2013

Impact of the stress of land use change on water resources: A case of Barind region

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IMPACT OF THE STRESS OF LAND USE CHANGE ON WATER RESOURCES: A CASE OF BARIND REGION

M. PHIL. THESIS

By

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May 2013

SACRIFICED TO

MY HONOURABLE PARENTS

DECLARATION

I here declare that my dissertation entitle “Impact of the stress of land use change on water resources: A case of Barind region” has been submitted to Dr. Raquib Ahmed, Professor and Chairman, Department of Geography and Environmental Studies, Rajshahi University.

I further declare that no person or no institution has made any research on that specific title and it is my original work of research shared by no one.

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CERTIFICATE

I hereby recommend and certify that the dissertation "Impact of the stress of land use change on water resources: A case of Barind region" is an original research work performed by Md. Emran Ali Sarder for the degree of Master of Philosophy (M. Phil.) under my supervision in the Department of Geography and Environmental Studies.

Dated: Rajshahi
May 2013

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ABSTRACT

Bangladesh is one of the biggest deltas of the world standing on the "Tropic of Cancer". Various rivers such as the Padma, the Meghna, the Jamuna flow over this country. The north western part of Bangladesh is of distinctive characteristic which is known to be the Barind tract. Though this region is under developed and neglected, it plays an important role for our economic development.

Land is the important natural resource. Land is used in various purposes. This land is being changed every day due to the increase of population. In case of taking the future development plan of any region, it is essential for anyone to have a better concept about land use change so as an under developed and inadvanced region, the Barind region displays the proper landuse change in this dissertation. So it becomes possible to accept more development plan in future. As the study area, four thanas of the Barind up land region have been accepted.

The remotely sensed information has been used in this research in determining land use. In conventional system, the determination of land use is as expensive as tardy. Again accuracy is doubtful. It is possible to evaluate landuse change easily and within a short time by remotely sensed information due to repetition.

Land use identification and change have been displayed in 1997 and 2006 by Landsat TM satellite image collected from "SPARRSO", Bangladesh Space Research Organization. During this period the growth of

settlement and forest of the study area is manifested as 6.15% and 48.17% respectively.

The real development of the Barind region will happen by taking the proper future development plan evaluating land use change and contribute to the economy of the country which is essential for the country.

ACKNOWLEDGEMENT

All the praises to the Almighty Allah by whose mercy it has been possible for me to put through my dissertation.

I have faced many problems while conducting my research entitled "Impact of the stress of land use change on water resources: A case of Barind region". I remember many of the virtuous men who cooperated with me to get over these problems. At first express my gratitude to Dr. Raquib Ahmed, Professor and Chairman, Department of Geography and Environmental Studies by whose genious supervision and overall timely cooperation, this research work has been nicely perpetrated. I also express my gratitude to Dr. Zahidul Hassan, Professor of the Department of Geography and Environmental Studies and Dr. Shitangsu Kumar Paul, my bosom friend, Dr. Ismail Hossain, ex-principal, Nazipur Government Degree College. Besides I am also grateful to all the teachers and learners of the Department of Geography and Environmental Studies who inspired me in my research work.

Then I remember the inspiration of my beloved wife Mohsina Akhter Banu who always encouraged me from the in her most part of her heart. I also remember with affection the heartiest cooperation of my nephew, Md. Ahsan Habib who also inspired me considerably. I also express my gratitude and pay respect to my honorable brother in law, Md. Abdul Hamid who was one of my partners in education. I also express my gratitude to Md. Serajul Islam, Principal, Krishnapur College who always inspired me to complete my research work.

I also thank various officials of the central library seminar librarian and staff, various officers of thana level of the study area, Barind project officer and the officials of water development board and soil development office.

I also express my gratitude to S. M. Mizanur Rahman, Senior engineer of SPARRSO who rendesed me all out cooperation in my research work. I also express my gratitude to S. M. Kamrul Hasan, my close friend who inspired me largely to complete my research work.

At last I express my heartiest gratitude to all my friends and well wishers.

Author

ABBREVIATIONS

AVHRR	-	Advanced Very High Resulation Radiometer.
ATS	-	Advanced or Applications Technology Satellite.
BBS	-	Bangladesh Bureau of Statistics.
BMDA	-	Barind Multipurpose Development Authority.
BPC	-	Bangladesh population Census.
BWDB	-	Bangladesh Water Development Board.
CCT	-	Computer Compatible Tape.
DBMS	-	Database Management System.
EOS	-	Earth Observation Satellite.
ERS	-	Earth Resources Satellite.
ERTS	-	Earth Resources Technology Satellite.
FCC	-	False Color Composite.
GEOS	-	Geostationary Operational Environmental Satellite.
GIS	-	Geographical Information System.
IR	-	Infra Red.
ITOS	-	Improved TIROS Observation Satellite.
HRV	-	High Resolution Visible (Satellite Sensor).
Landsat	-	Land Resources Satellite (American Satellite).
MSS	-	Multispectral Scanning System (Satellite Sensor).
NASA	-	National Aeronautics and Space Administration (USA).
NOAA	-	National Oceanic and Atmospheric Administration (USA).
NAQ	-	Normal Saturation Quantity.

RBV	-	Return Beam Vidicon (Satellite Sensor)
SOB	-	Survey of Bangladesh.
SPARRSO	-	Space Research and Remote Sensing Organization (Bangladesh).
SPOT	-	System Probatoired Observation de la Terre (French Satellite).
SRDI	-	Soil Research and Development Institute.
TIROS	-	Television Infrared Observation Satellite.
TM	-	Thematic Mapper (Satellite Sensor).
WRS	-	World Reference System.

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CHAPTER-1

INTRODUCTION

1.1 Introduction

For the sake of the large-scale economic development of any country, land use and its change act as a key factor in various countries of the world. Bangladesh as a growing country is in need of more research concerning land use change. There is no denying the fact that any research as to land use change demands many aspects necessary for its perfection.

It is important that natural resources are indispensable for the all-out development of any country, particularly countries like Bangladesh, which is largely dependent on proper/balanced utilization of land. Land is the fundamental element of natural resources and is used in various ways. The characteristics of lands of north-western Barind region are significantly different from those of the other parts of the country. The population of this region is also rapidly increasing. Land is also being changed owning to their pressure inflicted upon it. Activities on the surface, either natural or man-made, may be reflected in land use pattern. In the truest sense of the term, human activity upon land which is directly related to land is called land use (Clawson and Stewart, 1965). Though land use is its self-exponent, at present the word "use" is the alternative word of "utilization" has given rise to complexity in terms of its thematic explanation.

The difference in nature of land use is manifested from one place to other in the course of time and due to necessity. In order to accept the future development plan of any region, the proper concept about land use change of that region is important. Apparently land is not properly used in Bangladesh. Otherwise it may be possible to meet food demand for more people comparing the present time.

The Barind region is basically agricultural. The closeness of crops is 117% where the average closeness in Bangladesh is 156%. So the identification of land use of the Barind region and the evaluation of its change is essential. Evaluation of this change may help to dispose the agricultural production and possible to take necessary initiatives for controlling the balance of environment. Sir Laurence Dudley Stamp had used students of high school of Britain for country's land survey. This traditional system was as lengthy and expensive and accuracy was good but not cost-effective in true sense.

Now it is possible to reduce this limitation through the use of remote sensing technology. Satellite imaging is very effective among all remote sensing devices. This system can bring out the proper identification of land use and its change within a short period of time.

Bangladesh Space Research Organization (SPARRSO) has been using this system regularly in various applications. Remote sensing (RS) has been used in determining land use change in this thesis. RS is being used with importance to implement various regional schemes and land use change at present.

1.2 The objective of research

The rate of population growth in Bangladesh is faster in comparison with other countries of the world. As a result the ratio between man and land is very high (0.124 ha). The socio-economic condition also changes with the change of population. As a result it influence land use/land cover and influence future development activities of any country. So, it is important to be aware of land use change of that region.

The Barind region has been out of attention for long and is important to evaluate the land use of this region to utilize this potentiality. In traditional survey system, determination of land use is expensive. A faster system is needed for the faster development plan. Remote sensing device is very effective in such case. This research has been conducted for determining the land use of four Thanas of the Barind Upland region using Landsat TM satellite image of various time phases.

This study aims to focus on the following aspects to a considerable extent,

(i) The evaluation of land use pattern

(ii) The land use change and preparation of map in between 1997 and 2006.

(iii) Land use change and impact on water resources of the study area.

1.3 Source of data materials and research methodology

It is possible to study with necessary and accurate materials. Materials might be of primary or from secondary sources. Here Landsat TM FCC 1997 Band 2, 3, 4 and Landsat TM FCC 2006 Band 3, 4, 5 have been used as the secondary information.

These are satellite image frame is 149-043 (WRS) of two time phases and was collected from SPARRSO. Besides this further accessory secondary information has been used in this research. Many difficulties were faced while gathering these data and information, such as high price, reliability, exact time/real-time data etc. Effort was paid to make a research as much accurate as possible. The pressure of human activity on surface and ground water results in land use and land use change was interpreted using these images of 1997 and 2006. Thana map has been used as base maps. The research has been made easier with the help of these maps. The union Geo-code of 2003 collected from Bangla Pediea was used.

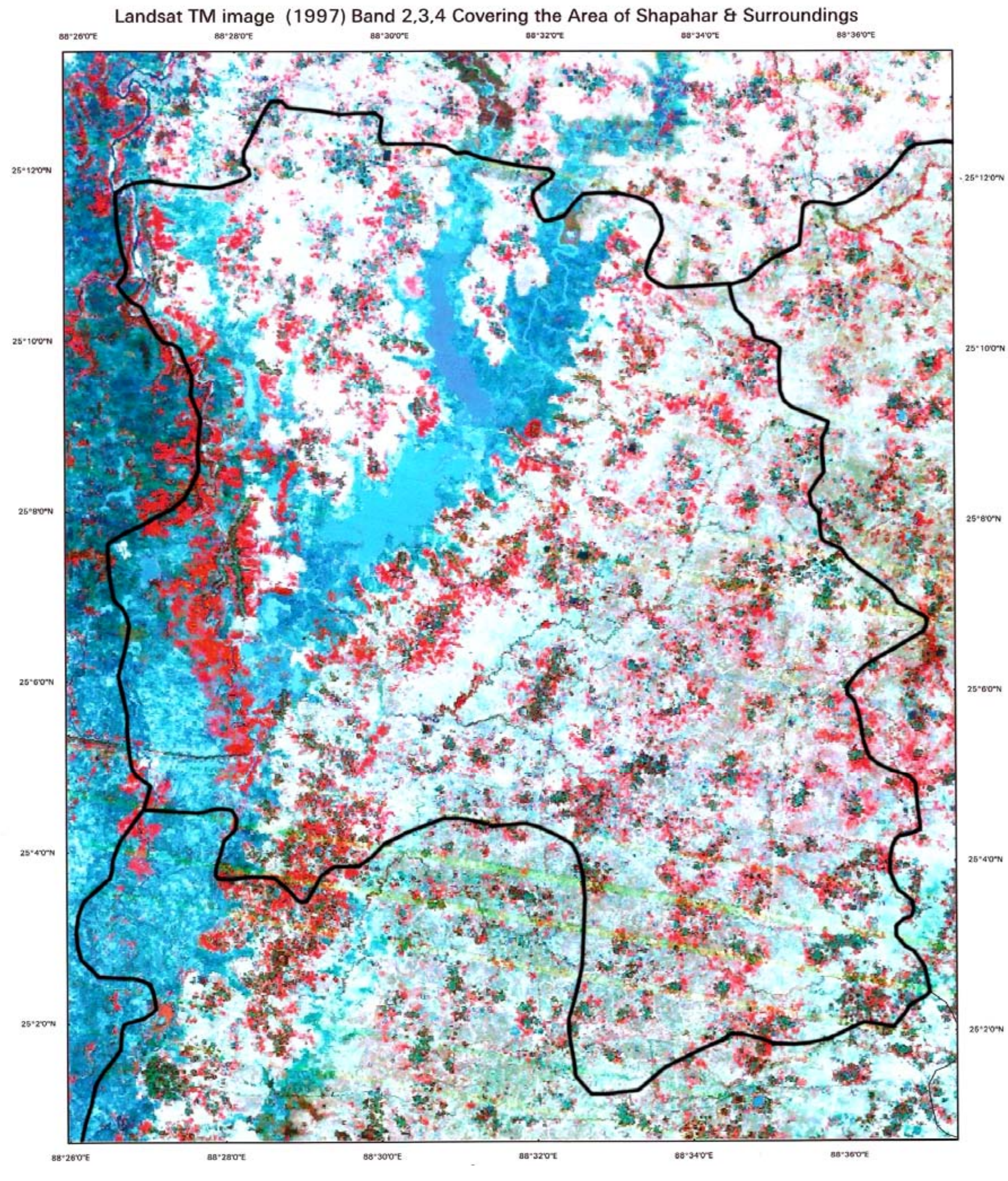


Figure 1.1 Landsat TM image (1997) Band, 2, 3, 4.

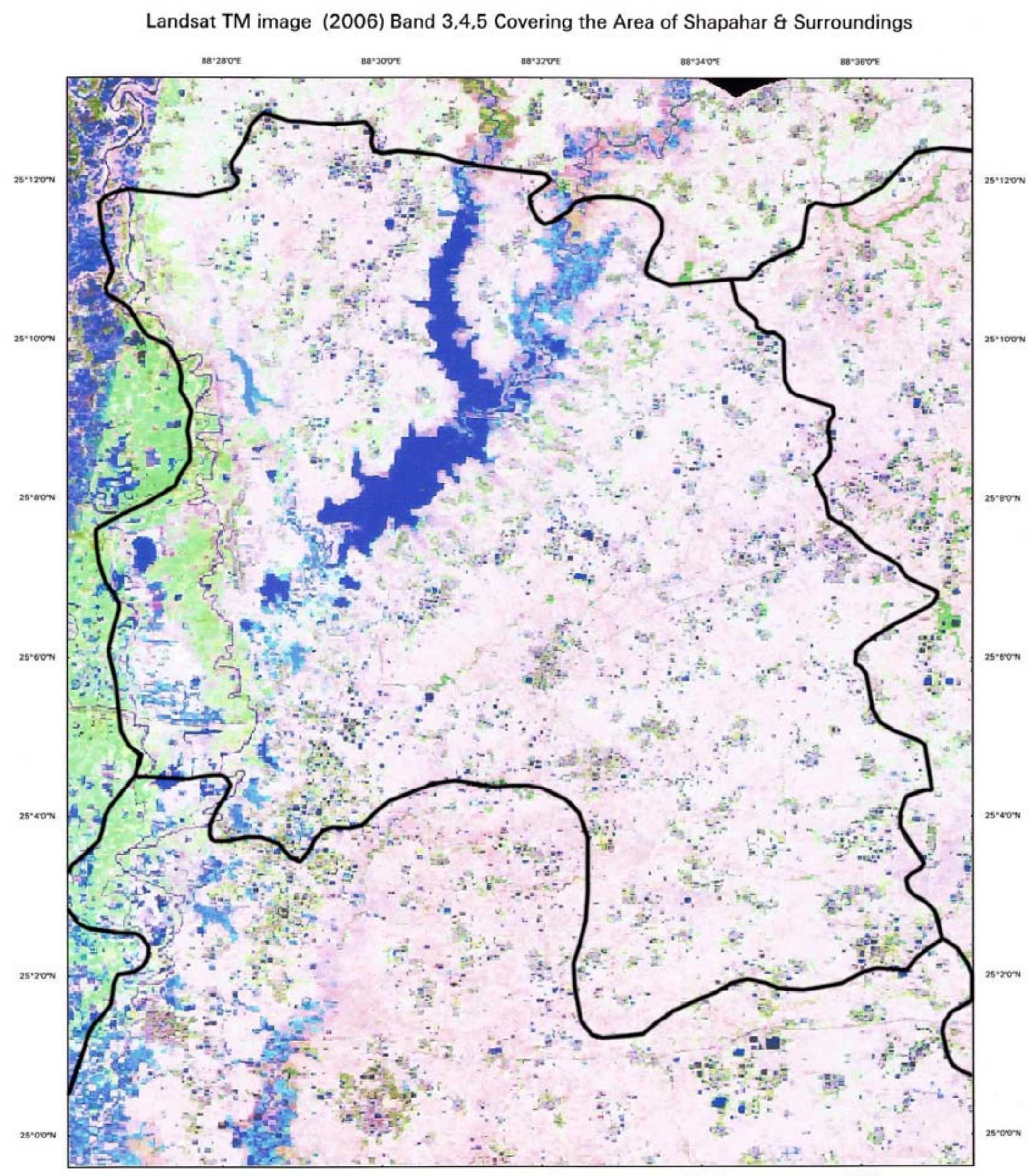


Figure 1.2 Landsat TM image (2006) Band, 3, 4, 5.

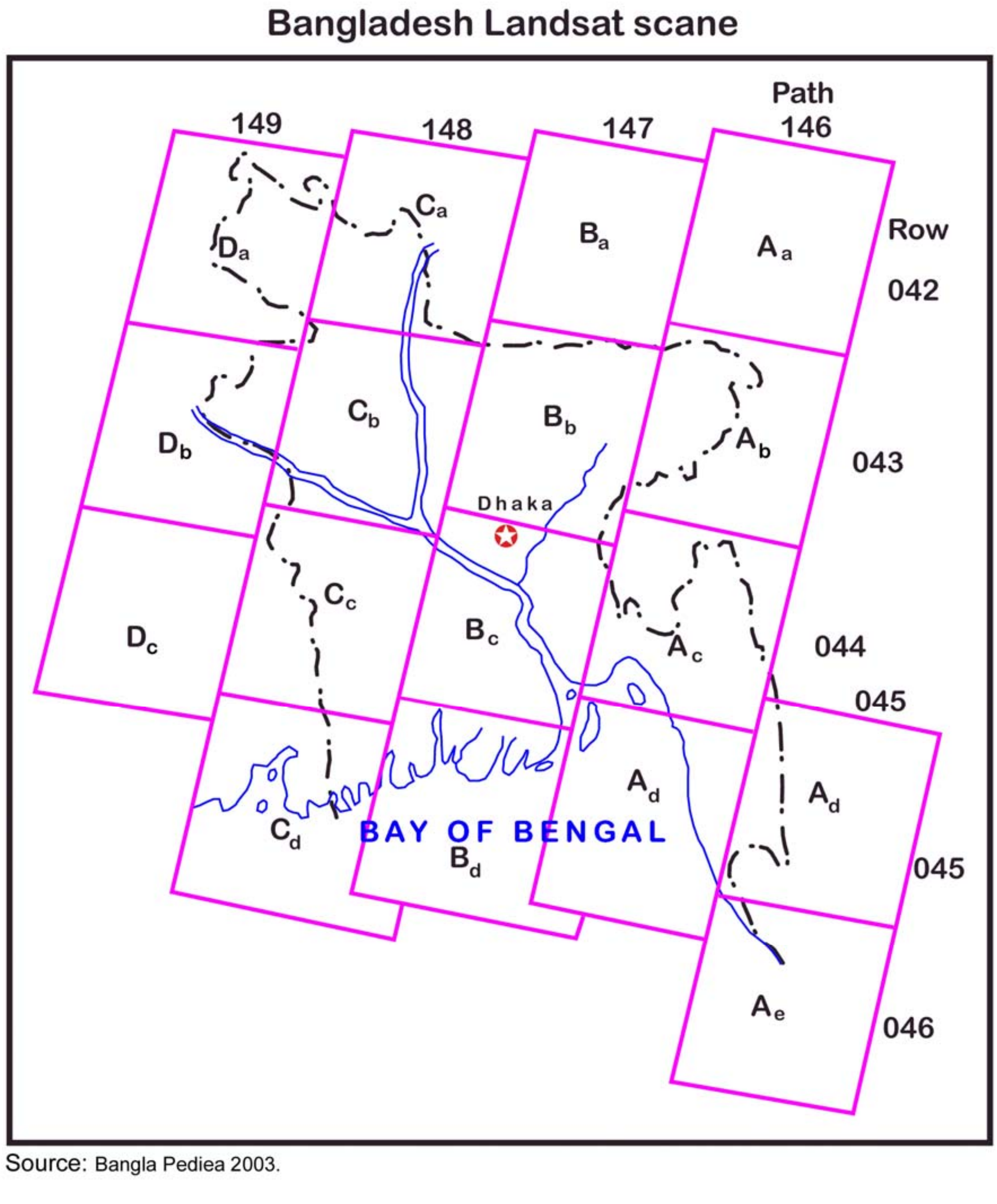


Figure 1.3 Bangladesh Landsat scane (SPARRSO)

1.4 Limitation of research

Every steps in research, many problems are faced. There remain many informative and systematic limitations in solving these problems. It is technology based research where the U.S.A. (Jensen and Dahlberg) and Europe dominate (Cusran and Wardley) and developing countries like Bangladesh are far behind. The use of satellite images in Bangladesh is very limited. In this research FCC images of 1997 and of 2006 have been used and were expensive to procure.

In image analysis, social forestry has not been identified separately, In addition to it, looking at the minor substance has been over-looked due to the excessiveness of the resolution of image.

All the hard copy images of the study area were collected from the SPARRSO (Space - Research and Remote Sensing Organization) of Bangladesh. Some other paper maps and Statistical data were also collected from different sources and used in the study. These maps and data were used to supplement the image interpretation and ground truth collection. A large number of published and unpublished text materials were collected from many sources viz. SPARRSO Library, Central Library (Rajshahi University), Seminar Library (Department of Geography & Environmental Studies, R.U.). These books, journals and dissertations were reviewed to construct the theoretical frame of the present research.

1.5 Methodology

Each and every research is conducted by a following well-fixed system. Mainly the effort of acquiring detailed knowledge about any topic through scientific analysis is called research. The satellite image that has been used in present research has also been analyzed into a few levels and a map has been prepared. Although satellite image is called the secondary information in terms of methodology, here it is used as primary information. Because there is no difference between satellite image and land use class achieved by direct survey. It is discussed in details below.

1.5.1 Land use

There is diversity in land use in terms of place. Classification of land use is essential to determine land use of any place. The land use in various places is of various types. Effectiveness of land use is mainly dependent on four factors such as land, water, air, man. The change of any of them also changes the land use. Land use means various uses upon land, but this sort of use is somewhere widespread, somewhere a misuse is manifested. There is no fully complied standard internationally recognized land use classification scheme. The differences in land uses are the main reason of it. It is classified on the basis of regional characteristics of study area. The difference is manifested in land use classification through general system and satellite image system. It is not always possible to identify the secondary land use through satellite image. In that case the main land uses are classified by reviewing the characteristics of study area and the potentiality of image.

Before the analysis of satellite image, land use classification scheme has been made tentatively. At the time of making this scheme things that are available in both the field verification and satellite images are considered.

This land use classification scheme was not suitable for every country. In next step aerial photography and remote sensing technique makes a great change in the field of land use and land resource assessment. The relevant works which have been done by various geographers and researchers during different period of time mentioned below. Remote sensing imageries can be used with technical effort in computers and software, and thus can be utilized in areas where such facilities are not readily available. Sexina and Vidhyanath applied this technique in studies ranging from forest cover, watershed planning to landuse evaluation. Remote sensing information increasingly is being used in the developing nations.

Land Use Trend in South Asia

The region has a land area of 641.08 M ha and a population of 1200.36 million. The agricultural population is 731.31 million, 61 % out of the total population. The area of cropland is 35% (224,38 M ha), of pasture 15 % (96.16 M ha) of the total land, and thus of cropland and pasture together here called agricultural land counts to 50% (321 M ha) of the total land (FAO. UNDP and UNEP, 1994).

These bare statistics indicate three basic characteristics of the region: the large total population, high density in relation to land resources, and large proportion of total land under agricultural use. Over 22% of the world's agricultural population lives on just under 5% of its land area; whilst almost exactly 50% of the total land is under agricultural use, a far higher proportion for the world as a whole.

Land Use in Bangladesh

Three broad physiographic regions are dissemble-floodplains occupy about 80 per cent, terraces (slightly uplifted fault blocks) about 8 per cent, and rolling uplands about 12 per cent of the land area. Each of these regions exhibits its own geomorphological characteristics, which make convenient a further sub-division into 19/20 generalized physiographic units as follows.

The most two important areas of environmental concern are rainy season inundation characteristics of land and frequency of occurrences of hazardous flood. Inundation characteristics provide information on whether a land is still inundated or not. If inundated, to what depth and how long the water stays on the land surface? So the topographic position of land in relation to the monsoon season inundation which, in other words called 'inundation land type' will largely decide the LUT in the country. Taking consideration of crop availability, six inundation land types have been recognized in Bangladesh.

In analysis of land use and land cover change using the combination of MSS Landsat and land use map of Indonesia Dimyati *et al.* (1995) reveals that land use and cover change were evaluated by using remote sensing to calculate the index of changes which was done by the superimposition of land use and land cover images of 1972, 1984 and land use maps of 1990. This was done to analyze the pattern of change in the area, which was rather difficult with the traditional method of surveying as noted by surveying as noted by Olorunfemi in 1983 when he was using aerial photographic approach to monitor urban land use in developing countries with Ilorin in Nigeria as the case study. But the author did not discuss the causes of land use and land cover change.

The land use land cover changed fast in Barind upland region at Sapahar, Porsha, Niyamatpur and Patnitola due to rapid growth of population and expansion of commerce and industry. Settlement increased 6.15% and cropland increased to about 20.62%. Decreasing trend was found in cases of current fallow 3.94%, marshy land 4.69% and surface water 40.17%. Again forest and uncovered soil increased to about 48.17% and 5.70% respectively. Cropland and uncovered soils have been converted into settlement and other purpose and the overall environmental condition was deteriorated in the study area. The Landsat TMFCC 1997 and 2006 have been used to detect the land cover change. Land use/cover founded in 1997 and 2006 image. Features were classified into 7 categories after being stretched uniformly. The accuracy assessment was conducted for both the classified data and obtained an overall accuracy level of 80% and 82% for the 1997 and 2006 respectively.

Table-1.1

Land use survey classification systems and scales (after Stamp, 1931; Van Valkenburg, 1950; Stamp, 1960; Coleman, 1961; Nicholson, Cornwall, and Raymond, 1961; McClellan, 1965)

First land utilization Survey in Britain (1931-)	World land-use survey (1949-)	Second land-use survey in Britain (1960-)	Canadian land-use inventory (1960-)
1. Land agriculturally unproductive (red) 2. Gardens, nurseries, orchards, allotments (purple) 3. Arabic land (brown) 4. Meadowland and permanent grass (light green) 5. Health and moor land (yellow) 6. Forests and woodlands (dark green)	1. Settlement and associated non-agricultural lands (red) 2. Horticulture (deep purple) 3. Tree and other perennial crops (light purple) 4. Crop land (brown) 5. Improved permanent pasture (light green) 6. Unimproved grazing land (orange and yellow) 7. Woodlands (different shades of green) 8. Swamps and marshes (blue) 9. Unproductive land (grey)	1. Settlement (grey) 2. Market gardening (purple) 3. Orchards (purple stripes) 4. Arable (brown) 5. Grass (light green) 6. Health,, moorland, and roughland (yellow) 7. Woodlands (dry green) 8. Water and marsh (blue) 9. Derelict land (black stripple) 10. Industry (red) 11. Transport (orange) 12. Open spaces (lime green) 13. Unvegetated land (white)	1. Urban (red) 2. Horticulture dark (purple) 3. Orchards and vineyards (light and medium purple) 4. Crop land (brown) 5. Improved pasture and forage crops (light green) 6. Rough grazing land (orange and yellow) 7. Woodland (different shades of green) 8. Swamp, marsh, or bog (light blue 9. Unproductive (grey) 10. Water (blue)
Scale of published maps 1: 63,360	Scale of published maps 1: 1,000,000	Scale of published maps 1: 1,25,000	Scales of published maps 1: 1,000,000; 1: 500,000 1: 250,000; 1: 126,720 1;50,000

Source: Geography and Resource analysis, Bruce Mitchell (1993) p. 51

Here in making land use scheme, the land use class of Anderson *et al.* (1976) has been followed.

Table-1.2

Land use classification scheme

No.	Nature of landuse	Description
1	Settlement	Rural settlement, office, commercial institution and social forest
2	Agricultural land	cropland and fallow land
3	Marshy land	Beel land shallow lake
4	Surface water	River, pond and Beel
5	Forest	Natural and Planted forest
6	Uncovered soil	Unused and uncovered soil.

Source: Anderson *et al.* 1976

1.5.2 Image interpretation

Though it is possible to show the landuse through satellite image within a short moment, it is difficult to interpret the satellite image properly. Satellite image is mainly analysed in two systems; computer or automated system and manual or visual system. In this research satellite image has been analysed in manual system.

Satellite image analysis mainly depends on experience of location of proficiency, prudence and various natural initiatives and formative concept. Here in case of Landsat TM FCC image analysis, a few substances have been emphasized:

Shape

The formative feature is the important factor of the identification of matter. The shape of various things is of various types. The individual land use is easily identified to see this shape from satellite image.

Area

The area of land is very important in identifying land use.

Color

There remain differences between color and brightness in satellite image due to the difference of reflective power of various things. There happens the difference of color in case of FCC image and the difference of brightness in case of FCC image. Various types of land use are separated by observing this land use.

Location

The location of substance plays an important in case of satellite image analysis. Because besides using this type of land other sort of land is also seen.

Texture

In satellite image the texture of various things is of various types. Many time forest and marsh display same type of picture. In that case texture plays an important role. The texture of marsh is sometimes rough.

There remain some mistakes in the analysis of satellite image by focusing on the afore-mentioned subjects. For this, pattern truth is needed.

1.5.3 Preparation of base map

For the analysis of satellite image base map is needed first. Mainly for showing the disposition of information, base map is equivalent to index map (Monkhouse 1978). This base map possesses various geographical location, administrative location, boundary of study area, rivers, communication system and many others. Primarily base map is used in determining location of the classes of land uses in the satellite images and direct survey. Mainly what kind of information will be attached to base map depends on the demand of work.

1.5.4 Map compilation

The base map is turned into the scale of satellite image (1:100,000) and that map is transparent to a transparent paper called miler paper. This miler paper is placed on the accurate place of satellite image and various land uses are marked from satellite image. Here in case of identification of land use, very small land uses are not accepted, many times problems arise in the identification of land use. The pattern survey has been conducted in the study area over and over gain for the solution of the problems and justification of identification.

1.5.5 Data analysis

The area of each and every land uses has been determined individually marked in the miler paper. Graph method has been used in determining this area. Graph paper has also been used. According to the scale of map, the biggest that is the area of one square centimeter room is 100 hector and the smallest, that is the area of every 0.04 square centimeter room is to represent 4 hector. Thus various areas based on the smallest and the biggest ones have been determined.

1.5.6 Final map preparation

After determining area, this land use map scale has been changed. Through changing scale of map in the smallest form of shadow and color has been presented in thesis.

1.6. Thesis organization

The main objective of this research is the preparation of land use map, the display of change of land use with the passage of time by analyzing the satellite image of various times.

The four upland Thanas of the Barind region have been chosen as the study area here. In this research, the Landsat TM FCC image of 1997 and the Landsat TM FCC image of 2006 have been used.

This research paper resolves into eight papers. The first three chapters include methodology, technical background, study area and the last five chapters include the result and analysis of research.

The first chapter is concerned with methodology, limitation and sources of data materials.

The second chapter deals with the technical background and literature review of the research. Here the remote sensing system and the merits and role of various satellite images have been discussed.

The third chapter is concerned with the detailed interpretation of geographical and non-geographical features of the study area.

The fourth chapter deals with two parts of land use of 1997 and 2006 and its change.

The fifth chapter focuses on the analysis of the characteristics of land use change.

The sixth chapter deals with the water resources of the study area.

The seventh chapter deals with the land use on water resources and environment.

The last chapter figures on conclusion of the analysis, result, remark and limitation of the research paper and the overall structure of the study paper.

CHAPTER TWO

REVIEW OF LITERATURE AND THEORETICAL BACKGROUND

2.1 Review of Literature

Although it is known that the use of satellite data from early seventies, significant works are found to appear mainly from the eighties. The increasing number of significant work are due to mainly the availability of increasing higher resolution of satellite born scanners i.e. the modern communication system for landuse feature identification, particularly, SPOT and Landsat TM. The feature detection capabilities of the sensors such as resolution and band spread had under gone extensive research and frequently changed and effectively increased the capability. Since the launching of Landsat- 1 (ERTS) in 1972 a lot of works were done on remote sensing application in the field of geographical, hydrological, geological, agricultural, landuse detection and analysis which comprises agricultural data collection and agricultural crop assessment, urban landuse mapping, coastal environmental assessment and coastal zone development, river course monitoring and flood alleviation, soil characteristics and mapping of degraded land, biomass, water and natural resources assessment. Summer of such works could be obtained from remote sensing manual vol. I & II (1975, 1985). Various theoretical and applied aspects of remote sensing applications were discussed in the manuals. There are a number of renowned journals specially in remote sensing *(e.g. Asian-Pacific Remote Sensing Journal, Canadian Journal of Remote Sensing, International Journal of Remote Sensing, Photogrammetric Engineering and remote Sensing, Remote* *sensing Quarterly).* These journals regularly publish different theoretical and applied research articles on remote sensing. These Remote sensing techniques play a vital role in agricultural crop monitoring, crop area and field assessment and agricultural planning in Bangladesh. In Bangladesh Landsat Program (BLP) / SPARRSO (Space Research and Remote Sensing Organization) in 1978 for ST. Martin Island and was documented as BLP report (1978). In the same year BLP did another land use classification for Nachole thana of Rajshahi district, Bangladesh using aerial photographs and Landsat images, in collaboration with Dhaka University. The result of the study was satisfactory, and classifications obtained from Landsat MSS data were almost same as that obtained from the aerial photographs.

2.2 The process by the other researchers

Pradhan (1990) used multistage remotely sensed data for landuse mapping on Nepal's Gulmi district. Landsat TM FCC hard copy of 1984 and panchromatic black and white aerial phonographs were visually interpreted in his study. Six landuse categories were generated from the remotely sensed data viz. forest, shrubs agriculture, grass, stream alluvium and land slides. The researcher faced a problem in interpreting the Landsat images because of the presence of shadow in the hilly lands and he was forced to include additional subclasses in the forest category.

Khorrnm *et al.* (1991) surveyed the landuse/land-cover types in Sicily using remotely sensed data. The overall goal of his study was to evaluate the digital analysis of Landsat TM data as a mechanism for providing information regarding landuse/land-cover type in Sicily. The digital analysis of Landsat TM Data accompanied by properly collected ground truth information proved to be a timely and cost effective mechanism for mapping Anderson Level-I and selected Level-II landuse/land-cover types. The study suggested that, cover-typed information derived from digital analysis of TM data may provide a database for monitoring temporal change in landuse/land-cover spatial pattern. The data may prove to be useful in developing region wise landuse planning strategies.

Khan (1992) identified the landuse changes of Meghna-Dhonagoda flood control drainage and irrigation project area of Bangladesh, between 1973 and 1988 using remotely sensed data. Landsat MSS, SPOT PAN imageries and color infrared (CIRRI) aerial photographs were interpreted manually for obtaining landuse maps of the study area. Five landuse classes viz. settlement, cropland, fallow land, water logged area and river/channel were detected from manual interpretation by the researcher. In this study modified from (applicable for Bangladesh) 'landuse and land cover classification system for use with remote sensing data' (Anderson *et al.* 1976) was used for the land classification scheme. The result of this study was significant and achieved better accuracy.

Salem *et al.* (1995) detected the current land cover classes of a representative area in the coastal agricultural land change of Egypt, have been observed recently due to the urban sprawl. The Landsat TM raw data of 15 may 1990 was in band sequential (BSQ) format and all the processing and output images were produced by IDRISI software. For the primary inspection and feature identification, the FCC image of the study area was produced from assigning TM-3 to red, TM-2 to green, TM-3 to blue (3-2-1/R-G-B). In the FCC vegetated area appeared on tones of green. For further different feature identification, Ratio Vegetation Index (RVI), Normalized Difference Vegetation Index (NDVI), Transformed Vegetation Index (TVI) and Infrared Index (II) and on linear index Environmental Vegetation Index (EVI) computed from TM bands. Using these five vegetation indices the researchers classified the landuse of the study area in six to ten different classes. The result of quantitative and qualitative comparison between these indices indicated that, the EVI and the NDVI are the best indices for better expression and to show variation in the study area. The class produced was found to be separable and types and fruit tree types caused by the limitations imposed by the deficiency of tree canopies, and varying ground moisture conditions. The results demonstrated the land transformation in the area under study. The increase of population was detected as the main cause that influenced the urban expansion which resulted in the transformation of most of the non-agricultural land and considerable parts of the agricultural land to densely habitude urban areas.

Samarakoon *et al.* (1995) studied the practical application of Landsat TM data for land cover mapping of an area of 20,000 km^2. The area divested by the volcanic eruption of Mr. Pinatubo in the Philippines. To process the images they used unsupervised classification technique. NDVI was employed for vegetation type mapping. TM band spectral characteristics were considered to select the spectral classes. To identify forest, grass, and highly vegetated inhabited areas Normalized Difference Moisture Index (NDMI) [(NIR-MIR)/(NIR+MIR)] had also been used. The researchers noted that, remote sensing data provides the current situation of land cover at the time of the satellite pass, and it is also time and cost saving technique. It has also been found suitable for moisture area mapping.

Prasad and Venkates (1993) estimated the landuse trends of Utter Kannada, Karnataka, India using remote sensing technique. 1:20,000 Scale color JR and B W aerial photographs of February 1984 were used in the study. To obtain more accuracy from visual interpretation, ground data were used in the study. To obtain more accuracy from visual interpretation, ground data were collected for the study area. Integration the ground data with the aerial photographs, the researchers delineated six major landuse classes viz, agriculture orchards, forests, miscellaneous land, water bodies and public land including eighteen sub-classes.

Madhavan and Khire (1992) prepared landuse/land-cover maps of the Godavari delta in the eastern coastal part of the Indian peninsula by visual interpretation of X - band synthetic aperture radar (SAR) images, and the IRS-IALISS-Il FCC (band 2, 3 & 4) of the study area. Basically, it was a comparative study on the utility of images from two different techniques. Though, from an interpretation point of view, SAR data were found to be more useful for detail landuse land cover mapping, both the SAR and IRS data use in this study provided the major landuse/ land-cover information of the study area.

Thant *et al.* (1988) mainly tried to find out the integration of GIS with remotely sensed data for preparing and updating landuse maps. For the study they prepare a landuse map of Khoku-ku ward of Yokohama city, Japan using Landsat TM FCC (extracted from bands 2, 3 & 4) hard copy of 1984. Here the researchers interpreted the image manually. The result of the study indicated that the identifications of detailed landuse classes were limited by the resolution of the TM data (30 m resolution). The effectiveness, however, depends largely on the map scale. So for small scale mapping of landuse feature Landsat TM data could be used with acceptable dependence as he mentioned. In this study both vector-based GIS software ARC/INFO and raster-based GIS software ERDAS were used for GIS operation. The amount of vector-raster conversion error was founded about 1% (except roads). The error was examined on a 1:2500 scale map. Considering the 30 m grid cell sizes, the 0.3 mm on a 1:100,000 Scale map and map and it is very close to the accuracy in mapping.

Doi (1991) prepared landuse map of entire Vietnam using remotely sensed data for the first time. He used Landsat TM color images scanned in 1989 and 1990, and interpreted by manual visual interpretation method. The manual interpretation was based largely on personal experience and field work, and also supplemented by supplied forest maps, provincial landuse maps, statistical data, etc. In this study the landuse features were classified into five major classes viz. agricultural land, forest land, residential land, specialized land (rocky mountains, wet sand, dry sand, ponds & marshes, and unused land), and other land (land for salt production and area for water products). According to Do Duc Doi, remotely sensed data are undoubtedly useful for landuse mapping.

Chutiratanaphan *et al.* (1995) identified and discriminated the landuse land cover changes in Phuket island of Thailand during the years between 1988 and 1993. In this study Landsat TM FCC (3-R. 2-G, 1-B) image of 13 December 1988 were used to identify 5 landuse / land-cover classes viz. built-up area, mangrove forest, shrimp farm, rubber plantation, and paddy fields. The use of remote sensing technique has proved to be an appropriate tool in monitoring landuse / land cover changes in the study.

The natural resources assessment of Phuket Island, the larger island of Thailand was performed by Ratanasermpong *et al.* (1995) using the integration of visual and digital analysis of Landsat TM data recorded in 1987, 1992, and 1995. Furthermore, using the method of overlaying, the natural resources change analysis during 1987, 1992 and 1995 was carried out on SPANS-GIS. The researchers identified and evaluated the decreasing natural resource and increasing other landuse patterns at various dates. Visual interpretation of Landsat TM hard copies were carried out in cooperation with collected ground truth information. From the satellite images, landuse of the study area was classified into (four) main categories, viz. built up area, forested land, agricultural land, miscellaneous. The study reveals that the multi-date satellite image analysis yields an excellent result of natural resources and landuse change. The researcher obtained the Landsat TM data of bands 3-2-l-/R-G-B, recorded during January through April, and differentiated more classes of landuse pattern than other combination.

Ghiassi and Nematzadeh (1995) made an attempt to prepare various landuse maps by visual and digital interpretation of the TM data in conjunction with field check, converting an area about 68,450 km^2, in northern part of Iran. In this work, for interpretation of the 9 quadrant from TM data, including visual interpretation, geometric in total 7 (seven) major landuse levels viz. irrigated land, forest and wood land, rang land, barren land, wet land, surface water, and urban built-up-land. Due to wide spectral range of TM data, the better manipulation ability was possible for analysis in different stages of hard copy interpretation and image processing. The author also recommended that, using other kinds of satellite data (SPOT, COSMOS, etc.) combined with TM data and integration of visual and digital interpretation obviously could provide more useful and correct landuse maps.

Gong and Howarth (1992) used cover frequency-method for landuse classification of SPOT HRV data. The cover frequency-method proved to be a superior method for landuse classification when comparable to the conventional maximum-likelihood classification (MLC). This is particularly true when such techniques are applied to high spatial resolution satellite data such as Landsat TM and SPOT HRV data. More and better landuse information could be obtained from remotely sensed data by using cover frequency-method, as he pointed out.

Rao (1991) prepared landuse maps using satellite data. Indian Remote sensing Satellite (IRS-1A) LISS-I (band 2, 3 & 4) 1: 250,000 scale hard copy FCC were used for visual interpretation, and CCT stored data were used for the digital analysis. The IRS-lA LISS-I data were found unique for landuse mapping. Rao found that, the remote sensing technology provided an opportunity to collect regional information or agricultural data with a minimum time and without excessive cost. This modem technology is a very effective means for landuse mapping.

Chowdhury (1983) classified the portions of Dhaka district, Bangladesh into five different land cover classes with the help of computer aided land cover classification technique using Landsat MSS data of 3^{rd} January 1977, February 1980, and 20^{th} February 1980.

Bryan (1983) classified urban landuse of Los Angeles, USA, using L(HH) (L band, horizontally transmitted and horizontal received) data on November 1981. But the Radar data had its own limitations because of either the system of the nature of the scanned image as he mentioned. Though the result of his study was not satisfactory, which, possibly because that the work was a step ahead for using radar data in landuse classification.

Chowdhury (1984) studied the landuse of Hail Haor (Sylhet), Bangladesh for his doctoral thesis, using remotely sensed data. To prepare the landuse map of the study area Landsat MSS data digitally classified into the eight classes, the result of the study significantly correlated with the ground information.

Nualchawee and Bacareza (1995) prepared a land cover map of the Pa Wang Phloeng-Muang Khom-Lam National Forest of Thailand using various computer assisted classification of Landsat TIVI digital data scanned on 18 July 1993. The digital analysis was perfumed at the Remote sensing laboratory at AIT, using the ERDAS Image processing. PC- based system, and CCT was used for data input. Based on the field visits to the study area and adopting the US geological survey classification (Anderson, 1967), 4(four) major (Lavel-1) landuse or resource classes viz. agricultural land, rangeland forest land, and water were obtained from the digital analysis. The overall classification accuracy derived from supervised classification approach was 80%.

2.3 Land use and land use changes

Urban populations are increasing and the land use patterns are changing in the transitional zone (Khan and Islam, 2000).

Shak and Haque (2000) mention two main objects about land use pattern and change. They are (i) To analysis the order of recent land use of Rajshahi town. (ii) To discover how can the civic facilities are confirmed by well planed way of land use and master plan of Rajshahi city well deliberation.

According to **Wang, Amundson and Trumbore (1998)** land use change have a significant impact on soil cycle and that shallow soil horizon are most susceptible to disturbance because of shorter turnover times of organic C in there horizons (C = carbon).

Veldkarnp and Lambin (2001) discussed about land use change modeling. Land-use change models should represent part of the complexity of land-use system and they offer the possibility to test sensitivity of land use patterns to change in selected variables. The study also discussed the work about land use / land cover models and was organized within the scope of the land use and land cover change project (LC/CC). The mentioned main points are as: (i) Modeling of driver of land-use change, (ii) Modeling of scale dependency of drivers of land use change (iii) modeling progress in predicting location versus quantity of land-use change, (iv) the incorporation of biophysical feedbacks in land-use models.

Jeremy, Kerr and Cihlar discussed about land use, land-use intensity remote sensing, environmental monitoring, and sustainable development. They mainly discussed about land use classification and land use intensity by national census information.

Yingcheng, Tongging, Xueyeu, Guangliang and Xiaomei (2003) discussed about the rapid land use changes especially in the urban area by the RS data, This data is collected from the land use RS monitoring project that began from 1999 and will keep for 12 gears which occurred by National land and Resource Department.

Zhan, Molenaar and Tempfli (2002) mentioned about the land use in Amsterdam, the Netherlands by high spatial resolution remote sensing. They discussed the combination of man-made feature and national features and mentioned that the urban area is expanding day by day.

According to **Patnankanog Shreshtha, Saengghonpinit, Sapet and Parshad (2004)** discussed land use and land cover change, land degradation, landslides and soil erosion with the application of remote sensing data, air photographs. This case study occurred in Thailand.

Civco, Hund, Wilson, Song, Zheang (2002) compared the results of different land use and land cover change detection approaches: traditional post classification cross-tabulation, cross-correlation analysis, neural networks, knowledge based expert system and image segmentation and object oriented classification. They practiced this project in the Stony Brook Millstone River watershed in New Jursey.

Mendaza, Santos, Rosa, Silva discussed about land use change and its mapping. In this study they mentioned that the main land use changes occurred between 2002 and 2003 were related to deforestation, since agriculture and pastures replaced many areas of tropical forest.

According to **Hanse (1998)** the growth of cities and huge problem for modem societies, which occurred for growth of cities, mapping urban landuse, is based on orthophotos and satellite images. He also discussed that generally land cover and use mapping are based on crisp classification but, in this project he has applied a fuzzy modeling approach to land-use mapping.

2.4 Land use change mapping

Rashid (2004) mentioned the relationship between RS (Remote sensing) and GIS (Geographic information system). He said that GIS is the most effective system of map production and for this system RS data is very much essential. If there is no RS data vector data (Vector data structures represent spatial variation using lines located in continuous coordinate space) can be used. In this paper he examines the potential integration in future reference. The main them of this articles is to see how RS and GIS will be increased significantly in near future and not only geography but also in other branches of social sciences and its possible benefits.

According to Kamruzzaman, Adri (2001) GIS of urban and regional planning, they said that man and spaces are the elements for planning, both spatial and non-data need to be analyzed. The aim of this paper is to explore the areas that GIS can cover to help out the planning problems. For this first, the most important sub-fields of urban and regional planning have been identified and secondly the applicability of GIS in these fields has been explored through the world. Last an attempt is made to explore the status of GIS application in Bangladesh of urban and regional planning. And all of those are discussed as "A set of GIS tools linked to an integrated data base of the socio-economic and land use information enables the planners to conduct exploratory spatial analysis (Goodchild. 1989; Openshaw, 1991).

Ramachandran, Padmaya (2001) discussed about using GIS and RS system for urban ecology. They discussed about cultural landscapes in urban centers in southern India, which are identified by GIS. They also mentioned that analysis of land use and land cover changes are indicating by using GIS.

According to **Francoismas and Ramirez (1996)** supervised classification results were improved by post-classification GIS procedures based on additional spatial information (Soil and geology map, terrain model, climatic codification) integrated into a database. They discussed this based on image. In this paper they discussed the classified land. Landsat TM sub- images of southwestern Mexico were used to compare visual and digital land cover classification.

Baja, Chapman and Dragovich (1996) discussed about a spatial modeling procedure for the assessment of land suitability using geographical information system (GIS). The model consists of two-models: land suitability indexing and erosion tolerance indexing. They also discussed a soil land use map which was complemented by New South Wales SALIS (Soil and Land Information System) was used in conjunction with Digital Elevation Model (DEM) to derive a land suitability evaluation by DEM and represents the change/evaluation by GIS.

Qihaoweng (received 2000, accepted 2001) indicated the rapid land use change of China such as the Zhujiang Delta which are investigated by the combined use of satellite remote sensing, geographic information system (GIS) and stochastic modeling technologies. In this article he mentioned that the urban growth of this area are increasing and the cropland become decrease during 1989 and 1997. He also discussed the integration of satellite remote sensing and GIS was as effective approach for analyzing the direction rate and spatial pattern of land use change.

Dimyati *et al.* (1995) an analysis of land use and land cover change using the combination of MSS Landsat and land use map of Indonesia reveals that land use and cover change were evaluated by using remote sensing to calculate the index of changes which was done by the superimposition of land use and land cover images of 1972, 1984 and land use maps of 1990. This was done 3 to analyze the pattern of change in the area, which was rather difficult with the traditional method of surveying as noted by surveying as noted by Olorunfemi in 1983 when he was using aerial photographic approach to monitor urban land use in developing countries with Ilorin in Nigeria as the case study. But the author did not discuss the causes of land use and land cover change.

Chowdhury and Ahmed (1998) studied the land use features and its change in the rapidly developing district of Gazipur in Bangladesh has identified, mapped and analyzed using multi-date satellite images and to a data base system to be used for geographical analysis using GIS. In spite of deferent types of satellite scanners used, such as Landsat MSS, Landsat TM and SPOT Pan it was possible to detect a broad land use category of 5 types. The study covered a period from 1980 to 1992. The identified land uses are settlement, agricultural land, forest, water bodies and uncovered soil. The features are generally considered for analysis in wider regional context. The accuracy achieved was 77.71% for Landsat MSS, 83.27% for Landsat TM and 89.17% for SPOT. It was I fund that, because of Dhaka city's urban pressure, agricultural land and water cover decreased particularly. The forest cover is alarmingly decreasing. But researchers did not discuss the loss of forest land and decreased agricultural land and effect of the change of environment.

Assaduzzaman (1985) in his seminar paper, 'Hydrology of Barind Tract' focuses on the general hydrological characteristics, nature of Hydrology condition of surface water and subsurface water components and source of surface and subsurface water of Barind Tract as whole.

Rahman and Saha (2009) the study of the spatial patterns and temporal changes of crop land is important to understand the underlying factors and the functional effects of the agricultural landscape. The author addressed a spatio-temporal analysis of cropland and cropping pattern change in the Bogra district of Bangladesh over the last 16 years (between

1988/89 and 2004/05). In this paper, crop mapping from multi-temporal and multi-sensor satellite images was described. Landsat TM arid IRS P6 LISS 111 satellite images were used with GIS for spatial dynamics of cropland and cropping pattern change analysis. First, seasonal cropland maps were derived from object-based classification of satellite images, then two-date classified image differencing with 015 overlay technique and decision rules were applied. Cropping pattern change was analyzed in a spatial and quantitative way for the 16 years and for this, Integrated Land and Water Information System (ILWIS) and Land Change Modular (LCM) of IDRISI Andes were used. The results showed that in the area, mono crop cultivation was found in summer, but in winter, areas under different crop cultivation had changed dramatically. Change analysis showed that the changes mainly occurred in the north northwest and southwest of the areas, and during the time the highest change area was found under the rice-potato pattern. The author does not describe the spatial change of the cropping pattern and the impact of land use practices and environment.

Mazumder, Jahan & Ghose (1993) in their paper, 'Hydrology of Tanore and Nachole thanas of the Barind projected Area' focused mainly on the ground water hydrology and surface water hydrology.

Dewan and Yamaguchi (2009) in this study evaluates land use/cover changes and urban expansion in Greater Dhaka, Bangladesh, between 1975 and 2003 using satellite images and socio-economic data. Spatial and temporal dynamics of land use/cover changes were quantified using three Landsat images, a supervised classification algorithm and the post- classification change detection technique in GIS. The researcher's analysis revealed that substantial growth of built-up areas in Greater Dhaka over the study period resulted significant decrease in the area of water bodies, cultivated land, vegetation and wet/lowlands. Urban land expansion has been largely driven by elevation, population growth and economic development. Rapid urban expansion through infilling of low-lying areas and clearing of vegetation resulted in a wide range of environmental impacts, including habitat quality. In this study will contribute to both the development of sustainable urban land use planning decisions and also for forecasting possible future changes in growth patterns. But the researcher does not study land use/cover change and the impact of environmental degradation in greater Dhaka.

Zubair (2006) worked in the study to map out the status of land use land cover of Ilorin between 1972 and 2001with a view to detecting the land consumption rate and the changes that has taken place in this status particularly in the built-up land. So was to predict possible changes that might take place in this status in the next 14 years using both Geographic Information System and Remote Sensing data. The static land use distributing for each study area was categoriesd in five classes of which farmland, built-up land, and water body were most important. However, the result of the work shows a rapid growth in built-up land between 1972 and 1986 while the periods between 1986 and 2001 witnessed a reduction in this class. It was also observed that change by 2015 may likely follow the trend in 1986/2001 things being equal. But the researcher did not mention the factors of land use change and the impact of environment.

CHAPTER-3

STUDY AREA

3.1 Preliminary concept

The Bengal basin which was previously known as Bangala possesses a distinctive characteristics of which the Barind region is a part. The average height of the places of Bangladesh from the sea level is from eight to twelve metres.

According to Harun-or-Rashid, the Barind region resolves into five parts,

(i) North-Eastern Barind land
(ii) Eastern Barind Land
(iii) Middle-east Barind land
(iv) Middle-west Barind land
(v) Western Barind land

These regions have been made different on the basis of some distinctive features.

3.2 Location and area

The Barind region consists of greater Rajshahi, Dinajpur, Rangpur, Bogra, Maldoh belonging to the west Bengal of India whose total area is 10,371.71 square kilometers of which 7,295.84 square kilometers belongs to Bangladesh.

The Sapahar, Porsha, Niyamatpur, Patnitola Thanas have been accepted as study area, which stands in north-western part of Bangladesh and middle-west and western region belong to the Barind region (Harun-or-Rashid 1991). The total area of study zone is 1326.26 square kilometers which stands between 24°39′ N and 25°13′N latitude and 88°24′E and 88°53′E longitude.

3.3 Socio-economic characteristics

Before the division of country in 1947, the Barind region was economically and commercially more advanced than it is now. At that time this place was the back-land of Kolkata port and they were prosperous for having good communication with port.

But after the division of the country, its connection with Kolkata closes down and this region gets socio-economically endangered due to the paucity of communication with other regions.

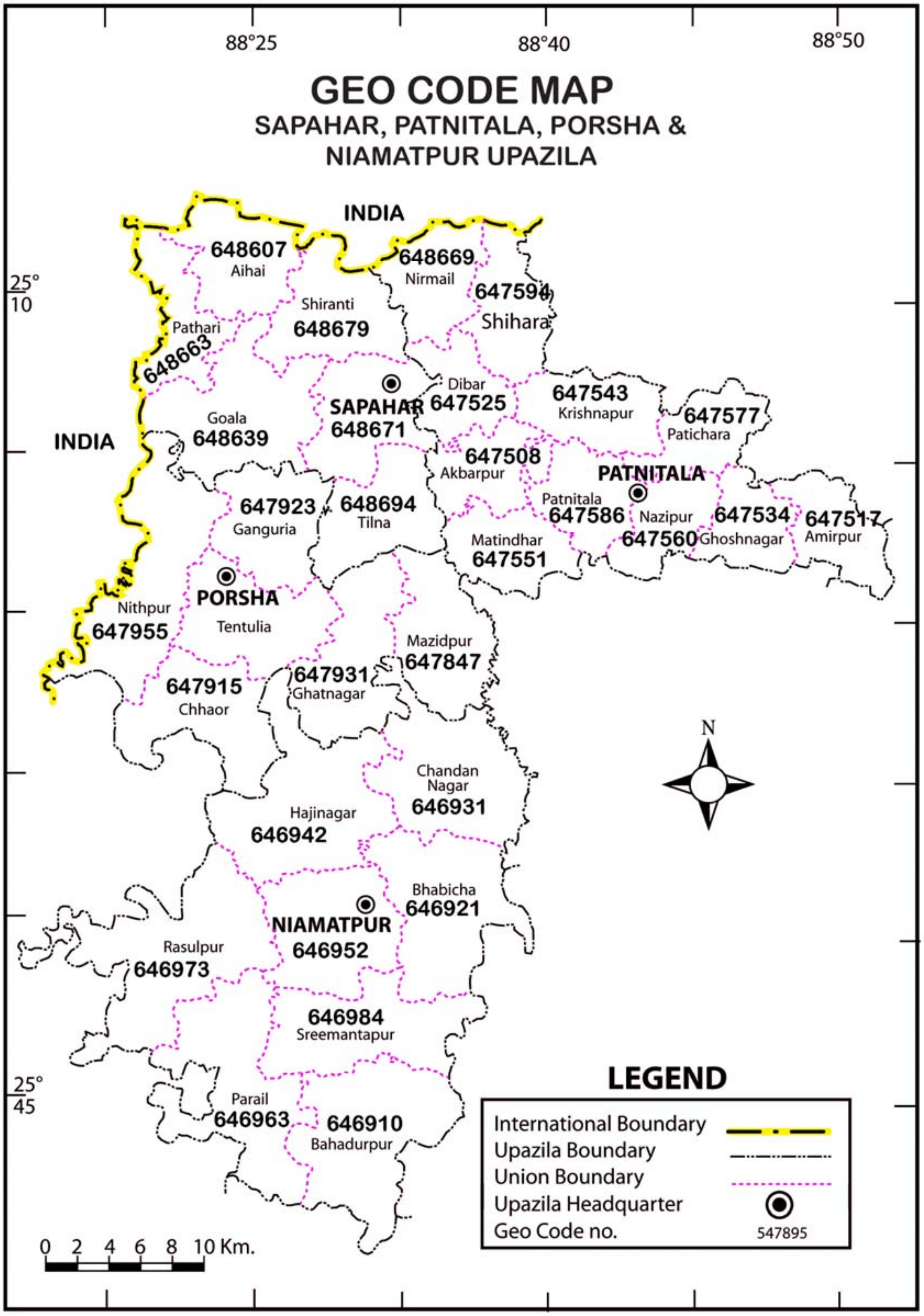
A publication titled “Rajshahi district land resources and cropping potentiality” from land survey department in 1973 shows that the thanas of the Barind region such as Sapahar, Porsha, Niyamatpur, Nachole etc. are mainly based on one crop that is Ropa Amon paddy. And as a result of it, this thought finds its way for the all-out development of the region necessary for the Barind project from 1979 to 1983 and now Barind multi-purpose development authority plays an important role for socio-economic of this region by accepting overall plan and its implementation.

3.4 Physiography

An understanding of Geomorphology is especially important in Bangladesh because differences between soils generally are related to their position on the relief and to the ages of different landscapes. Geomorphology also is important in relation to the planning of agricultural development with the aid of irrigation, drainage, flood protection and soil conservation structures. For all of which knowledge of relief and drainage, river behavior and/or surface run-off is important. The Barind tract is one of the several terraces of Pleistocene epoch within the Bengal basin (Rashid 1991). The area is slightly raised and compressed to the surrounding area due to tectonic movement. Here the elevation of the land is comparatively higher than the adjacent flood plain. The Barind is a dome shaped slightly elevated land. The elevation is about 40 meters is the western side and the elevation is about 20 meters in the eastern side. The Barind tract appears in the landscape in the form of series of titled, uplift and fault blocks. The land form comprises mainly level in eastern and northern part where as dissected and undulating in the western part. The area is moderately undulation with large level and passing into relatively low laying area with gentle slope. The ridge tops are almost level. In the eastern side, the tract passes the adjoining flood plain sediments.

In the Barind region, various kinds of physiographical changes are seen according to place. The western region enriched with small uplands is comparatively high (39.7m) in comparison with low (19.8m) eastern land. The piedmont plain land of middle-western region formed with recent silt expands from south Dinajpur to the Padma, which is 145 Km long and whose width is from 16 to 37 km in terms of place and Ghodagari, Tanore, Niyamatpur, Nachole, Porsha, Sapahar etc. belong to this region. The Western part of Sapahar and Porsha standing on the bank of the Ponorbhoba and the Tangoon is comparatively low which is known to be ‘beel’ locally.

Many of the waterless gullies have given the form of wave to the piedmont plain land which is high and low upto 19 meters with respect to place.



Source: Bangla Pediea 2003.

Figure 3.1 Administrative Unite of Research Area.

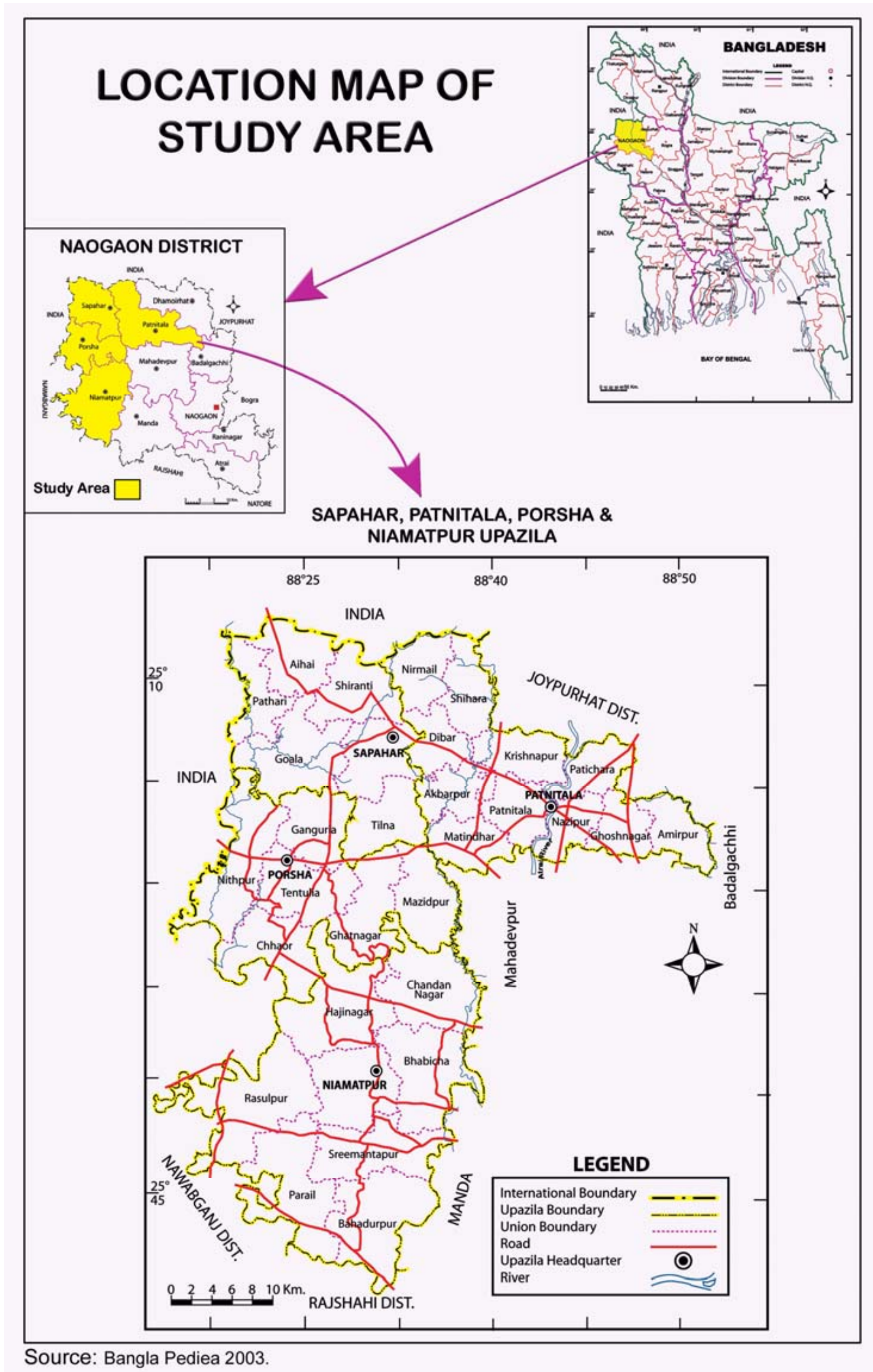


Figure 3.2 Location of the study area

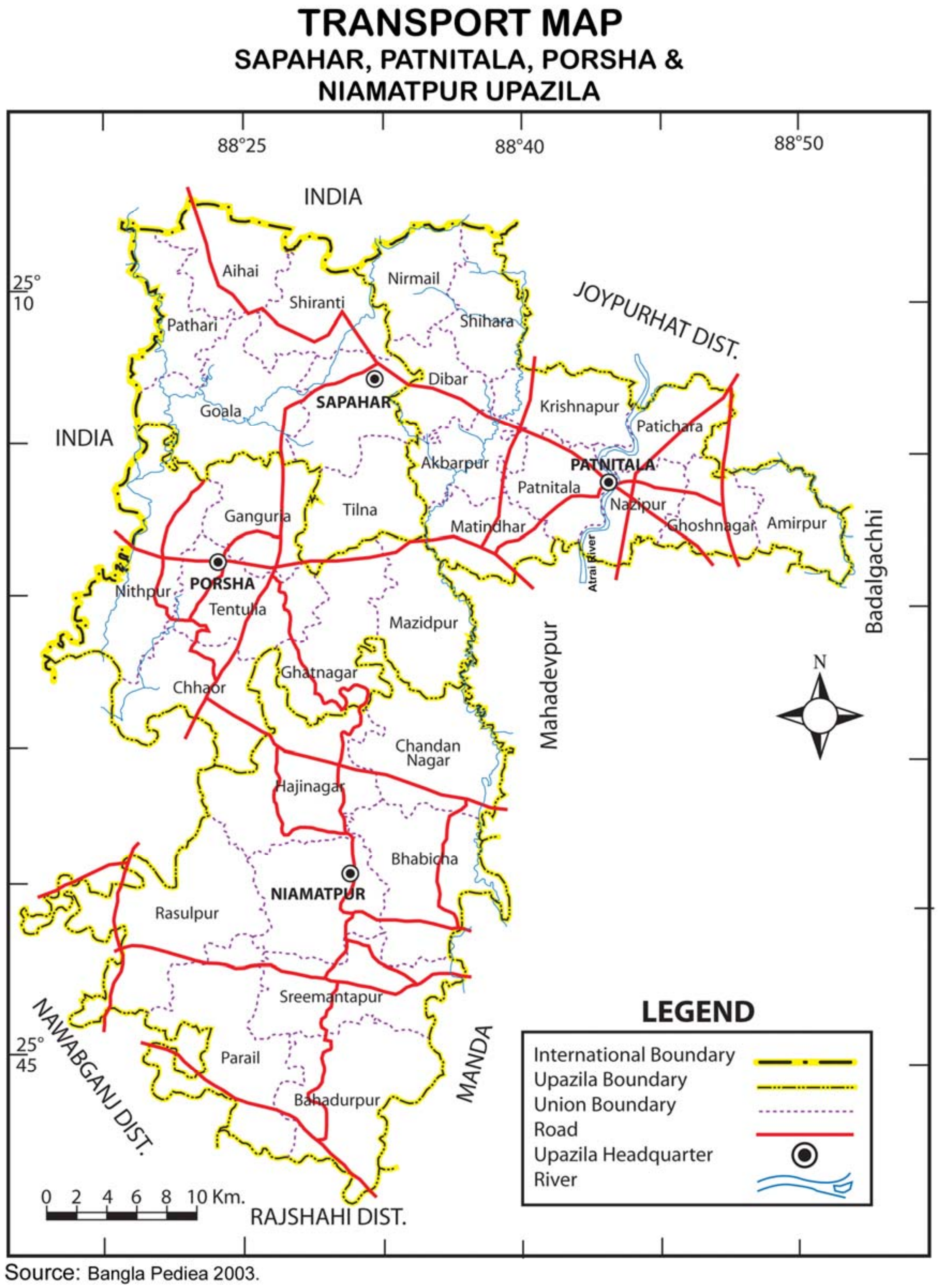


Figure 3.3 Selected thana map

3.5 Climate

The clearest index of conferring natural, social and economic frame work of any region is the climate of that place. Here the climate of the accepted research region is beset with many characteristics which have separated this place from others. Bangladesh is a country of tropical monsoon region. Totally the climate of Bangladesh is liberal but that of the Barind region is extreme.

Temperature

According to the concept of many environment to logists about the Barind region desertification is supposed to be seen. Various ideas are held from this symptoms. The widespread ups and down of temperature of the Barind region is responsible for this reason. Temperature that is shown in table is the average temperature. In terms of time this temperature may be at highest 45°C and at the lowest below 5°C.

Table - 3.1

Normal Maximum and Minimum Temperature (°C) (study area)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Maxi	24.5	27.7	33.1	35.7	33.4	32.1	32.1	32.3	31.7	31.7	29.3	25.8	30.98
Mini	11	13.1	17.8	22.7	24.3	25.8	26	26,1	25.6	23.2	17.9	12.6	2051

Source: http:/www.bmd.gov.bd_climate/php

Table - 3.2

Average monthly temperature (°C)-1994

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Maxi	24.39	26.2	31.2	35.9	36.2	32.7	32.2	32.7	32.5	32.6	24.9	26.0
Mini	11.7	12.5	18.2	22.0	24.4	25.9	23.2	26.1	24.7	22.3	17.7	11.1

Source: Statistical year book 1995.

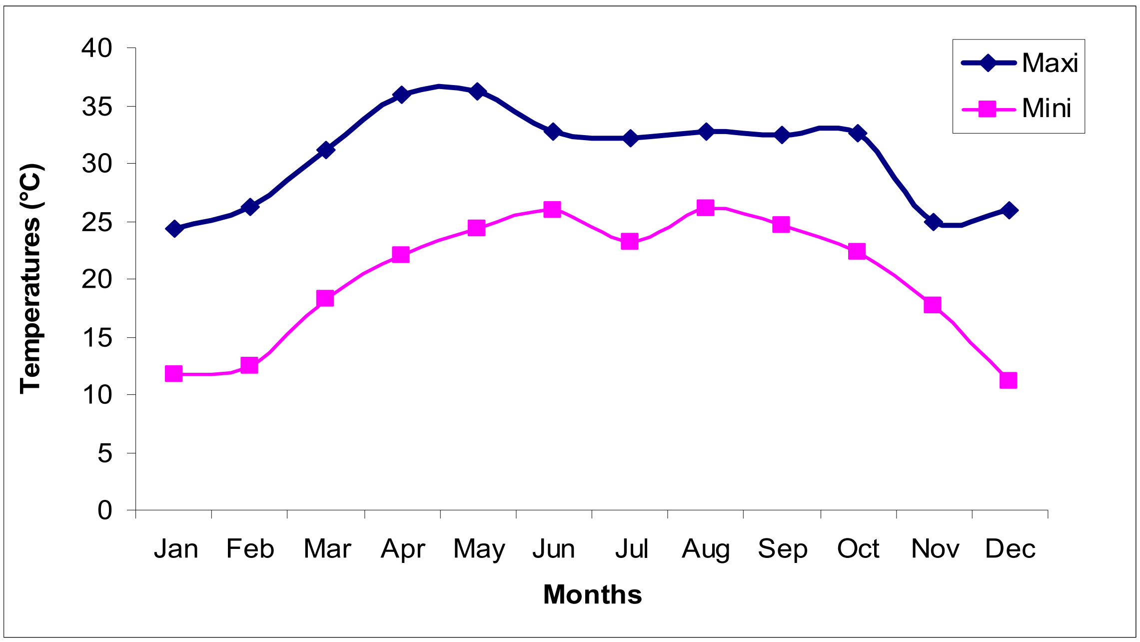


Figure 3.4 Average monthly maximum and minimum temperature (°C)-1994

Rainfall

The rainfall in the Barind region is comparatively low in comparison with other parts of Bangladesh (average 1500-2000mm). The Barind region is known to have warm summer and the region of less rainfall (Harun-or-Rashid). The humidity in summer is almost 50% and the magnitude of NSQ is 250 (Mayer). If the average rainfall of the earlier years are observed, gradual increase is seen.

Table - 3.3

The Trend of rainfall of research area (1990-2009)

Year	Thana		
	Sapahar	Porsha (Nitpur)	Patnitola (Nazipur)
1990	1145.0 (M.M.)	1151.0 (M.M.)	1516.6 (M.M)
1991	1915.5	1998.8	1882.2
1992	1296.0	1200.4	1033.0
1993	1320.0	1418.1	1733.0
1994	1053.0	1120.8	1145.0
1995	1977.0	2139.7	1930.0
1996	1429.0	1683.6	1563.0
1997	1039.0	1035.7	1572.0
1998	1610.0	1750.1	2021.0
1999	2008.0	1990.4	1978.0
2000	1525.0	1969.2	1508.0
2001	1464.7	1327.0	1282.0
2002	1613.0	1806.4	1297.0
2003	1705.0	2185.1	1395.0
2004	1837.0	2097.9	1690.0
2005	1426.0	1897.6	657.0
2006	1520.0	1911.2	751.0
2007	1510.0	2521.7	855.0
2008	1189.0	1366.0	742.0
2009	1209.0	782.9	1194.0

Source: Bangladesh water development board-2009.

As there is the difference of annual rainfall in the thanas of research area. So there is also seen the difference of monthly rainfall. The monthly rainfall of 2009 of the thanas is given below.

Table - 3.4

The trend of monthly rainfall of research area (mm)-2009.

Thana	Month											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Sapahar	0.0	10.0	15.0	15.0	211.0	20.0	272.0	343.0	85.0	2330.0	5.0	0,0
Patnitola (Nazipur)	0.0	0.0	4.0	9.0	79.0	40.0	175.0	500.0	181.0	265.0	1.0	0.0
Porsha (Nitpur)	1.5	0.0	0.0	0.0	148.0	36.0	264.0	146.8	60.2	124.1	2.0	0.0

Source: Bangladesh water development Broad-2009.

3.6 Soil

Most of the Barind regions belong to piedmont plain land formed with the silt of Pleistocene age. Difference is also seen in the merits of soil in terms of place. The soil of this almost flood-free region is catosol whose texture is equilivalent to clay, brownish-gray to reddish brown the colour enriched with iron, Aluminium phosphate, but the quantity of silicon and nitrogen is very little. There is sufficient lime in this soil. Most of the topsoil is gray and mixed brown and sub-soil is from clayish red to yellowish-brown. The soi of dry Barind region is as hard as field.

Table-3 .5

The nutrients of soil of the Barind region:

(Percent)

Nitrogen (N) 0.07	0.07
Phosphorus pentoxide	0.07
Potassium oxide	0.90
Calcium oxide	0.34

Source: Harun-or-Rashid 1991.

The nutrients in the Barind region is comparatively low in comparison with other parts of the country. So the fertility of land is also low. So this soil is effective for paddy.

The difference of soil in terms of place is seen. This difference also creates disparity in surface level.

Soil Associations:

Oldest Meander Floodplain
1-Jaonia — Santhia association

Old Floodplain Basin
5-Jaonia - Beel association

Young Atral Meander Floodplain
2-Mainam — Manda complex

Little Jamuna Meander Floodplain
3- Dohail made — land — Malanchi complex

Level, Intermittently Flooded Terrace
4-Amnura — Nijhuri association

6- Nijhuri association

Broadly Dissected Terrace
7-Nijhuri - Anmura association (Boardly dissected phase)

8a-Anmura - Nachole association (Boardly dissected phase)

Closely Dissected Terrace
8b-Amnura - Nachole association (Closely dissected phase)

8c - Amnura - Nachole association (Steeply dissected phase)

Source: SRDI, Rajshahi, March, 1984.

3.7 Population

Population and natural environment are inextricably related. The difference of land use depends on distribution of people and its density, the whole research is consists of four Thanas. Here the total population of 1981 is 471744 and of 1991 is 603960 and of 2001 is 701714. The average density of the population of 1991 is 455.39 per square kilometers which is less than average density of Bangladesh. Here the difference of the distribution of population is seen in terms of place. The rate of average growth of population in one last decade (1981-1991) was 2.19%. At present the rapid growth of population plays an important role in land use change, in the difference in distribution of population and its density is manifested in study area.

Table - 3.6

Characteristics of population of the study area

Thana	2001			1991			1981		
	Total population	Density (sq.km)	Education percentage (%)	Total population	Density (sq.km)	Education percentage (%)	Total population	Density (sq.km)	Education percentage (%)
Sapahar	143853	588.12	40.38	115320	417.47	23.1	85032	347	20.1
Porsha	121807	481.57	35.59	97279	384.59	26.5	80790	320	21.3
Niyamatpur	226614	504.36	41.05	193197	429.99	25.8	152252	339	21.1
Patnitola	209440	552.01	49.78	198164	518.01	32.9	153670	405	27.6

Source: BPC-2001, BPC-1 991 and BPC-1981

3.8 Agriculture

Food crop production is the main agricultural activity in the thana. More than 80% of agricultural land is devoted to rice cultivation. The agricultural land has been divided into two parts in this research. The total area of the cropland of the study area is 11952 hectors which is 9.02% of the total area (Table 4.1.1). However, rice, yield and wheat are very high. Other crops like Jute. Potato, watermelon, mustard, pulse, chili, vegetables etc. are grown in this study area.

3.9 Water resources

There are many beels, ponds, dighis and streams flowing on the study area. The main source of water is the beel region of the basin of the Ponorbhoba and Tangoon to the west-northern border, the biggest 'Jobai beel'. The area of the surface water is more at Sapahar. The total area of the water body is 1456 hectors which is 79.48% of the surface water are under Sapahar (1997).Most of the water bodies are located at the union parisad of Aihai, Pathani and Goala. The total area of the surface water is about 792 hectors which is 72.26% (2006). During the rainy season rivers filled with water but they become dry in winter. In this season the Ponorbhoba river gets a large volume of water from rainfall and the rivers turns into a new artery of communication network. Sometimes the river floods the surrounding area and this time different types of fishers are found in this river. In dry season, the river becomes dry. The farmers can not get much water for irrigation during the dry season and a little portion of water is for domestic consumption. Precipitation is source of all classes of water in the surface and subsurface bodies and it maintains a cycle. The forms of precipitation are rainfall, hail, dew, fog etc. In a broad sense, the source of almost all our water is the sea. Rainfall is the most significant source of surface water in the study area. Rainfall in Bangladesh originates from three sources. The western depressions of winter which account for 5% of the total and 80% comes from the monsoon in May-June generally associated with tropical depression in the Bay of Bengal and Indian ocean. July is the wettest month. From August to May it experiences a dry season particularly in the west but a secondary monsoon rain fall peak may occur in September. From November to April, it experiences a rainfall of less than 100 mm some times it contains up to May.

CHAPTER-4

LAND USE

4.1 The land use pattern 1997

Landsat TM. (Band-2, 3, 4) has been used in map preparation to determine land features of the month of December, 1997. As most of the part of the study area was rural, attention has been paid to identify features by dividing the full area into several parts for proper interpretation and regional difference of land uses.

Table 4.1.1

The land use land sat TMFCC (Band 2, 3, 4) of 1997 of the study area

(Land sat TM)

Land use	Area (Hector)	Area (%)
Settlement	20,216	15.24
Cropland	11,952	9.02
Current fallow	85,578	64.53
Marshy land	10,148	7.65
Surface water	1,832	1.38
Forest	1,636	1.23
Uncovered soil	1,264	0.95
Total	132,626	100.00

Source: Landsat TM Image 1997.

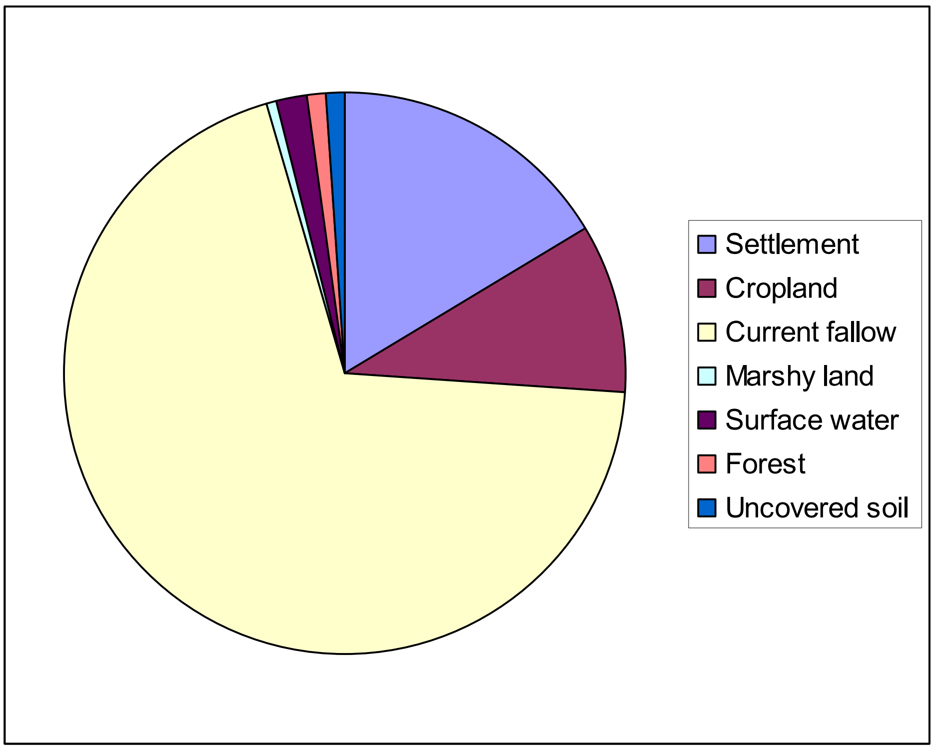


Figure 4.1.1 The land use of 1997 of the study area.

Table 4.1.2

The Thana based land use of 1997

(Landsat TM FCC)

Land use \ Thana	Sapahar		Porsha		Niyamatpur		Patnitola	
	Area (Hector)	Area (%)	Area (Hector)	Area (%)	Area (Hector)	Area (%)	Area (Hector)	Area (%)
Settlement	3,376	13.80	4256	16.83	6,880	15.31	5,704	15.03
Cropland	1,456	5.95	680	2.69	4,796	10.67	5,020	13.23
Current fallow	15,084	61.67	15,406	60.90	31,639	70.42	23,449	61.80
Marshy land	2,404	9.83	4,256	16.83	1,204	2.68	2,284	6.02
Surface water	1,456	5.95	188	0.74	28	0.06	160	0.42
Forest	308	1.26	256	1.02	304	0.68	768	2.02
Uncovered soil	376	1.54	252	0.99	80	0.18	556	1.47
Total	24,460	100.00	25,294	100.00	44,931	100.00	37,941	100.00

Source: Landsat TM Image 1997

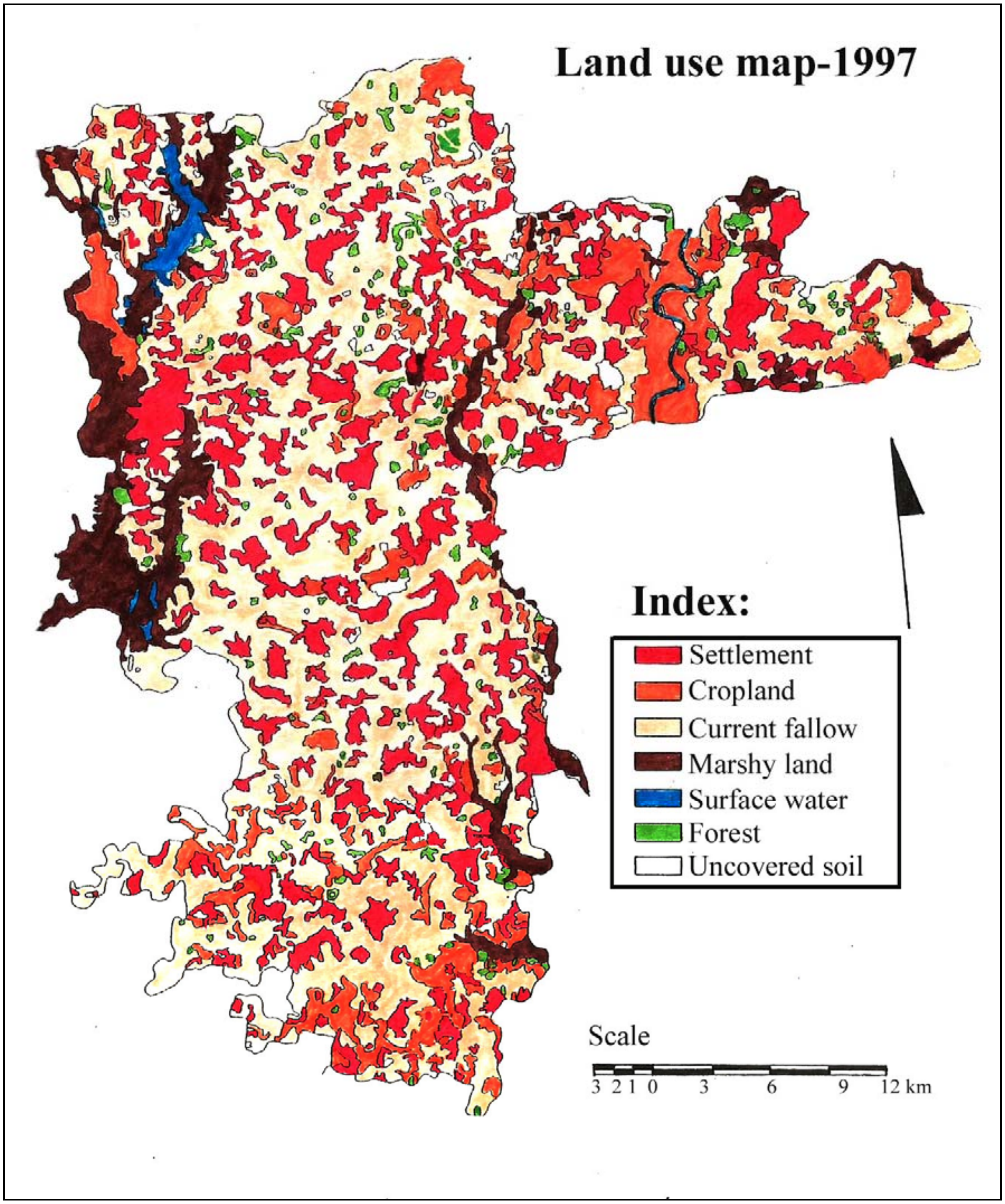


Figure 4.1.1 (a) Land use map of 1997 of the study area

In this research four thanas have been included and its total area is 1326.26 square kilometers. It has been resolved into seven parts. They are described below in a successive order.

4.1.1 Settlement

There may be two kinds of settlement such as urban settlement and rural settlement. Most of the settlements of the study area are rural. It has not been possible to distinguish rural and urban settlement due to the limitation of scale and resolution of satellite image (30 meters). The settlements become apparent as tiny square shaped of dark grey color. Settlement indicates residential commercial, various public and private institutions and other institutions of small industries. The important characteristics of rural settlement are its association with social forests (Bamboos and bushes vegetables garden and various fruit trees). Social forests have been mingled with settlements (Photograph 4.1). The total area of settlement of the study area in 1997 was 20216 hectors. It is 15.24% of the total study area (Table 4.1.1).

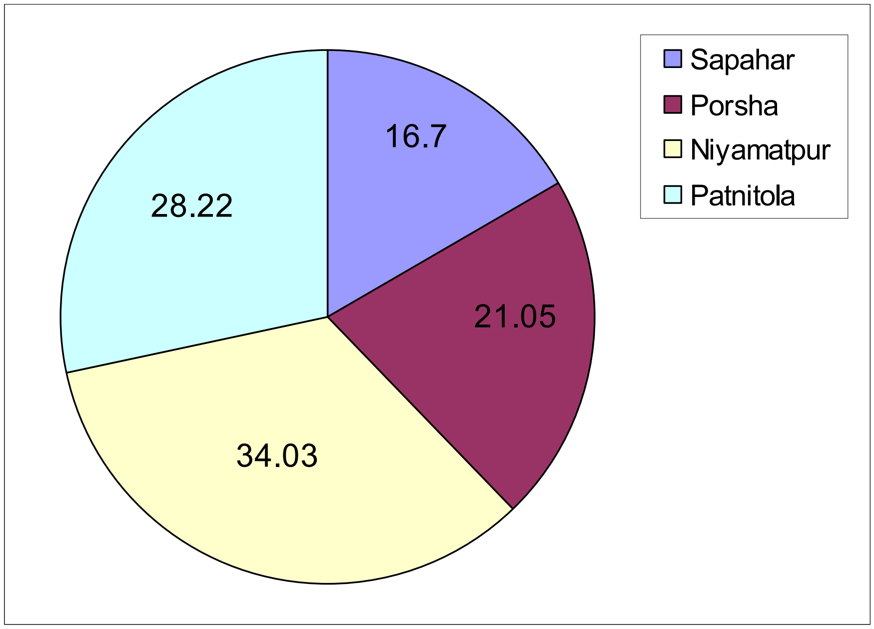


Figure 4.1.2 Distribution of settlement according to thanas

Photograph 4.1 Settlement

This area consists of four administrative thanas. The distribution of settlement is indicates more settlement in Porsha 16.83% and less settlements in Sapahar 13.80% (Table 4.1.2) In the union of Aihai, Shironti, Goala and Tilna, more settlements are found.

The total area of settlement at Porsha appears to be 4256 hectors which is 21.05% of the total settlement. In this thana more settlements are seen to the north and middle part of Nitpur union parisad, but the bordering western and southern parts are almost without settlements.

Niyamatpur is the biggest thana of this region which contains 6880 hectors of settlements. In this thana more settlements are seen to the north than to the south, that is the union parisad of Chandannagar and Hajinagar retain more settlements. A few settlements are seen in the union parisad of Amoir to the east whereas less settlements are seen at Patichora, Nazipur, Patnitola, Krishnapur and Motindhar union parisad. The total area of settlement at Patnitola is 5704 hectors which is 28.22% of the study area. (Figure 4.1.2).

Table 4.1.3

The density of settlement of 1997

Name of Thana	Population** 1997	Total settlement (Hector)	Density* (per hector)
Sapahar	106234	3376	31.47
Porsha	92332	4256	21.69
Niyamatpur	180914	6880	26.30
Patnitola	184816	5704	32.40
Total	564296	20216	27.91

*The total people living at per hector settlement.
**The determined people of 1997 from normal growth rate (approved).

The people of the study area live in settlement but their density is not same. The most density 32.40% is seen at Patnitola and the least of that 21.69% is seen at Porsha.

4.1.2 Cropland

The agricultural land has been divided into two parts in this research (Table 1.2). Here cropland refers to those land uses that were immature while taking the satellite image (1997) and that looked green. The crops of that time were Robi crops (specially wheat and sugar cane). The total area of the cropland of the study area is 11952 hectors which is 9.02% of the total area (Table 4.1.1).

As a result of the insufficiency of rain the growth of the Robi crop is very poor, but some of the croplands are seen on the bank of the Attrai and beel.

Photograph 4.2 Crop land

The cropland exists lowest in Porsha 5.69% and maximum in Patnitola 42.00% (Figure 4.1.3).

In the union parisad of Pathari and Tilna, more croplands are seen. The total area of crop land at Sapahar is 1456 hectors which is 12.18% of the total crop lands (Figure 4.1.3).

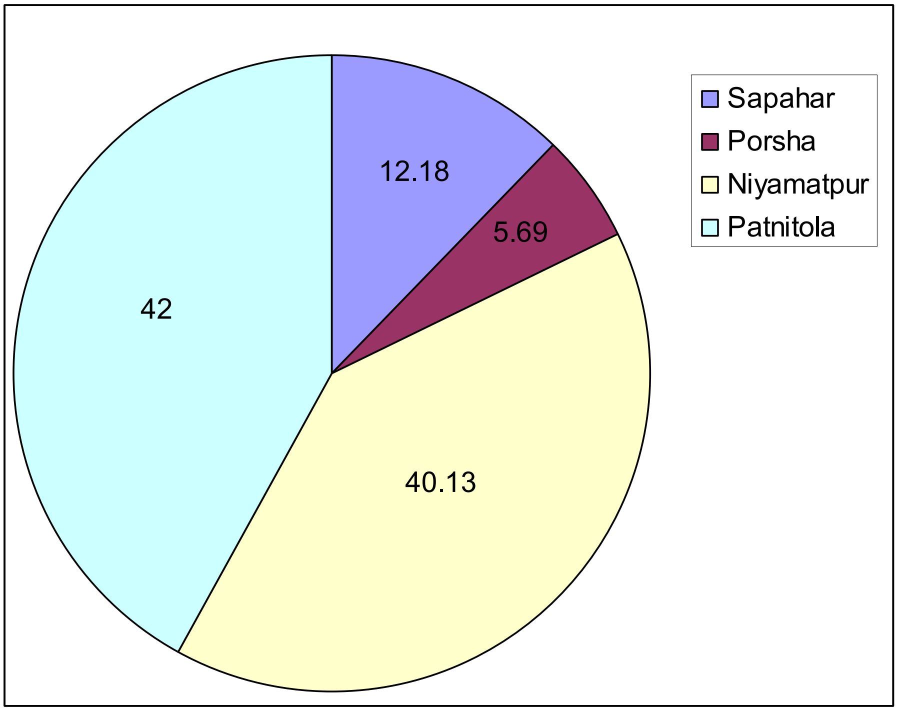


Figure 4.1.3. The distribution of crop land according to thanas

The less of cropland at Porsha is manifested. The total area of cropland at Porsha is 680 hector which is about 5.69%.

At Niyamatpur the crop lands exist at sporadic way, but comparatively more croplands exist to the south, the total area of crop land at this thana is 4796 hectors which is 40.13% of the total croplands (Figure 4.1.3).

The more croplands are seen at Patnitola. In this thana, more croplands exist on the bank of the river of Attrai and Shib. Besides the union of Nirmoil is almost cropless.

4.1.3 Current Fallow

In the study area, fallow land refers to those which are cropless just after the harvest (Photograph 4.3). The total area of fallow land of the study area is 85578 hectors which is 64.53% of the total area. It is seen that current fallow occupies more than half. Though they are shown as fallow land, they play an important role for socio-economic development of this region.

Photograph: 4.3. Current fallow land

Approximately 15406 hectors of current fallow land exist at Porsha which is 18% (Figure 4.1.4) of the total fallow land.

At Patnitola there remains 23,449 hectors of current fallows, which is 27.40% as the total amount. This area is 61.80% with respect to other land uses of this thana (Table 4.1.2).

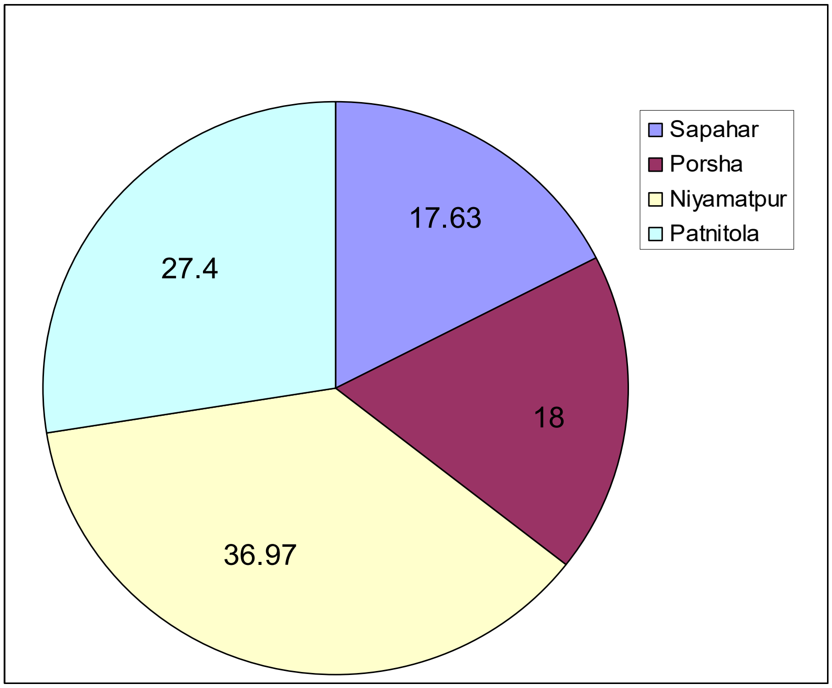


Figure 4.1.4 The distribution of current fallow according to thanas

4.1.4 Marshy land

Some geo physiographical conditions of distinctive features are found in the Barind upland region. The abundance of marshy land is seen in various places due to special characteristics. Specially they are seen on the basin of the Ponorbhoba and Tangoon to the west, on the basin of the Shib in the middle and beels to the south. The total area of marshy land in the study area is 10148 hectors which is 7.65% of the total area. The merits of soil of this region are somewhat different from those of others the magnitude of pH of soil of most of the places is from 4.8 to 5.9, whereas its magnitude is below 4.5.

Though less quantity of water is seen in the Barind region, marshy lands are seen on the basis of places due to geo-physiographical reason. The total area of marshy land is 10148 hectors with respect to land use of 1997 which is 7.65% of the total land use (Table 4.1.1).

Photograph 4.4 Marshy land

In the thana of Sapahar, most of the marshy lands are seen in the union parisad of Aihai and Pathari bordering India. 2404 hectors of marshy lands exist at Sapahar which is 23.69% of the total marshy land.

The maximum marshy lands are seen at Porsha, specially in the western part. The Nitpur union retains extensive marshy lands. Besides some of them are seen in Mosidpur union. Porsha occupies 4256 hectors of marshy land which is 41.94% of the total marshy land (Figure 4.1.5).

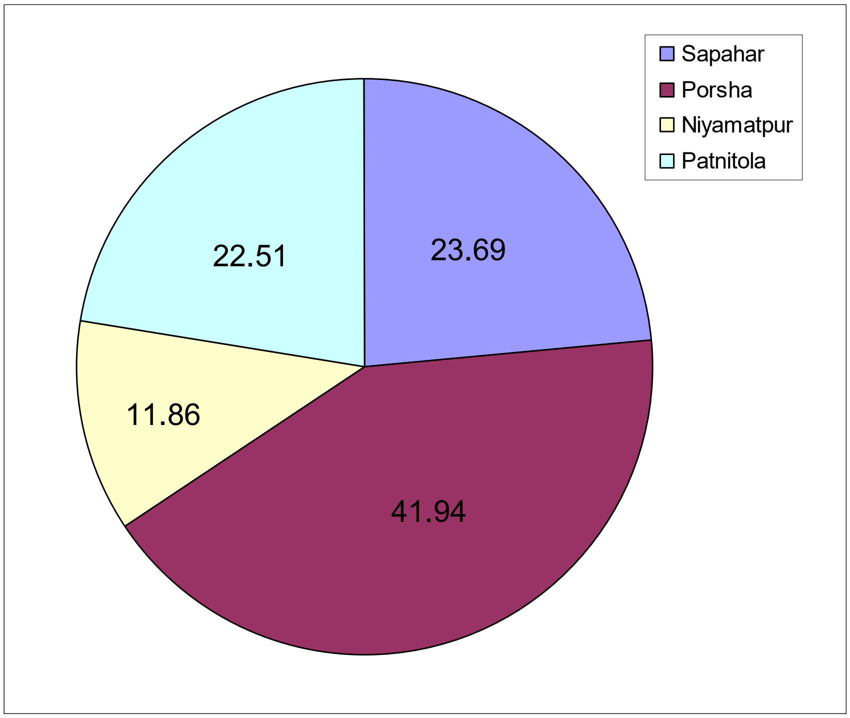


Figure 4.1.5 The distribution of marshy land according to thanas.

The least amount of marshy lands is seen at Niyamatpur. The total area of marshy land in this thana is 1204 hectors which is 11.86% (Figure 4.1.5).

In Patnitola, 2284 hectors of marshy lands exist which is 22.51%. A difference is seen in the distribution of the marshy lands. The marshy lands of Akbarpur and Matindhar are located to low land of the basin of the Shib.

4.1.5 Surface water

There are various sources of surface water includes various types of rivers, ponds, beels which are regarded as the sources of surface water (Photograph 4.5).

The total area of surface water is 1832 hectares which is 1.38% of the total area (Table 4.11).

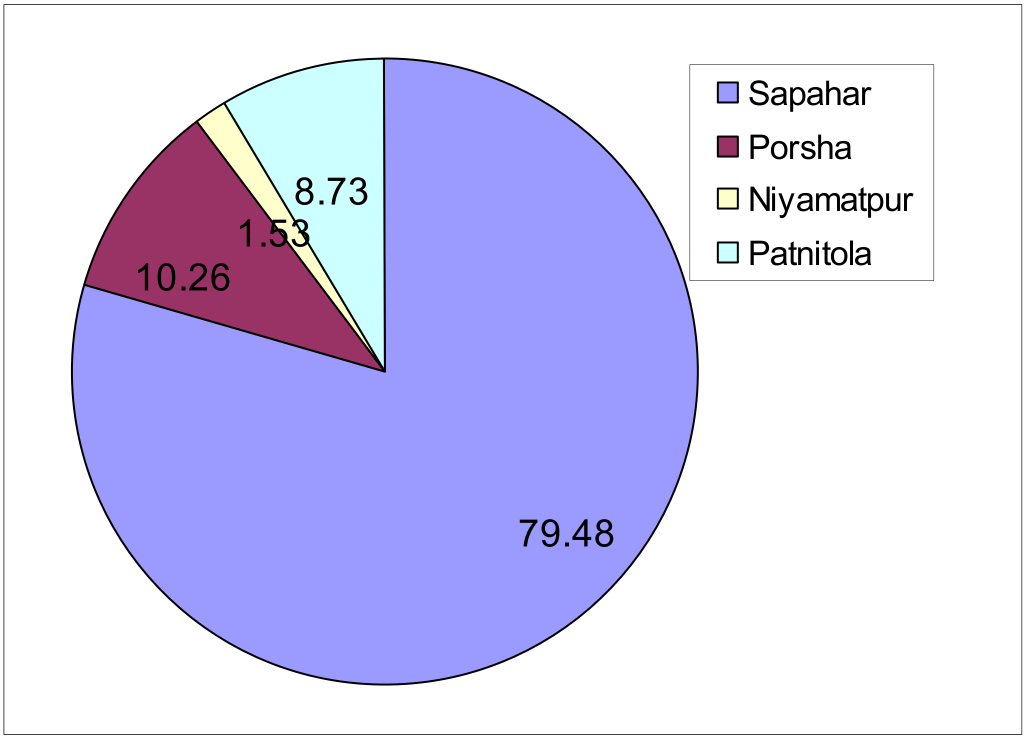


Figure 4.1.6 The distribution of surface water according to thanas

Photograph 4.5 Surface water

The main source of surface water is beel region of the basin of the Ponorbhoba and Tangoon to the west-northern border. The biggest one is Jobai beel of this region covers 996.24 acres (Approximately). This surface water contributes a lot to the economic development of this region the stored water is used for irrigation.

The area of surface water is more at Sapahar occupies 1456 hectors of land as 79.48% of the surface water under Sapahar (Figure 4.1.6). Most of the marshy lands are located at the union Parisad of Aihai, Pathari and Goala. These marshy lands are known to be “Jobai beel” and “Maheel beel”.

The surface water is scarcely seen at the thana of Porsha. The surface of 188 hectors area is located at the south of Nitpur union. The small amount of surface water are seen in the thana of Niyamatpur. Only 28 hectors of land makes 1.53% (Figure 4.1.6) of the surface water is seen in this thana.

A big marshy land is found in Attrai and a river flows over Patnitola this river as the source of surface water in this thana. Big ponds are also used as the source of water. The name of Dibor Dighi is worth mentioning as the source of surface water. About 160 hectors of land makes 8.73% (Figure 4.1.6) of the surface water in this thana.

4.1.6 Forest

There are three types of forest such as natural, social and planted forest. From this viewpoint, most of the forests of the study area are of social and planted type natural forest doesn’t come into sight in this region. So forests of this area are of plantation type (Photograph 4.6).

In Landsat TM FCC image, the forests rough tone. So by noticing at this tone, it is possible to separate forest from the surface water.

The forest of the Barind region is 2% which is very less in comparison with average quantity. The total area of forest in 1997 is 1636 hectors, that is 1.23% of the total area (Table 4.1.1).

Photograph 4.6 Forest

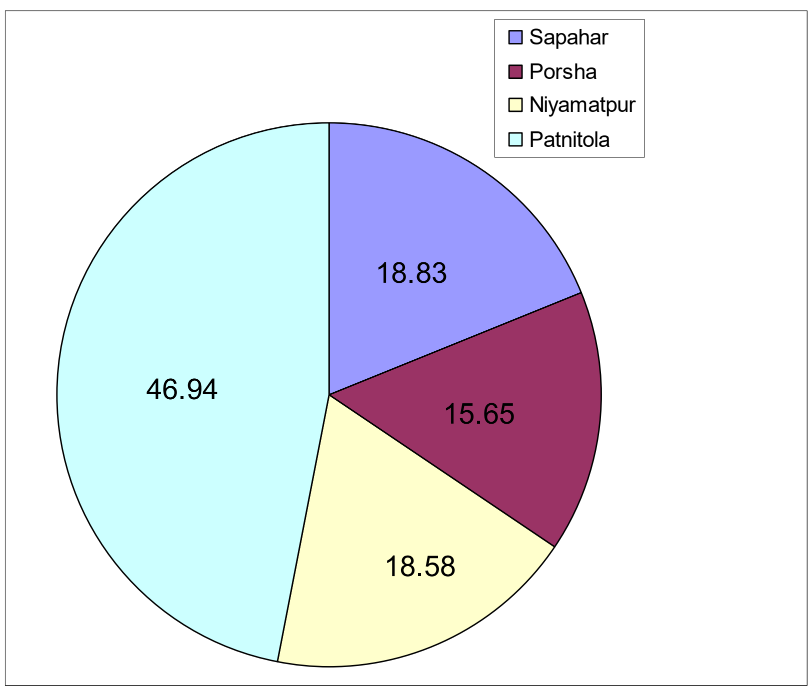


Figure 4.1.7 The distribution of forest according to thanas

The forests of this region are in the Sporadic way. Most of the individual forests are below 50 hectors.

In the study area the littleness of forest is easy to notice. It has been mentioned before that the forests of this region are planted. So the sporadic distribution of these forests is easily manifested. The total area of forest at Sapahar is about 308 hectors which is 18.83% of the total forest (Figure 4.1.7). Most of the forests of this thana are located at Shironti and Tilna union parisad. In Sapahar Sadar forests are seen as well.

The forests of Porsha are located to the north of Ghatnagar and Mosidpur union Parisad and also at Nitpur union parisad. The total area of forest at this thana is about 256 hectors, which is 15.65% of the total forest (Figure 4.1.7)

At Niyamatpur, 304 hectors of forest exist as the 18.58% (Figure 4.1.7). In this thana more forests are seen to the east and middle than to the west. Most forests are seen at the thana of Patnitola. These forests are not equally seen every where. More forests are seen in Nirmoil, Shihara, Krishnapur and Patichora union parisad of this thana. The total area of forest of this thana is about 768 hectors (Table 4.1.2).

4.1.7 Uncovered soil

The lands that are unused and uncovered are marked as uncovered soil. As the humidity of soil of this region is less, soil remains dry and causes higher reflectance. So, it is possible to identify them easily in Landsat TM FCC image.

The total area of uncovered soil of the study area is 1264 hectors which is 0.95% (Table 4.1.1) of the total area. The uncovered soil of the basin of Attrai are found more in the west and middle part of the study.

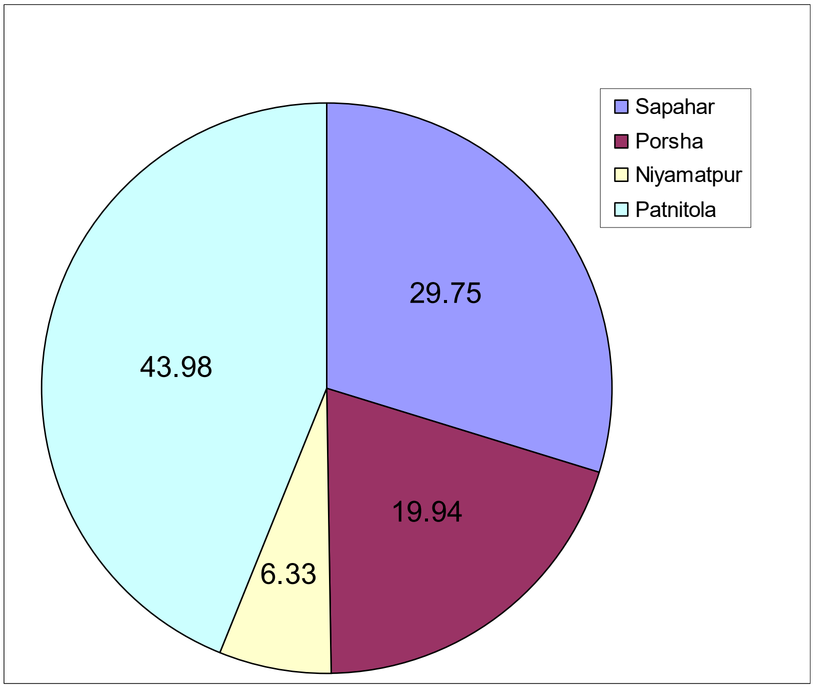


Figure 4.1.8. The distribution of uncovered soil according to thanas

The difference is seen in the distribution of uncovered soil spread over the whole region. Uncovered soil is seen in the basin of the Attrai, Krishnapur union, Patnitola Sadar, Niyamatpur thana Sadar, Nitpur and Ghatnagar union parisad of Porsha and Pathari union parisad of Sapahar.

4.2 The land use pattern 2006

Land use

Land use indicates proper utilization of land. The total economic development of any country considerably depends on land use. There are various types of land uses. The major change of land use that we find is the rapid urbanization, the remote rural places of twenty or thirty years back are gradually being transformed to urban area. Land use is also considered with the types of utilization that is seen over land in a particular period of time.

Land sat TM FCC (Band 3, 4, 5) Satellite image has been used in the identification of land use of 2006.

Satellite image of Barind region has been collected for the month of December of 1997. Various methods have been adopted for the analysis of the image. First, the land use scheme has been prepared for the identification of land use. The landuse of the Barind is somewhat different from the others regions. So land use scheme has been prepared to comply with the land use of this region.

The study area consists of four administrative thanas. There are 30 union parisad in the region, whose total area is 1326.26 square kilometers (132626 hectors). The map scale used image is 1:100000 and spatial resolution is 30 meters. Though the resolution is higher, it has been possible to identify landuse properly through the combination of various synoptic observations. In case of image analysis the identification of land use, the color, feature tonal variation, shape, volume, style, brightness, location etc. have been considered.

Table 4.2.1

The landuse Landsat TM FCC (Band 3, 4, 5) of 2006 of the study area

Land use	Area (Hector)	Area (%)
Settlement	21460	16.18
Cropland	14416	10.87
Current fallow	82202	61.98
Marshy land	9672	7.29
Surface water	1096	0.84
Forest	2424	1.83
Uncovered soil	1356	1.01
Total	132626	100.00

Source: Landsat TM image-2006.

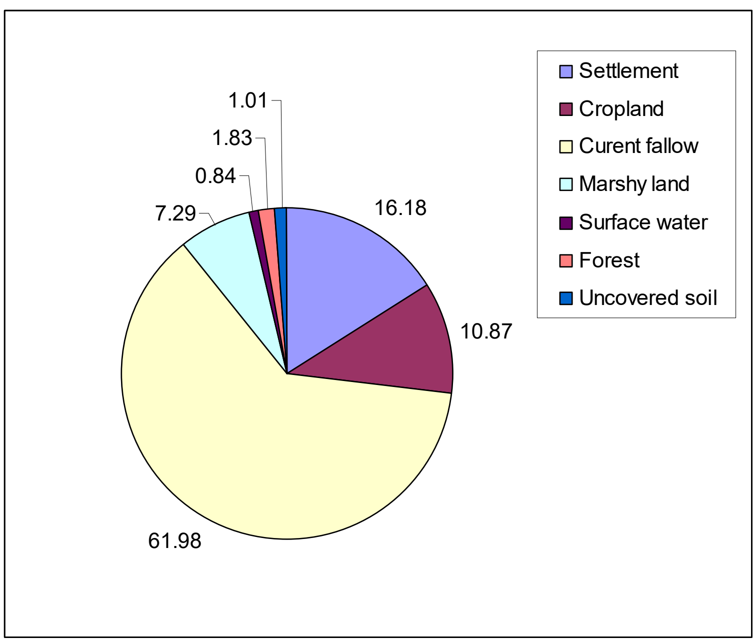


Figure 4.2.1 The land use of 2006 of the study area

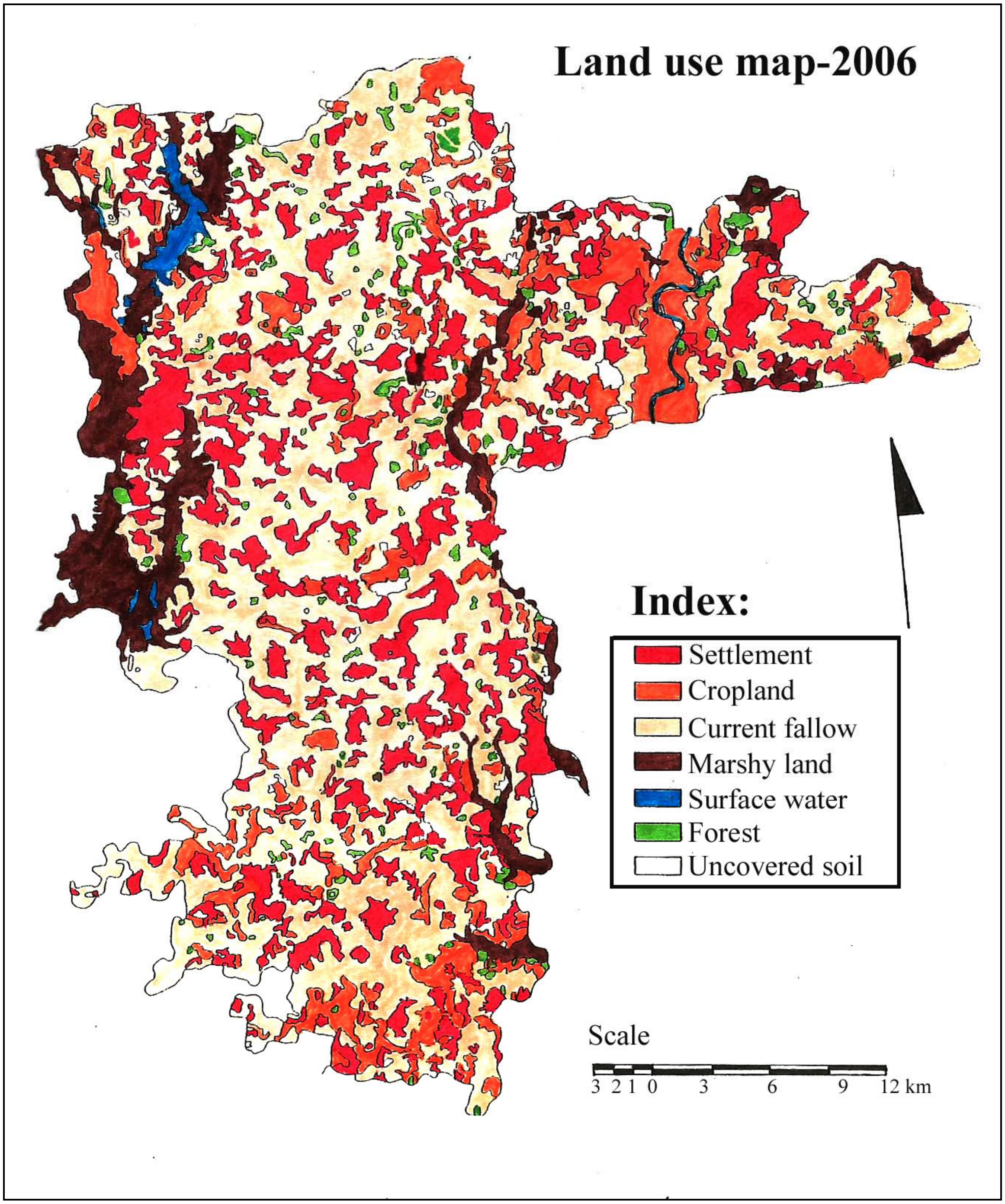


Figure 4.2.1 (a) The land use map of 2006 of the study areas

Table 4.2.2

The Thana based land use of 2006

(Landsat TM FCC)

Thana / Land use	Sapahar		Porsha		Niyamatpur		Patnitola	
	Area (Hector)	Area (%)	Area (Hector)	Area (%)	Area (Hector)	Area (%)	Area (Hector)	Area (%)
Settlement	3492	14.28	4592	18.14	7276	16.19	6100	16.08
Cropland	1952	7.98	556	2.20	4896	10.90	7012	18.48
Current fallow	15368	62.83	14870	58.78	30763	68.47	21201	55.87
Marshy land	1992	8.14	4572	18.08	1296	2.88	1812	4.78
Surface water	792	3.24	92	0.36	32	0.07	180	0.48
Forest	504	2.06	392	1.55	564	1.26	964	2.54
Uncovered soil	360	1.47	220	0.87	104	0.23	672	1.77
Total	24,460	100.00	25,294	100.00	44,931	100.00	37,941	100.00

Source: Landsat TM Image 2006

The land use of 2006 has been shown in (Figure 4.2.1) land use has been divided into seven parts for this proper identification and change evaluation. They are described below-

4.2.1 Settlement

Various kinds of settlements are seen in the Barind upland area. In Sadar thana some urban settlements are seen, but most of them are rural. As the resolution of satellite image is coarse, the classification of settlement has not been possible. In Landsat TM FCC (Band 3, 4, 5) image settlements are seen to be gray to deep-gray and sometimes reddish gray. Though the difference of color is seen, they have been marked to see their shape and location. As the rural settlements are found to be mixed with social forests, they often come in combination and not clear separation

According to Landsat TM FCC (Band 3, 4, 5) image the total area of settlement of the Barind upland region is almost 21460 hectors (Table 4.2.1) which is about 16.18% of total area.

Most of the lands of the Barind region are high and fit for settlement. But the distribution of settlement is not equally noticed everywhere. Settlement is less on the bank of the river Attrai due to crops cultivation. More settlement is seen in the middle part. More disparity is seen in thana-based settlement distribution (Table 4.2.2). More settlements are seen in Niyamatpur and less in Sapahar.

A few settlements are seen in Pathari and Aihai union where comparatively more settlements are seen to the south eastern part of Shironti union parisad, to the south eastern part of Goala union parisad in north Sapahar and the whole Tilna union parisad the area of settlement of Sapahar is almost 3492 hectors which is 16.27% of the total area.

Special characteristics are manifested in disposition of settlement at the thana of Porsha. Their area is also the biggest. The north-eastern part of Nitpur union adjacent to Sapahar are Bishupur, Chalk Bishupur, Colaibari and Srikrishno includes a vast settlement. The south western part of Nitpur is almost without settlement. Besides, some distribution of settlement is seen in other region of this thana and covers 4592 hectors by settlement as 21.40% of the total settlement (Figure 4.2.2).

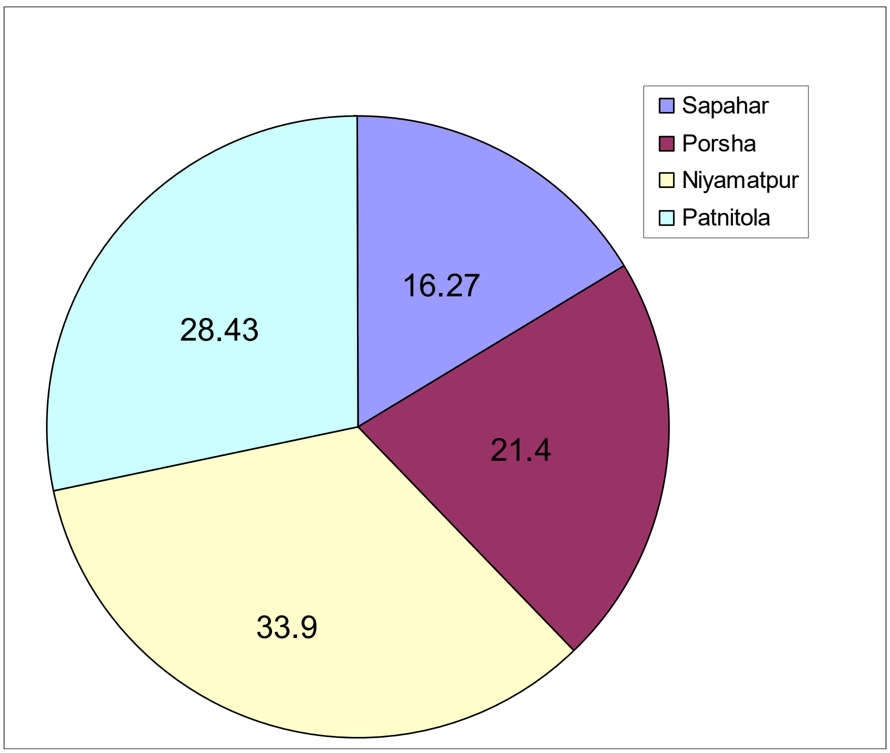


Figure 4.2.2 The distribution of settlement according to thanas

Most of the settlements of Niyamatpur are very small. But the biggest settlement is seen in Chandannagar and Bhabicha union parisad. Overall less settlements are seen on the western part than on the eastern part. There exists almost 7276 hectors of settlement which is 33.90% of the total settlement (Figure 4.2.2).

In the thana of Patnitola less settlements are seen, particularly in Nirmoil union and on the bank of the Attrai near the border of India. The biggest settlements are seen in the union parisad of Matindhar, Patnitola, Patichora and Ghosnagar. The total area of settlement of Patnitola is 6100 hectors which is 28.43% of the total area.

The density of the population can be shown in two ways; the people living in per unit area according to total area and the people living in per central settlement. The idea about the closeness of people in settlement is clearly found. This closeness of settlement has been shown as density of settlement. The difference of this settlement is found on the basis of thana. The settlement density found was more in Sapahar and the less settlement in Porsha.

Table 4.2.3

The density of settlement of 2006

Name of Thana	Population ** (2006)	Total settlement (Hector)	Density* (per hector)
Sapahar	127435	3492	36.49
Porsha	103875	4592	22.62
Niyamatpur	209575	7276	28.80
Patnitola	215962	6100	35.40

* The people living in per hector settlement area
* * The determined people of 2006 from normal growth rate (Approved)

4.2.2 Crop land

Landsat TM FCC has been used to show the use of the Barind upland region. The difference of color is seen in image as a result of difference of crops. The crops contain light red and reddish gray color. All the crops have been marked as cropland not to show them individually. The problems that have risen in marking the crop field have also been removed through direct survey (ground verification data). The Robi crop is not fit for cultivation in the study area as a result of ineffectiveness of weather and merit of soil. The scattered cropland is easily noticeable as the time of taking satellite image was in Robi season.

The quantity of total cropland of the study area is 14,416 hector which is only 10.87% of the total area (Table 4.2.1). A difference is seen in the distribution of these croplands. More croplands exist in the basin of the

Tangoon and the Ponorbhoba on the west in the basin of the Shib and the Attrai in the middle and in beel region of the south.

This difference is more apparent in thana based cropland distribution. It is more at Patnitola 48.64% and less at Porsha 3.86% which is clearly noticed. Almost 1952 hectors of croplands exist at Sapahar which is 13.54% of the total croplands. Most of the crop lands of this thana are located at Pathari, Sapahar and Tilna union. The irrigation system of the croplands is also located near small marshes.

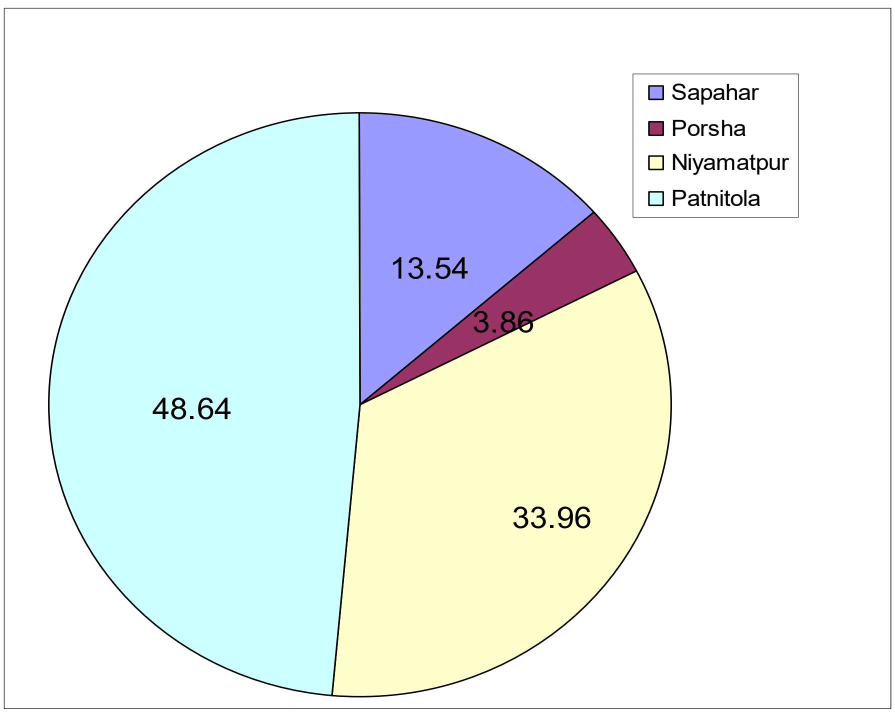


Figure 4.2.3 The distribution of crop land according to thanas.

The lesser distribution of croplands at Porsha is noticeable. Most of the croplands of Porsha are located at Mosidpur and Ghatnagar union. In comparison with other thanas, the distribution of cropland at Niyamatpur thana is well. But abundance is noticeable on the Southern part rather than on eastern part. More croplands are seen at Bahadurpur, Parail and Rasulpur union.

In the study area, more crop lands were found in Patnitola thana. The water of the river of the Attrai and Shib is helpful to this extensive cropland. About 7012 hectors, i.e., 48.64% of the total cropland exists in this thana. Less croplands are seen at Nirmoil and Ghosnagar union.

4.2.3 Current fallow

The current fallow land can easily be identified by analyzing Landsat TM FCC. More than half of land area of the study area is under fallow category.

Totally 82202 hectors of fallow land exist in the study area which is 61.98% of the study area. It is seen that more in the western part of the study area has been occupied by current fallow. Actually the current fallow lands are agricultural. Here agricultural lands have been divided into both cropland and current fallow land. Difference of current fallow land on the basis of thana is seen. The least fallow land is seen at Porsha 18.09% and the maximum fallow land is seen at 37.42% Niyamatpur (Figure 4.2.4)

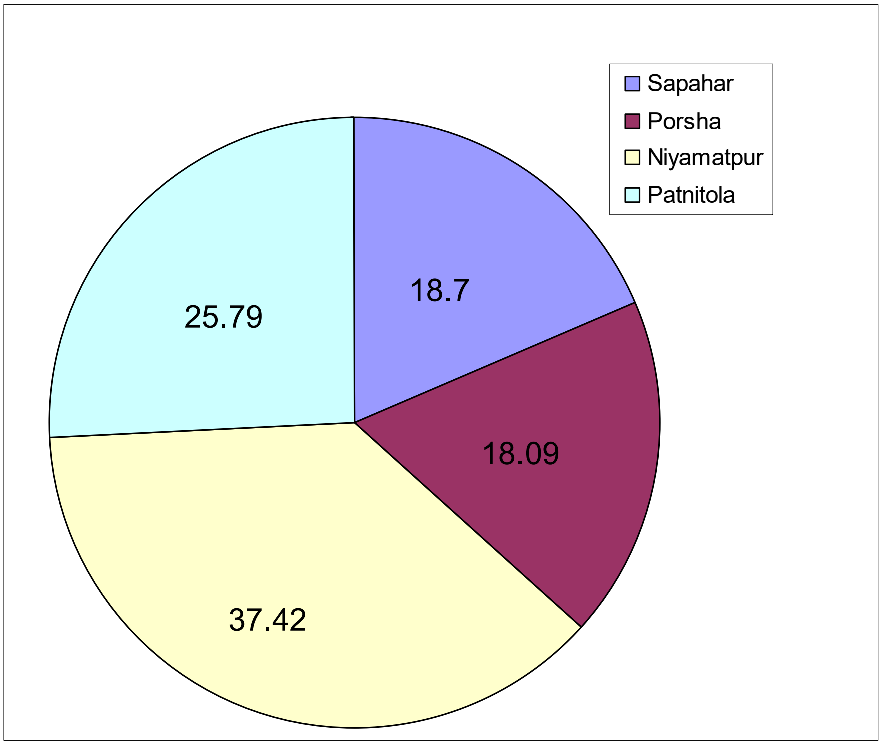


Figure 4.2.4 The distribution of current fallow land according to thanas

15,368 hectors of fallow land exists at Sapahar which is 18.70% of fallow land and 62.13% current fallow land exists at Sapahar with respect to other land uses (Table 4.2.2). As there is plenty of marshy land at Aihai and Pathari union parisad, the amount of area of fallow land is very less in these areas. Comparatively less fallow lands are seen at Tilna union Parisad.

There are almost 14870 hectors of fallow land at the thana of Porsha which is 18.09% of total land (Figure 4.2.4). There are 58.78% of fallow land in this region with respect to other land use (Table 4.2.2). Less fallow land is seen on the western part of this thana. At Nitpur union parisad, this type of land is very less in this region.

The Niyamatpur is the biggest thana in this research. Here about 30,763 hectors of current fallow lands exist as 37.42% (Figure 4.2.4). About 68.47% of land of total land use belongs to this type in this thana (Table 4.2.2). More fallow lands exist at Rasulpur and Hajinagar Union. In Patnitola there is almost 21201 hectors of fallow land which is 25.79% in Nirmoil union of this thana. Less fallow lands are seen at Krishnapur, Patichora and Nazipur Union Parisad.

4.2.4 Marshy land

Though the study area is the Barind upland is not high every where, there are low lands within the available high lands. The humidity and muddiness that have been created as a result of the stored water in these low lands are marked as marshy land. The stored water of these lands is shallow and most often the soil remain humid.

A greater disparity is seen in the distribution of these marshy lands. Only these marshy lands exist in some specific places of distinctive features. These marshy lands are seen in the basin of the Ponorbhoba and Tangoon bordering India and the river Shib in the middle, the beel region of Manda and Mohadevpur to the south and at Dhamoirhat to the east.

The Landsat TM FCC images show the land use of 2006 and give a tone of blue from light blue for the marshy land. But it does not contain the light blue color continuously.

As there are small plants, the marshy lands contain mixed red color. The total area of the marshy land of the study area is about 9672 hectors which is only 7.29% with respect to other land uses (Table 4.2.1).

The research area is to some extent an upland region. Naturally the marshy lands are expected to be very less. But the dominance of marshy land in various places is seen which is a difference in normal understanding for many reasons.

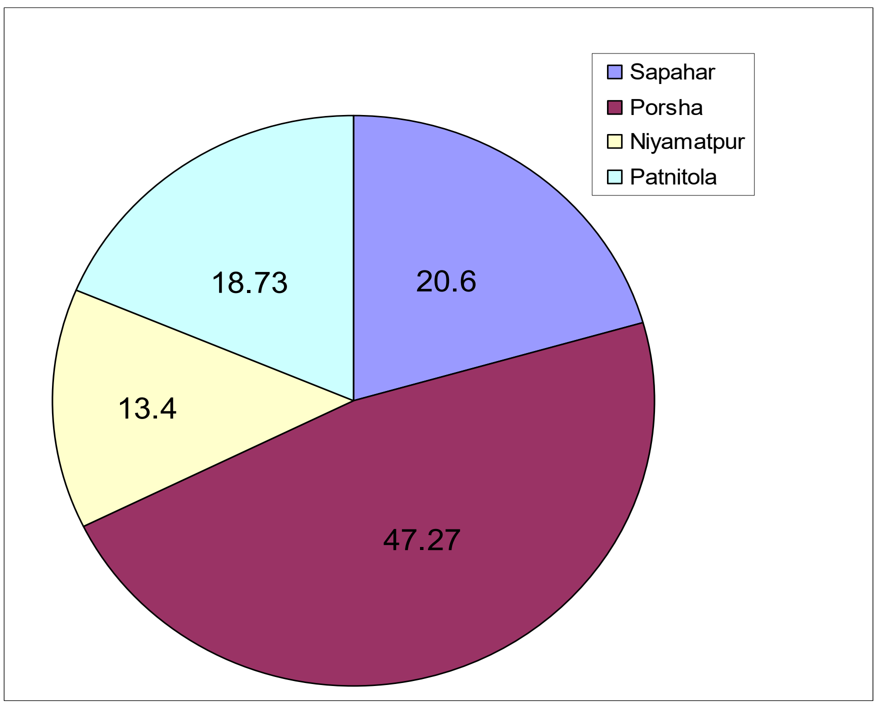


Figure 4.2.5 The distribution of marshy land according to thanas.

According to survey of 2006, the quantity of marshy land at Sapahar is almost 1992 hectors which is 20.60% of the total marshy land. These marshy lands of Sapahar are close to the border line of India.

In the thana based marshy land distribution, it is seen that more marshy lands exist at Porsha. These widespread marshy lands exist due to geo-physiographical condition of distinctive feature in the basin of Ponorbhoba. Besides some marshy lands are seen to the west of Titolia and Choaor union and to the east of Mosidpur union Parisad. In this thana there are 4572 hectors of marshy lands which is 47.27% of the total land.

The least marshy lands are seen in the thana of Niyamatpur on the western part of this thana. The total area of marshy land is 1296 hectors which is 13.40% of the total marshy lands (Figure 4.2.5). There are 1812 hectors of marshy lands at Patnitola which is 18.73% of the total marshy lands (Figure 4.2.5).

4.2.5 Surface water

The Barind upland region is regarded as the driest part of this country. As a result surface water areas are less. Mainly the beel is the source of surface water of this region. Besides, there are a lot of ponds and rivers many of which gets dry during dry summer. It is possible to determine whether the water is deep or shallow by noticing at the characteristics of Landsat TM satellite image, as source of surface water. The shallow marsh becomes visible from light blue to blue and deep marsh becomes black to the dark blue.

But in this study marshy lands are single category. Here one thing is note-worthy that due to the limitation of image scale many small marshes have not been identified as independent entity, rather generalized in the surrounding category of land use. But the bigger ponds have been identified of course.

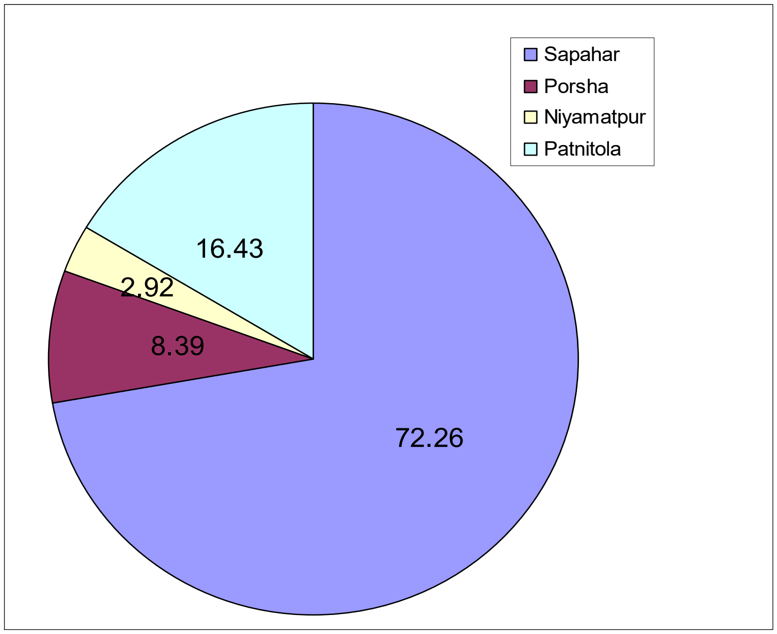


Figure 4.2.6 The distribution of surface water according to thanas.

The total area of surface water is 1096 hectors which is 0.84% (Table 4.2.1) of the total area of study region. The area of surface water is more in Sapahar thana. In 2006 the area of this kind of land is about 792 hectors which is 72.26% of the total surface water.

The quantity of surface water is very little at Porsha. Here they are marshy land to the South of marshy land. There was 92 hectors of marshy in this thana in 1997 which is 8.39% of the total surface water.

The quantity of surface water in the thana of Niyamatpur is the least. There are 32 hectors surface water which is 2.92% of the total marsh.

The source of surface water of Patnitola is the river Attrai. There is a big lake in the union of Dibor. The area of surface water of this region is 180 hectors which is 16.43% of the total marshy lands.

4.2.6 Forest

The paucity of forest in the Barind region from various reports of desertification is easily imagined. Though there are many kinds of forests, the forest of the study area are planted (photograph 4. 6). Social forests have been unified with settlement land.

The percentage of forest of Bangladesh is 13.36% (according to BBS and DoF) which is only 1.83% in the Barind region.

As of the Landsat TM image shows, the total area of forest of the study area in 2006 was 2424 hectors which is only 1.83% of the study area. The disparity is seen in various thanas of the study area.

About 504 hectors of forests exist at Sapahar. This area is 20.79% of the total area with respect to other land use ratio, the quantity of forest of this thana is 2.06% (Table 4.2.2).

A little area of forests is seen at Porsha. Most of them are located at Nitpur, Ghatnagar and Mosidpur union Parisad. There are 392 hectors of forests which is 16.17% of the total forests at Porsha. The quantity of forest with respect to other land uses is 1.55%.

Most of the forest of Niyamatpur thana are located in the middle and eastern part. The western part attached to Nachole contains less forests. The total forest of Niyamatpur is 564 hectors which is 23.27% of total forest. The forests of Patnitola are more in the study area. There are 964 hectors of forests in this thana which is 39.77% of the total forests. It is 2.54% with respect to other land use. Though this quantity is more in comparison with other thanas, it is the least 13.36% comparing with that of national data of forest.

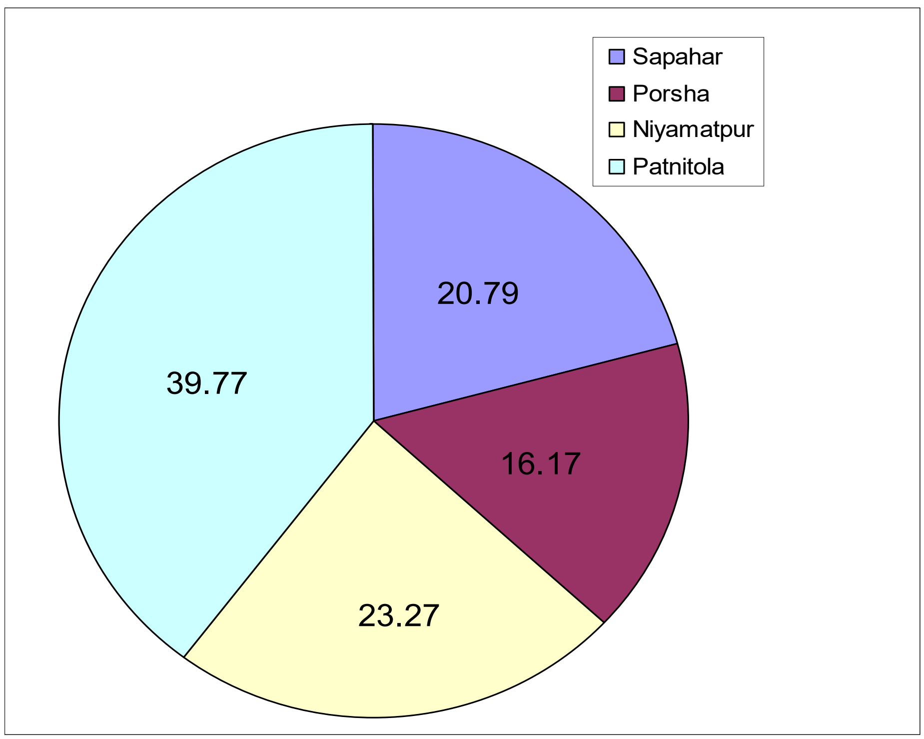


Figure 4.2.7 The distribution of forest according to thanas

4.2.7 Uncovered soil

The uncovered soil comes as bright grayish to whitish in Landsat TM FCC due to higher reflectance. There remains humidity in the soil of uncovered land region. These kinds of soils are mainly unused land.

There are 1356 hectors of uncovered soil in the study area. This amount is only 1.01% of the total land use (Table 4.2.1). The difference of the amount of uncovered soil in various thanas is noticeable.

There remains 360 hectors of uncovered soil in the thana of Sapahar which is 26.55% (Figure 4.2.8) of the total uncovered soil. Its degree is only 1.47% with respect to other land uses. The uncovered soil is seen in the union parisad of Pathari and Goala of this thana.

There remains 220 hectors of uncovered soil which is 16.22% (Figure 4.2.8) of the total soil of Porsha. This type of soil is seen at Nitpur and Ghatnagar of this thana.

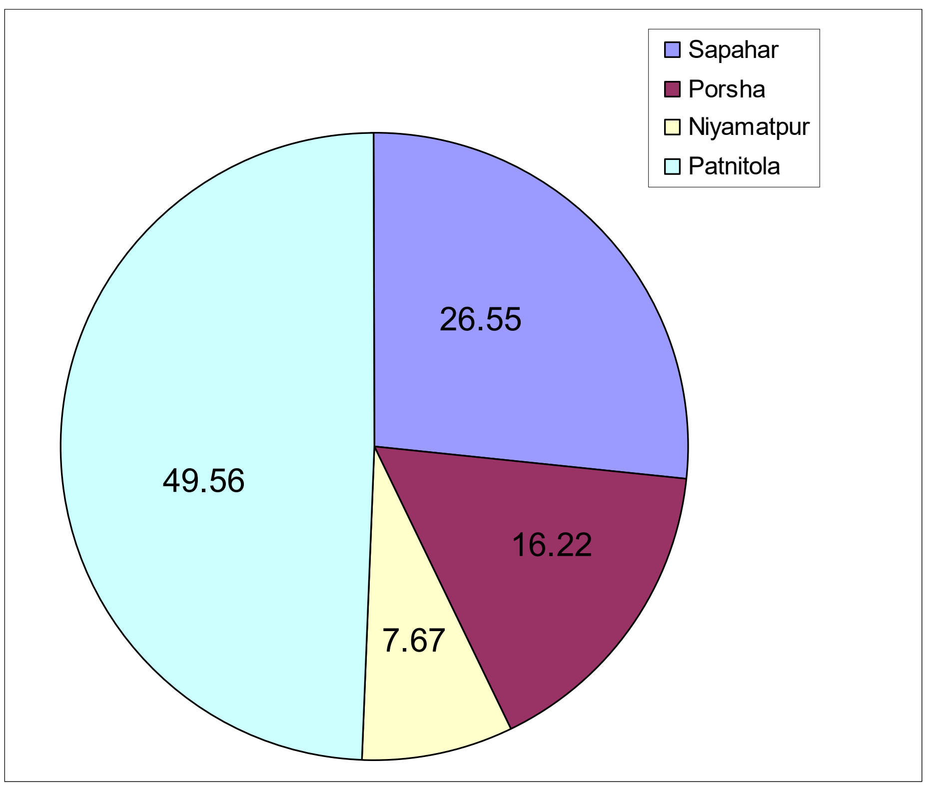


Figure 4.2.8 The distribution of uncovered soil according to thanas.

The uncovered soil is least in this area which is 104 hectors at the thana of Niyamatpur. This quantity is only 7.67% (Figure 4.2.8) of total uncovered soil and only 0.23% (Table 4.2.2) in proportion to other land use. Uncovered soil is also seen at Niyamatpur Sadar and Bahadurpur union parisad.

A half 49.56% (Figure 4.2.8) of the total uncovered soil exists at Patnitola. The area of uncovered soil is about 672 hectors in this thana. This type of soil is seen at Patnitola Sadar and Krishnapur union parisad. The main sources of uncovered soil of the thana of Patnitola is the charlands of the Attrai.

CHAPTER-5

LAND USE CHANGE

5.1 Land use change

Land use is changed due to many surrounding reasons. Among them climate, economy and population are note-worthy. Land use change is inter-related. If one land use increases, other kinds of land use changes. To display the land use change of the Barind up land region, Landsat TM FCC image of 1997 and 2006 have been used. A bigger change of soil is clearly manifested over these ten years (Figure 4.1.1 and 4.2.1). Previously, the Barind region was under-developed and neglected. For this reason in 1979-83, Barind project was found necessary for the all-out development of the region. Subsequently, Barind Multipurpose Development Authority has changed the land use of this region considerably. As a result the economic development of this region gets acceleration which plays a vital role in changing other land use as well.

Table 5.1

The land use change of the Barind upland region (1997-2006)

(Four selected thanas)

Land use	1997		2006		1997-2006
	Area (Hector)	Percent (%)	Area (Hector)	Percent (%)	Change (%)
Settlement	20216	15.24	21460	16.18	+6.15
Cropland	11952	9.02	14416	10.87	+20.62
Current fallow	85578	64.53	82202	61.98	-3.94
Marshy land	10148	7.65	9672	7.29	-4.69
Surface water	1832	1.38	1096	0.84	-40.17
Forest	1636	1.23	2424	1.83	+48.17
Uncovered soil	1264	0.95	1356	1.01	+ 7.28
Total	132626	100.00	132626	100.00	

Source: Land sat TM Image- 1997 and 2006.

During 1997-2006, widespread land use change occurred in four selected thanas. This land use has been shown in seven parts.

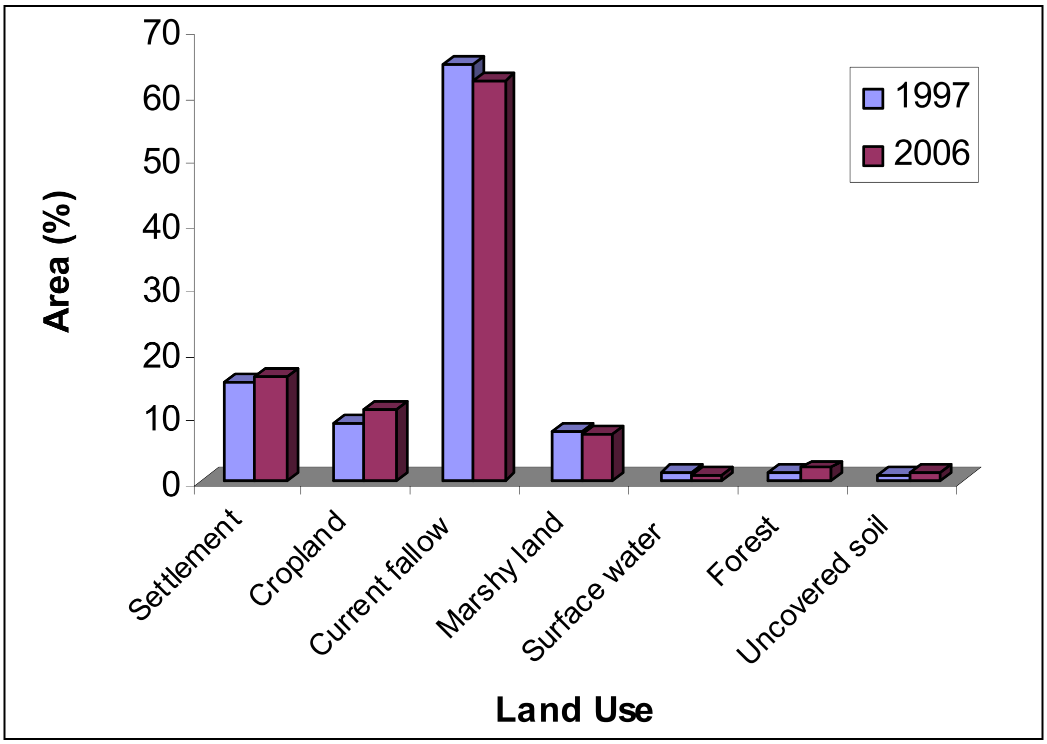


Figure 5.1 Land use change (1997-2006)

5.1.1. The change of settlement

In the study area, the change of settlement is clearly visible in 1997. The area of settlement was 20216 hectors and it has reached 21460 hectors in 2006 which was 15.24% and 16.18% respectively. About 1244 hectors of settlement increased in this region. The growth is manifested as 6.15% (Table 5.1). This growth is more in the thana of Porsha 7.89% (Table 5.2).

The growth of settlement is not same everywhere and economic development accelerates the development of settlement. But the settlement doesn't increase every-where. In some cases, settlement decreases due to surrounding adversity. The thana based change of settlement is given below.

Table 5.2

The change of settlement on the basis of thanas (1997-2006)

Name of Thana	1997		2006		1997-2006
	Area (Hector)	Percent (%)	Area (Hector)	Percent (%)	Change (%)
Sapahar	3376	13.80	3492	14.28	+ 3.44
Porsha	4256	16.83	4592	18.14	+ 7.89
Niyamatpur	6880	15.31	7276	16.19	+ 5.76
Patnitola	5704	15.03	6100	16.08	+ 6.94

Source: The Percentage of settlement in ratio to the land uses of thana (Table 4.1.2 and 4.2.2)

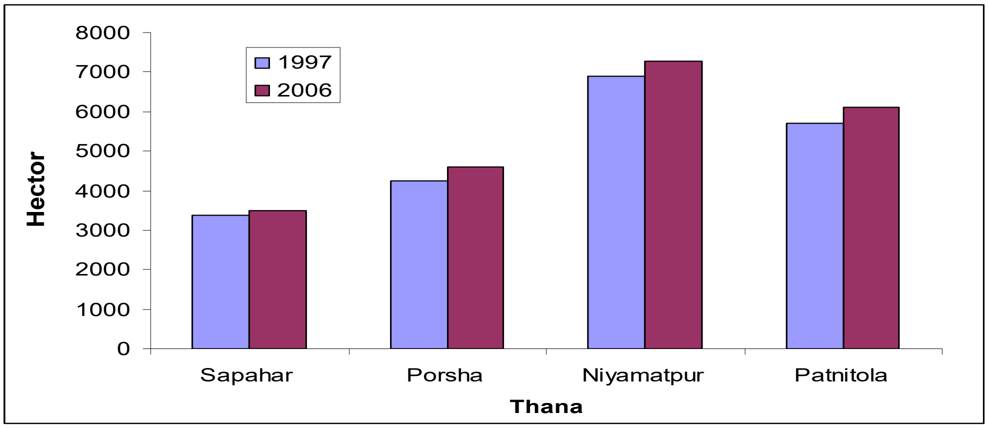


Figure 5.2 Change of settlement on the basis of thanas (1997-2006)

At Sapahar the settlement was 3376 hectors in 1997 and became 3492 hectors in 2006. In these 10 years, about 116 hectors of settlement have gone up. This growth has been made as 3.44% in this thana. This change is very less with respect to other thanas. At the Sadar union parisad of Sapahar, this growth is more. Besides, the growth of settlement is also noticed at the Aihai and Tilna union Parisad (Figure-5.1).

The settlement of Porsha increases by 7.89% where there were about 4256 hectors of settlement as 16.83% in 1997 it has reached 4592 hectors as 18.14% in 2006 (Table 5.2). The growth of settlement is more in this thana. It has increased more at Nitpur union Parisad. Besides, this change is noticeable at union of Titolia and Gangoria.

The biggest thana of the study area is Niyamatpur. In 1997 this area settlement occupied 6880 hectors and it has reached 7276 hectors. The rate of this growth is 5.76%. The settlement has increased in the union of Chandannagar.

This growth is also manifested at Niyamatpur Sadar and Bhabicha. This change is not seen to the west of this thana.

The growth of settlement at Patnitola is clear. In this thana the area of settlement was 5704 hectors in 1997 and it has reached about 6100 hectors by increasing 396 hectors. It has increased by 6.94% (Table 5.2). The settlement has increased at Nirmoil and Shiharaunion and decreased at Akbarpur and Matindhar union.

5.1.2 The change of crop land

In the study area, there were 11952 hectors of croplands 9.02% in 1997 and it has increased to 14416 hectors in 2006. During that time the area of cropland was 10.87% of the total land use. From 1997 to 2006 the growth of cropland is 20.62% (Table 5.1). But this growth is not same everywhere.

Table 5.3

The change of cropland according to thanas. (1997-2006)

Name of Thana	1997		2006		1997-2006
	Area (Hector)	Percent (%)	Area (Hector)	Percent (%)	Change (%)
Sapahar	1456	5.95	1952	7.98	+ 34.07
Porsha	680	2.69	556	2.20	- 18.24
Niyamatpur	4796	10.67	4896	10.90	+ 2.09
Patnitola	5020	13.23	7012	18.48	+ 39.68

Source: The Percentage of cropland in ratio to the land uses of thana (Table 4.1.2 and 4.2.2)

At Sapahar, the area of vegetation in 1997 was 1456 hectors. This was 5.95% of the total land use, whereas, it has reached about 1952 hectors with an increase of 7.98% in 2006. Here the amount of the growth of cropland was 34.07% (Table 5.3). This growth is noticeable at Pathari union and Sapahar Sadar union whereas it has come down at Tilna union. At Aihai union, the cultivation of crop was not seen in 1997, but it is seen in 2006 to some extent.

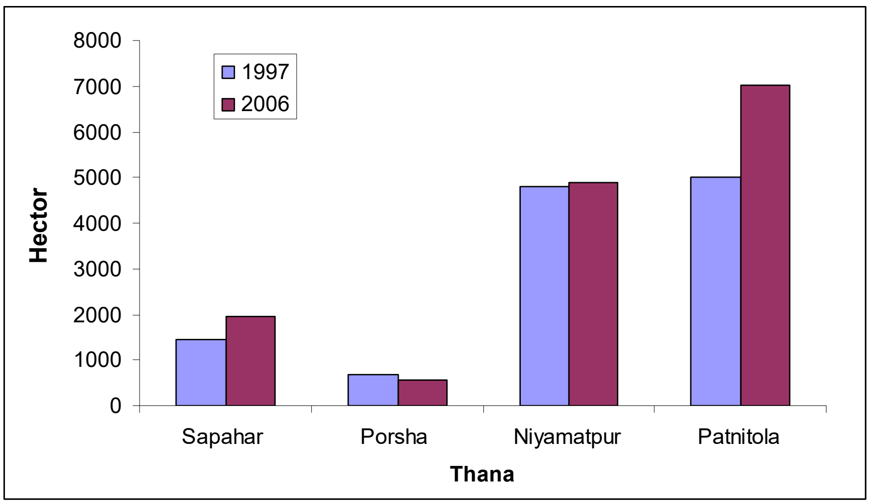


Figure 5.3 The change of cropland according to thanas (1997-2006).

The area of cropland is very less at Porsha in the study area. There were about 680 hectors of cropland in this thana in 1997. But it has decreased to about 556 hectors in 2006. This area is 2.20% with respect to other landless. The quantity of reduction of cropland is 18.24% (Table 5.3). Crop is cultivated at Mosidpur union to the east of this thana. A lot of crop lands are seen at Niyamatpur. In 1997 it was about 4796 hectors which has increased to about 4896 hectors. The growth rate of cropland is 2.09% (Table 5.3). At this thana, more croplands are seen at Rasulpur union.

In the study area, most croplands exist at Patnitola and its change is also widespread. It was 5020 hectors in 1997 which has increased to 7012 hectors. This time this quantity is 18.48% with respect to other land uses and it growth rate is about 39.68% (Table 5.3). So it is seen that the growth rate at Patnitola is more. Croplands have increased remarkably at Shihara, Krishnapur and Patnitola Sadar union parisad.

5.1.3 The change of current fallow land

In 1997 the area of current fallow land was about 85578 hectors and it has decreased to 82202 hectors in 2006. The reduction rate of current fallow land is about 3.94% (Table 5.1).

This difference is also seen on the basis of thanas. The current fallow land has increased in Sapahar to a large extent. The cause of it is the reduction of marshy land. There were 15084 hectors of current fallow land in 1997 and 15368 hectors in 2006. During this period the growth rate of this type of land use is about 1.88% (Table 5.4).

At Porsha, current fallow land has decreased. There were 15,406 hectors of current fallow land in 1997 in and 14870 hectors in 2006 at Porsha. During this period, its reduction rate is 3.48% (Table 5.4).

Table 5.4

The change of current fallow land according to thanas (1997-2006).

Name of Thana	1997		2006		1997-2006
	Area (Hector)	Percent (%)	Area (Hector)	Percent (%)	Change (%)
Sapahar	15084	61.67	15368	62.83	+ 1.88
Porsha	15406	60.90	14870	58.78	-3.48
Niyamatpur	31639	70.42	30763	68.47	-2.77
Patnitola	23449	61.80	21201	55.87	-9.59

Source: The Percentage of fallow land in ratio to the land uses of thana (Table 4.1.2 and 4.2.2)

There were about 31,639 hectors and about 30,763 hectors of current fallow land in 1997 and 2006 respectively at Niyamatpur. During this period, this type of land had decreased by 2.77%.

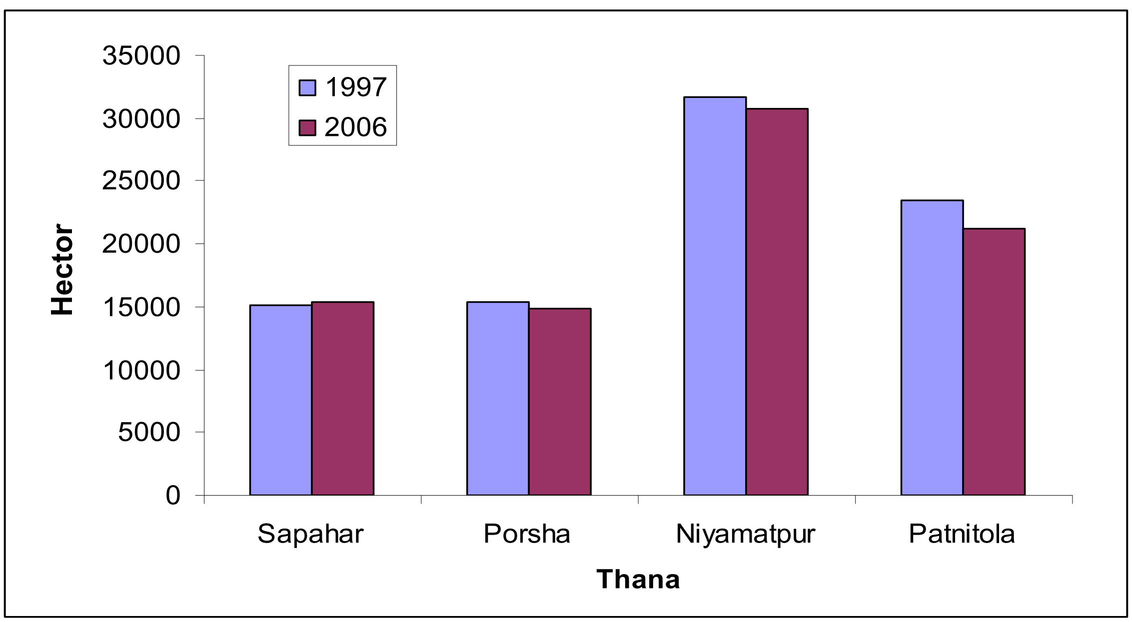


Figure 5.4. The change of current fallow according to thanas (1997-2006)

The current fallow land has decreased at Patnitola crop land and settlements are the main reason of it. There were about 23449 hectors and 21201 hectors of current fallow land in 1997 and 2006 respectively. Its quantity was 61.80% and 55.87% respectively with respect to other land uses. During this period the quantity of reduction of current fallow land of this thana was 9.59% (Table 5.4)

5.1.4 The change of marshy land

According to Landsat TM FCC image, the total area of marshy land of the study area was 10148 hectors in 1997 and it changed to 9672 hectors in 2006 according to Landsat TM FCC. During this period, the reduction rate of marshy land is 4.69% (Table 5.1).

The marshy lands of Sapahar are located at the union of Pathari and Aihai. Its total area was about 2404 hectors in 1997 and became about 1992 hectors in 2006. Here the marshy lands have decreased by 17.14% (Table 5.5). During this period the marshy lands of Pathari union have decreased considerably.

Table 5.5

The change of marshy land according to thanas (1997-2006).

Name of Thana	1997		2006		1997-2006
	Area (Hector)	Percent (%)	Area (Hector)	Percent (%)	Change (%)
Sapahar	2404	9.83	1992	8.14	- 17.14
Porsha	4256	16.83	4572	18.08	+ 7.42
Niyamatpur	1204	2.68	1296	2.88	+ 7.64
Patnitola	2284	6.02	1812	4.78	+ 20.67

Source: The Percentage of marshy land in ratio to the land uses of thana (Table 4.1.2 and 4.2.2)

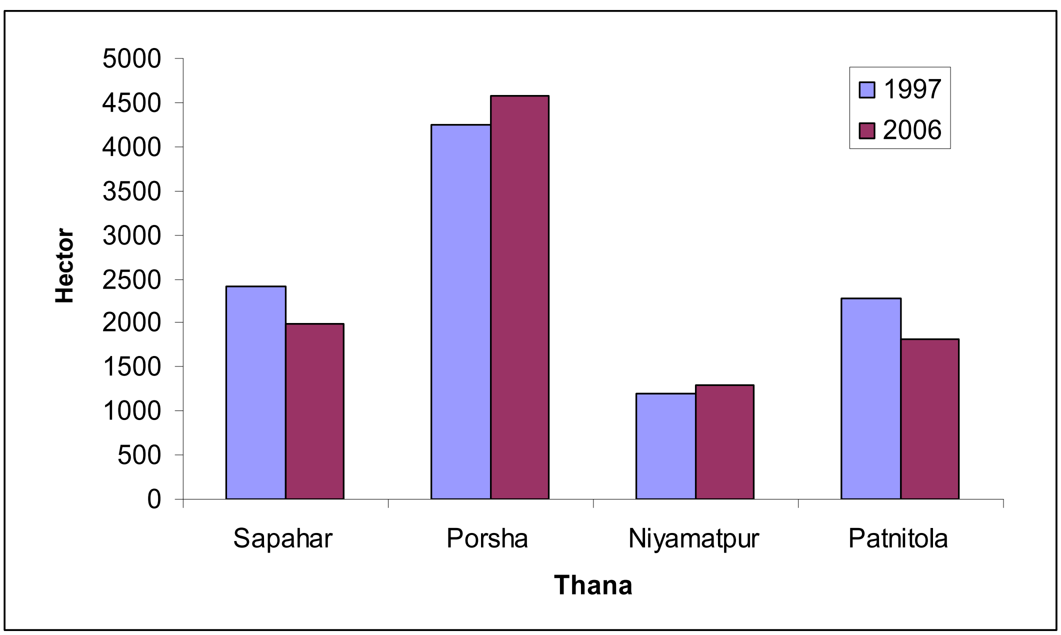


Figure 5.5 The change of marshy land according to thanas (1997-2006)

There are more marshy lands in the thana of Porsha of the study area. The area of marshy land of this thana was about 4256 hectors in 1997 which has increased to 4572 hectors in 2006. This growth rate is 7.42% (Table 5.5). This growth is seen at Nitpur union.

The quantity of marshy land is comparatively less at Niyamatpur. No marshy land is seen to the west of this thana. But they are mainly seen to the east i.e. beside Manda.

The total area of marshy land was about 1204 hectors in 1997 and 1296 hectors in 2006 its growth rate is 7.64% (Table 5.5).

A lot of marshy lands are seen at Patnitola. Here the reduction of marshy land is seen. Its area was about 1812 hectors in 2006 which was about 2284 hectors in 1997. As a result of draught, the marshy lands have been modified into crop land.

5.1.5 The change of surface water

The quantity of surface water has decreased in 1997 in comparison with 2006. The quantity of surface water was about 1832 hectors in 1997 and it decreased to about 1096 hectors in 2006. The quantity of this decrease is about 40.17% (Table 5.1).

More surface water exists at Sapahar. The “Jobai” and “Maheel” beel are the sources of water. The quantity of surface water was about 1456 hectors in 1997 and it decreased to 792 hectors in 2006.The reduction rate of surface water is 45.60% (Table 5.6).

More surface water has decreased at Porsha in 1997. There were 188 hectors of surface water where it became 92 hectors in 2006. The reduction rate of surface water is 51.06% (Table 5.6).

Table 5.6
The change of surface water according to thanas (1997-2006)

Name of Thana	1997		2006		1997-2006
	Area (Hector)	Percent (%)	Area (Hector)	Percent (%)	Change (%)
Sapahar	1456	5.95	792	3.24	-45.60
Porsha	188	0.74	92	6.36	-51.06
Niyamatpur	28	0.06	32	0.07	+ 14.29
Patnitola	160	0.42	180	0.48	+ 12.50

Source: The Percentage of surface water in ratio to the land uses of thana (Table 4.1.2 and 4.2.2)

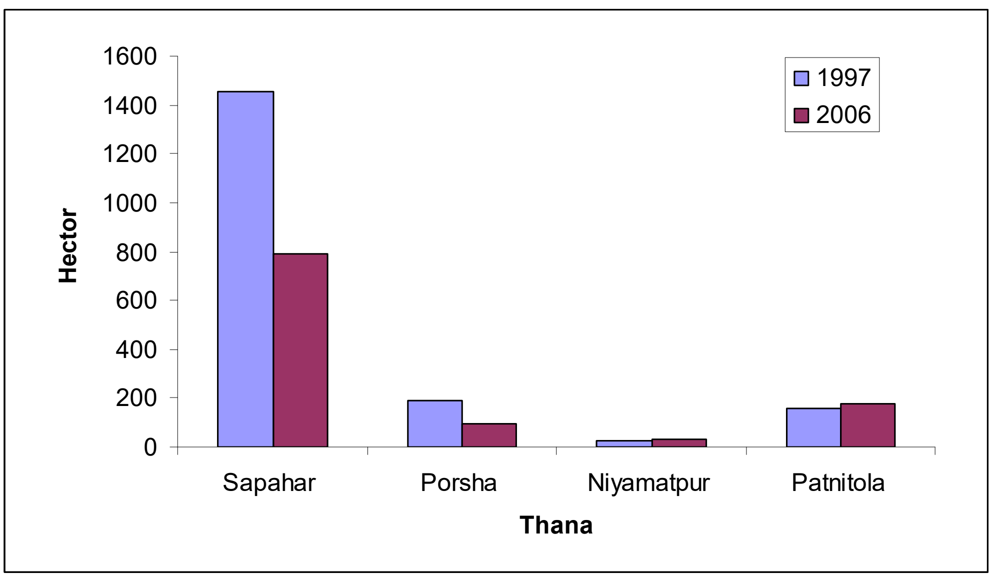


Figure 5.6 The change of surface water according to thanas (1997-2006)

Only source of surface water at Niyamatpur is pond. In 1997 the area of surface water was 28 hectors which become 32 hectors in 2006. This growth rate is 14.29%. The main reason of this growth is “Moja” pond which was difficult to identify.

The area of surface water increased in Patnitola. In 1997, the quantity of surface water at Patnitola was 160 hectors and increased to 180 hectors in 2006. Here the growth rate is 12.50% (Table 5.6). The river Attrai flown over this thana doesn’t show the difference of water.

5.1.6 The change of forest

The most important class of landuse is forest. Forests play an important role in controlling other land uses. This is because the role of forest is active in protecting the balance of environment. For protecting the environment there should be 25% of forests of the total area in any country. Whereas the forest of Bangladesh is 13.36%.

The total area of forest in 1997 was 1636 hectors which is 1.23% with respect to other land uses. It has also increased to 2424 hectors which is 1.83% the growth rate of forest is 48.17% (Table 5.1).

This quantity and change varies from thana to thana. The quantity of forest at Sapahar in 1997 was 308 hectors which increased to 504 hectors in 2006. This amount of change was 2.06% of the total land use. During this period, the growth rate of forest was 63.64% (Table 5.7) which appeared to be a widespread increase of forest at Sapahar, Pathari and Tilna union.

Table 5.7

The change of forest according to thanas (1997-2006).

Name of Thana	1997		2006		1997-2006
	Area (Hector)	Percent (%)	Area (Hector)	Percent (%)	Change (%)
Sapahar	308	1.26	504	2.06	+ 63.64
Porsha	256	1.02	392	1.55	+ 53.13
Niyamatpur	304	0.68	564	1.26	+ 85.53
Patnitola	768	2.02	964	2.54	+ 25.52

Source: The Percentage of forest in ratio to the land uses of thana (Table 4.1.2 and 4.2.2)

The amount of forest is very less at Porsha. Its quantity was about 256 hectors in 1997 which increased to 392 hectors in 2006. This growth rate is 53.13% (Table 5.7).

The quantity of forest is very less at Niyamatpur. Its quantity was 304 hectors as only 0.68% which increased to 564 hectors. This growth rate is about 85.53% (Table 5.7).

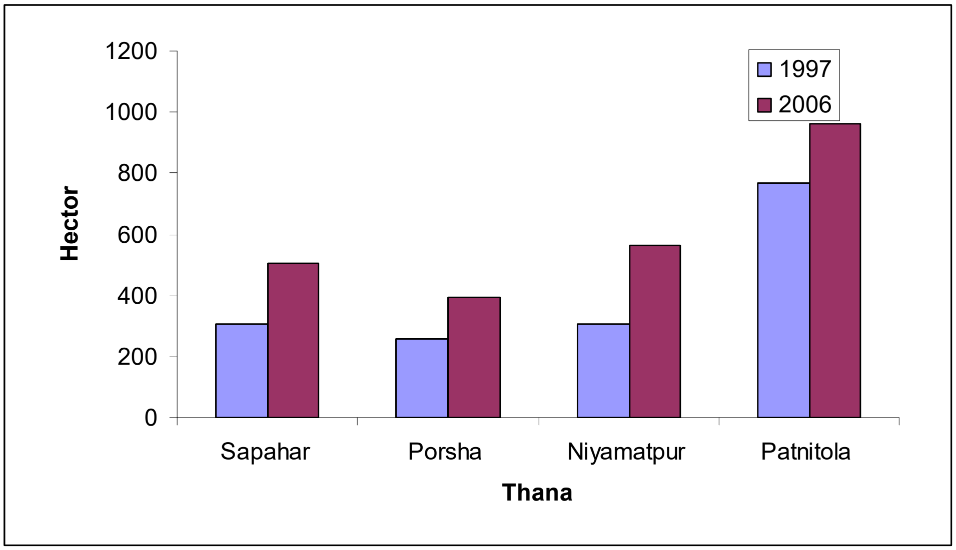


Figure 5.7 The change of forest according to thanas (1997-2006).

The amount of forests was more at Patnitola in the study area. But its quantity was also 2.54% which is very negligible in comparison with total necessity. In 1997 the forest was about 768 hectors which increased to 964 hectors in 2006. This growth rate was 25.52% in this thana.

5.1.7 The change of uncovered soil

Some of the uncovered soil is seen in the Barind upland region. This type of land is unproductive. In most cases uncover soil is not used at any time of the year.

The total area of uncovered soil in 1997 of the study area was about 1264 hectors and it became 1356 hectors in 2006. Though it is extremely small with respect to total land use, it is not negligible. This time the growth rate of uncovered soil was 7.28% (Table 5.1). Its thana-wise difference is given below.

At Sapahar the quantity of uncovered soil in 1997 was about 376 hectors and 360 hectors in 2006. The uncovered soil has come down at this thana. The rate of this reduction was 4.26% (Table 5.8).

Table 5.8

The change of uncovered soil according to thanas (1997-2006).

Name of Thana	1997		2006		1997-2006
	Area (Hector)	Percent (%)	Area (Hector)	Percent (%)	Change (%)
Sapahar	376	1.54	360	1.47	-4.26
Porsha	252	0.99	220	0.87	- 12.70
Niyamatpur	80	0.18	104	0.23	+ 30.00
Patnitola	556	1.46	672	1.77	+ 20.86

Source: The Percentage of uncovered soil in ratio to the land uses of thana (Table 4.1.2 and 4.2.2)

At Porsha the quantity of uncovered soil was about 252 hectors and 220 hectors respectively. Its reduction rate was 12.70% (Table 5.8).

At Niyamatpur the quantity of uncovered soil is comparatively less. Its quantity was about 80 hectors and increased to about 104 hectors in 2006. This growth rate is about 30.00% (Table 5.8). This growth is clearly seen at Rasulpur and Chandannagar union.

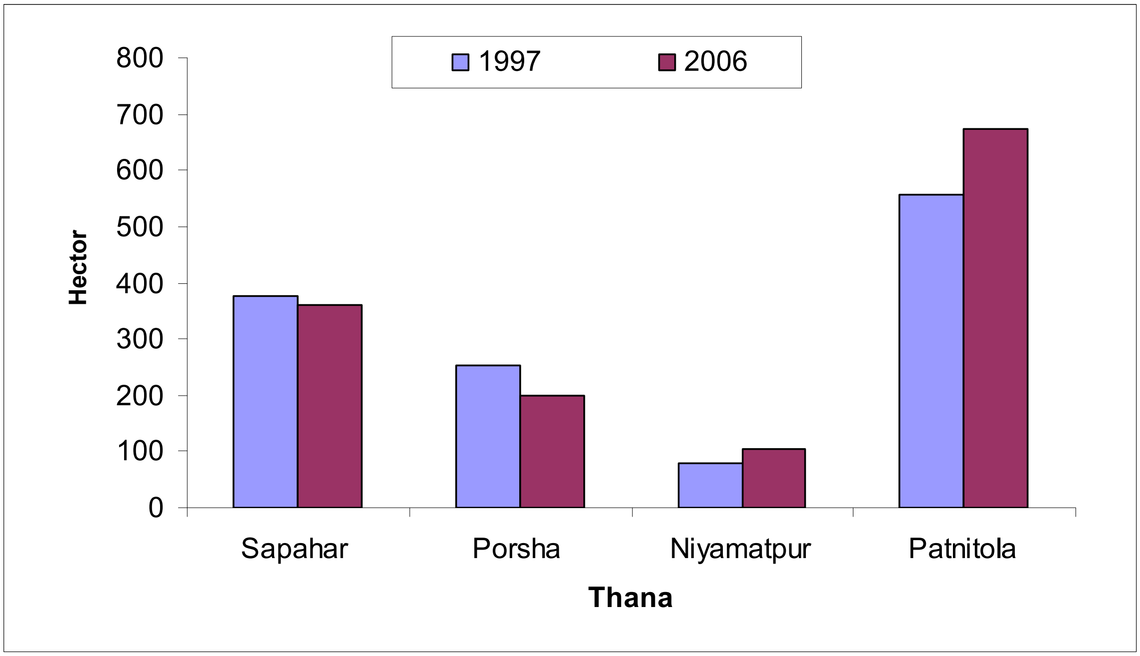


Figure 5.8 The change of uncovered soil according to thanas (1997-2006).

More uncovered soil is seen at Patnitola. In 1997 quantity was about 556 hectors and became 672 hectors in 2006. Here the growth rate of uncovered soil is about 20.86% (Table 5.8).

CHAPTER-6

WATER RESOURCES IN THE STUDY AREA

6.1The distribution of marshy land of 1997

In Barind Tract there are many kinds of ponds, canals, dighis, beels and rivers as source of surface water. Some distinct geo-physiographical features are also seen as well. The abundance of marshy lands is seen due to these special characteristics. Particularly this abundance is seen to the Ponorbhoba and Tangoon river basin of the west and in the Shib river basin where it is found mostly in the middle zone, and also the abundance of beel is seen to the south-eastern Manda thana frontier. Though marshy land means the beels and shallow marshes, the ponds, rivers and canals are not beyond it. Among many kinds of marshes, the Jobai beel and Maheel beel are the best. Besides there are many kinds of big and small ponds such as Laxmi dighi of Goala Sundara dighi, Vulca dighi to me mentioned as the best. The dighi of Soighati Aihai of Ghatnagar are in best condition.

Here marshy land refers to humid muddy and a bit stored water in a particular place. In spite of having a little water, the clear picture has been done by Landsat TM FCC image. It is seen while separating surface deep water from marshy land to be deep concentrated and smooth, whereas forest seems to be blacker in spite of its being rough.

It is seen from Landsat TM FCC image that the total marshy land in the study area was 10148 hectors which is 7.65% of the total area. Though this marshy land remains unused for most of the time, paddy is planted in the month of January and February depending on the surface water beside (photograph-4.4). The feature of soil in the study area is of various types. The features of this marshy land are quit different from those of others where the soil pH of other places varied between 4.8 to 5.9. The pH of the soil of there marshy lands are less then 4.5. The soil of this marshy land belongs to Jaonia bed association.

Table-6.1

The distribution of marshy land and surface water 1997

Pattern of water	Sapahar		Porsha		Niyamatpur		Patnitola	
Area (hector)	Area (hector)	Area (%)	Area (hector)	Area (%)	Area (hector)	Area (%)	Area (hector)	Area (%)
Marshy land	2404	9.83	4256	16.83	1204	2.68	2284	6.02
Surface water	1456	5.95	188	0.74	28	0.06	160	0.42
Total	3860	15.78	4444	17.57	1232	2.74	2444	6.44

Source: Landsat TM FCC 1997 (Table-4.l.2)

Some selected locations are seen in the distribution of marshy land of the study area. Though there is paucity of water in the Barind region. Various types of marshes are seen on the basis of geo-physiographical features. The total amount of land were 1997 was 10148 hectors which is 7.65% of the total land use (Table 4.1.1). It is seen in the thana-based marshy land distribution that more marshy land is seen in thana of Porsha.

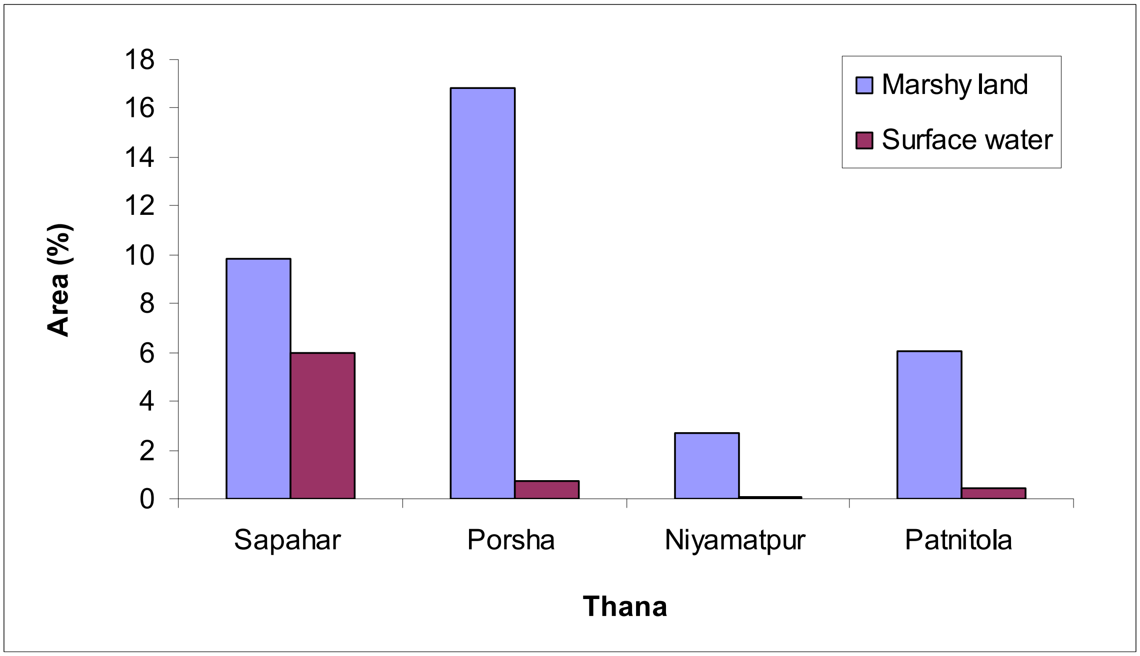


Figure 6.1 The use of marshy land and surface water- 1997

It is seen in the distribution of marshy land of Sapahar that most of the marshes are located in Aihai and Pathari union areas. There are many big marshes in Aihai, Ghatnagar and Goalaunion. Among them Ghatnagar Soighati is important. The rest of the dighis are located at Goala. There are 2404 hectors of marshy land at Sapahar which is 23.69% of the total marshy land (Table-6.2).

Marshy lands are seen more in Porsha. Some marshy lands are seen to the west of Porsha and border line of Mohadevpur. Most of the marshy lands of this thana are located at Nitpur and some marshy lands are seen at Mosidpur union. There are 4256 hectors of marshy land at Porsha which is 41.94% of the total marshy lands (Table-6.2).

The marshy lands are very less at Niyamatpur. The marshes of this thana are adjacent to Mohadevpur and Manda. The total area of marshes at Niyamatpur is 1204 hectors (Table 6.2). There are 2284 hectors of marshes at Patnitola which is 22.57% of the total marshy land. A great difference is seen in the distribution of this marshy land. Some of the marshy lands are seen at Akbarpur, Matindharr, Krishnapur adjacent to Sapahar and Porsha. This marshy land is mainly the lowland of the basin of the river, the Shib. Most of the marshy lands of this thana are located at Patichora and Ghosnagar union to the east.

Table-6.2

Distribution of marshy land according to thanas 1997

Thana	Area of marshy land (Hector)	Percentage (%)
Sapahar	2404	23.69
Porsha	4256	41.94
Niyamatpur	1204	11.86
Patnitola	2284	22.51
Total	10148	100.00

Source: Table 4.1.2.

6.2 The distribution of surface water of 1997

Though there remains one-third water in the whole world paucity of water is seen in many places. There may be various sources of water such as pond, big pond, dighi, beel, canal, river etc. It is possible to find out the location of water though Landsat TM FCC image. The total quantity of surface water of the study area is 1832 hectors which is 1.38% of the total area (Table-4.1.1).

The basin of the Ponorbhoba and Tangoon and beel are the main sources of water. The biggest beel of this region is Jobai beel which is 996.24 acres (approximately).There is enough dryness in the Barind region and rainfall is negligible. The degree of rainfall is more at Sapahar. Its percentage is 79.48% out of 1456 hectors (Table-6.3). Though Sapahar is high from other thanas, there are various beels such as Jobai beel, Maheel beel and others.

Table-6.3

Distribution of surface water according to thanas-1997

Thana	Area of surface water (hector)	Percentage (%)
Sapahar	1456	79.48
Porsha	188	10.26
Niyamatpur	28	1.53
Patnitola	160	8.73
Total	1832	100.00

Source: Table 4.1.2

The surface water varies from thana to thana. It is very little at Porsha. The surface water of 188 hectors is at Nitpur. There is no notable source of water at Niyamatpur. There are many big and small ponds in this thana which have not been easy to identify from the satellite images.

Table 6.4

Monthly high and low water level of the Ponorbhoba river (meter)-2009

Level	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
High	16.07	15.96	15.87	15.83	16.02	16.05	17.65	18.80	18.75	17.25	14.72	14.71
Low	15.17	15.89	15.82	15.75	15.73	15.88	15.78	17.68	17.27	14.85	14.61	14.49

Source: Bangladesh water development board 2009.

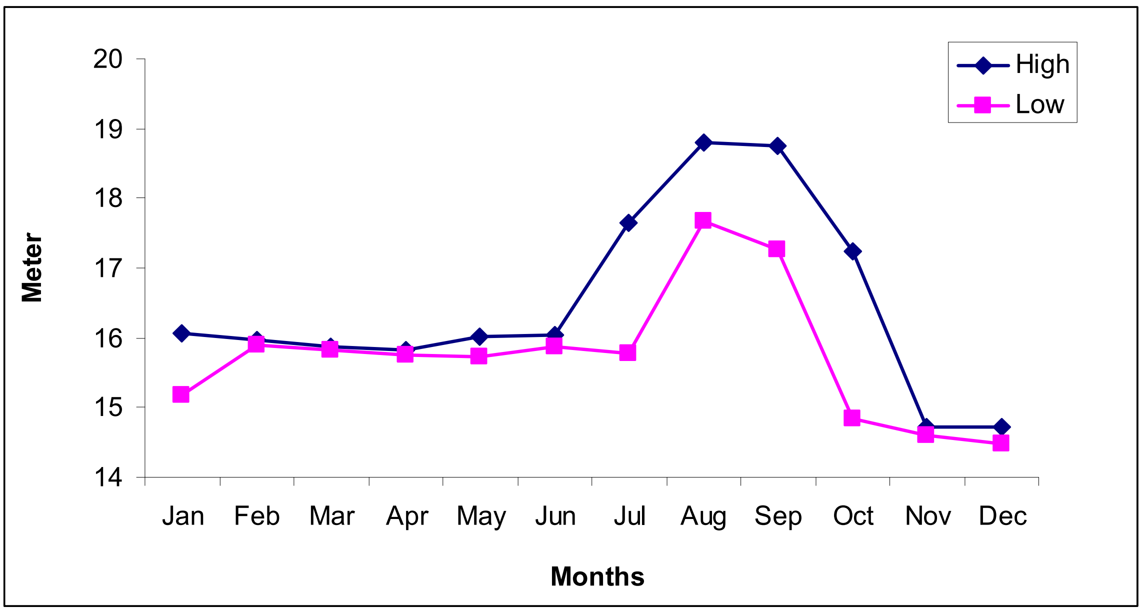


Figure 6.2 monthly high and low water level of the study area.

6.3 The distribution of marshy land of 2006

There are various wet and muddy tracts of lands in the Barind region. This region stands at the middle of the Ponorbhoba, Tangoon and Shib.

The total area of the marshy land was 9672 hectors which was 7.29% with respect to total land use. (Table: 4.2.1) According to the observation in

2006, the total area of marshy land at Sapahar was about 1992 hectors which was 20.60% of the total marshy land (Table 6.5)

Table-6.5

Distribution of marshy land according to thanas (2006)

Thana	Area of marshy land (Hector)	Percentage (%)
Sapahar	1992	20.60
Porsha	4572	47.27
Niyamatpur	1296	13.40
Patnitola	1812	18.73
Total	9672	100.00

Source: Table 4.2.1

The marshy lands of Sapahar are beside India. There are various marshy lands in the union of Pathari, Aihai and Goala. There are more marshes at Niyamatpur. Some marshy lands are seen at Chandannagar, Bhabicha and Bahadurpur. The total area of marshes is 1812 hectors which is 18.73% of the total marshy lands. There are various marshy lands at Akbarpur, Matindhar, Patichora, Ghosnagar and Amoir union.

6.4 The distribution of surface water of 2006

It is easily possible to see the characteristics of color of shallow and deep sources of water by using Landsat TM FCC Band 3, 4, 5 satellite image. The Barind is a dry region of the sources of surface water is very little. Beels and dighis are the main sources of water of this region. There are many rivers and ponds here. The shallow marshes look from light blue to blue in the images for the deep marshes. The marshes of all types have been clubbed in one category in this research. The big marshes and ponds have been considered but small marshes and ponds have been ignored.

Table 6.6

Distribution of surface water according to thanas (2006)

Thana	Area of surface water (hector)	Percentage (%)
Sapahar	792	72.26
Porsha	92	8.39
Niyamatpur	32	2.92
Patnitola	180	16.43
Total	1096	100.00

Source: Table 4.2.1

The total area of surface water of study area is 1096 hectors which is 0.84% (Table 4.2.1) of the total study area. The sources of flowing surface water of this regions are the Attrai and Ponorbhoba. Besides there are many other ponds, canals and dighis. The total area of ponds in Sapahar was about 669.26 hectors. According to the report of 2003 number of the total ponds was 2999 out of which 1210 was usable. According to the survey of 2006 the total number of ponds at Sapahar was 3172 which is comparatively less at Porsha but more at Niyamatpur. In 2006 there were 92 hectors of surface water at Porsha which is 8.39% of the total surface water (Table 6.6).

In Niyamatpur area surface water surface water was found less. It contains 32 hectors of surface water which is 2.29% of the total surface water. The river of Attrai is important source of surface water at Patnitola. There is a big dighi called Dibor dighi which is a historical place. The water of this marshes are used in irrigation which play an important role for the economic development of the region. In this area the total area of surface water was 180 hectors which is 16.43% of the total surface water. The amount of marshy land at Patnitola is more. Patnitola stands after Sapahar. Though the river of Attrai is the main source of water here, there are also many kinds of ponds, Dighis, canals etc. There is 'Karol Dighi' whose area is 14 acres in 1990. There is also 'Bono Dighi' whose area is 20 acres. The famous Dibor Dighi covers an area is 101 acres.

6.5 The change of marshy land in the study area (1997-2006)

A great difference in marshy land of the study area is clearly manifested. Marshy land means beel and shallow land. There are 7 beels in Sapahar. There are also numerous small canals here. But marshy land doesn't mean river, pond and canal. A difference is seen in marshy land during 1997 to 2006. The depth of water at Jobai and Maheel beel was more at 1997, but it has decreased in 2006. At present marshy land has turned into pasture land (Field survey).

According to Landsat TM FCC image, the total amount of marshy land in the study area was 10,148 hectors in 1997 which has been 9672 hectors in 2006. Here about 476 hectors of marshy land has come down during 10 years. The rate of the reduction of marshy land was 17.14%. The reduction rate is more at Aihai and Pathari union.

Table 6.7
The change of marshy land according to thanas (1997-2006)

Thana	1997		2006	
	Area (hector)	Percentage (%)	Area (hector)	Percentage (%)
Sapahar	2404	9.83	1992	8.14
Porsha	4256	16.83	4572	18.08
Niyamatpur	1204	2.68	1296	2.88
Patnitola	2284	6.02	1812	4.78

Source: Table 4.1.2 and 4.2.2

The amount of marshy land at Niyamatpur was very less. But some of them are seen to the west of this thana. The quantity of marshy land at Niyamatpur was 1204 hectors which becomes 1296 hectors in 2006. Within ten years 92 hectors goes up. Its rate comes down at Patnitola because the marshy lands that ware at 1997 comes down at 2006. There were more marshy lands at Patichora, Ghosnagar and Amoir union at 1997.

6.6 The change of surface water in the study area (1997-2006)

Surface water means the water on the ground. Generally river, canal, beel, pond and dighi belong to this category. The surface water has decreased to a large extent during the observed ten years. Here water has decreased due to agricultural irrigation, household use and draught. About 736 hectors of surface water has decreased from 1997 to 2006. Its rate is 40.17%.

Table 6.8

The change of surface water according to thanas (1997-2006)

Thana	1997		2006	
	Area (hector)	Percentage (%)	Area (hector)	Percentage (%)
Sapahar	1456	5.95	792	3.24
Porsha	188	0.74	92	0.36
Niyamatpur	28	0.06	32	0.07
Patnitola	160	0.42	180	0.48

Source: Table 4.1.2 and 4.2.2

Though irrigation is supposed to be the main reason draught plays an important role for water reduction. Water table rises up and falls down for rainfall and draught. About 10 or 15 years ago there were a few sources of water like canal water etc. But at present tube-well has been established in those localities. As a result surface water has changed considerably.

The amount of surface water is more at Sapahar. There are many big beels here. Among hem Jobai beel and Maheel beel are famous. These two beels belong to Aihai and Pathari which are the main sources of water. In rainy season these beels are full and becomes impossible to produce crop and after rainy season they dry up. In the study area the amount of surface water was 1456 hectors which becomes 792 hectors in 2006. This time the reduction rate of surface water is 45.60%. This difference is also seen at Porsha. This difference is seen to the south of Nitpur too. Here water is less in comparison with Sapahar. This difference is seen to be about 96 hectors within those ten years. This time the reduction rate is 51.06%.

Table 6.9

The change of surface water according to Dighi (1990-2010).

Name of Dighi	Name of union	Surface water (acres) 1990	Surface water (acres) 2010
Conta Dighi	Goala union	12	11
Dighirhat Dighi	Goala union	33	31
Balta Dighi	Patnitolaunion	27	25
Shabajpur Dighi	Sapahar union	11	8
Futkhail Dighi	Sapahar union	20	17
Bonogram Dighi	Dibor union	23	24
Karol Dighi	Patnitola union	14	14
Bono Dighi	Dibor union	20	18
Thakral Dighi	Krishnapur union	5	6
Total	-	165	154

Source: Field survey 2010.

Only one source of surface water at Niyamatpur is pond. The area of surface water in 1997 was 28 hectors which become 32 hectors in 2006. Here the growth rate is 14.29% many new ponds have been dug here. As a result surface water has increased at Patnitola. Many ponds along with the Attrai are the main sources of water. There are many big ponds here. Some of the big ponds and dighis are described below. The Balta dighi which is located at Patnitola is about 27 acres in 1990. Another dighi called Bonogram which is about 23 acres in 1990 is located at Dibor union. But the quantity of water has decreased in this dighi for settlement. Besides there are also Thakral dighi, Korol dighi, Hat dighi, Noira dighi etc. The most important dighi of the study area is "Dibor dighi" which is located at Dibor union. Its area was 101 acres at past. But water area is decreased significantly now. There is a big pillar in the middle of this dighi as the ancient relics. Another important characteristic of this dighi is that there are 101 ponds around this dighi.

6.7 Ground water level

A large difference of the ground water is manifested in the study area. The water level has gone down due to this difference. This difference is more during 2000 and 2010. The difference is about 7.04 meters from the last 2000 from the deep tube-well of Sapahar whose J.L. No. 09, line no. 294. In the month of January of 2000, the ground water was available at the depth of 4.91 meters, but it becomes available at the depth of 14.97 meters in 2010 as per the information of SWL. It is seen in the information of January that water was available at the depth of 9.18 meters at that deep tube-well where ground water is available at the depth of 14.97 meters. It becomes apparent that the ground water is going down day by day. In 2007, water was available at the depth of 13.20 meters as per the survey of SWL which become 17.41 meters in 2008. In 2009 it was 17.46 meters and increased to 17.72 meters in 2010.

From between 2000 and 2010 the ground water has gone down from 8.63 meters to 17.77 meters respectively. From this statistics, we can say that the water level varied went down day by day. The cultivable land in the village of Rasulpur has increased in comparison with the past. But various complexities in the tube-well are seen due to the lowering of water level. As per the survey of SWL, water was available at the depth of 8.63 meters in 2000 which become 9.82 m in 2001. Thought it come down a bit in 2002, but increases in 2003. The water level is 10.09 m in 2004, 13.66m in 2005, 10.73 m in 2006, 12.56 m in 2007, 17.65 m in 2008, 17.87 m in 2009, 17.68 m in 2010.

The ground water plays an important role in controlling various types of land uses. The increase-decrease of this type of land use also changes other land uses. Overall it is seen that the surface water has come down in 2007 in comparison with 1997. The main reason of the decrease of water is irrigation. As a result of irrigation, the ground water comes down and water level is also going down rapidly.

The surface water is more in the thana of Sapahar. Its sources are Jobai beel and Maheel beel of Aihai and Pathari union. The region where there is no sufficient water, it is irrigated with deep tube-well for crop production. For example a deep tube-well has been set to uplift water for irrigation in the village of Rasulpur. The upliftment of ground water has changed the agriculture to a large extent. Land use has been changed widely.

The ground water was available at the depth of 10.15 m in area that water level comes up a bit in 2009 and once again goes down and becomes

17.13m. Thus it is seen that the ground water level is going down successively always.

In the village of Rasulpur in Sapahar whose JL No. 09, Line no. 294, the ground water level goes down to 15.34 m from 9.39 m from 2007 to the June of 2010. The ground water level is manifested at the depth of 10.15 m in the month of July in 2007. It also comes up in 2008 whose depth is a bit less than in 2007. In 2009 the ground water had multiplied largely, where the water level was 10.15 m in 2007 which becomes 12.38 m in 2009. Again within a gap of 1 year, the depth of water increase to 14.36 m.

As per the information of SWL of the month of August from the deep tube-well of 2007, the ground water was available at the depth of 8.51m which became 8.48m in 2008.

The ground water increased largely in 2009. It was 8.72 m in 2008 and became 13.93m in 2008 and became 13.93 m in 2009. This depth increased largely in 2010 in comparison with that of 2009 and became 14.88 m. It was available at the depth of 7.01m in the month of September which increased 0.91 m within one year and became 7.93. The depth of ground water in 2009 was 13.81m and became 13.11m in 2010.

In the month of October, 2007, the ground water level was at the depth of 6.71 m and it became 6.89 in 2008. 13.45 m in 2009 and 13.54m in 2010 respectively.

Table 6.10

The ground water levels of 2007 and 2010
Mauza: Rasulpur, J. L. No. 09, Line No. 294
Study area

Ground water level measuring point in meter		
Name of Month	Year-2007	Year-2010
January	9.18	14.97
February	11.77	17.44
March	13.20	17.72
April	12.56	17.68
May	10.15	17.13
June	9.39	15.34
July	10.15	14.36
August	8.51	14.88
September	7.01	13.11
October	6.71	13.41
November	8.84	-
December	8.66	-

Source: B.M.D. Sapahar-2011

The depth of ground water was 8.84m in the month of November, 2007 and it became 8.66 m in 2008 which increases to 13.72 m in 2009. The information of 2010 was not available. In the month of December 2007, the depth of ground water was 8.66 m which increased in 2008. The depth was 8.66m in 2007 which became 8.87m in 2008. It became 14.05 m in 2009. The information of December SWL is not available.

Though the Barind land is high of the study area, various respects to places are also different. Various deep tube-wells have been sunk on the basis of the difference of these marshes in various upland areas which contributes a lot to agriculture. The information from SWL about these deep tube-wells suggests that the ground water level has gone down day by day. On the other hand the marshy lands have been different in size and area due to draught rainfall and flood as they are shallow. A huge amount of surface water is available in Jobai beel and Maheel beel of Sapahar. Analysing the image of 1997, the marshy land of this area was 10,148 hectors in 1997 (Table 4.1.1) which became 9672 hectors in 2006 (Table 4.2.1).

It indicates that surface water is coming down day by day whereas ground water level is also going down. The amount of month-wise stable water of the village of Joypur of Sapahar whose JL No. 133, Line no. 315 from 2007 to 2010 is given below.

Table 6.11

The Ground water levels from 2007 to 2010
Mauza: Joypur, J. L. No. 133, Line No. 315
Study area

Ground water level measuring point in meter				
Name of Month	Year-2007	Year-2008	Year-2009	Year-2010
January	1.92	12.38	12.84	8.63
February	14.18	18.75	17.20	16.00
March	17.43	20.79	15.88	15.88
April	12.90	21.80	16.46	15.21
May	8.26	13.48	11.01	12.53
June	7.65	9.60	9.18	11.01
July	8.87	8.79	9.76	10.34
August	8.51	8.48	7.38	10.49
September	3.32	4.45	7.32	4.70
October	4.05	4.02	5.06	4.85
November	5.21	4.88	5.67	-
December	12.59	9.94	5.54	-

Source: B.M.D. Sapahar-2011

The information that is available from the Barind multi-purpose development authority is that the ground water is coming down year after year i.e., the water level is going down. The water level was at the depth of

1.92 m in 2007 in the month of January which was 12.38 m in the January of 2008. It indicates that the water level has gone down by 11.23 meters within one year. It was 12.84 m in 2009 and 8.63 m in 2010 respectively.

It was 14.18 m in February 2007 which became 18.75 m in 2008. Again the water level was 17.20 m in 2009 and became 16.00m in 2010. The water level of the study area was 17.43 m in the month of March 2007, 20.79 m in 2008, 15.88 m in 2009 and 15.88 m in 2010.

In the month of April, 2007, the ground water level was 12.90 m which became 21.80m in 2008. Again it became 16.46m in 2009 and changed to 15.21 m in 2010. The water went down to 8.26m in the month of May, 2007 and became 13.48 m, 11.01m and 12.53 m in 2008, 2009 and 2010 respectively.

We can understand from three main tube-wells of the study area that the ground water level is not coming up at all, rather it is going down day after day.

From 2007 to 2010 if the ground water level is analysed it is seen that its level has gone down largely. The stability of water has been determined with the help of some important tube-wells. It indicates that it has been changed in various months and years. In the Barind upland region, the level of ground water has been different on the basis of places. Its difference is seen at various moments. The study area is very high. Besides the water level goes down due to draught less rainfall and pressure is created on surface water for growing crops. Not only the surface water is influenced, but also the ground water is highly influenced. It creates the paucity of water and crop production is highly damaged. It is possible to grow crop through irrigation in the study area. Aman crop can be produced with the help of rain in rainy season. Though Robi crop is produced here, the Barind region is not good to produce the Robi crop. The paucity of water has delimited the crop production of this region.

Table 6.12

The Ground water levels of 2002 and 2010
Mauza: Joypur, J. L. No. 133, Line No. 315
Study area

Ground water level measuring point in meter		
Name of Month	Year-2002	Year-2010
January	7.99	8.63
February	9.18	16.01
March	11.50	15.88
April	11.04	15.21
May	6.13	12.53
June	7.68	11.01
July	6.37	10.34
August	4.33	10.49
September	1.89	4.70
October	5.82	4.85
November	2.84	10.55
December	9.57	12.84

Source: BMD Sapahar-2011

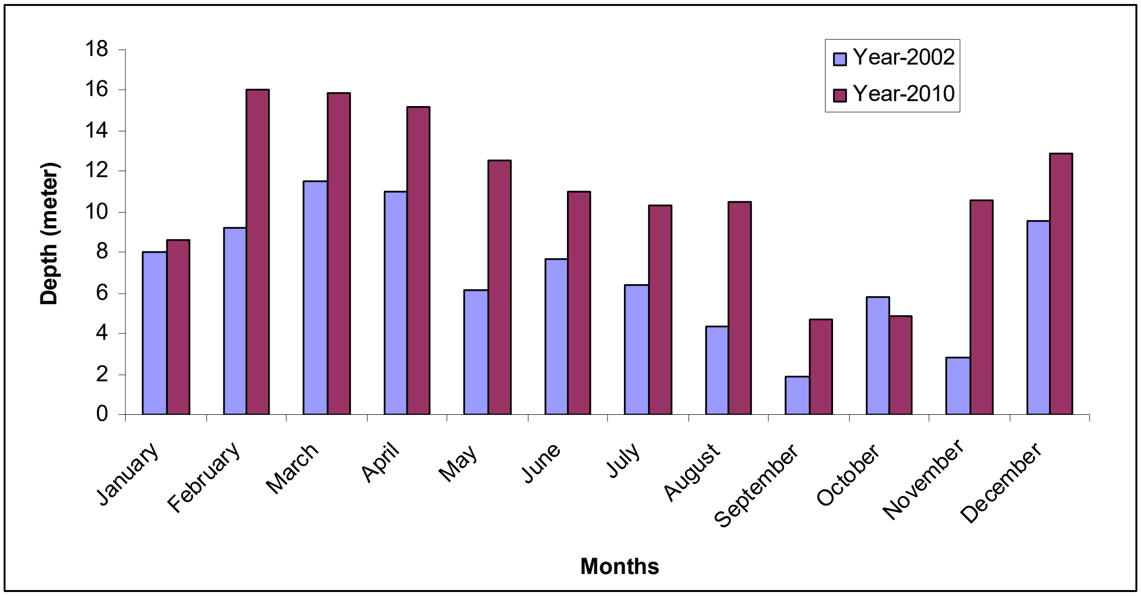


Figure 6.3 The trend of ground water level 2002 and 2010

The quantity of cropland is increasing due to modern irrigation system. For the production of crop in the Barind region, the ground water is also being used along with surface water. In the study area, there were about 11952 hector crop land as 9.02% in 1997 of the study area, which increased to 14416 hector in 2006. This time the amount of cropland was 10.87% of the total land use. From 1997 to 2006, total growth of cropland is 20.62%. This growth is not same every where because it depends on the availability of surface and ground water. The quantity of crop production increases some where or decreased somewhere. This increase-decrease depends on places. Sufficient crop is not seen at Pathari and Sapahar Sadar union of this thana. The deep tube-well that has been sunk in the village of Joypur by the Barind authority shows that the ground water is more from 2000 to 2010. In 2000, the ground water was available at the depth of 4.30m which became available at the depth 2000, the ground water was available at the depth of 4.30 m which became available at the depth of 10.27m.

Here it is note-worthy that the ground water level was available at the depth of 5.79m within the last 9 years.

The ground water level was available at the depth of 102.23 m from January to December of 2007. But its level was at the depth of 123.69 m from January to December in 2009. It indicates that ground water level has changed by 21.46 m from 2007 to 2009 within these three years. Its average change was 2.13 m and total change was 21.46 m. It becomes apparent from above discussion that the ground water is going down at an alarming rate which is damaging for our environment. There has been a significant change of ground water during the last 2000 to 2010.

Land is being changed due to land use in the study area and influencing the surface water and ground water. Agricultural land is decreasing for settlement and infra-structural development. On the other hand, a great pressure is being laid upon agricultural land to meet the demand of ever increasing people. As a result crop is produced three or four times in this agricultural land in a year. As a result of over production, surface and ground water are being highly pressurized. Though forest has increased in the study area, built is yet a half as per requirement for our balance of environment. Besides, man uproots the forest for necessity or unnecessary as a result of which rainfall has come down and surface water also decreases.

Table 6.13

The trend of ground water levels of 2007 and 2010
Mauza: Rasulpur, J. L. No. 09, Line No. 804
Study area

Ground water level measuring point in meter		
Name of Month	Year-2007	Year-2010
January	7.5	15.46
February	9.57	17.87
March	13.20	18.02
April	12.56	17.44
May	10.46	16.89
June	9.24	15.00
July	9.85	14.02
August	9.21	14.91
September	6.98	13.60
October	6.10	14.05
November	8.23	14.12
December	7.74	14.91

Source: BMD Sapahar-2011

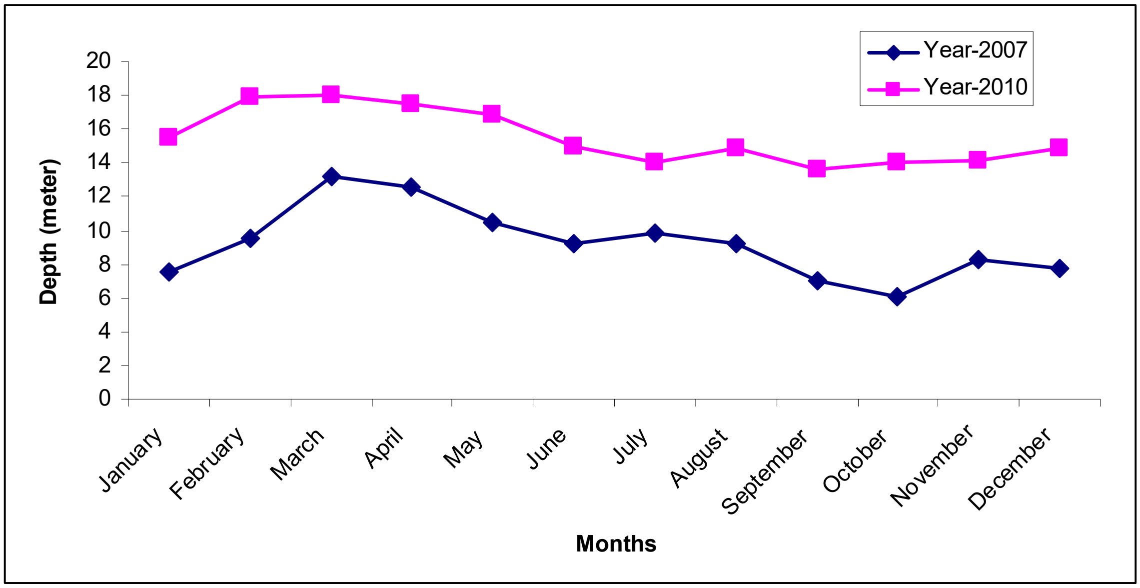


Figure 6.4 The trend of ground water level 2007-2010

For more production, the use of surface water increases to a large extent. On the other hand, rainfall happens to a small extent. Considering these, surface water comes down largely in comparison with the past. There are many sources of small and big dighis, ponds, rivers, Jobai beel and Maheel beel. In spite of being these sources, the Barind authority has introduced deep tube-well for irrigation. With the help of deep tube-well, ground water is being uplifted from the ground. As a result of uplifting the ground water again and again, the ground water is going down rapidly consequently the co-ordination between surface water and ground is being damaged. As a result of it, imbalance is being created in our environment. Both man and environment will fall into a great danger if water is uplifted in such a way.

CHAPTER-7

LAND USE ON WATER RESOURCES AND ENVIRONMENT

The present study has been carried out to characterize the changing pattern of land use on Sapahar thana, its erosion and accretion over time and to assess the socio-economic impacts caused by the changes. The population, flora, water fauna and the environment and ecosystem of the Barind region as a whole are in danger for the continuous depletion of agricultural land and other green vegetable area at a tremendous rate for the use of huge open Barind land for agriculture, settlement, industry and many other activities. As a result it is causing degradation to soil stability. Erosion of the land and intrusion of ground and surface water over the huge plain cultivated land areas are also influencing to various ecological imbalances in the study area.

With a view to address these problems, reliable information and updated data are much required to determine where, why and how natural resources and environment are being affected and what preventive measures can be adopted. In this respect, use of remotely sensed data integrated with GIS technology may provide the appropriate solution to these problems. Land use pattern is the basic activity of every country in the world. It is the main base that reflects the economic activities in any country. Land is the main factor of the environment and it is the basic resource, which has no alternative. The development of any country is possible by the proper utilization of land.

Generally land use and land utilization is very close in meaning. Man utilizes the land for his own choice and needs. Land utilization is concerned with the type of use which man carries out over a certain area at a certain time or non-utilization of an area on account of its particular nature on the presence of its unfavourable environmental condition. Land utilization is a fundamental element for the knowledge of a region; it supplies its main features and gives synoptic view of the technical and economic aspects.

Land use or utilization is the most important phenomenon because man's economic activities depend on it. In the past time almost every place was rural. But with the passage of time and development of modern technology, land use pattern is changed and maximum rural area is transferred to urban area. So, urbanization is an important factor for land use change. On the other hand, this land use pattern or urbanization influences people's socio-economic condition, service centre and standard of living. Land use pattern is changeable of people's choice and needs. In this chapter first let us discuss the land use pattern on water resources and environment of the study area.

Land and water are the main important element of the environment. There is a close relation between land and water of the environment. It can be said that they are closely connected. It can be known from the survey of this area, that between the years 1997-2006, the environmental condition of the people of this area has been significantly changed. Behind this change, many causes have been pointed out.

During the past the houses were raw and at present, these are brick-built. There changes have been brought by the financial development, change in making choice of urbanization and so on. The main causes behind this development are the spread of knowledge, change in occupation and income and the change in the choice of people.

Again, the facility of the education of this area has also been developed and increased day by day. On the other side, the occupation of the people of this area has been changed. Man has changed his occupation for the demand and choice of his own.

For the achieved information of the survey, this is clear that many health case facilities such as healthcare, the source of drinking water, sanitation facility, drainage system, etc. have been changed than before. Mainly, this change has been occurred with the development of urbanization, change in economic condition of the people and so on.

On the other hand change is observed in the land use pattern of this area. In the income, expenditure and savings of the people of this area, there is rapid change. Day by day the expenses of the people are increasing and with this the income is also increasing. But, there is no balance in income and expenditure. The expenditure is more than the income and so the amount of savings has also been decreased than before.

Extra earning to the people appeared in this area to some extent. For this reason, the people of low income have developed their self employment by getting the loan. As a result, there is a great change observed in the occupation, income and etc. of the people of this area.

The change of environmental condition of any area has its great influence upon the people of that area. The survey area is not exception of this. Among the development of this area, the increase of health care center is very remarkable.

The social system of this area has been changed greatly for the change of the social aspects. It can be seen that in the past there was rural atmospheric in the social condition of this area. But, by analyzing the social picture of this area, this is clear that, there is a touch of country-wide urbanization in the social condition of this area. As a result, the social condition is developing day by day.

Again, if we look at the economy of the region, it is clear that the number of shopping center of this area is also increasing. So there is a sign of transformation. Economic activities of primary stage are decreasing and the second and third stages activities are increasing. There is change also in the type of occupation of the people of this area. Through the discussion, one point is very much clear that the socio-economic condition controls the life style of the people of any area.

From the overall analysis, it can be said that the land use pattern of the study area has been developed day by day. It has been changed for the demand and necessity of the people for urbanization. This change of land use pattern also influences upon the water and environmental condition of the people. From the above discussion, it can be seen that the farmlands are being changed and most of the land area has been changed into settlement/residential area. As a result, the production area of farmland has been decreased. That’s why the economic development of very primary stage has been decreased. Against this development in the secondary and tertiary, economic activities have taken place; Again, these economic activities also changed the field of social activities. As per analysis on the study area, the social aspects are seen to be changed.

Change in land use pattern is a remarkable part of this research. By changing the pattern in using land area, the socio-economic condition of the people also changes and this is the main sum and substance of this research/ study. By analyzing the land use system of the study area, the matter is clear that between the years 1997-2006 remarkable change was found in land use, water and environment pattern. In the past 90% land of this Mouza were in the farmland. This change in land use has also changed the socio-economic condition of the people of this area.

With the change of land use pattern, the service centers in this area have been increased, which has influenced the socio-economic condition of the people many social aspects of this area, such as the type of houses, type of families, type of health care, the type of education and also in the change of facilities of the people service center has its effective role. The information proves that the environmental condition of this area was underdeveloped in 1997. But in 2006, this condition had been developed and the blessing of urbanization has overpowered this change in the area.

Again, water plays a great role in changing the economic condition of the people. With the decrease of water, there is a change also in the occupation of the people. In the past, where these people were engaged in agriculture, in the present, they are engaging themselves in business and service. The level of income of the people of this area has been changed with the change of their occupation. From the taken information, it happens that with the increase of the income of the people in this area than before, the expense has also been increased. This result is that the savings of the people has been decreased in amount than before. This change has happened only for the influence of the environment.

CHAPTER-8
CONCLUSION

It is no denying the fact that the Barind region is a diversified place owing to the disparity of temperature, climate, physiography, but it is noted for its production of paddy. It can also be assessed that this region affords to meet the food demand of our over population by dint of its fertile land.

This can also be said that in the past the number of people was very few and environment influenced man to a large extent. As a result the balance of the environment was controlled very easily. But now as a result of excessive population, men's influence upon environment begins to impinge upon it.

Now the most important part of Geography is the identification of land use. Land is such a fundamental asset of a country which has no alternative. Man depends on land for his basic demands including food, cloth and shelter largely. Land is at the root of economic activities and overall development of a country. So, each and every developed and developing country should emphasis on proper use of every square inches of land by proper plan and its implementation. But it is a regrettable fact that even at present land is being misused in an unplanned way considerably. For removing this probable proper land use survey and accordingly a proper plan is essential.

Through various systems, land use changes. For the developing country like Bangladesh land use survey within a little period and at a cheap expense is also needed. In this case remote sensing information plays an important role as well.

The north western Barind upland region of Bangladesh is distinctive and potential but on the other hand neglected. The land use of this region is gradually being changed. In this research we have shown the analysis of Landsat TM FCC satellite image for showing land use change that direct pattern survey has also been accepted for a good application in a root-level change detection. While analyzing the satellite image with the help of direct pattern observation, the land use that is seen here is also possible to categorize into seven groups. Though there is no clear continuity of the available change, its changes are very significant.

In the research area, the increase of slum land is noticed (6.15%). As a result of the increase of slum land, agricultural land is decreasing. So naturally it is seen that slum land is turning into agricultural land. So it is said that increase of slum land will decrease agricultural land as a result of which the whole economy will be badly affected.

The quantity of agricultural land is the maximum in the research area. Almost three-fifth regions are agricultural land. But it is seen that most of the agricultural lands are current fallow, that is, 84% occupies single-one cropped, 13% occupies double-cropped and all the rest are three cropped. As a result the closeness of crop is 117%. So as a result of the agricultural development of this region, the closeness of GOP can be increased, but revolutionary change in irrigation system is a must.

Though the Barind region is known to be a backward region, here the quantity of marshy land or surface water is not insufficient. But their distribution is not equal. This land should be made effective through a planned system. As it is possible to cultivate fish by increasing the stored water through digging shallow land, the surrounding land will also turn into agricultural land. The higher authority should look into it. Here it is noteworthy that this sort of land is affected by flood and draught.

The most burning issue of the present time is imbalance of environment. The scarcity of forest is largely responsible for this. The forest of the Barind region is insufficient comparing its need for balance of environment although there has been extensive afforestation under the Barind Multipurpose Development Authority. Most of the forests of this region are created. It is seen from the land use of the earlier years that forests are rapidly going. The Barind project is playing an important role. A lot of trees are also being planted and the authority has also succeeded. As recognition, the Barind authority has stood first in national level in tree plantation in 1993. Even after them, the quantity of forest is not satisfactory. So mass-awareness along with tree plantation programme is a must.

According to the report of the U. N. about desertification, the sign of desertification in the Barind region is clear. Draught is largely responsible for desertification. Besides excessive cultivation, uncontrolled uprooting of trees, faulty irrigation system, quality of surface water and ground water are also considerably responsible. According to the chief of the Barind multipurpose development authority rainfall, recharge and forest are going up in this region. But all should be conscious to implement this optimism.

Mainly satellite image is used in seven ways. First of all, land use classification is used in satellite image. Land use change has been shown in this system. As the presentation of land use of four selected thanas of the Barind upland region after dividing it into 7 categories.

Overall, it is seen that the identification of land use and its change has been shown through satellite image of the Barind upland region is realistically appropriate which also mentions the acceptability of this system. In future evaluating the identification of land use and its change of this region through satellite image, it is possible to accelerate the rapid improvement by taking proper initiatives.

The Barind region is a rich hard-land of agricultural production, which is situated in the north-west parts of Bangladesh. The Barind is an older alluvium formation of the Pleistocene Epoch and it is undulating in nature. The Barind region divided into three categories: Higher Barind, flat Barind and Lower Barind. Sapahar thana is in the higher Barind in the district of Naogaon.

For the importance of land use change and water resources, a detail hydrological investigation has been conducted in this research work to identify the nature and pattern of Sapahar thana land use and water resources in various mode. Geomorphologically, the study area includes both part of uplifted Barind tract of the ‘Pleistocene Upland’ and Recent Ganges flood plain. The study area falls under tropical-humid-monsoon climate characterized by very humid, wet south-west monsoon from June to November. From December to May, a cool dry northeast monsoon blows from central Asia bringing lowest temperature and humidity and its later part, conventional storm.

In the study area, surface water is very limited. A large number of water bodies have been found but most of them are dried-up during the dry season. Jobai beel is the vast surface water body in this study area. Ponds, khals and rivers are the most important surface water bodies. In rainy season, they contain a lot of water in and some times they overflow the lands. During dry season, they gradually lose water by means of horst land surface and longer dry season. Rainfall is the main sources of water. Mud cracks accelerate the percolation of rainwater in to the aquifer. The aquifer also receives recharge from the rivers in the late monsoon when the river stage remains at a higher level than the ground levels. But throughout the dry season, the rivers receive groundwater from the aquifer as base flow.

It has been observed that in the study area, the over increasing population pressure on the limited arable lands forced to exploit subsurface water resource by means of tube-wells. For this purpose the unknown groundwater quality i.e. physical and chemical quality are to be investigated properly and the data represented in the study area. The tube-well sites should be obtained from groundwater resources. Therefore, groundwater is one of the earth’s most widely distributed resources and its role in the very existence of lives on the planet needs hardly any elaboration.

The overall finding of water quality observation, the average values of the physical and chemical properties are not objectionable. The effective use of groundwater irrigation will help the farmers for intensive farming, which will generate increasing production. The quality of ground water in the study area has not impact on the environment and human health. The assessment of large-scale utilization of water is also necessary prior to the formulation of water resource development. If these steps are taken, the physical environment and human health of this area will be effectively protected from degradation.

It is revealed from trend analysis that the ground water occurrence is highly related to rainfall occurrence during a particular year or session but trend of groundwater table and fluctuation through year to year is not related to annual rainfall variation in the study area. It is related with artificial heavy groundwater exploitation from the study area. After all, the study area shows the alarming declining condition of depth of water table and high fluctuation of water table.

It is revealed from above discussion that the investigated area becomes surplus area in food grains due to groundwater resources. Although the study area is located within the Barind region, the top clayey stratum is thinner. In spite of suitable aquifer, there have been made a declining water table condition in the recent years when artificial exploitation with high rate has been practiced from the year 2007-2010 because of unplanned abstraction and lack of appropriate investigation of groundwater resources.

It is mentionable that geographically, man-land-nature and resources are closely related with one another by a chain system that refers to balance of environment. Merely unplanned human intervention on the nature makes the environmental degradation. That is for the unplanned human intervention on the surface and groundwater resources. And consequently the water table declines through year to year which refer to an alarming condition. The resultant land subsidence is not a predicted version. Substantial subsidence resulting from reduction of groundwater storage have been recorded in California, Texas, Georgia and Nevada, while outside of the united states important examples including Mexico City and London (Ward, 1967). For the cause of the development of bone of depression, drastically water level can be lowered and rate of pumping of wells can be reduced through time. Qualitative problem may be occurred due to water table depletion. For the example in the village Rasulpur in Sapahar whose J.L No. 09, line no. 294, the ground water level goes down to 15 meter from 9.24 meter from 2007 to the June of 2010. The ground water level is manifested at the depth10.15 meter in the month of July in 2007. It also comes up in 2008 whose depth is a bit less than in 2007. In 2009 the ground water had multiplied largely, where the water level was 10.15 meter in 2007 which becomes 12.34 meter in 2009. Again with a gap on one year the depth of water increases to 14.35 meter. If seasonally high fluctuation is continuing in the study area, it will become a desert for the cause of subsoil weathering with the span of time.

After all, if it is desirable to free from environmental degradation such as land subsidence, qualitative problems, high magnitude of cone of depression, dissertation and so on, it is very important to stop unplanned and inappropriate artificial ground water exploitation from the study area.

However, considering all the facts and reasons discussed above, particularly the overdraft condition prevailing in the area, it is recommended that the installation of tube-wells by different agency should be stopped immediately. Any further installation of wells should be very much selective. Moreover, the spacing of the wells should be selected cautiously not to influence two wells in common. So, care must be taken for the uniform distribution of tube-wells. Pumping efficiency will increase if proper maintenance of the well is made. It is also recommended that great care must be taken to supply water for irrigation from other natural sources immediately.

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APPENDICES

Appendix-A

List of Administrative units of the Research Area.

GEO CODE	THANA/UNION	GEO CODE	THANA/UNION
6469	NIYAMATPUR	6479	PORSHA
646910	BAHAPUR	647915	CHAOR
646921	BHABICHA	647923	GANGORIA
646931	CHANDANNAGAR	647931	GHAT NAGAR
646942	HAJINAGAR	647947	MOSIDPUR
646952	NIYAMATPUR SADAR	647955	NITPUR
646963	PARAIL	647987	TITOLIA
646973	RASULPUR		
646984	SREEMONTOPUR		
6475	PATNITOLA	6486	SAPAHAR
647508	AKBARPUR	648607	AIHAI
647517	AMOIR	648639	GOALA
647525	DIBOR	648663	PHATHARI
647534	GHOSNAGAR	648671	SAPAHAR SADAR
647543	KRISHNAPUR	648679	SIRONTI
647551	MATINDHAR	648694	TILNA
647560	NAZIPUR		
647569	NIRMOIL		
6475 77	PATICHORA		
647586	PATNITOLA SADAR		
647594	SHIHARA		

Appendix-B

Population Information of the Research Area

GEO CODE	THANA /UNION	AREA (in sq.km)	2001		1991	
			Population	Density	Population	Density
6469	NIYAMATPUR	449.31	226614	504.36	193197	429.99
646910	BAHAPUR	56.47	32097	568.39	29023	513.96
646921	BHABICHA	52.99	30995	584.92	24930	470.49
646931	CHANDANNAGAR	51.89	24164	456.68	206203	397.46
646942	HAJINAGAR	61.96	25716	415.04	208649	336.84
646952	NIYAMATPUR SADAR	44.40	25896	583.24	20545	462.76
646963	PARAIL	58,16	27864	479.09	25264	434.40
646973	RASULPUR	75.62	32257	426.57	274513	363.02
646984	SREEMONTOPUR	47.83	27625	577.57	24490	512.02
6475	PATNITOLA	379.41	209440	552.01	198164	518.01
647508	AKBARPUR	33.67	19508	579.39	19201	570.24
647517	AMOIR	34.06	19483	572.02	19379	568.95
647525	DIBOR	31.53	15145	480.34	19379	464.66
647534	GHOSNAGAR	30.66	20466	667.51	20101	655.70
647543	KRISHNAPUR	41.43	21004	506.98	20817	502.47
647551	MATINDHAR	35.39	18206	514.44	16781	474.14
647560	NAZIPUR	30.72	11045	359.54	22546	733.81
647569	NIRMOIL	36.81	12675	344.34	12987	352.83
647577	PATICHORA	31.98	18219	569.70	16393	512.61
647586	PATNITOLA SADAR	36.09	19454	539.04	18896	523.53
647594	SHIHARA	37.06	17306	466.97	16412	442.79
	NAZIPUR POURO		16929			

Population Information of the Research Area.

GEO CODE	THANA/ UNION	AREA sq.km)	2001		1991	
			Population	Density	Population	Density
6479	PORSHA	252.94	121807	481.57	97279	384.59
647915	CHAOR	45.73	17378	364.09	14306	299.71
647923	GANGORIA	35.40	15587	440.31	12833	362.51
647931	GHATNAGAR	35.49	20371	589.45	16034	451.84
647947	MOSIDPUR	38.20	18989	497.09	15879	415.65
647955	NITPUR	59.07	29467	501.90	21491	363.80
647987	TITOLIA	37.04	20017	540.42	16376	451.78
6486	SAPAHAR	224.60	143853	640.49	115320	471.47
648607	AIHAI	38.03	18763	493.37	15176	399.07
648639	GOALA	57.91	32227	556.50	25115	433.68
648663	PATHARI	28.60	21619	755.90	17502	611.98
648671	SAPAHAR SADAR	39.21	26279	670.21	18693	476.78
648679	SHIRONTI	40.51	24661	608.76	20088	495.88
648694	TILNA	40.34	20304	503.32	18746	464.65

Source: BPC-2001, BPC-1991

Appendix-C

SOIL ASSOCIATIONS:

Oldest Meander Floodplain

1 -Jaonia — Santhia association

Old Floodplain Basin

5-Jaonia —Beel association

Young Atrai Meander Floodplain

2-Mainam — Manda complex

Little Jamuna Meander Floodplain

3- Dohail made — land — Malanchi complex

Level, Intermittently Flooded Terrace

4-Amnura — Nijhuri association

6- Nijhuri association

Broadly Dissected Terrace

7-Nijhuri — Amnura association (Boardly dissected phase)

8a-Amnura — Nachole association (Boardly dissected phase)

Closely Dissected Terrace

8b-Amnura — Nachole association (Closely dissected phase)

8c — Amnura — Nachole association (Steeply dissected phase)

Source: SRDI, Rajshahi, March, 1984.

Appendix-D

Annual Rainfall of the Research Area

Station—R—211 —SAPAHAR

(Rainfall — M.M)

Year	Jan	Feb	March	April	May	June	July	August	September	October	November	December	Total Annual Rainfall
1996	02.0	03.0	00.0	19.0	58.0	170.0	192.0	273.0	610.0	102.0	00.0	00.0	1429.0
1997	04.0	01.0	00.0	78.0	94.0	303.0	231.0	197.0	131.0	00.0	00.0	00.0	1039.0
1998	01.0	01.0	33.0	133.0	105.0	211.0	385.0	323.0	272.0	1350.0	02.0	00.0	1610.0
1999	00.0	00.0	00.0	85.0	242.0	339.0	422.0	332.0	452.0	145.0	00.0	00.0	2008.0
2000	00.0	26.0	11.0	159.0	140.0	375.0	110.0	257.0	424.0	23.0	00.0	00.0	1525.0
2001	00.0	00.0	00.0	00.0	144.7	351.0	121.0	236.0	362.0	235.0	15.0	00.0	1464.7
2002	04.0	00.0	17.0	157.0	85.0	214.0	294.0	324.0	491.0	17.0	10.0	00.0	1613.0
2003	08.0	22.0	167.0	100.0	44.0	390.0	343.0	108.0	253.0	265.0	00.0	05.0	1705.0
2004	15.0	00.0	00.0	123.0	121.0	321.0	519.0	178.0	190.0	370.0	00.0	00.0	1837.0
2005	00.0	00.0	19.0	00.0	105.0	113.0	396.0	272.0	125.0	396.0	00.0	00.0	1426.0
2006	00.0	00.0	23.0	72.0	95.0	344.0	232.0	300.0	389.0	45.0	20.0	00.0	1520.0
2007	00.0	24.0	-	-	-	487.0	405.0	269.0	230.0	95.0	00.0	00.0	1510.0
2008	49.0	00.0	15.0	5.0	93.0	336.0	357.0	188.0	89.0	27.0	00.0	00.0	1159.0
2009	00.0	10.0	15.0	15.0	211.0	20.0	272.0	343.0	85.0	233.0	5.0	00.0	1209.0
2010	00.0	00.0	00.0	63.0	70.0	400.0	92.0	183.0	175.0	158.0	-	-	-

Source: Bangladesh water development Board-2009.