2946	1493	2928	103	220	353	185	374	13	29
TOTAL		2711	1387	2639	131	242	402	206	394	19	37

Table 7.17. Household demand characteristics of respondents households (HHT= Household Types; NS= Not significant, *= Significant at 0.05 level, **= Significant at 0.01 level, ***= Significant at 0.001 level) (All the variables were first tested for normality and if normal homogeneity of variances were also tested based on the grouping variables. One-way ANOVA was used where data were both normal and homogeneous in variances otherwise Kruskal-Wallis test option was used).

Grouping Factors	Variable	Test Option	n	df	Test Statistics	P-value
Division	Rice (Kg)	Kruskal-Wallis	48	2	H= 0.937	0.626 NS
District		Kruskal-Wallis	24	5	H= 4.379	0.496 NS
Thana		Kruskal-Wallis	12	11	H= 15.956	0.143 NS
HHT		Kruskal-Wallis	48	2	H= 51.533	0.000 ***
Division	Per capita rice (Kg)	One Way ANOVA	48	2	F= 7.633	0.001 ***
District		One Way ANOVA	24	5	F= 3.392	0.006 **
Thana		One Way ANOVA	12	11	F= 2.182	0.019 *
HHT		One Way ANOVA	48	2	F= 16.755	0.000 ***
Division	Vegetable (Kg)	Kruskal-Wallis	48	2	H= 0.591	0.744 NS
District		Kruskal-Wallis	24	5	H= 11.742	0.039 *
Thana		Kruskal-Wallis	12	11	H= 28.745	0.002 **
HHT		Kruskal-Wallis	48	2	H= 7.027	0.030 *
Division	Per capita vegetable (Kg)	One Way ANOVA	48	2	F= 0.493	0.612 NS
District		One Way ANOVA	24	5	F= 1.552	0.180 NS
Thana		One Way ANOVA	12	11	F= 3.720	0.000 ***
HHT		One Way ANOVA	48	2	F= 0.093	0.912 NS
Division	Fuel wood (Kg)	Kruskal-Wallis	48	2	H= 6.149	0.046 *
District		Kruskal-Wallis	24	5	H= 9.127	0.104 NS
Thana		Kruskal-Wallis	12	11	H= 19.371	0.055 NS
HHT		Kruskal-Wallis	48	2	H= 17.267	0.000 ***
Division	Per capita fuel wood (Kg)	Kruskal-Wallis	48	2	H= 5.275	0.072 NS
District		Kruskal-Wallis	24	5	H= 6.394	0.270 NS
Thana		Kruskal-Wallis	12	11	H= 23.682	0.014 *
HHT		Kruskal-Wallis	48	2	H= 0.786	0.675 NS
Division	Meat (Kg)	Kruskal-Wallis	48	2	H= 5.685	0.058 NS
District		Kruskal-Wallis	24	5	H= 10.751	0.057 NS
Thana		Kruskal-Wallis	12	11	H= 13.828	0.243 NS
HHT		Kruskal-Wallis	48	2	H= 37.369	0.000 ***
Division	Per capita meat (Kg)	Kruskal-Wallis	48	2	H= 8.031	0.018 *
District		Kruskal-Wallis	24	5	H= 20.694	0.001 ***
Thana		Kruskal-Wallis	12	11	H= 23.502	0.015 *
HHT		Kruskal-Wallis	48	2	H= 18.698	0.000 ***
Division	Fish (Kg)	Kruskal-Wallis	48	2	H= 2.091	0.352 NS
District		Kruskal-Wallis	24	5	H= 6.837	0.233 NS
Thana		Kruskal-Wallis	12	11	H= 11.030	0.441 NS
HHT		Kruskal-Wallis	48	2	H= 35.672	0.000 ***
Division	Per capita fish (Kg)	One Way ANOVA	48	2	F= 2.177	0.118 NS
District		One Way ANOVA	24	5	F= 2.043	0.078 NS
Thana		One Way ANOVA	12	11	F= 1.522	0.134 NS
HHT		One Way ANOVA	48	2	F= 6.786	0.002 **

Table 7.18 shows the percentage response of different sample households to the source of their daily necessities. The variables used were own cultivation, market or both. Most of the respondents were found to be dependent for rice (83 per cent) and vegetables (54 per cent) on their own cultivation.

Table 7.18. Sources of different household necessities.

Necessities	Source (%)			Total
	Own	Market	Both	
Rice	83	9	8	100
Vegetables	54	24	22	100
Meat	3	91	6	100
Fish	16	22	62	100
Fuel wood	48	10	42	100

7.6.2. *Living Standard.*

Generally the living standard was not good in village areas. Table 7.19 shows that most of them live in a medium condition (54 %). To investigate the overall living standard the household living area was observed in respect to house condition, general family health condition, sanitation facility and availability of luxury goods. From the results it is clear that all of these variables are interrelated and have a strong positive correlation with total land resources and family income (Table 7.20).

Table 7.19. Household living standard of respondent households grouped by different living standard variables and ranked into different conditions (ranking of different variables was done from the author's observation while interviewing).

Variables	Very Bad (%)	Bad (%)	Medium (%)	Good (%)	Very Good (%)
House Condition	1	27	49	22	1
Health	1	25	55	18	1
Sanitation	1	24	53	20	1
Luxury Goods	2	26	46	25	1
Overall Living Standard	1	24	54	20	1

Table 7.20. Correlation between different household living standard variables (HC= Housing condition, HEAL= Family health condition, SANI= Sanitation facilities, CLOTH= Clothing, LUXU= Luxurious goods possessed, HSL= Household living standard, TLR= Total land resources (ha), TFI= Total family income (US$), ***= Significant at 0.001 level. Spearman's correlation coefficients are used. Values in parenthesis show P-value).

	HC	*HEAL*	*SANI*	*CLOTH*	*LUXU*	*HLS*	*TLR*	*TFI*
HC	-	-	-	-	-	-	-	-
HEAL	.845*** (.000)	-	-	-	-	-	-	-
SANI	.787*** (.000)	.906*** (.000)	-	-	-	-	-	-
CLOTH	.814*** (.000)	.864*** (.000)	.889*** (.000)	-	-	-	-	-
LUXU	.804*** (.000)	.836*** (.000)	.820*** (.000)	.833*** (.000)	-	-	-	-
HLS	.874*** (.000)	.927*** (.000)	.921*** (.000)	.926*** (.000)	.879*** (.000)	-	-	-
TLR	.624*** (.000)	.708*** (.000)	.625*** (.000)	.644*** (.000)	.639*** (.000)	.662*** (.000)	-	-
TFI	.644*** (.000)	.682*** (.000)	.624*** (.000)	.603*** (.000)	.636*** (.000)	.660*** (.000)	.665*** (.000)	-

7.7. Land Use History.

No clear response about land use history was found from the survey. Most of respondents (89 per cent) had traditional land use systems, which their ancestors used, and very few said that "they really don't know" anything about history (11 per cent) (Table 7.21). Variations in responses were observed between household types regarding land use history. Almost all of respondents (100 per cent) from large and medium households and 69 per cent of small households responded about traditional land use practices in the village areas. However they do change their land use (76 per cent) in the form of change from one crop to another whenever they find it more beneficial (88 per cent). Medium and large households responded more (about 90 per cent) compared to small households (52 per cent) in their decision to change land use (Table 7.21). Respondents from Rajshahi (83 per cent) and Chittagong (81 per cent) divisions change land use more than Dhaka (65 per cent) division. The decision to change cropping pattern is usually made by the landowner himself (92 per cent) not the tenant/farmer (Table 7.21).

Table 7.21. Land use history characteristics of respondent households grouped by division and household type (values are in percentage of total respondents).

Division	Household Type	Land use history			Do you change land use?			Reasons for land use change				Land use change decision maker		
		Traditional	Don't know	Total	Yes	No	Total	More production	More benefits	Other	Total	Land owner	Tenant/ farmer	Total
Rajshahi	Small (n= 16)	69	31	100	63	37	100	13	62	25	100	88	12	100
	Medium (n= 16)	94	6	100	94	6	100	13	87	0	100	100	0	100
	Large (n= 16)	100	0	100	94	6	100	6	88	6	100	94	6	100
	Total (n= 48)	88	12	100	83	17	100	11	79	10	100	94	6	100
Dhaka	Small (n= 16)	63	37	100	25	75	100	0	88	12	100	88	12	100
	Medium (n= 16)	100	0	100	75	25	100	6	88	6	100	94	6	100
	Large (n= 16)	100	0	100	94	6	100	0	94	6	100	100	0	100
	Total (n= 48)	88	12	100	65	35	100	2	90	8	100	94	6	100
Chittagong	Small (n= 16)	75	25	100	69	31	100	0	100	0	100	94	6	100
	Medium (n= 16)	100	0	100	100	0	100	0	100	0	100	88	12	100
	Large (n= 16)	100	0	100	75	25	100	6	88	6	100	81	19	100
	Total (n= 48)	92	8	100	81	19	100	2	96	2	100	88	12	100
Overall	Small (n= 48)	69	31	100	52	48	100	4	83	13	100	90	10	100
	Medium (n= 48)	98	2	100	90	10	100	6	92	2	100	94	6	100
	Large (n= 48)	100	0	100	88	12	100	4	90	6	100	92	8	100
	Total (n= 144)	89	11	100	76	24	100	5	88	7	100	92	8	100

7.8. Livestock and Poultry.

In village areas almost all the households rear livestock and poultry mainly for their own use. Cattle are used to plough the land and sometimes for economic benefits. Goats are usually used for own consumption or sold in the market. Poultry are usually used for own consumptions. Table 7.22 shows the result of the response of the sample households on rearing livestock and poultry. Almost all the households (96 per cent) were found to have poultry and the majority (83 per cent) of them keep cattle at home to help them in their land cultivation and get some money from their sale when they need it. Again, medium (92 per cent) and large (85 per cent) households were found to rear more cattle than small (71 per cent) household (Table 7.22). This is probably because small households cannot afford to buy and rear cattle. Goats are not usually kept at home, and very few households (24 per cent) were found to have goats at home (Table 7.22). The percentage of respondent households rearing goats is very low in Chittagong division (12 per cent) compared to Rajshahi (27 per cent) and Dhaka (31 per cent) divisions.

Table 7.22. Livestock and poultry rearing characteristics of respondent households grouped by division and household type (values expressed in the percentage of respondent households).

Districts	Household	Cattle			Goat			Poultry		
		Rear	None	Total	Rear	None	Total	Rear	None	Total
Rajshahi	Small	69	31	100	31	69	100	94	6	100
	Medium	87	13	100	19	81	100	94	6	100
	Large	94	6	100	31	69	100	100	0	100
	Total	83	17	100	27	73	100	96	4	100
Dhaka	Small	62	38	100	38	62	100	87	13	100
	Medium	94	6	100	31	69	100	94	6	100
	Large	87	13	100	25	75	100	100	0	100
	Total	81	19	100	31	69	100	94	6	100
Chittagong	Small	81	19	100	6	94	100	94	6	100
	Medium	94	6	100	19	81	100	100	0	100
	Large	75	25	100	12	88	100	100	0	100
	Total	83	17	100	12	88	100	98	2	100
Overall	Small	71	29	100	25	75	100	92	8	100
	Medium	92	8	100	23	77	100	96	4	100
	Large	85	15	100	23	77	100	100	0	100
	Total	83	17	100	24	76	100	96	4	100

7.9. Tree Resources.

In village areas every house household has some areas left aside for trees, shrubs or bamboos known as 'homestead forests'. Homestead forests are highly productive and efficiently managed compared to government owned forests (Gain, 1998). Common trees (Table 7.23) found in and around the homestead are mainly fruit trees (73 per cent) and very few are timber trees (12 per cent) and other trees (15 per cent). Larger households were found to have more land area for trees and bamboos than smaller households due to size of the homestead. Tree area differed significantly between different household types and thanas (Table 7.24). However tree area per cent were not found significant at different household types although it was found significant at different thanas. Total numbers of trees available in the homestead and trees/ha/household were both found to differ significantly between divisions, districts, thanas and household types. However trees/ha/homestead were found significant in different locations but not different household types. This means that tree area is mainly dependent on the geographical locations but not the household types. However, smaller households were found to plant more trees/ha than the larger households (Table 7.23). Again, Chittagong division was found to be more suitable for tree resources containing an average of 337 trees per household than Rajshahi (21 trees) or Dhaka (74 trees) divisions (Table 7.23). This is probably because the abundance of betel nut (*Areca catechu*) locally known as 'shupari' in Cox's Bazaar district, one of the commercially most important palms grown in Bangladesh.

Table 7.23. Tree resources characteristics of respondent households grouped by division, district, thana and household type (Trees/ha/hs= Trees/ha/homestead, Trees/ha/hh= Trees/ha/household, ToTr= Total Trees, TTr= Timber Trees, FTr= Fruit Trees, OTr= Other Trees).

Grouping variables				Variables							
Division	District	Thana	Household	Tree area		Trees/ha/hs	Trees/ha/hh	ToTr	TTr	FTr	OTr
				(ha)	(%)			(nos.)	(%)	(%)	(%)
Rajshahi				0.130	5	123	14	21	17	70	13
	Rajshahi			0.171	6	99	12	16	13	70	17
		Paba		0.279	10	114	16	21	15	70	15
			Small	0.018	5	191	30	14	17	62	21
			Medium	0.190	10	64	9	17	12	76	12
			Large	0.630	16	85	8	32	15	74	11
		Puthia		0.063	3	84	8	12	12	70	18
			Small	0.010	1	91	10	7	10	75	15
			Medium	0.073	4	117	8	14	7	70	23
			Large	0.105	3	44	4	16	18	64	18

Table 7.23. continued.

	Bogra			0.089	4	148	16	25	20	69	10
		Sonatala		0.114	4	118	18	23	11	70	19
			Small	0.010	3	142	35	11	12	84	4
			Medium	0.090	5	150	11	19	8	53	38
			Large	0.243	5	63	8	41	12	74	15
		Bogra Sadar		0.064	3	177	14	26	30	68	2
			Small	0.005	2	42	11	3	24	76	0
			Medium	0.090	5	269	18	36	37	63	1
			Large	0.098	3	221	12	40	29	66	5
Dhaka				0.130	12	538	90	74	8	67	25
	Tangail			0.119	12	827	105	101	7	56	37
		Tangail Sadar		0.054	3	234	16	25	13	68	18
			Small	0.010	1	220	15	12	14	68	19
			Medium	0.073	4	437	30	49	9	82	13
			Large	0.080	2	45	3	13	21	56	23
		Modhupur		0.184	21	1421	195	176	2	43	56
			Small	0.208	48	1125	369	143	0	37	63
			Medium	0.160	11	2913	195	310	1	58	41
			Large	0.185	5	224	21	77	4	33	63
	Gazipur			0.141	12	249	75	48	9	79	12
		Gazipur		0.104	12	153	60	27	14	69	17
			Small	0.050	23	281	163	34	16	60	24
			Medium	0.193	9	82	9	18	5	95	0
			Large	0.070	2	95	7	29	21	51	28
		Sripur		0.178	12	345	91	70	4	89	7
			Small	0.190	25	643	232	86	1	82	18
			Medium	0.103	5	112	16	26	8	92	0
			Large	0.240	7	279	26	96	3	93	4
Chittagong				0.159	7	1106	161	337	12	82	7
	Chittagong			0.109	6	143	24	34	21	67	12
		Hathazari		0.050	3	194	20	27	12	76	13
			Small	0.015	4	189	42	16	14	63	23
			Medium	0.015	1	205	10	14	4	88	8
			Large	0.120	3	187	10	52	17	76	6
		Lohagara		0.168	9	93	27	40	30	58	12
			Small	0.055	8	97	38	23	17	71	12
			Medium	0.188	12	91	34	50	29	59	12
			Large	0.263	6	92	11	49	45	43	12
	Cox's Bazar			0.209	8	2069	298	641	2	97	1
		Cox's Bazar Sadar		0.186	7	1332	182	520	5	94	1
			Small	0.028	4	603	91	61	11	87	1
			Medium	0.185	9	2165	294	646	0	100	0
			Large	0.345	7	1229	162	852	3	95	2
		Ramu		0.233	10	2805	415	763	0	100	0
			Small	0.055	10	2823	516	322	0	100	0
			Medium	0.210	12	2562	516	946	0	100	0
			Large	0.433	9	3031	211	1020	0	100	0
			Small	0.050	11	537	129	61	11	71	17
Overall			Medium	0.130	8	764	96	179	10	78	12
			Large	0.230	6	466	40	193	16	69	15
Total				0.140	8	589	88	144	12	73	15

Table 7.24. Tree resources characteristics (HHT= Household Types; NS= Not significant, *= Significant at 0.05 level, **= Significant at 0.01 level, ***= Significant at 0.001 level) (All the variables were first tested for normality and if normal homogeneity of variances were also tested based on the grouping variables. One-way ANOVA was used where data were both normal and homogeneous in variances otherwise Kruskal-Wallis test option was used).

Grouping variables	Variable	Test Option	n	df	Test Statistics	P-value
Division	Tree Area (ha)	Kruskal-Wallis	48	2	H= 1.72	0.424 NS
District		Kruskal-Wallis	24	5	H= 8.25	0.143 NS
Thana		Kruskal-Wallis	12	11	H= 22.24	0.023 *
HHT		Kruskal-Wallis	48	2	H= 44.63	0.000 ***
Division	Tree Area (%)	Kruskal-Wallis	48	2	H= 1.75	0.417 NS
District		Kruskal-Wallis	24	5	H= 8.86	0.115 NS
Thana		Kruskal-Wallis	12	11	H= 30.49	0.001 ***
HHT		Kruskal-Wallis	48	2	H= 0.38	0.829 NS
Division	Trees/ha/homestead	Kruskal-Wallis	48	2	H= 30.33	0.000 ***
District		Kruskal-Wallis	24	5	H= 58.34	0.000 ***
Thana		Kruskal-Wallis	12	11	H= 74.99	0.000 ***
HHT		Kruskal-Wallis	48	2	H= 3.35	0.187 NS
Division	Trees/ha/household	Kruskal-Wallis	48	2	H= 29.76	0.000 ***
District		Kruskal-Wallis	24	5	H= 51.62	0.000 ***
Thana		Kruskal-Wallis	12	11	H= 67.54	0.000 ***
HHT		Kruskal-Wallis	48	2	H= 14.35	0.001 ***
Division	Total Trees (nos.)	Kruskal-Wallis	48	2	H= 32.20	0.000 ***
District		Kruskal-Wallis	24	5	H= 57.28	0.000 ***
Thana		Kruskal-Wallis	12	11	H= 73.93	0.000 ***
HHT		Kruskal-Wallis	48	2	H= 12.20	0.002 **
Division	Timber Trees (nos.)	Kruskal-Wallis	48	2	H= 4.01	0.135 NS
District		Kruskal-Wallis	24	5	H= 12.51	0.028 *
Thana		Kruskal-Wallis	12	11	H= 24.65	0.010 **
HHT		Kruskal-Wallis	48	2	H= 19.32	0.000 ***
Division	Timber Trees (%)	Kruskal-Wallis	48	2	H= 10.65	0.005 **
District		Kruskal-Wallis	24	5	H= 26.84	0.000 ***
Thana		Kruskal-Wallis	12	11	H= 50.63	0.000 ***
HHT		Kruskal-Wallis	48	2	H= 7.79	0.020 *
Division	Fruit Trees (nos.)	Kruskal-Wallis	48	2	H= 33.89	0.000 ***
District		Kruskal-Wallis	24	5	H= 61.91	0.000 ***
Thana		Kruskal-Wallis	12	11	H= 73.65	0.000 ***
HHT		Kruskal-Wallis	48	2	H= 11.36	0.003 **
Division	Fruit Trees (%)	Kruskal-Wallis	48	2	H= 11.02	0.004 **
District		Kruskal-Wallis	24	5	H= 41.45	0.000 ***
Thana		Kruskal-Wallis	12	11	H= 52.92	0.000 ***
HHT		Kruskal-Wallis	48	2	H= 4.39	0.111 NS
Division	Other Trees (nos.)	Kruskal-Wallis	48	2	H= 7.15	0.028 *
District		Kruskal-Wallis	24	5	H= 36.12	0.000 ***
Thana		Kruskal-Wallis	12	11	H= 51.29	0.000 ***
HHT		Kruskal-Wallis	48	2	H= 3.21	0.201 NS
Division	Other Trees (%)	Kruskal-Wallis	48	2	H= 10.05	0.007 **
District		Kruskal-Wallis	24	5	H= 40.34	0.000 ***
Thana		Kruskal-Wallis	12	11	H= 52.38	0.000 ***
HHT		Kruskal-Wallis	48	2	H= 1.86	0.394 NS

7.10. Socio-economic and Land Use Models.

Bangladesh is a rural country and masses of the population are dependent on agriculture for their livelihood. Poverty is a common phenomenon for the majority of the population who have less access to food, good health, good sanitation, education, and luxury goods. This is probably due to inadequate family income and increasing unemployment in the rural areas as a result of population growth. Again, agriculture is the major land use (Table 7.5) and contributes a major share in family income (Table 7.13). But agriculture does not seem to be a profitable business at all. Modelling socio-economic conditions and land uses in village areas in Bangladesh could be an important tool to understand the actual picture of the rural areas. In this attempt some important socio-economic and land use characteristics were modelled to help policy makers set up appropriate development land use options for the future.

Cropped Area

Cropped area is the net area used for producing different crops (although same area is found to be used twice or thrice for the same crop or different crops). Large households (defined in terms of land resources they operate) generally own more land and as a result have more cropped area (Table 7.8). But cropped area (%) was found to be significantly negatively related to total land resources (Figure 7.2). The larger the household the less will be the cropped area (%). This implies that if larger households could be divided in to smaller households total cropped area (%) will increase and as a result more area will be put to cultivation increasing the total production. Cropped area (%) was also found to be related to household occupation (Equations 7.1, 7.2, 7.3 & 7.4). Household occupations were first grouped into four different categories, which were used as dummy variables in the analysis (a value of '1' was used if the family had the particular occupation otherwise a value of '0' was used). The four occupation categories were agriculture (agriculture being the only family occupation), primary agriculture (agriculture being the primary occupation with other as secondary occupation), secondary occupation (agriculture being the secondary occupation with other as primary occupation) and non-agriculture (other occupation(s) except agriculture). The analysis shows that cropped area per cent is significantly positively related to agriculture but negatively related to non-agriculture and secondary agriculture as

occupation. This implies that as the household moves away from agriculture to other occupations cropped area (%) will decrease.

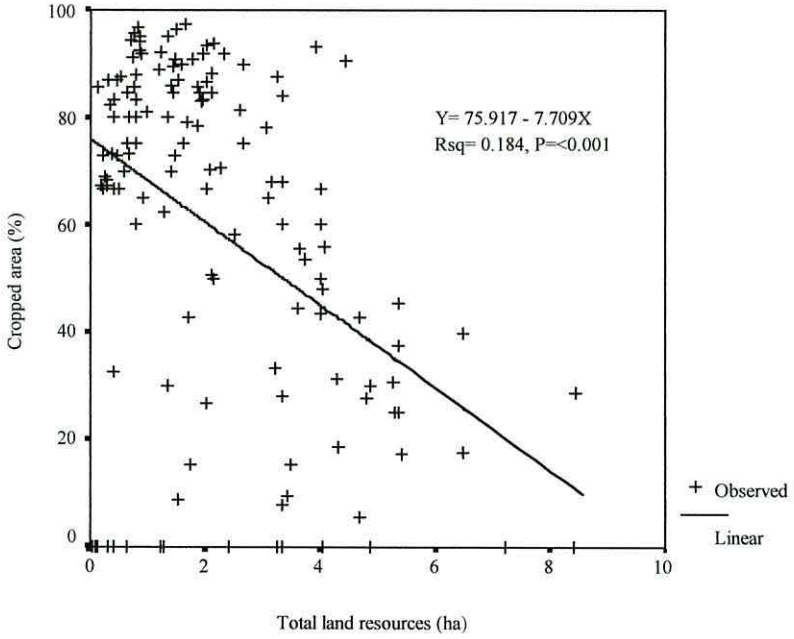

Figure 7.2. Relationship between cropped area (%) and total land resources (ha) every household operates.

CA= 66.278 – 65.942*NA (R^2= 0.439, P= <0.001).....(Equation 7.1)
(<0.001) (<0.001)

CA= 83.427 – 65.576*NA – 7.606*TLR (R^2= 0.618, P= <0.001).....(Equation 7.2)
(<0.001) (<0.001) (<0.001)

CA= 88.487 – 69.094*NA – 8.276*TLR – 20.496*SA (R^2= 0.668, P= <0.001).....(Equation 7.3)
(0.001) (<0.001) (<0.001) (<0.001)

CA= 85.278 – 65.965*NA – 8.241*TLR – 17.341*SA + 8.416*AG (R^2= 0.680, P= <0.001).....(Equation 7.4)
(0.747) (0.001) (<0.001) (<0.001) (0.026)

where, CA= Cropped area (%); TLR= Total land resources (ha); NA= Non-agricultural occupation; SA= Secondary agricultural occupation; AG= Agricultural occupation (values in the parentheses express significance value for respective explanatory variable).

Rice Area

Rice is the major agricultural land use in village areas. It is a common land use practice in every location. Generally farmers use most of their cropped area for rice production (Table 7.8). However rice area (%) was found to be significantly negatively related to total land resources and cropped area (Figure 7.3) meaning the less the total land resources or cropped area the more per cent of land was used for rice. This implies that smaller households use most of their total land and cropped area for rice as they have less scope to use their land for other crops, which the larger households usually practice. Rice area (%) was also found to be significantly related to household occupation where stepwise multiple regression analysis resulted in significant relationships between rice area (%), household occupation and total land resources (Equations 7.5, 7.6 & 7.7 This suggests that the more a household is engaged in occupations other than agriculture the less will be the rice area (%).

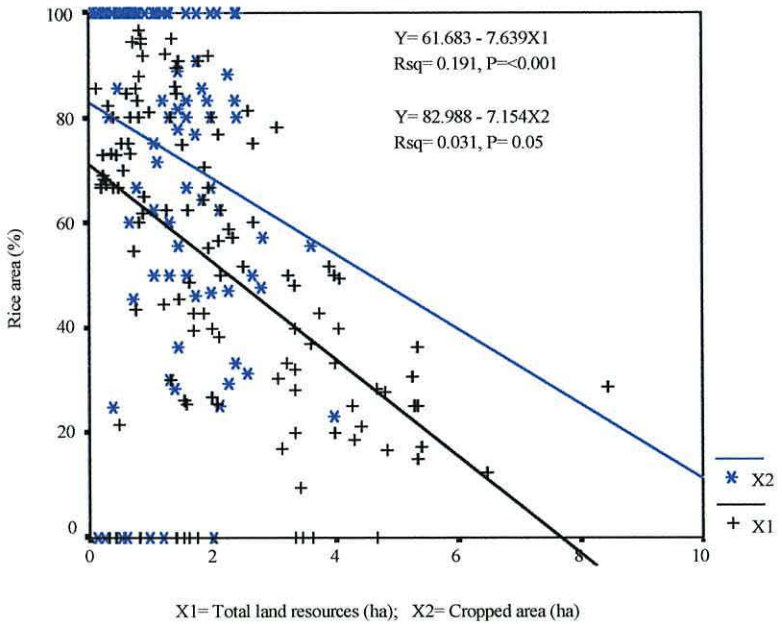

Figure 7.3. Relationship between rice area (%) against total land resources (ha) (X1) and cropped area (ha)(X2).

RA= 50.360 – 50.360*NA (R^2= 0.270, P= <0.001)..... (Equation 7.5)
(<0.001) (<0.001)

RA= 67.409 – 49.997*NA – 7.561*TLR (R^2= 0.457, P= <0.001) ..... (Equation 7.6)
(<0.001) (<0.001) (<0.001)

RA= 70.564 – 52.191*NA – 7.979*TLR – 12.780*SA (R^2= 0.478, P= <0.001) ..... (Equation 7.7)
(<0.001) (<0.001) (<0.001) (<0.001)

where, RA= Rice area (%); TLR= Total land resources (ha); NA= Non-agriculture; SA= Secondary agriculture; AG= Agriculture (values in the parentheses express significance value for respective explanatory variable).

Rice Demand

Rice is the staple food in Bangladesh. So rice demand can be considered as an important factor in determining the future land use. Per head rice demand was found significantly positively related to total land resources of the household (Figure 7.4). As total land resources imply the economic condition of the household (Figure 7.6), so more land resources means more food the household can afford to consume and as a result more demand. On the other hand larger households also maintain social activities more than the smaller households and feed more people in excess of their family members and family demand increases which ultimately increases the per head rice demand (although it does not mean that people from larger households eat more rice than those from the smaller counterpart).

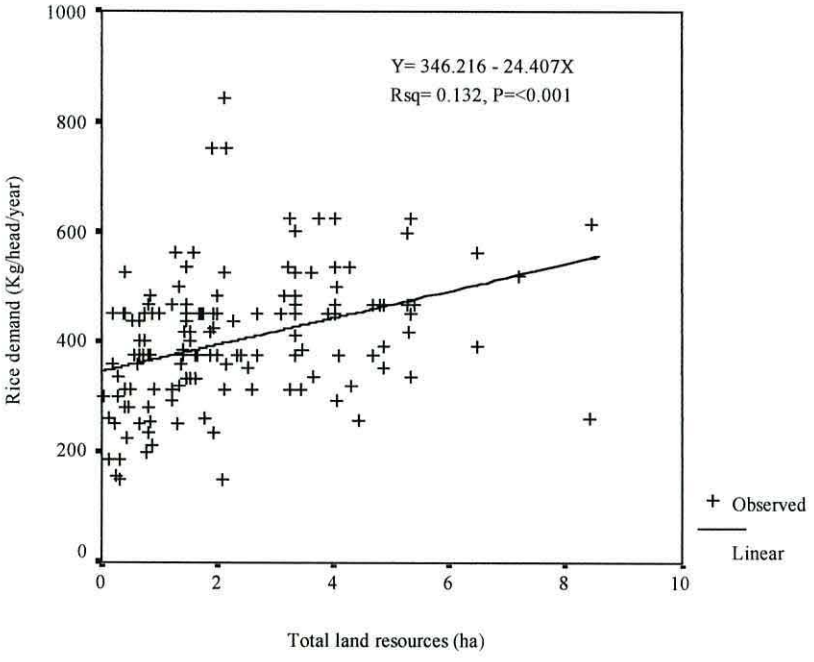

Figure 7.4. Relationship between per head rice demand (Kg/head/year) and total land resources (ha).

Tree Area

Tree area in the village areas are generally known as homestead forests and supply most of the country's total forest products requirements in the form of fuelwood and timber or bamboo (Chapter 4). It also provides fruits for the households' own consumption and as a source of income for the rural household (such as, mango, jackfruit, guava, papaya, coconut, betel nut etc.) and fodder for their livestock. It thus plays an important role in increasing the total tree cover of the country. In this respect it would be wise to try and determine the variables that influence household tree area in the village areas. Trees and bamboos are usually found in and around the homestead. However in some cases trees and bamboos are also found in areas other than homestead. Tree area (%) was found to be significantly positively related to homestead area and negatively related to total land resources (although R^2 is very small) (Figure 7.5). This implies that the more the land resources the less will be the per cent of tree area the household possess and the greater the homestead the more will the per cent of tree area. On the other hand homestead area (%) was also found significantly negatively related to total land resources (Figure 7.6). Based on these relationships stepwise multiple regression analysis shows that tree area (%) is significantly positively related to homestead area and negatively related to total land resources (Equations 7.8 & 7.9).

$TA = 3.531 + 17.411*HA$ ($R^2 = 0.0.071$, $P = 0.001$)..... (Equation 7.8)
(0.039) (0.001)

$TA = 6.881 + 45.299*HA - 4.586*TLR$ ($R^2 = 0.290$, $P = <0.001$)..... (Equation 7.9)
(<0.001) (<0.001) (<0.001)

where, TA= Tree area (%); HA= Homestead area (ha); and TLR= Total land resources (ha) (values in the parentheses express significance value for respective explanatory variable).

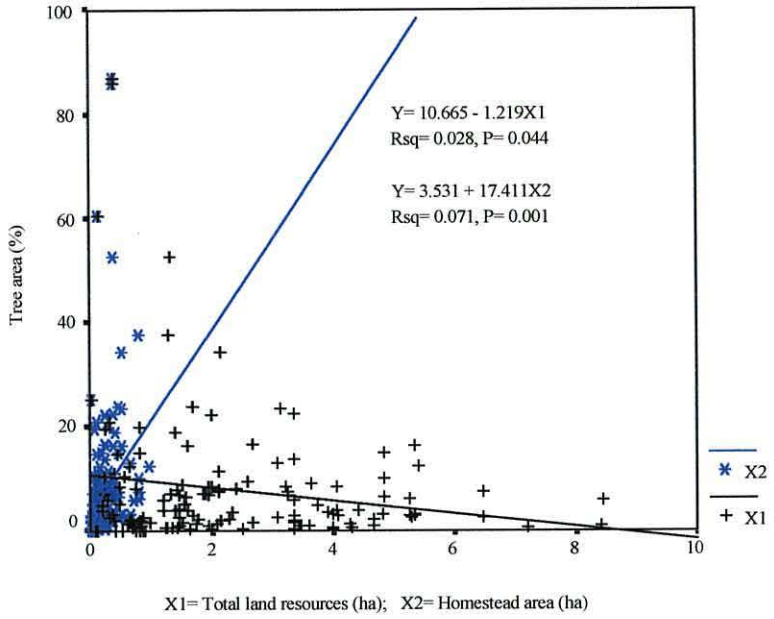

Figure 7.5. Relationship between tree area (%) against total land resources (ha) (X1) and homestead area (ha) (X2).

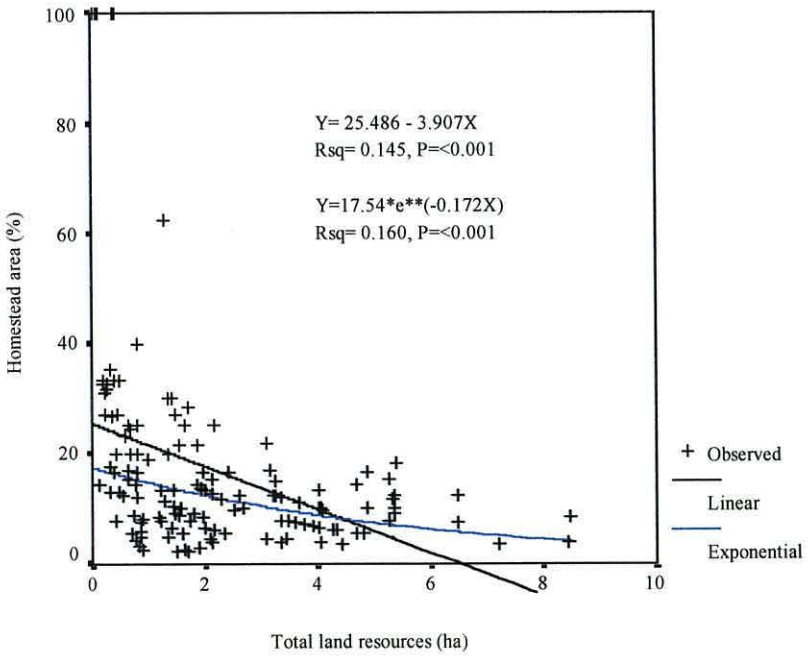

Figure 7.6. Relationship between homestead area (%) and total land resources (ha).

Family Income

Family income is an important criterion in determining the socio-economic condition of a household. It determines the ability of the household to access basic necessities like food, clothing, shelter. Family income was found to be positively correlated with household type, family size, and total land resources (Table 7.10). Family size differs significantly between household types with the larger households (categorised on the amount of land the household operates) having larger family size (Tables 7.1 & 7.2). Family income was found to be significantly positively related to total land resources the family operates (Figure 7.7). The larger the family operating more land the richer the family with higher family income. Stepwise multiple regression analysis revealed that family income was also significantly dependent on family occupation (Equations 7.10, 7.11 & 7.12). Family occupations were first grouped into four different categories which were used as dummy variable in the analysis (a value of '1' was used if the family had the particular occupation otherwise a value of '0' was used). The four occupation categories are agriculture (agriculture being the only family occupation), primary agriculture (agriculture being the primary occupation with other as secondary occupation), secondary occupation (agriculture being the secondary occupation with other as primary occupation) and non-agriculture (other occupation(s) except agriculture). The multiple regression analysis showed that family income is significantly positively related to total land resources and non-agricultural occupation and negatively related to agricultural occupation. This implies that although total land resources increase family income family occupation also has impact on family income (Equations 7.10, 7.11 & 7.12). It was interesting to see that agriculture generally contributes less income than other occupations like business, service etc. (Table 7.15). As agricultural occupation has some negative influence (Equation 7.12) on the family income so family income increases while the family moves away from agriculture to other non-agricultural occupations.

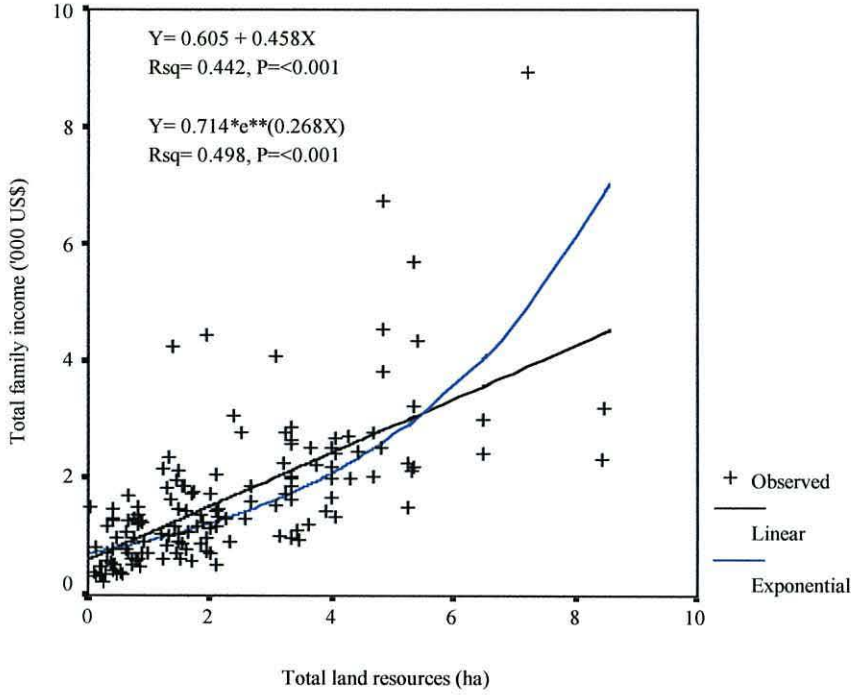

Figure 7.7. Relationship between family income (US$) and total land resources (ha).

TFI= 604.769 + 458.446*TLR (R^2= 0.442, P= <0.001).....(Equation 7.10)
(<0.001) (<0.001)

TFI= 486.849 + 456.834*TLR + 1029.712*NA (R^2= 0.514, P= <0.001).....(Equation 7.11)
(<0.001) (<0.001) (<0.001)

TFI= 656.267 + 461.599*TLR + 849.321*NA – 586.682*AG (R^2= 0.557, P= <0.001).....(Equation 7.12)
(<0.001) (<0.001) (<0.001) (<0.001)

where, TFI= Total family income (US$); TLR= Total land resources (ha); NA= Non-agricultural occupation; AG= Agricultural occupation (values in the parentheses express significance value for respective explanatory variable).

Household Living Standard

Household living standard is a term used here to mean the average living situation of a household considering house condition, health, sanitation, clothing and possession of luxury goods. This scored from 1 (very bad) to 5 (very good). Household living standard was positively correlated (P value <0.001) with both total family income and total land resources (Table 7.20, Figure 7.8). It

is interesting to see that household living standard was also significantly related to the proportion of family members educated (Figure 7.8). Based on these observations stepwise regression analysis developed a number of significant multiple regression models to explain the overall living standard of a household in the village areas (Equations 7.13, 7.14 & 7.15). The model (Equation 7.15) explains that household living standard was significantly related to total family income, proportion of family members educated and total land resources the family operates. This implies that the larger the household having more land resources, the more the family income and the more percentage of family members educated the more will be its living standard.

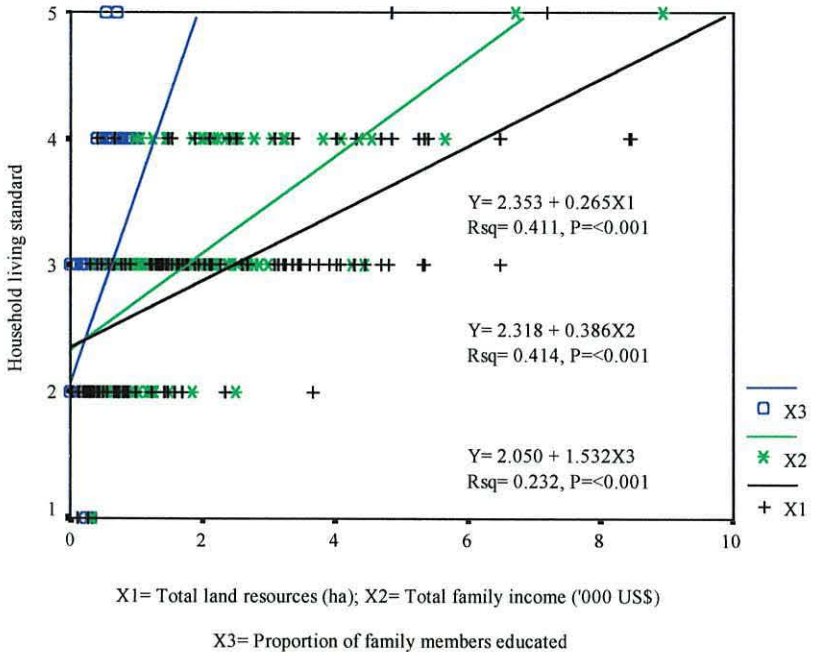

Figure 7.8. Relationship between household living standard against total land resources (ha) (X1), family income ('000 US$) (X2) and proportion of family members educated (X3).

HLS= 2.318 + 0.386*TFI (R^2= 0.414, P= <0.001).....(Equation 7.13)
(<0.001) (<0.001)

HLS= 1.775 + 0.333*TFI + 1.071*PFME (R^2= 0.520, P= <0.001).....(Equation 7.14)
(<0.001) (<0.001) (<0.001)

HLS= 1.814 + 0.239*TFI + 0.848*PFME + 0.109*TLR (R^2= 0.554, P= <0.001).....(Equation 7.15)
(<0.001) (<0.001) (<0.001) (<0.001)

where, HLS= Household living standard; TFI= Total family income ('000 US$); PFME= Proportion of family members educated; and TLR= Total land resources (ha) (values in the parentheses express significance value for respective explanatory variable).

7.11. Discussion.

The village survey was valuable in observing the land uses and life styles of the rural populace. There are still more issues to investigate in this topic. As this study was conducted within time and fund constraints it was not possible to investigate in detail all the reasons behind their poor economic conditions and land use decisions. Should the time and funding allow a detailed study could prepare a land use map of each individual household, village and thana level in order to investigate the land use, life style and economic activities at household levels. However, the present survey results display that in village areas the majority of the households are directly or indirectly dependent on agriculture and most of their land resources are used for crop production. However there was observed variation in the use of land for different crops in different regions. The farmers could not give a clear history of their land use. According to survey result, they are following the traditional land use system that their ancestors used in the past (Table 7.21). However they do change their land use in the form of one crop to another whenever they find it beneficial. Farmers' living standard was not very impressive. In the village areas land areas were observed for use as homestead, agriculture, trees and bamboos and fishing (Table 7.5). Trees and bamboos are found in and around the homestead and in some cases other areas as well that supply the majority of the country's forest product needs (Gain, 1998). However fruit trees dominated in homestead forests acting as major source of calories, vitamins and income to rural families. Large and medium households usually use these fruit tree for their own consumption and use, whereas small households usually use them as their source of income. Farmers also use a substantial amount of land for their homestead that if used wisely could free up more land for cultivation and thereby increasing the food production. The majority of respondents live in a medium condition (Table 7.19). This living standard was found to be dependent on household types, family income and percentage of family members educated.

In village areas it was the land resources that determine the socio-economic characteristics of the households. As seen from Table 7.10 there is a strong relationship with type of household. More land resources are related to family size, homestead area, cropped area, tree areas and tree resources, having strong positive relationships. Most importantly it determines family income that in turn has significant positive influence on household living standard. Again it was the

occupation that determines family income. Generally households shift from agriculture as a primary occupation to secondary or higher occupations, in order to increase family income (Equation 7.12). This suggests that agriculture is not as profitable as other occupations. This is particularly worrying in rural areas where opportunities for secondary occupation are lower. In these situations agricultural incomes would need to increase in order to prevent migration to urban areas. With the increase of family income, households tend to live in a better condition increasing their living standard. As a result their demand for food, housing, better health, sanitation, education, luxury goods increase.

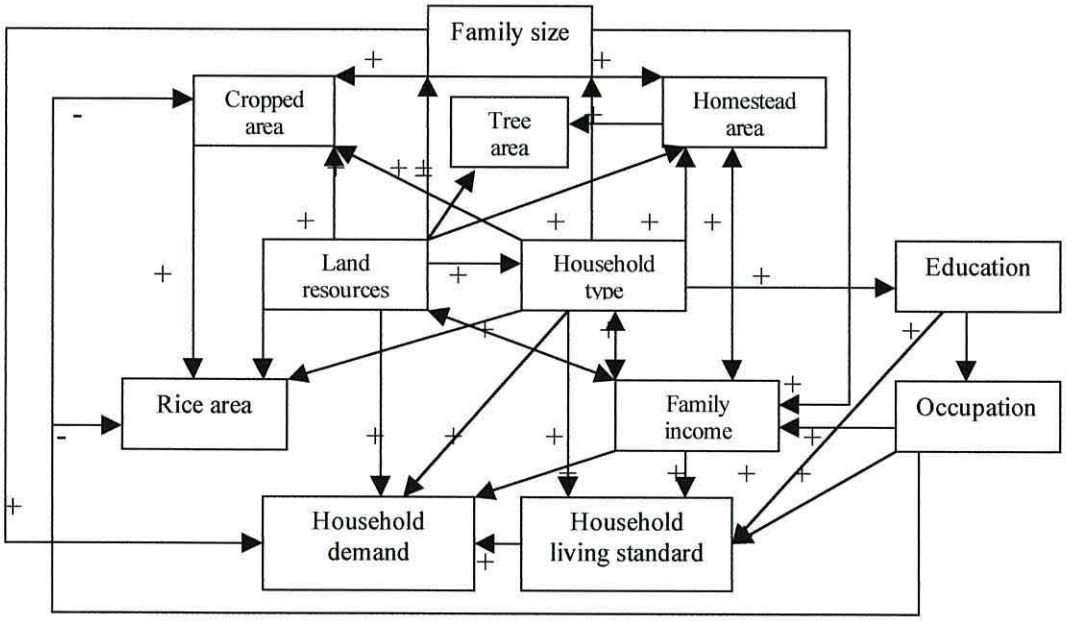

Figure 7.9. Socio-economic and land use characteristics flow chart for rural Bangladesh.

Based on these observations a flow chart explaining the interrelationships of variables for important socio-economic and land use characteristics emphasising tree areas can be established, as in Figure 7.9. This flow chart explains very clearly what happens in the village areas according to the survey results. Here it implies that the fate of the rural people is mainly dependent on land resources. If they have more land they are better off with more income, higher living standard, education and then occupation. Otherwise they live very miserable lives with less income, poor

living standard, less education and as a result less chance to go for higher occupation. At present about 40 per cent of the rural population live in absolute poverty and about 6 per cent of rural population own no land at all (WARPO, 2000). Unless the fate of these people can be changed the country's drive towards improving the living condition of all people, as a long-term objective could not be achieved. In the short term, while the economic development could be met by increased output from the richer sectors of society, it is desirable to aim to increase economic and social condition for all citizens. So to support economic growth due importance should be given to improve the living standard of the poor masses. This can be done either by a massive land reform to give these people ownership of minimum amount of land by splitting the large household into several smaller households to produce more food and trees by increasing the proportion of cropped area and tree area (Figures 7.2 & 7.5) or by increasing their family income creating opportunities for non-agricultural occupation in the rural areas. Land reform is a complex issue and it requires firm political commitment to materialize as 87 per cent of the total households operate only 24 per cent of the country's total area (Table 4.5). Extension of improved agricultural technology in the village areas may also increase the present production level thereby increasing family income. On the other hand, providing them free education, better health, creating more employment opportunities, can increase family income. The government needs appropriate policy options to improve the quality of life for the masses and engender use of land resources. The following chapters aim to discuss more about these and try to recommend some policy options for the betterment of the country and increase of the tree cover.

CHAPTER 8

GENERAL DISCUSSION

8.1. Introduction.

Socio-economic development depends on unavoidable manipulation of the landscape for the purpose of gaining access to enough biomass on the one hand (food, fodder, fibre, fuelwood, timber), and enough water on the other (Falkenmark and Suprapto, 1992). Again, changes in land use are linked with economic development, population growth, technology, and environmental change (Houghton, 1994). However, in the South the production activities needed to fulfil increased demands may well be constrained due to the limited speed in technological advancement as well as societal constraints (Falkenmark and Suprapto, 1992). This chapter addresses the overall discussion on land use and its changes in Bangladesh based on the previous chapters. The most important driving force in land use change appeared to be population growth. Technological growth (Chapter 4) also played a vital role in this respect influencing agricultural land use changes in most of the cases.

8.2. Bangladesh: Current economic activities.

Bangladesh is making slow but steady progress towards economic development and as a result all the socio-economic criteria to reflect the level of economic development of a country are showing upward trends. The Minister for Finance, Government of the People's Republic of Bangladesh, in his annual budget speech at the National Parliament on 7th June 2001, has showed some positive impact of the current economical activities of the country (Ittefaq, 2001). According to him the coefficient of inequalities of income has decreased from 42 per cent in 1994-95 to 36 per cent in 1998-99 in rural areas and from 49 to 43 for urban areas which definitely shows a positive response of the economy. It still shows that there exist great

inequalities in both rural and urban areas but the situation is slightly better in rural areas. The rate of poverty also decreased from 47.9 per cent in 1995-96 to 44.9 per cent in 1998-99 in rural areas. Average life expectancy has increased from 58.7 years in 1995-96 to 61.8 years in 1999-2000. Average calorie intake also increased from 2206 kcal in 1996 to 2274 kcal in 1999 in rural areas and from 2220.6 kcal to 2288.8 kcal in urban areas. The human development indicator also increased from 42.6 per cent in 1995-97 to 48.5 per cent in 1998-99 and at the same time human poverty indicator has decreased from 41.6 per cent in 1996-97 to 34.8 per cent in 1998-00. The overall analysis shows that Bangladesh is showing not only quantitative but also qualitative improvement to its endeavour for economic development. This discussion clearly demands a well-defined land use policy to meet the demand for a more developed increasing mass of population.

8.3. Land Use Predictions.

So far this work has developed some regression models in understanding land uses in Bangladesh at national, divisional, district and village scales (Chapters 4, 5, 6, & 7). The study emphasized forest and agricultural land uses only. If significant linear regression models (both simple and multiple) are used in a predictive sense then it is observed that both forests and net-cropped area will decline at national scale with time and population leaving only 7 per cent land area under forests and 40 per cent under agriculture by 2050 (Table 8.1).

Table 8.1. Land use predictions at national scale (land use data calculated using regression models (Figure 4.8, Equations 4.2 & 4.3) and population data (Table 4.2) in Chapter 4).

Year	Population (millions)	Forests		Net-cropped area	
		(mha)	(%)	(mha)	(%)
2000	129	1.42	9.99	7.66	53.93
2010	150	1.35	9.47	7.26	50.76
2020	170	1.27	8.88	6.87	47.82
2050	227	1.00	6.90	5.75	39.74

This implies that by 2050 Bangladesh will be more vulnerable to environmental degradation and face a serious food shortage if the present rate of deforestation and conversion of agricultural lands to non-agricultural uses continues. This situation is true if there is no government intervention over land use. As stated in Chapter 3 the government of Bangladesh has already formulated some important national policies related to forestry, agriculture and environment. So we can hope that the situation would not be worse in the future with the proper implementation of all the national policies. However it is still a matter of question whether the government could achieve the policy goals. For example, according to National Forestry Policy 1994 (Chapter 3) the government targets to bring 20 per cent of country's total land under tree cover by 2015. This policy fails to show the possible impact on agriculture and non-agricultural land uses due to increasing population size and development needs. So there should be clear policies for the government to achieve all its development goals and at the same time ensure a sustainable production system in both forestry and agriculture. The land use prediction at the national level will help the government to decide on future land uses at national level but it fails to predict the specific conditions for land uses at different locations. As land uses at different locations are not homogeneous it would be wise to predict future land uses at smaller scale.

Land use predictions at divisional scale show some interesting features in the case of forest and agricultural land use, which seem unrealistic (Table 8.2). All the divisions show a pessimistic prediction of forests with very low proportions by 2050. According to negative exponential model (Figure 5.8) forests would approach zero in most of the divisions by 2050. Chittagong, containing 41 per cent forests at present, shows a pessimistic prediction of 1 per cent forests by 2050. This is not true as land at high altitude in some areas in Chittagong cannot be converted to land uses other than forestry. Same is true for Khulna which also shows a prediction of only 1 per cent forests by 2050 against a modest 26 per cent at present (2000) as saline water in the mangrove forests will not allow any other land use except forest. On the other hand proportion of agricultural area cannot be greater than 1 (one) as appeared to be for Dhaka division by 2050. So the prediction does not show the real situation of the country at the divisional scale. This is partly due to model structure and partly because lack of temporal data showing a historical land use change in different time period at divisional scale. Prior to creation of two new divisions in

Bangladesh in mid 1990s all the available data were arranged according to four former divisions in most of the organisations. Hence, data from only one time period were used to model land uses at divisional level, and these models failed to show the real situation in Bangladesh. Again lack of coordination among different related government organizations regarding data collection and storage also restricts this study in predicting a realistic land use scenario in the future. Geographic Information Systems (GIS) could make this analysis more realistic using aerial photographs or satellite imagery collected at different time periods. But lack of funds restricted this study from using GIS in modelling land use changes at different time periods. The same sorts of results were also observed in predicting land uses at district level (Table 8.3). Some districts show optimistic predictions and some show pessimistic predictions far away from reality. This is again due to lack of temporal data at district scale. In both division and district scale negative values can be considered as zero. However district scale was found to be suitable to study land uses more conveniently due to wide variations in land uses at divisional scale. So further research is needed to establish a temporal database on land use changes at district scale to support policy makers in deciding best land use options in the future.

Table 8.2. Land use predictions at divisional scale (forest area was calculated using negative exponential model in Figure 5.8 and net-cropped area was calculated using linear regression models in Equations 5.4 & 5.5; and population data were calculated from Table 4.2 considering the same proportion of country's total population for different divisions as in Table 5.1; actual corresponds to data on 1996-2000).

Division	Proportion of forest area					Proportion of net-cropped area				
	Actual	2000	2010	2020	2050	Actual	2000	2010	2020	2050
Barisal	0.03	0.10	0.06	0.04	0.01	0.47	0.43	0.48	0.52	0.63
Chittagong	0.41	0.08	0.05	0.03	0.01	0.30	0.45	0.50	0.54	0.66
Dhaka	0.03	0.01	0.00	0.00	0.00	0.59	0.66	0.74	0.82	1.04
Khulna	0.26	0.09	0.05	0.03	0.01	0.45	0.44	0.48	0.52	0.64
Rajshahi	0.01	0.03	0.02	0.01	0.00	0.63	0.53	0.59	0.64	0.80
Sylhet	0.06	0.13	0.08	0.05	0.02	0.44	0.41	0.45	0.48	0.59

Table 8.3. Land use predictions at district scale (land use data were calculated using regression models (Equations 6.3 & 6.6), district database and population growth rate (%) (WARPO, 2000); actual corresponds to data on 1996-2000).

District	Proportion of forest area					Proportion of net-cropped area				
	Actual	2000	2010	2020	2050	Actual	2000	2010	2020	2050
Barguna	.07	0.24	0.22	0.20	0.17	0.49	0.44	0.46	0.47	0.50
Barisal	.00	0.05	0.02	0.00	-0.04	0.48	0.54	0.56	0.57	0.59
Bhola	.04	0.26	0.25	0.23	0.20	0.35	0.42	0.43	0.44	0.45
Jhalakati	.00	0.09	0.05	0.02	-0.03	0.61	0.57	0.59	0.62	0.66
Patuakhali	.05	0.27	0.25	0.24	0.21	0.45	0.41	0.42	0.43	0.45
Pirojpur	.00	0.13	0.09	0.07	0.02	0.74	0.53	0.56	0.58	0.61
Bandarban	.67	0.39	0.39	0.39	0.38	0.08	0.33	0.33	0.33	0.33
Brahmanbaria	.00	-0.08	-0.11	-0.14	-0.18	0.62	0.64	0.65	0.66	0.68
Chandpur	.00	-0.11	-0.14	-0.17	-0.21	0.48	0.65	0.67	0.68	0.69
Chittagong	.23	0.16	0.15	0.14	0.14	0.27	0.43	0.43	0.42	0.39
Comilla	.00	-0.06	-0.08	-0.10	-0.11	0.63	0.59	0.59	0.59	0.56
Cox's Bazar	.39	0.15	0.12	0.10	0.07	0.26	0.49	0.51	0.52	0.54
Feni	.01	0.02	-0.02	-0.05	-0.10	0.53	0.62	0.64	0.66	0.68
Khagrachari	.66	0.36	0.36	0.35	0.34	0.14	0.35	0.35	0.36	0.37
Lakshmipur	.07	0.07	0.04	0.01	-0.04	0.54	0.56	0.59	0.61	0.63
Noakhali	.24	0.22	0.21	0.19	0.16	0.40	0.44	0.45	0.46	0.47
Rangamati	.94	0.39	0.39	0.39	0.38	0.09	0.32	0.33	0.33	0.33
Dhaka	.00	0.01	0.22	0.49	1.24	0.26	0.21	-0.09	-0.47	-1.47
Faridpur	.00	0.04	0.01	-0.01	-0.05	0.56	0.56	0.57	0.59	0.62
Gazipur	.16	0.14	0.11	0.08	0.03	0.50	0.53	0.55	0.57	0.59
Gopalganj	.00	0.00	-0.03	-0.06	-0.10	0.66	0.58	0.61	0.62	0.66
Jamalpur	.02	0.02	0.00	-0.03	-0.07	0.62	0.57	0.59	0.61	0.63
Kishorganj	.00	-0.03	-0.06	-0.08	-0.12	0.62	0.58	0.60	0.61	0.63
Madaripur	.00	-0.04	-0.07	-0.10	-0.15	0.67	0.62	0.65	0.67	0.70
Manikganj	.00	-0.01	-0.04	-0.07	-0.12	0.52	0.60	0.62	0.64	0.67
Munshiganj	.00	-0.11	-0.15	-0.18	-0.23	0.52	0.68	0.70	0.72	0.74
Mymensingh	.04	0.14	0.12	0.11	0.09	0.68	0.47	0.47	0.47	0.47
Narayanganj	.00	-0.26	-0.29	-0.29	-0.26	0.44	0.76	0.75	0.72	0.62
Narsingdi	.00	-0.08	-0.12	-0.15	-0.18	0.68	0.67	0.68	0.69	0.69
Netrakona	.00	0.18	0.16	0.14	0.10	0.63	0.47	0.49	0.50	0.52
Rajbari	.00	0.10	0.07	0.04	-0.01	0.56	0.55	0.57	0.59	0.62
Shariatpur	.00	0.00	-0.03	-0.06	-0.12	0.63	0.60	0.62	0.64	0.68
Sherpur	.06	0.09	0.06	0.03	-0.02	0.65	0.55	0.58	0.60	0.63
Tangail	.15	0.11	0.09	0.07	0.04	0.58	0.50	0.51	0.52	0.53
Bagerhat	.58	0.29	0.27	0.26	0.24	0.33	0.40	0.40	0.41	0.43
Chuadanga	.00	0.08	0.06	0.03	-0.02	0.67	0.55	0.57	0.59	0.63
Jessore	.00	0.09	0.07	0.05	0.01	0.66	0.53	0.54	0.55	0.57
Jhenaidah	.00	0.11	0.08	0.06	0.01	0.64	0.53	0.54	0.56	0.59
Khulna	.41	0.27	0.26	0.24	0.22	0.25	0.40	0.41	0.42	0.43
Kushtia	.00	0.04	0.01	-0.02	-0.07	0.56	0.58	0.60	0.61	0.64
Magura	.00	0.12	0.09	0.06	0.01	0.63	0.54	0.56	0.58	0.62
Meherpur	.00	0.08	0.04	0.02	-0.04	0.65	0.56	0.58	0.61	0.65
Narail	.00	0.13	0.10	0.08	0.03	0.60	0.52	0.55	0.57	0.60
Satkhira	.43	0.27	0.26	0.25	0.22	0.31	0.40	0.41	0.42	0.44
Bogra	.00	0.09	0.06	0.04	0.01	0.63	0.53	0.54	0.55	0.56
Dinajpur	.02	0.15	0.13	0.11	0.08	0.71	0.48	0.49	0.50	0.52
Gaibandha	.00	0.06	0.04	0.01	-0.03	0.61	0.55	0.57	0.58	0.60
Joypurhat	.00	0.05	0.02	-0.01	-0.07	0.72	0.58	0.60	0.62	0.66

Table 8.3. continued.

Kurigram	.00	0.11	0.09	0.07	0.03	0.50	0.52	0.53	0.55	0.57
Lalmonirhat	.00	0.08	0.05	0.02	-0.03	0.64	0.55	0.58	0.60	0.63
Naogaon	.01	0.16	0.14	0.12	0.09	0.69	0.47	0.49	0.50	0.51
Natore	.00	0.04	0.01	-0.01	-0.06	0.67	0.56	0.58	0.59	0.62
Nawabganj	.00	0.13	0.10	0.08	0.03	0.60	0.52	0.54	0.56	0.59
Nilphamari	.01	0.07	0.04	0.01	-0.04	0.69	0.56	0.58	0.60	0.63
Pabna	.00	0.03	0.00	-0.02	-0.06	0.57	0.56	0.58	0.59	0.61
Panchagarh	.01	0.15	0.13	0.11	0.07	0.64	0.50	0.51	0.53	0.56
Rajshahi	.00	0.12	0.10	0.07	0.03	0.50	0.52	0.53	0.55	0.57
Rangpur	.01	0.06	0.03	0.01	-0.03	0.69	0.55	0.57	0.58	0.60
Sirajganj	.00	0.07	0.05	0.02	-0.01	0.53	0.54	0.56	0.57	0.58
Thakurgaon	.01	0.14	0.11	0.09	0.05	0.72	0.50	0.52	0.54	0.57
Habiganj	.05	0.09	0.06	0.05	0.01	0.50	0.52	0.53	0.55	0.57
Moulvibazar	.11	0.20	0.19	0.17	0.14	0.33	0.45	0.47	0.48	0.50
Sunamganj	.02	0.07	0.05	0.04	0.01	0.51	0.51	0.52	0.53	0.54
Sylhet	.07	0.10	0.08	0.06	0.03	0.42	0.50	0.51	0.52	0.54

8.4. Land Use Decisions.

A critical challenge for land use and management involves reconciling conflicting goals and uses of the land. The diverse goals for use of the land include resource-extractive activities, such as forestry, agriculture, grazing, and mining; infrastructure for human settlement, including housing, transportation, and industrial centres; recreational activities; services provided by ecological systems, such as flood control and water supply and filtration; support of aesthetic, cultural, and religious values; and sustaining the compositional and structural complexity of ecological systems (Dale *et al.*, 2000). These goals often conflict with one another, and difficult land use decisions may develop as stakeholders pursue different land use goals. For example, conflicts often arise between those who want to extract timber and those who are interested in the biodiversity values of forests. Local vs. broad scale perspectives on the benefits and costs of land management also provide different views of the implications of land actions.

Population growth can be considered as the ultimate cause for land use changes (Dale *et al.*, 2000; Sage, 1994, Grübler, 1994). However, population growth is affected by many factors, such as political dynamics and policy decisions that influence local and regional trends in sub-

urbanization, urbanization, and colonization. Moreover, local demography and variability in per capita resource consumption can modify the effects of population.

A rising level of per capita income, as part of the process of economic development, is a major variable of land use change (Sage, 1994). In the industrialised countries of the North, for example, the income elasticity for food is low and approaching zero, whereas it is high and positive for such functions as recreation and housing (Pierce, 1990 as cited in Sage, 1994). In the South, by contrast, rising per capita incomes stimulate relative large increases in demand for basic food goods, although as incomes rise this creates a change in the composition of demand (Crosson, 1986 as cited in Sage, 1994). Rising income also creates other far-reaching changes in relation to land use, for example, by increasing demand for living space, transport, and recreational uses, especially among urban populations.

8.4.1. Agriculture.

Historical analysis shows that relative importance of agriculture has declined in developing countries as a result of land, the main input to agriculture, being diverted to other competing uses, income elasticity of demand for agricultural products is relatively low and therefore its demand grows at a lower rate than that of non-agricultural products and finally low productivity, income and savings, etc. compared to other sectors (Gain *et al.*, 1998). Bangladesh is no exception to this view where the contribution of the agricultural sector in the national income has already declined from 65 percent in 1950 to 32 per cent in 1995 (Figure 4.4).

Grübler (1994) concluded that land use patterns have changed over millennia, but the most dramatic transformations have taken place over the last 300 years. Land transformation patterns were accelerated with increasing population growth, where agriculture dominated both land use patterns and their dynamic transformations. According to him technological change has led to these transformations in agriculture through increases in land productivity and in labour productivity.

The major source of growth in the food systems of both developed and developing countries comes from a variety of intensification strategies which have boosted yields and cropping intensities and in turn production. The adoption of Green Revolution technology, first by Mexico, followed by countries of the Indian subcontinent, China and other regions of South-East Asia, required dramatic increases in energy-intensive technology (Pierce, 1990). With increased reliance upon fertilizers, irrigation, herbicides/pesticides and mechanisation there was also a shift to a more science based agricultural system involving new high-yielding variety grains as for example HYV rice in Bangladesh (Chapter 4).

8.4.1.1. Production Potential.

Bangladesh requires more food to feed its ever-increasing population each year. However recent estimates show a decreasing trend for net-cropped area although total cropped area still shows an increasing trend due to an increase in cropping intensity. As a result total production has increased (Chapter 4). Rahman *et al.* (1994) explained increases in net-cropped area by several factors, such as encroachment into forestland, decrease in culturable waste and current fallow and movement of population to frontier islands in the Bay of Bengal. However at the same time a considerable amount of valuable agricultural land, particularly around the growing cities and growth centres (thana/upzila headquarters) has been converted into non-agricultural use. Population growth has been identified as the major driving force for land use change in Bangladesh in the previous chapters so it will exert continuous pressure on limited land resources for both agricultural and non-agricultural uses. Again, there still exists a wide gap between potential and realized yields for all crops in Bangladesh (World Bank, 1998). For example, the yield potential of the HYV rice is more than 4.0 M.Ton/ha which is at least twice the average yield now realized by most farmers (World Bank, 1998; Table 4.14). The National Agriculture Policy 1999 (Chapter 3) also supports taking appropriate measures in reducing the gap between potential yield and farmers' realized yield of different crops to raise the present level of production significantly. Choudhury (1987) pointed out that most of the land is not producing even half its potential due to the predominance of traditional technology, complex landownership, insecure tenancy pattern and fragmentation of holdings. According to him there is little incentive for sharecroppers to produce more because the absentee owners get 50 per cent of

produce without making any investment and about 90 per cent of land is cultivated under oral contracts of sharecropping from season to season with no security of tenure for the sharecropper.

The National Forestry Policy 1994 (Chapter 3) strictly prohibits expansion of net-cropped area through encroachment or illegal occupation of forestland simultaneously. However there is increasing demand for non-agricultural land uses. One option for achieving the balance in land use could be careful zoning of agricultural land based on production potential. Use of modern technology and improved cultural practices along with the increased use of HYV seeds would be the best possible option to increase the realized yield and total food production of the country.

Again, the introduction and spread of new technology are being hampered due to insecurity of tenure, fragmentation of land holdings, and inadequate supply and services. When small and medium sized farmers are responsive to the adoption of new technology, they achieve higher cropping intensities and a higher yield than large farmers. Therefore, sustained efforts must be made to bring these farms under the new technology, free them from unfavourable tenancy arrangements, and provide them with adequate inputs and supporting services (Choudhury, 1987). These attempts will surely increase the country's total food production.

8.4.2. Human Settlement.

Settlement refers to the occupation of land for human living space (CRGEC, 1991 as cited in Douglas, 1994). Settlement is a place where people live and to which they bring materials for consumption and for transformation into other objects. It represents the most profound alteration of the natural environment by people, through the imposition of structures, buildings, paved surfaces, and compacted bare soils on the ground surface (Douglas, 1994). It also creates demands that lead to other land cover changes, such as pond (water reservoir), yard, home gardens, parks, sports grounds and so on. Existing cultivable land in the rural areas is gradually decreasing due to erratic expansion of homesteads, imprudent alignment of roads and bridges, irrigation channels, ponds, construction of brickfields, industries, commercial establishments,

office buildings, and housing at upzila level on good agricultural land (Choudhury, 1987; Rahman *et al.*, 1994). Roads constructed in rural areas are usually zigzag, take up much more land than they should and are without culverts for proper drainage (Rahman *et al.*, 1994). Brick making on the other hand is not only taking up valuable land but also contributing to destruction of topsoil and tree resources (Hussain, 1981 as cited in Siddiqui, 1994). Planned human settlement is considered by many, as one of the ways of releasing land for productive use, in view of the scattered nature of human settlement pattern in rural Bangladesh (Siddiqui, 1994). An estimate suggested release of 600,000 acres of land through planned human settlement, the total homestead land being about one million acres, or 4.27 per cent of the total owned area (BBS, 1986 as cited in Rahman *et al.*, 1994). One option could be restricting horizontal expansion of homestead areas and encouraging vertical expansion instead. The Local Government Engineering Department (LGED) could play a vital role in this respect assessing the suitability of vertical expansion of households, which could house more people without consequent loss of land. The government could initiate laws and regulations for proper implementation of planned human settlement.

8.4.3. Urbanization.

Urbanization is the spatial dimension of the industrial and technological revolution of the past two centuries (Jakobson and Prakash, 1971 as cited in Qutub, 1992). The process of urbanization is largely irreversible, resulting from occupational migration of the civilian labour force from primary to secondary and tertiary occupations. From an economic point of view, urban growth is a function of overall development, and especially of imbalances in productivity in industry and agriculture, and in terms of trade for goods and services produced by them (Qutub, 1992). Demographically the components of urban growth are natural population increase, net rural to urban migration, and spatial amalgamation or transformation of previously non-urban areas into urban areas. Due to rapid growth of urbanization and industrialization in recent years, the demand for land for non-agricultural purposes and urban uses has increased sharply. Croplands lying in the peripheries of metropolitan cities and large towns are being purchased from farmers by offering them high prices for setting up industries, commercial establishments, housing societies,

and brick fields in the private sector. The situation has been further accentuated due to high demand for urban land from Bangladeshi expatriates working abroad who consider investment in land a highly attractive and solid hedge against inflation. Substantial quantities of land are also being acquired every year by government agencies for implementing development projects, such as the construction of roads, bridges, government offices, schools, colleges, hospitals, and power stations (Choudhury, 1987). Siddiqui (1994) also pointed out that there is a direct linkage between urbanization and loss of good agricultural land, because this land is generally free from flooding. To avoid the situation laws should strictly prohibit any unplanned encroachment of croplands for urban and other non-agricultural purposes.

8.4.4. Forests.

The forestry sector has traditionally received very little government attention and as a result the policy, legislation, forest industries, research and forest institutions and management have been ineffective. Coupled with increasing landlessness, land fragmentation, and land use conflicts, there has been tremendous pressure on the forest resources of the country (both in forest reserves and homestead forests) resulting in deforestation, encroachment, and unsustainable exploitation levels (FMP, 1993). Population pressure, forest management prescriptions and government rehabilitation programmes were identified as the major causes of forest cover loss in Bangladesh (Appendix 8.1). The government also imposed a moratorium on logging in 1989 to reduce the loss of forest cover which increased illegal logging in collusion with dishonest forest officials and eventually enhanced loss of forest cover in the country (Appendix 8.1). However, the National Forestry Policy 1994 gives some good policy measures for the development of the forestry sector in Bangladesh and aims to bring about 20 per cent of the country's total area under tree cover by the year 2015 (Chapter 3). The policy seems very optimistic to attain a tree cover of 20 percent against only 6 to 8 per cent at present. The aim can only be achieved if the government take coordinated efforts engaging all related government and non-government organisations to increase tree cover throughout the country. Some possible areas where government should concentrate in order to increase tree cover are discussed below.

8.4.4.1. Potential to Increase Forest Cover.

State forests

There is immense scope to increase tree cover in state forestlands as half of the forest lands controlled by Forest Department lacks tree cover (Chapter 4). In view of the National Forestry Policy 1994 massive afforestation of the degraded state forestlands can substantially increase forest cover. Participatory forestry, social forestry and agroforestry in some cases can contribute substantially to the total forest cover bringing up encroached forestlands, sides of the road, railway tracks, dams and fallow lands under afforestation. Newly accreted char lands are also a potential source for afforestation in the coastal belts. Professional honesty and devotion to the nation's development works are important in this case to achieve target tree cover at the state forestlands, as dishonest forest officials were identified as one of the causes of forest cover loss (Appendix 8.1).

Strip plantations

Strip planting along roadsides, railway lines, and embankments has been a major focus of social forestry in Bangladesh. But due to lack of care and protection these programs have not been successful. Again problems associated with land tenure and lease agreements have limited these attempts. Thus, there are many social and technical problems, which must be solved before these programs can be made successful. However there is a great scope to increase forests in Bangladesh through strip plantations by 26,290 ha as suggested by the Forestry Master Plan (FMP, 1992a) using 1989/90 data. As the transport network is spreading all over Bangladesh day by day the opportunity for strip plantations is also increasing.

Khas lands

There are about 562,115 ha of khas lands of which 322,579 ha is suitable for agriculture and 239,539 ha is not suitable for agriculture. These khas land are not productively used. The government has taken a land reform program and gradually transferring these khas lands to landless people. If the land ownership debate is settled then these lands will get the proper chance

to be used to their potential and as a result there will be a great opportunity to increase the country's net-cropped area by cultivating the land suitable for agriculture and, by planting forest on that land which is less suitable for agriculture.

Homestead forests

The homestead in Bangladesh is another potential area to increase total forests in Bangladesh. Traditionally every homestead contains trees mainly fruit trees (Chapter 7) and contributes largely to meet the country's total forest products' demand (Chapter 4). The present view of the government to plant more trees in and around the homestead and make it an ideal farmhouse with the wise use of homestead areas will certainly increase the tree cover area. Household survey results show that households contain 8 per cent of its total land resources under tree area irrespective of household type and locations (Table 7.5). Again, there are 17.8 million households in Bangladesh who operate a total of 8.3 mha (Table 4.5). Assuming the proportion of land under tree area is true, then it can be estimated that homestead forests in the country will stand at 0.66 million ha (8 per cent of 8.3 mha) comprising 4.5 per cent of the country's total area, which is only 0.27 mha (1.9 per cent of the country's total area) at the moment (Table 4.10). This will substantially increase the country's total tree cover. So the government should concentrate more on homestead forests along with the state forests. Again, total operated land has a negative impact on both homestead area (%) and tree area (%) (Figures 7.5 & 7.6) in the rural areas meaning less operated area per household will lead to more homestead area (%) and tree area (%). Tree area (%) will also increase with the increase of homestead area (Figure 7.5). Generally larger family size leads to more fragmentations of land resources and results in more tree area (%). Government could initiate a programme for splitting the land holdings of larger households and redistributing the land to a number of smaller households in order to increase the proportion of tree areas in the rural areas.

8.5. Limitations of the Study.

As a developing country Bangladesh lacks a well-organised database for all sectors on both national and regional levels. In this era of development, planners are relying more and more on time series to guide a country to its development path. Currently computerised databases are gaining in importance in every government and non-government department in Bangladesh. It is expected that Bangladesh will make a great success in data storage and preservation in coming years. However in this situation planners in Bangladesh have to rely on published and unpublished books, journals, articles, statistical year books and data from different government and non-government organisations which sometimes varies from that in Statistical Yearbooks published by the Bangladesh Bureau of Statistics. This may be due to a lack of coordination among different organisations and in some cases unwanted interventions from the government policy makers to show up more progress than is actually happening at the regional or local level. The present study has been conducted with the same sort of limitations. However it is wise here to outline the limitations of the present study as follows:

- Lack of land use data on peasant farms or on smaller administrative divisions except for a few sample case studies.
- Lack of any government or non-government department responsible for recording all aspects of land use at national, divisional, district, thana and village levels.
- Lack of detailed land use maps on Bangladesh for at least two time periods to identify the causes of land use change in different locations.
- Limited time and funds to conduct the research. It requires more time and funds to collect and analyse satellite images on Bangladesh for different time periods so that changes in land use could be done more accurately.
- Lack of coordination among major land use authorities, such as forestry, agriculture, urban and rural planning, and other development agencies.

8.6. Future Research Needs.

The land resources and land problems of Bangladesh are not uniformly distributed throughout the country. There are considerable regional variations in land productivity and suitability for specific uses (Chapters 5, 6 & 7). This study fails to identify these variations clearly at different scales such as, national, divisional, district and thana level due to lack of appropriate data. Research is needed at smaller scales to identify these regional variations more clearly and help the policy makers to formulate appropriate policies.

The absence of an up to date, systematic, and universally accepted source of information on land resources availability and land rights is considered as a major limitation to the successful implementation of land reform programmes and as well as successful adjudication of land disputes (FMP, 1992b). The government must consider this problem on a priority basis and take proper initiatives to develop computerised databases for land resources and land rights at thana level so as to implement any proposed land reform programmes effectively. Further research is needed to find a system to identify easily all the problems related to land resources and their use at different locations.

Some government organisations such as, Space Research and Remote Sensing Organisation (SPARRSO), Soil Resources Development Institute (SRDI), Local Government Engineering Department (LGED), Water Resources Planning Organisation (WARPO), Department of Agriculture, Department of Forestry, Department of Environment are preparing some computerised databases related to land resources and using GIS and have prepared some land use maps on Bangladesh. But there is no coordination and consistency among the different organisations regarding these databases and maps. Hence a coordinated and collaborative effort is urgently required to a more consistent land use database at national, divisional, district and thana levels to help both the policy makers and the administrators solve all land related problems in Bangladesh.

8.7. Conclusion.

Population growth has emerged as a serious threat to socio-economic development and environmental conservation of Bangladesh. Again, there is no way that land area of Bangladesh can be extended. So in this critical situation, Bangladesh has no other choice except a national land use policy to guide its land uses and changes to conflicting land uses. Despite the fact that this study lacks an appropriate land use database in many cases, previous discussion suggests that there should be a rational management of limited land resources of the country on the basis of its suitability for different conflicting land uses for the sound economic and environmental development of the country. The following and final chapter discusses some of the policy measures for a national land use policy that Bangladesh desperately needs to continue its endeavour towards economic development.

CHAPTER 9

POLICY RECOMMENDATIONS

9.1. Introduction.

Bangladesh is the most densely populated country in the world with 834 people living per sq. km according to the recent nation-wide population census held in January 2001 (Ittefaq, 2001a; Prothomalo, 2001). Agriculture is the main occupation in Bangladesh. The increasing population demands more and more land every year for settlement and food production. As a result land use change is happening in erratic ways with forests and protected areas being converted to agriculture, and agricultural land going to housing, commercial, industrial and urban sites. It has now become imperative to formulate a national land use policy to guide wise use of this limited natural resource base. The government of Bangladesh has formulated national polices for forestry, agriculture and environment wherein land use forms a part, although there is no coordination and collaboration among different related government agencies to implement all these policies for the betterment of the country. On the other hand these policies also fail to address some of the very important issues for the sound economic and environmental development of Bangladesh such as population growth, development needs and land use conflicts. Population growth generates enormous conflicts for land among forestry, environmental protection, agriculture and urban and industrial development. Wise use and allocation of land between different competing land uses based on multiple land use principles has become the need of the time. Several authors have also stressed the need for a comprehensive land use policy for Bangladesh (Choudhury, 1987; FMP, 1992b; Hasan and Mulamoottil, 1994; Hussain, 1984). This study tried to focus on land use patterns in Bangladesh at different scales such as national, divisional, district and village level. Forest area and net-cropped area were found to decrease significantly with time and population growth whereas 'other land uses' significantly increased (Figures 4.7 & 4.8). From the discussion it is clear that time, population growth and development needs are the major driving forces for land use changes in different

parts of Bangladesh (Chapters 4, 5, 6, 7 & 8). Based on this and previous discussion this chapter aims to recommend some policy measures for a national land use policy in Bangladesh.

9.2. Policy Formulation.

Every policy formulation requires setting up premises based on which policy outlines are defined. According to OECD (1976) land use policy is based on the premise that land is a limited resource, that it does not have the same value or the same capacities everywhere and that its use should therefore be managed rationally. The optimum use of land requires that land resources be well characterised, their spatial relations delineated, and their capacities for all likely uses determined (Swindale, 1991). In the South self-sufficiency in food production, improved economic efficiency, equity and social justice are important goals of national development. Bangladesh is also trying to achieve these goals and achieved some success especially in food production in recent years (Chapter 8). Improved technology and agricultural intensification have made it possible to achieve this success (Figure 4.6, Table 4.14). But there is a threat for land degradation due to erratic use and in some cases overuse of land for more food production. However potential production has not yet been achieved (Chapter 8). Unequal distribution of agricultural land also constrains achieving potential production due to lack of secure ownership over the land farmers use to cultivate. A land reform programme could be a necessary and timely option for the government to assure the cultivators access to land on manageable terms to improve the production efficiency and/or equity in distribution of agricultural resources (Hasan and Mulamoottil, 1994; Morvaridi, 1990; Rahman *et al.*, 1994). Economic development requires the fullest exploitation of human and material resources available to a country (Shariff, 1987). Widespread unemployment and underemployment in Bangladesh made it imperative to look for alternative employment opportunities other than agriculture, as this sector can no longer support the growing labour force. New industries and improved service sectors could employ surplus labour. On the other hand, agricultural land can hardly be increased in Bangladesh due to increasing pressures from competing land uses such as forestry, industry, development works, and urban development. In this view a national land use policy is recommended to guide land use

planners and policy makers to take appropriate actions for wise use of limited land resources in a land hungry country like Bangladesh.

9.2.2. Policy Objectives.

The objectives of the recommended land use policy are:

- Efficient use of land for the sustainable social and economic development of the country.
- Efficient and prudent allocation of land resources among different competing land uses.
- Development of the agricultural sector through adoption of improved technology.
- Creation of alternative employment opportunities to free up excessive labour force from the agricultural sector.
- Preservation and protection of environmental quality.

9.2.3. Policy Directives.

Major policy measures for the recommended land use policy are stated as follows with their explanations:

(a) *Farm size should be smaller for efficient land use.*

Explanation: Smaller farms (defined based on the total operated land resources) were found to be significantly increasing cropped area and tree area per cent in the rural areas (Figures 7.2 & 7.5, Chapter 7) meaning both cropped area and tree area will substantially increase if farm size could be kept smaller. Smaller farm households also tended to crop more intensively than larger farm households (Table 7.8, Chapter 7) due to a desire to get more production from their limited land

resources meaning more production from less land resources. So the government should formulate appropriate laws to disintegrate larger farms into a number of smaller farms in order to increase effective cropped area and tree area in the country thereby encouraging more efficient land use.

(b) *Land zoning and allocation for best possible land uses.*

Explanation: There was observed variability in land uses at different locations of Bangladesh at different scales such as national, divisional, district and thana/village level especially agriculture and forests. Population density was also found to be variable in different divisions and districts (Chapters 5 & 6). So it would be wise to zone the available land in every location, say for every thana, based on the suitability of the land for specific uses. The Soil Resources Development Institute (SRDI), Dhaka, Bangladesh has prepared a thana level land and soil resource utilization guide (in Bengali) for 460 thanas in Bangladesh. This guide is very useful in providing data on land, soil and water resources in every thana, the present crop pattern, recommended fertilizer use for specific crop, limitations to land use, and crop suitability and possible crop distribution. It would be relatively easy to find good agricultural land and present homestead areas in every thana. But the guide fails to show other land uses such as commercial areas, educational and religious institutions, government and non-government office sites, roads, railway tracks and other development sites with their areas. Hence a detailed land use study for every thana is necessary for this purpose, based on the thana level land and soil resource utilization guide to prepare a detailed map containing present land use pattern including agriculture, forestry, housing, commercial and industrial sites, different institutions, roads and other development works. It could then be used to allocate land to different competing land uses. Good agricultural land should be identified and left aside only for crop production. Forest areas should be protected against any illegal occupation or encroachment. Potential areas for tree plantation should be identified and planted with both fruit trees and timber trees by the owner in each thana such as unproductive khas land, road sides, office premises, periphery of the agricultural land, dams, ponds etc. The Forest Department can play an important role in encouraging tree planting providing them with free seedlings and technical knowledge.

(c) *Projection of population and development needs at national, division, district and thana level for wise use and allocation of limited land resources among competing land uses.*

Explanation: Population was observed as the major driving force for land use changes in different scales. Population density is expected to double in the next 50 years (Table 4.2). As a result demand characteristics will also increase with the increase of population. As the country slowly advances towards development the living standard will increase demanding more luxurious needs other than the basic needs (food, shelter, clothing) such as educational and health facilities, improved communication facilities, recreational facilities, amusement parks, etc. Higher family income increases household living standards thereby increasing household demand for both basic and luxury needs (Figure 7.8, Chapter 7). Education has also a positive impact on household living standard (Figure 7.8, Chapter 7), meaning the greater the proportion of family members educated the higher is the household living standard. Again, non-agricultural occupation increases family income more than agricultural occupation (Equations 7.11 & 7.12, Chapter 7) thereby encouraging people to switch to non-agricultural occupation to increase family income. This will eventually result in an excessive labour force in non-agricultural occupations. So, the government needs to be careful to create more employment opportunities and plan to supply increased demand. Coping with the growing population will be difficult, as land area is static in nature. So the policy makers need to decide future land use options and allocation among different land uses to fulfil food demand and other development needs.

(d) *Increased food production through adoption of improved technology.*

Explanation: In Bangladesh land is still not used to full potential for production (although there were some outstanding developments in crop production in Bangladesh in the last few decades) (Figure 4.6, Table 4.14, Chapters 4 & 8). This is probably due to a lack of proper education, lack of awareness about improved technology, faulty tenure arrangements, and lack of incentives for the farmers to increase food production. The Department of Agriculture can play a vital role in this respect to extend modern technologies to farmers' doorstep and thus motivate them to produce up to the potential level. Present tenancy agreements also restrain farmers from producing optimum production as in most cases half of the production goes to the owner of the land without any involvement. So the farmers have less interest in improving the productivity of

the land by adopting new technologies. Again, landowners (92 per cent) decide the type of crop (Table 7.21) to be grown leaving no provision for the farmers to cultivate the land according to their own expertise and wish. Otherwise the tenant may lose the agreement to other farmers, which would be undesirable. So farmers' access to land with right of ownership or firm tenancy agreement may improve the situation.

(e) *Land reform programmes should be introduced to replace existing land reform legislations for the betterment of the cultivators and improve land productivity.*

Explanation: Three sets of legislations have so far been introduced in Bangladesh regarding land reforms, such as East Bengal State Acquisition and Tenancy Act of 1950, Presidential Orders of 1972, and Land Reforms Ordinance of 1984 (Rahman *et al.*, 1994). All these legislations were related to restrictions on land ceiling, distribution of government land among the landless, improvements in the terms of share cropping, fixing a minimum wage for agricultural labourers, abolition of statutory landlordism and intermediary rent receiving interests, ban on illegal (*benami*) land transfers (Rahman *et al.*, 1994). However these provisions did not improve the situation especially for the sharecroppers. This may be due to lack of proper implementation. There was also a wide gap between actual requirements on the ground and the land reform legislations enacted (Rahman *et al.*, 1994). Again, the existing agrarian structure can be considered as a serious obstacle to both growth of modern productive forces and higher production (Rahman *et al.*, 1994). Hence the need for land reform has become imperative for Bangladesh where higher production from limited land resources could be an important development policy as smaller farm size could intensify efficient land use increasing significantly proportion of both agricultural and forest area in the country (Figures 7.2 & 7.5, Chapter 7). To this view massive land reform programmes throughout the country could be the best option to solve the land tenure problems wherein the ownership of all cultivable land goes to the farmers who cultivate that land. So under this reform no person other than the farmer could own cultivable land. The farm owners may employ paid farm labours to cultivate his land with minimum wage set by the government. Strong laws and regulations should also be enacted to support these land reform programmes and their implementing authority without facing any

problem from the political leaders or local elites. Consensus among the political parties prior to introduction of new legislation regarding land reforms could ease the whole system.

(f) *Afforestation programmes and mass tree planting to increase the tree cover and improve environmental quality.*

Explanation: Mass afforestation programmes in both government forests and private areas could substantially increase the total tree cover in the country. The government of Bangladesh has already taken initiatives to increase the total tree cover of the country up to 20 per cent by 2015 under the new National Forestry Policy, 1994, although this sounds optimistic without specifying exact area to be afforested (Chapter 3). The new policy aims to address the major problems related to forestry development in Bangladesh. Proper legislation and implementation of the policy directives are necessary to achieve policy goals. Successful coordination among different related government and non-government agencies related to land and forestry development in Bangladesh is a precondition to achieve these goals. For example the Ministry of Environment and Forest, Ministry of Agriculture, and Ministry of Land could take collaborative efforts to ensure best possible land uses using multiple land use concepts to improve both forestry and agriculture in the country. However the Forest Department will face tremendous challenge from those State forestlands that have been encroached or converted to agriculture. Agroforestry or social forestry techniques could be a good option in those situations to deal with the encroachers on humanitarian ground and increase the forest cover at the same time. Mass motivation and awareness to plant trees (both fruit trees and timber trees) at homestead areas and at the periphery of cultivable lands could substantially increase the tree cover. Government could formulate legislation in keeping household size smaller (based on land resources each household operates) so that tree area (%) could be increased (Figures 7.5 & 7.6; Chapter 8) that will increase tree resources in the country. It is estimated that the current homestead forests could be increased from 0.27 million ha to 0.66 million ha if all the households plant trees in their homesteads contributing to an extra 2.5 per cent tree cover to the national total tree cover (Chapter 8). The Forest Department should play a vital role providing technical knowledge and inputs (seedlings) free of cost or with minimal cost to encourage mass tree planting by the populace. The Forest Department have to be careful in implementing the policy directions as it is the dishonest forest

officials who in most cases are responsible for loss of forest cover in the country (Appendix 8.1). Unproductive khas lands and fallow lands adjacent to homesteads, croplands, sides of roads, railway tracks and ponds, and dams could be planted to increase the tree cover by the Forest Department and the right of ownership of the trees should be given to the owner of the adjacent land or the community institutions such as Mosque, Madrasha (religious education centre), other religious institutions, schools, colleges, and local clubs and cooperative organisations for the better management of the trees.

(g) *Preservation and protection of genetic resources.*

Explanation: Preservation of genetic resources is a matter both of insurance and investment that is necessary to sustain and improve the production in agriculture, forestry, and fisheries, to protect against harmful environmental changes, and to prevent causing of extinction of species whose virtues are yet to be known (Khan, 1991). The government of Bangladesh has established some protected areas such as national parks and wildlife sanctuaries comprising only 5 per cent of the total forest areas (Table 4.16). Economic interests get the priority over conservation interests and the forest areas are poorly managed under the existing system due to encroachment and lack of trained staff (Khan, 1991). The National Forestry Policy, 1994 has given due importance in this regard and aimed to increase protected areas up to 10 per cent of the forest areas by 2015 (Chapter 3). This may lead to diminishing timber supply from the state forests and proper initiatives should be adopted to increase homestead forests that will substantially contribute to the total timber supply of the country. One option could be to divide larger farms into smaller ones as less land resources operated by farm households lead to more proportion of timber area and thereby substantially could increase total homestead forests in the country (Figure 7.5, Chapter 7).

(h) *Creation of alternative employment opportunities other than agriculture.*

Explanation: Population growth has made it difficult for the agriculture sector to support increasing labour force due to limited land resources available for agriculture. This has encouraged migration of rural population to urban areas for better chance of employment

(Chapter 4). It is estimated that the agricultural population has decreased by more than 15 per cent from 1965 to 1995 (Figure 4.2). Again, in rural areas excessive labour forces are engaged in cultivation making the production system less efficient in terms of labour productivity and hence low average labour output or income. Creation of alternative employment opportunities in rural areas such as setting up new industries will substantially reduce the migration of rural people to urban areas enabling them to meet economic needs and improving their life.

(i) *Prohibit transfer of good agricultural land to non-agricultural uses.*

Explanation: Strict laws and regulations should be adopted to prohibit transfer of good agricultural land to non-agricultural uses. The government needs to plan ahead for the future food demand and the minimum agricultural land that would be required to meet that food demand using improved technology. In this regard good agricultural land should be identified by the proper authority such as SRDI and the government should restrict by laws the transfer of these good agricultural lands to non-agricultural uses.

(j) *Planned housing and settlement programmes.*

Explanation: At present there is no planning authority to guide housing and settlement practices in the rural areas. People decide where and how they build their own houses and other infrastructures. In most cases lands are being used indiscriminately for this purpose and sometimes at the cost of good agricultural lands. The traditional practice for homesteads is horizontal extension using more land and hence leaving less land for agriculture. The initiation of vertical extension of house buildings could save lands and free up more lands for agriculture. The government could introduce strict laws in this regard.

(k) *Improve the quality of life through coordinated efforts from multidisciplinary planning.*

Explanation: As a developing country Bangladesh will continuously face more demand for basic as well as luxury needs from the growing masses in the future. Unless and until the government can take positive initiative to improve the living standard of the mass population all its development efforts will eventually end up with no success. So the government has to improve

the service sector especially those related to masses such as education, health, sanitation, electricity, gas and water supply, communication network throughout the country, recreational sites etc to improve the living standard of the mass population. In reality it is very difficult for a poor country like Bangladesh where per capita income is only US$350 (WARPO, 2000). So a multidisciplinary planning attempt comprising economists, social scientists, agriculturists, foresters, environmentalists, and policy makers is necessary to plan for a sound economic development of a country.

9.3. Conclusion.

Population growth and indiscriminate use of land resources are the major hindrance to socio-economic development of Bangladesh. Formulation of a national land use policy could be an important attempt for a developing country like Bangladesh to achieve sound economic development. The land use policy recommended here aims only to give the policy makers a general idea about the possible policy directions. Still there are lots of things to be done. The government of Bangladesh should not wait further to formulate and announce a national land use policy. The policy should consider the interests of the mass population not the few elites who virtually own and control most of the land resources. An evaluation of ministries and government departments should be undertaken with a view to avoid overlapping jurisdictions and to effect coordination and cooperation. Resource management, although it draws together skills and knowledge from many disciplines, is primarily a political activity. It is the political leaders who will decide and formulate the policy. So there is a need for firm commitment and mass general consensus among the political leaders, both government and opposition, to implement the policy for the benefit of the poor masses.

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Appendix 6.1. District wise Forest Land in Bangladesh (USF= Unclassified State Forests; DoF= department of Forest; DC= Deputy Commissioner) (Source: Tabular data from Water Resources Planning Organisation (WARPO), Dhaka, Bangladesh).

Sl No.	District	Reserved Forest (ha)	Protected Forest (ha)	Acquired Forest	Vested Forest (ha)	USF (ha)		Khas Land (ha)	Total Forest Land (ha)
						Under DoF	Under DC		
1	BARGUNA	9753.13						2797.78	12550.92
2	BHOLA	12885.24							12885.24
3	PATUAKHALI	11764.15						4916.94	16681.09
4	BANDARBAN	102326.32				29732.21	168646.53		300705.06
5	BRAHAMANBARIA			0.46					0.46
6	CHANDPUR			0.85					0.85
7	CHITTAGONG	95040.76	18724.20	4002.70	2635.29				120402.95
8	COMILLA	679.32		6.68					686.00
9	COX'S BAZAR	81956.49	15414.20						97370.69
10	FENI	886.84							886.84
11	KHAGRACHHARI	37480.20				83513.16	57456.61		178449.97
12	LAKSHMIPUR	10724.18							10724.18
13	NOAKHALI	84615.54	1936.31						86551.85
14	RANGAMATI	255221.15				12752.83	306844.17		574818.14
15	DHAKA	117.56						6.07	123.63
16	GAZIPUR	25820.92		238.79	86.66			1069.87	27216.25
17	JAMALPUR	4187.04							4187.04
18	MYMENSINGH	15661.86							15661.86
19	NETRAKONA	738.42							738.42
20	SHERPUR	7878.71							7878.71
21	TANGAIL	49872.65							49872.65
22	BAGERHAT	230917.88							230917.88
23	KHULNA	181598.80							181598.80
24	KUSHTIA							49.98	49.98
25	SATKHIRA	164523.07							164523.07
26	BOGRA							204.91	204.91
27	DINAJPUR	4977.72			2465.97			115.76	7559.45
28	KURIGRAM	52.05							52.05
29	LALMONIRHAT	33.44							33.44
30	NAOGAON	191.80	2424.76	275.99					2892.55
31	NATORE							264.66	264.66
32	NILPHAMARI			674.82	429.53			63.46	1167.81
33	PANCHAGARH	14.20			1850.88			1.06	1866.13
34	RAJSHAHI							276.28	276.28
35	RANGPUR	682.20		9.73	734.44			193.97	1620.34
36	THAKURGAON	468.12			331.78			106.43	906.33
37	HABIGANJ	13511.75					890.31		14402.06
38	MAULVIBAZAR	26179.82		4424.03			436.82		31040.67
39	SUNAMGANJ	7128.32							7128.32
40	SYLHET	23631.94					400.19		24032.12
	TOTAL	1461521.59	38499.47	9634.04	8534.56	125998.21	534674.62	10067.18	2188929.66

Appendix 6.2. Distribution of different districts into different categories.

District	Forest availability class		Population density class		Literacy class	
Barguna	3	Low forest (1-10%)	1	Low (<500 persons/sq.km)	3	High (50.1-60 %)
Barisal	1	No forest (0%)	2	Medium (501-1000 persons/sq.km)	4	Very high (>60 %)
Bhola	3	Low forest (1-10%)	2	Medium (501-1000 persons/sq.km)	1	Low (<40 %)
Jhalakati	1	No forest (0%)	3	High (1001-1500 persons/sq.km)	4	Very high (>60 %)
Patuakhali	3	Low forest (1-10%)	1	Low (<500 persons/sq.km)	3	High (50.1-60 %)
Pirojpur	1	No forest (0%)	2	Medium (501-1000 persons/sq.km)	4	Very high (>60 %)
Bandarban	5	Very rich forest (>25%)	1	Low (<500 persons/sq.km)	2	Medium (40.1-50 %)
Brahmanbaria	2	Very low forest (<1%)	3	High (1001-1500 persons/sq.km)	2	Medium (40.1-50 %)
Chandpur	2	Very low forest (<1%)	3	High (1001-1500 persons/sq.km)	3	High (50.1-60 %)
Chittagong	4	Rich forest (10-25%)	3	High (1001-1500 persons/sq.km)	4	Very high (>60 %)
Comilla	2	Very low forest (<1%)	4	Very high (>1500 persons/sq.km)	2	Medium (40.1-50 %)
Cox's Bazar	5	Very rich forest (>25%)	2	Medium (501-1000 persons/sq.km)	2	Medium (40.1-50 %)
Feni	2	Very low forest (<1%)	3	High (1001-1500 persons/sq.km)	3	High (50.1-60 %)
Khagrachari	5	Very rich forest (>25%)	1	Low (<500 persons/sq.km)	2	Medium (40.1-50 %)
Lakshmipur	3	Low forest (1-10%)	3	High (1001-1500 persons/sq.km)	3	High (50.1-60 %)
Noakhali	4	Rich forest (10-25%)	3	High (1001-1500 persons/sq.km)	3	High (50.1-60 %)
Rangamati	5	Very rich forest (>25%)	1	Low (<500 persons/sq.km)	3	High (50.1-60 %)
Dhaka	2	Very low forest (<1%)	4	Very high (>1500 persons/sq.km)	4	Very high (>60 %)
Faridpur	1	No forest (0%)	2	Medium (501-1000 persons/sq.km)	2	Medium (40.1-50 %)
Gazipur	4	Rich forest (10-25%)	3	High (1001-1500 persons/sq.km)	4	Very high (>60 %)
Gopalganj	1	No forest (0%)	2	Medium (501-1000 persons/sq.km)	3	High (50.1-60 %)
Jamalpur	3	Low forest (1-10%)	3	High (1001-1500 persons/sq.km)	1	Low (<40 %)
Kishorganj	1	No forest (0%)	2	Medium (501-1000 persons/sq.km)	2	Medium (40.1-50 %)
Madaripur	1	No forest (0%)	3	High (1001-1500 persons/sq.km)	2	Medium (40.1-50 %)
Manikganj	1	No forest (0%)	2	Medium (501-1000 persons/sq.km)	2	Medium (40.1-50 %)
Munshiganj	1	No forest (0%)	3	High (1001-1500 persons/sq.km)	3	High (50.1-60 %)
Mymensingh	3	Low forest (1-10%)	3	High (1001-1500 persons/sq.km)	2	Medium (40.1-50 %)
Narayanganj	1	No forest (0%)	4	Very high (>1500 persons/sq.km)	4	Very high (>60 %)
Narsingdi	1	No forest (0%)	4	Very high (>1500 persons/sq.km)	2	Medium (40.1-50 %)
Netrakona	2	Very low forest (<1%)	2	Medium (501-1000 persons/sq.km)	2	Medium (40.1-50 %)
Rajbari	1	No forest (0%)	2	Medium (501-1000 persons/sq.km)	2	Medium (40.1-50 %)
Shariatpur	1	No forest (0%)	2	Medium (501-1000 persons/sq.km)	2	Medium (40.1-50 %)
Sherpur	3	Low forest (1-10%)	2	Medium (501-1000 persons/sq.km)	1	Low (<40 %)
Tangail	4	Rich forest (10-25%)	3	High (1001-1500 persons/sq.km)	2	Medium (40.1-50 %)
Bagerhat	5	Very rich forest (>25%)	1	Low (<500 persons/sq.km)	3	High (50.1-60 %)
Chuadanga	1	No forest (0%)	2	Medium (501-1000 persons/sq.km)	1	Low (<40 %)
Jessore	1	No forest (0%)	2	Medium (501-1000 persons/sq.km)	3	High (50.1-60 %)
Jhenaidah	1	No forest (0%)	2	Medium (501-1000 persons/sq.km)	2	Medium (40.1-50 %)
Khulna	5	Very rich forest (>25%)	2	Medium (501-1000 persons/sq.km)	4	Very high (>60 %)
Khustia	2	Very low forest (<1%)	3	High (1001-1500 persons/sq.km)	2	Medium (40.1-50 %)
Magura	1	No forest (0%)	2	Medium (501-1000 persons/sq.km)	2	Medium (40.1-50 %)
Meherpur	1	No forest (0%)	2	Medium (501-1000 persons/sq.km)	1	Low (<40 %)
Narail	1	No forest (0%)	2	Medium (501-1000 persons/sq.km)	3	High (50.1-60 %)
Satkhira	5	Very rich forest (>25%)	1	Low (<500 persons/sq.km)	2	Medium (40.1-50 %)
Bogra	2	Very low forest (<1%)	3	High (1001-1500 persons/sq.km)	3	High (50.1-60 %)
Dinajpur	3	Low forest (1-10%)	2	Medium (501-1000 persons/sq.km)	2	Medium (40.1-50 %)
Gaibandha	1	No forest (0%)	3	High (1001-1500 persons/sq.km)	1	Low (<40 %)
Joypurhat	1	No forest (0%)	2	Medium (501-1000 persons/sq.km)	3	High (50.1-60 %)
Kurigram	2	Very low forest (<1%)	2	Medium (501-1000 persons/sq.km)	1	Low (<40 %)
Lalmonirhat	2	Very low forest (<1%)	2	Medium (501-1000 persons/sq.km)	2	Medium (40.1-50 %)
Naogaon	2	Very low forest (<1%)	2	Medium (501-1000 persons/sq.km)	3	High (50.1-60 %)
Natore	2	Very low forest (<1%)	2	Medium (501-1000 persons/sq.km)	2	Medium (40.1-50 %)
Nawabganj	1	No forest (0%)	2	Medium (501-1000 persons/sq.km)	1	Low (<40 %)
Nilphamari	2	Very low forest (<1%)	2	Medium (501-1000 persons/sq.km)	2	Medium (40.1-50 %)
Pabna	1	No forest (0%)	2	Medium (501-1000 persons/sq.km)	3	High (50.1-60 %)
Panchagarh	3	Low forest (1-10%)	2	Medium (501-1000 persons/sq.km)	2	Medium (40.1-50 %)
Rajshahi	2	Very low forest (<1%)	2	Medium (501-1000 persons/sq.km)	3	High (50.1-60 %)
Rangpur	2	Very low forest (<1%)	3	High (1001-1500 persons/sq.km)	1	Low (<40 %)
Siranjganj	1	No forest (0%)	3	High (1001-1500 persons/sq.km)	2	Medium (40.1-50 %)
Thakurgaon	2	Very low forest (<1%)	2	Medium (501-1000 persons/sq.km)	2	Medium (40.1-50 %)
Habiganj	3	Low forest (1-10%)	2	Medium (501-1000 persons/sq.km)	2	Medium (40.1-50 %)
Moulvibazar	4	Rich forest (10-25%)	2	Medium (501-1000 persons/sq.km)	2	Medium (40.1-50 %)
Sunamganj	3	Low forest (1-10%)	2	Medium (501-1000 persons/sq.km)	2	Medium (40.1-50 %)
Sylhet	3	Low forest (1-10%)	2	Medium (501-1000 persons/sq.km)	3	High (50.1-60 %)

Appendix 7.1. Husehold Survey Questionnaire.

1. Location :

Village:..... Thana:..... District:..... Zone:.....

2. Respondent:

Name:..... Age: ..... Sex:..... Religion.....
Occupation: Primary..... Secondary..... Others.....
Education level: ..... No ..... Primary ..... Secondary ..... Higher secondary .....Graduate

3. a). Family size: ..... and family information:

(i) Name..... Age..... Relation..... Sex..... Education.....
(ii) Name..... Age..... Relation..... Sex..... Education.....
(iii) Name..... Age..... Relation..... Sex..... Education.....
(iv) Name..... Age..... Relation..... Sex..... Education.....
(v) Name..... Age..... Relation..... Sex..... Education.....
(vi) Name..... Age..... Relation..... Sex..... Education.....
so on.....

b). Family type: ..... Single ..... Joint

4. Land Resources(acre/ha): .....Own .....Rented .....Others

a. Homestead : Size.....(acre/ha) Tenure : Own..... Rented..... Leased.....
Land utilisation : Dwelling unit.....(acre/ha) Pond.....(acre/ha) Trees.....(acre/ha)
Yard.....(acre/ha) Animal shed.....(acre/ha) Others.....

b. Crop field : Size..... (acre/ha) Tenure : Own..... Rented..... Leased.....
Utilisation : Rice..... (acre/ha) .....Season/time period
Jute..... (acre/ha) .....Season/time period
Vegetables..... (acre/ha) Type: ..... Season/time period .....
Others..... (acre/ha) Type: ..... Season/time period .....

c. Tree/Bush : .....(acre/ha) Tenure : Own..... Rented..... Leased.....

d. Bamboo groves: .....(acre/ha) Tenure : Own..... Rented..... Leased.....

e. Fishing : .....(acre/ha) Tenure : Own..... Rented..... Leased.....

f. Business centre.....

g. Housing/settlement.....

h. Others.....

5. Land utilisation and crop rotation:

Crops	Hot summer season	Humid Monsoon season	Cool dry season
Rice	.....	.....	.....
Wheat	.....	.....	.....
Jute	.....	.....	.....
Vegetables	.....	.....	.....
Fallow	.....	.....	.....
Others	.....	.....	.....
	.....	.....	.....
	.....	.....	.....

6. Total Production :

Rice..... Jute..... Wheat..... Others.....
Vegetables..... (specify types)
Trees..... (specify no. and species)
Fish.....
Others.....

7. Total family income: ..... (specify different sectors separately)
Source: ..... Primary
..... Secondary
..... Others

8. Demand : (daily/weekly/monthly/yearly demand in weight as well as in monetary values)

a. Rice..... Source: Own..... Market..... Others..... Tk.....
b. Vegetables..... Source: Own..... Market..... Others..... Tk.....
c. Meat..... Source: Own..... Market..... Others..... Tk.....
d. Fish..... Source: Own..... Market..... Others..... Tk.....
e. Fruit..... Source: Own..... Market..... Others..... Tk.....
f. Fuelwood..... Source: Own..... Market..... Others..... Tk.....
g. Gas/Paraffin.... Source: Own..... Market..... Others..... Tk.....
h. Other fuel..... Source: Own..... Market..... Others..... Tk.....
i. Timber..... Source: Own..... Market..... Others..... Tk.....
j. Others..... Source: Own..... Market..... Others..... Tk.....

9. Surplus :

a. Rice :..... Tk.....
b. Jute..... Tk.....
c. Vegetables..... Tk.....
d. Fuel..... Tk.....
e. Others..... Tk.....

10. Land use History:

.....
.....
.....
.....

11. Reasons for land use change:

Do you change your land use ? .....Yes .....No

Nature of change :.....

Why? How frequent?

Who is the decision maker? ---------- Land owner
---------- Tenant

Choose one reason

------Economic
------Motivation
------More Production
------More Benefit
------Taste
------Tradition
------Other

12. Living Standard:

Criteria	House	Health/safety	Sanitation	Clothing	Luxury goods	Vehicle
a. Very bad	.....	.....	.....	.....	.....	.....
b. Bad	.....	.....	.....	.....	.....	.....
c. Medium	.....	.....	.....	.....	.....	.....
d. Good	.....	.....	.....	.....	.....	.....
e. Very good	.....	.....	.....	.....	.....	.....

Overall facilities:.....

Overall Rating:.....

13. Tree species planted/owned:

a. Timber species.....
b. Fruit species.....
c. Fuelwood.....
d. Others.....

14. Cattle/Poultry:

a. Cattle.....
b. Goat.....
c. Poultry.....

15. Market information:

Distance to local market---------- cost of product transport----------
Distance to Thana/ major market---------- cost of product transport----------
Distance to District market---------- cost of product transport----------

Product Prices	Local	Thana	District	National
Rice				
Jute				
Wheat				
Potato				
Vegetables				
Others				

Production Costs	Yearly production	Total costs	Total value
Agricultural product:			
Rice			
Jute			
Wheat			
Potato			
Vegetables			
Others			
Poultry:			
Livestock:			
Cattle			
Goat ___			
Fisheries:			

THANK YOU

Appendix 7.2. List of study villages.

Zone/Division	District	Thana	Village
1. Rajshahi	1. Rajshahi	1. Paba	1. Chandrapukur
		2. Puthia	2. Shibpur Hat
	2. Bogra	3. Sonatala	3. Daxin Atkaria
		4. Bogra Sadar	4. Shahpara
2. Dhaka	3. Tangail	5. Tangail Sadar	5. Aloapikosta
		6. Modhupur	6. Jangalia
	4. Gazipur	7. Gazipur Sadar	7. Gazariapara
		8. Sripur	8. Maouna
3. Chittagong	5. Chittagong	9. Hathazari	9. Jobra
		10. Lohagara	10. Rashiderghona
	6. Cox's Bazar	11. Cox's Bazar Sadar	11. Muktarkul
		12. Ramu	12. Lamarpara

Appendix 8.1. The causes of loss of forest cover in Bangladesh. (Source: Salam *et. al.*, 1999).