CHAPTER - 1
INTRODUCTION

1.1 INTRODUCTION TO THE PROBLEM

We are entering twenty-first century amid the prospects and problems of the human society in various aspects. 'The range of human development in the world is vast and uneven, with astounding progress in some areas amid stagnation and dismal decline in others. Balance and stability in the world will require the commitment of all nations, rich and poor, and global development compact to extend the wealth of possibilities to all peoples... It has started with an unprecedented declaration of solidarity and determination to rid the world of poverty. In 2000 the United Nations Millennium Declaration, adopted at the largest ever gathering of heads of state, committed countries — rich and poor — to doing all they can to eradicate poverty promote human dignity and equality and achieve peace, democracy and environmental sustainability. World leaders promised to work together to meet concrete targets for advancing development and reducing poverty by 2015 or earlier. Addressing poverty requires understanding its causes. During 1990s debates about development focused on three sets of issues. The first was the need for strong economic reforms to establish macroeconomic stability. The second was the need for strong institutions and governance — to enforce the rule of law and control corruption. The third was the need for social justice and involving people in decisions that affect them and their communities and countries. These issues are all crucial for sustainable human development and they continue to deserve priority attention in policy-making. The fourth factor which was overlooked during that period is the structural constraints that impede economic growth and human development’ (UNDP, 2003).

The advancement of knowledge in almost all spheres of human life including science and technology has widened the prospects of development and living standards of people in this planet on the one hand and on the other there is growing problem of sustainability of human civilization. In this context, the issues are ranging from growing population to dwindling of resources, environmental crises, socio-economic and political
instabilities and ever widening the distribution of wealth among nations and regions. The growing world population is seriously increasing demands on the earth’s resources of land, water, air and raw materials. Earlier, times excess population could migrate to more sparsely populated areas or numbers were reduced by plague or war; these options are no longer possible nor acceptable to civilized society at the end of twentieth century. At the same time, human societies are becoming more organized, not just to ensure that people have sufficient land and natural resources for basic needs, but also to support the multifarious activities of increasingly complex social and economic behaviour patterns. As the pressure on natural and land resources increases the greater is the need for properly organized agreements about how they should be shared not only for the benefit of humans, but also for all forms of life. This requires not only an understanding of spatial and temporal patterns of resources but also insight into the spatial and temporal processes governing their availability. History has amply demonstrated many that the deterioration of renewable resources and the reduction of sustainable means of livelihood may produce tensions and stresses of overpopulation and pollution that increase to the point where civilized life breaks down. Aggressive confrontations between different groups of people over land occupation and land resources occur daily all over the globe (Burrough and McDonnel, 2000). From earliest civilizations to modern times spatial data have been collected by navigators, geographers and surveyors to be recorded in coded, pictorial form by mapmakers and cartographers. The mapping sciences – geodetical surveying, photogrammetry and cartography – developed a powerful range of tools for accurately recording and representing the locations and characteristics (usually referred to as attributes) of well-defined natural and anthropogenic phenomena (Goudie et al. 1988, Johnston et al. 1988). The basic units of geographic information were decided long time ago and the first modern cartographers represented the real world objects or administrative units by accurately drawn point, line and area symbols that were chosen to illustrate their most important attributes. Today, much of the geographical information concerns the location of and interaction between well-defined objects in space like trees in a forest, houses on a street or administrative units like villages. As the scientific study of the earth advanced different kinds of attributes needed to be mapped. The study of the earth and its natural resources – geophysics, geodesy, geology, geomorphology, soil
science, ecology and land that began in the nineteenth century has continued to this day. Depending on the kinds of symbolism adopted by cartographers to provide information about the resources or objects on the earth’s surface, the maps may vary from general purpose topographic or distribution maps of rock types or soil series to specific purpose thematic maps. The representations of spatial phenomena are made by different colours or shading for area, various points or line symbols. Such spatial models are referred to as chorochromatic maps in the case of area representation by shades or colours. They are one form of choropleth map or a map showing areas deemed to be of equal value. Similarly, when the representations are done by the line of equal value, such spatial model may be referred to as isopleths. Certain attributes such as value of elevation above sea level, the soil pH over an experimental field, the variation of land value in a city or the variation of air pressure on meteorological charts are more usefully represented by a continuous quantitative surface that may be modeled mathematically. Generally, most of the environmental surveys generate thematic qualitative maps based on the various methods of classification. Quantitative descriptions were not only hindered by data volume but also by lack of quantitative observation. Further, there was lack of appropriate mathematical tools for describing spatial variation quantitatively. The first use of mathematics and statistics for spatial problems started during 1930s and 1940s. The development of digital computers in 1960s and 1970s has revolutionized the world and enabled us to have the science and technology of Geographical Information Systems (GIS) to handle spatial problems. It is a computer compatible process, capable of capturing, storing, analyzing, visualizing and displaying geographically referenced spatial information, that is the data identified according to their location in geographical space. GIS can be used for resource management practices, development planning processes, scientific investigations and many other human activities. The task of building information systems of various kinds is equally important in this era of Information Technology (IT). The Geographical Information Systems (GIS) are the most popular and effective tools available now a days to analyze spatial data for a wide variety of purposes. It is a basic aid in spatial decision support modelling using digital database for space either in vector or raster format along with the attribute information of space. It is the common platform to use the remote sensing data, aerial photographs, data generated
through Global Positioning System (GPS), conventional maps and survey data. Hence, this branch of knowledge is referred to as Spatial Information Science or in short form as Geoinformatics and often as Geomatics. Geoinformatics, operational combination of Remote Sensing, GIS and GPS technologies play facilitator role in collection, visualization, integration and analysis of the up-to-date spatial and nonspatial database with existing datasets created so far in the process of various studies over time and space dimensions. In dealing with such data either in graphics form that is maps / images or their attributes using Geoinformatics for environmental mapping requires Geo-environmental indicators and Geo-environmental units in relation to natural system unit or terrain mapping unit. Rational and optimal utilization of Geoinformatics for identification, integration and analysis of thematic aspects of terrain units in relation to the generated numerical attributes may be considered as the most holistic approach to conclude on decision rules for geo-environmental indicators and geo-environmental units. However it demands trained multi-disciplinary personnel. In this vast area of knowledge, Photogrammetry, Remote Sensing, GIS and GPS are developing as independent science and technology tools to address spatial problems of decision making for the resource managers and planners in this century. The convergence of multiple technologies including GIS, Internet, wireless communications has given rise to exciting new types of information utilities that may be referred to as location based services.

Under such a coexistence of various problems among countries and regions, there are emerging possibilities to deal with the problems using the recent developments in science and technology. Our country is entering into the phase of becoming a developed country. To meet these challenges, we are well equipped with the space technology to provide information about our natural resources through Indian Remote Sensing (IRS) satellites. This space technology has given earth resource scientists enormous advantages for generating useful information on exploitation and management of resources. The land and water resource evaluation studies arose through the need to match the land requirements for producing food and supporting populations under a given conditions of physical and cultural environment.
1.1.1 Statement and Significance of the Problem

In the context of various issues that plagued the present century and the present emerging spatial information technology tools, more particularly Remote Sensing and Geographic Information System, the basic problems to be addressed in this study are related to development of spatial and attribute database in digital environment for the evaluation and analysis of physical and cultural environment of an area, that finally leads to evolve decision support spatial models of resources and infrastructure management, based on available information from various sources. There is growing consciousness on the status of environment and societal change. We are aware that environment is degraded day by day at a faster pace due to expansion of industrial and economic activities to meet human needs and requirements. Our resources are depleting due to extreme pressure of population. The growing aspiration of mankind for raising the standard of living and the decreasing carrying capacity of the limited land and natural resources have created a fear psychosis among on the question of sustainability of various life forms including mankind on this planet. That is why monitoring, assessment, management and planning of both natural and cultural resources have become an urgent need of mankind to survive on this planet. The advancement of space technology and the information technology has added impetus to deal with the resources and phenomena over the earth’s surface very meaningfully. The science of Geoinformatics dealing with these aspects has provided a wide scope for the researchers of every discipline of natural sciences, technology and humanities to deal with the situation holistically and in integrated manner so that everyone can extend co-operation and participate in caring nature and conserving natural and cultural resources for betterment of human civilization on this planet for the future of mankind. The Integrated Mission for Sustainable Development (IMSD) during 1990s in India and various projects undertaken for watershed management, infrastructure planning and management have added impetus to develop local area planning and management of resources and infrastructure for equitable distribution of development and maintenance of quality of life. The local self government in three tier Panchayati Raj System (PRS) of our national polity will have a great impetus by using the database of resources and infrastructure in decision making processes and welfare schemes including planning for the future. So, there is an urgent
need for applications of space technology in community or local area development. Hence remote sensing and GIS tools are now inseparable from decision-making processes. These are becoming popular and widely used to create meaningful information from a wide variety of data sources. The poor database for geographic features and their attributes cause faulty planning and management of resources and infrastructure in an area. This is one of the reasons of backwardness of rural India. Recently, it has been emphasized by the Govt. of India through its different agencies, to develop such spatial database at block level, the lowest level of geographic unit for planning and rural development. The spatial database of rural area is an urgent need for fruitful application of Spatial Information Technology in order to make effective decisions on use, management and planning of resources and infrastructure. A good spatial database and its attribute information is itself a kind of infrastructure and it is often referred to as Geospatial Data Infrastructure (GSDI). This data infrastructure can be abstracted from the real world as Digital Landscape Model (DLM). Such models using GIS are converted into Digital Cartographic Model (DCM), represented on maps with dots, dashes and patches. When the DLMs are considered suitable for communication to other persons, and these are to be produced in hard copy form, such models are converted into DCM with various geometric elements, shapes, sizes and colours applying cartographic grammar. This kind of infrastructure helps planners, decision makers and researchers to analyze the information in GIS environment for achieving effective spatial decisions.

The digital database development in GIS using various sources like Remote Sensing and conventional data sources and generation of spatial models taking various aspects of resources and infrastructure will not only bridge the gap of data inadequacy in a rural area like Kathiatoli Development Block, Nagaon district in Assam for which the study has been undertaken but also create awareness in its use for various purpose including local area planning and management of resources by the decision-makers. The output of spatial analysis with various parameters, representation and visualization of numeric data in GIS environment will lead to better spatial decisions for utilizing the local resources and explore new horizons of research and development activities in the area. It will bring the results of space technology applications to the rural masses.
1.1.2 The Study of Relevant Works

Human societies have collected and processed geographic information for millennia. Some of the first written records from Mesopotamia and Egypt contain property boundary information as a part of legal transactions. Other records describe routes and characteristics of distant places. Maps and geographical representations seem to be at least as ancient as the written words (Harley and Woodward, 1989). Demand for Geographic Information has exceeded the supply. In earliest civilizations, the supply of geographic information was limited, probably because this kind of information was more difficult to collect, represent and transmit than other kinds of information scratched on ancient clay tablets.

The literatures on Geographical Information System vary extensively from simple description of the technology and scientific aspects of the discipline to very complex and wide areas of applications. Early on, planners and landscape architects, particularly in the United States of America, realized that the data from several monodisciplinary resource surveys could be combined and integrated simply by overlaying transparent copies of the resource maps on a light table and looking for the places where boundaries on several maps coincided. One of the best known of this simple technique was proposed the American architect Ian McHarg (McHarg, 1969). In 1963 another American architect Howard T. Fisher, elaborated Edgar M. Horwood’s idea of using the computer to make simple maps by printing statistical values on a grid of plain paper (Sheehan, 1979). Fisher’s programme SYMAP, the abbreviated form of SYnagraphic MAPping System, includes a set of modules for analyzing the data, and manipulating them to produce choropleth or isoline interpolations, with results to be displayed in many ways. Fisher became the Director of the Harvard Graduate School of Design’s laboratory for Computer Graphics and SYMAP was the first in a line of mapping programmes that were produced by enthusiastic, internationally well-known and able staff. Among these programmes were the Grid cell (or Raster) mapping programmes GRID and IMGRID that allows the users to do in the computer that McHarg had done with transparent overlays. Naturally the Harvard Group was not alone in this new field and many other workers developed programmes with similar capabilities (e. g. Duffield and Coppock, 1975; Steiner and Matt, 1972; Fabos and Caswell, 1977 to name a few). Initially none of
these overlay programmes allowed the user to do anything that McHarg could not do; they merely speeded up the process and made it reproducible. However, users soon began to realize that with little extra programming effort, they could do other kinds of spatial and logical analysis on mapped data that were helpful for planning studies (Steinz and Brown, 1981) or ecological analysis (Luder, 1980). Previously these computations had been extremely difficult to do by hand. SYMAP, GRID, IMGRID, GEOMAP, MAP and many other relatively simple programmes were designed for quick and cheap analysis of gridded data and their results could only be displayed using crude line printer graphics. Many cartographers refused to accept the results produced by such computer-based programmes as maps. Cartographers had begun to adopt computer techniques in the 1960s and by 1970s there had been considerable investments in the development and application of computer-assisted cartography (Tomlinson et al., 1976; Teicholz and Berry, 1983). It is very difficult to separate computer technology from the practice of digital cartography. The designs of many algorithms for solving problems and even theoretical developments have been strongly influenced by the available technology. Morrison (1980) has divided the computer assisted cartography into three stages - (1) the period of the early 1960s when cartographers had a wait-and-see attitude, (2) the period of the late 1960s and 1970s when cartographers replicated products which were done manually by a previous technology, and (3) the post 1980s when there was a full implementation of new products (Cromley, 1992). Technology, in its broadest conceptual and cultural sense, has been a driving force in the ability to construct and disseminate geographic information. Many of the developments of the twentieth century involve the combination of some new ingredients from outside the field with the basic concepts from the past. The equipments have become much more sophisticated but the underlying principles have remained the same. A wide variety of hardwares are used in present day geographic measurement. The most critical hardware element is the computer, which has conquered the work in most of the developed world. Alongside the impressive development in computer hardware, the development of software has sparked a fundamental rethinking of the concepts underlying geographic information. The separate specialties known as aerial photography, remote sensing, digital cartography, spatial analysis, multipurpose land information systems, and a host of others have converged to
create an interdisciplinary focus on geographic information systems. Each of these contributory technologies has expanded rapidly, but the combination has expanded even faster (Chrisman, 1997).

Taking advantage of the emerging new technologies, more effective and innovative methods of research, training and education programmes are being launched in various countries. It is observed that GIS industry suffers from lack of adequate manpower, especially professionals with considerable exposure to applications. In India, presently we have around 238 universities, 135 autonomous colleges connected with 29 universities, 303 postgraduate institutions approved by All India Council of Technical Education (AICTE), and about 800 undergraduate engineering colleges and a few thousand other colleges. However, there is only one institution in the country, Anna University that offers a degree course in Geoinformatics while a dozen institutions offer post-graduate degree in Remote Sensing / Geomatics / Geoinformatics. Similarly, there are hardly a dozen institutions offering post-graduate diploma. Such a scenario does not project a bright picture for the country in exploiting the full potential of Geomatics for economic development. Our hope lies in the initiatives taken by the University Grants Commission (UGC) and AICTE during the last 2-3 years in introducing the courses on Remote Sensing and Geomatics, both at undergraduate and post-graduate levels. GIS was introduced in India by the Department of Space (DOS) during the 1980s as a sequel to launching of National Natural Resources Management System (NNRMS) in 1983. Remotely sensed data was considered as the primary input for GIS and hence the growth, development and dissemination of GIS was strongly linked to the progress of remote sensing activities in the country. Of course one has to understand this in the context that the first textbook on GIS by P. A. Burrough was published in 1986. During the last 20 years, starting with the applications in regional planning, watershed development, urban planning, wasteland development etc. the gamut of applications has covered practically every facet of natural resources management. Recognizing the importance of satellite-based remote sensing systems for management of natural resources, DOS has been identified as the nodal agency for the establishment of the NNRMS, which has the participation of various central and state agencies and departments. Towards the NNRMS, ISRO has undertaken the design and development of a series of Indian Remote
Sensing (IRS) satellites (Chandrasekhar, 1994). This rightly shows that as a fast developing country like India has to deploy the latest technologies to meet the challenge of sustainable development. Today every body talks of e-governance at all levels – from Gram Panchayat (GP) / Municipality to Central Government. This implicitly includes development and judicious management of natural resources, infrastructure, utilities, and of course the transparency – right to information. The country has already made commitment to develop National Spatial Data Infrastructure (NSDI). Our country is on threshold of becoming a world power in IT. Our GIS industry, primarily a value addition industry, is growing with double-digit figure 10 –15% annually. Our GIS export is estimated to grow to USD 150 million by this year of 2005 (Sahai, 2003).

The developments have created enough scope for all theoretical and scientific workers in changing GIS Systems to GIS Science. The rate of change of education and training had been significant. In fact now the words GIS stand for Geographic Information Science giving recognition that this discipline has gone well beyond a set of tools and techniques to a field of scientific investigation. For teaching and research, we can say that GIS can be split into Geo-information and GIS technology. Presently Geo-information is identified as a topic specially dealing with the information within GIS applications, such as – what data is available and where, what types data to be used in different applications, what are the constraints that exist in both data and its applications, and developments that are or should be undertaken for new applications etc. (Muralikrishna, 2003).

Natural Resources Information System (NRIS) is a Department of Space (DOS) programme to facilitate planning personnel at district and state level in making appropriate decisions for sustainable development of natural resources as well as developmental activities. The integrated database of NRIS consists of 20 spatial, 8 non-spatial primary database elements, and 17 spatial and 3 non-spatial derived database elements. It is decided to create such integrated database from Indian Remote Sensing satellite data and relevant collateral information. The digital database for various states of India has been created in the spatial framework of World Georeferencing System, 1984 (WGS-84) datum and Lambert Conformal Conic (LCC) Projection System using GPS Technology. The Survey of India (SOI) topographic map-based spatial framework in
creation of digital data is not possible due to restriction policy of the surveying agency. However, one of the biggest achievements in usage of geospatial data in public domain is the release of digital maps on November 20, 2002 by Survey of India on WGS-84 datum for Gujarat state at 1:25,000 scale. This is a significant step on the part of Survey of India as in a few years the user community is demanding reliable high-resolution data in digital form. So far, the data was not available for the whole country except a low-resolution data derived from 1: 250,000 scale topographical maps. As per current restriction policy of Ministry of Defence (MoD), topographical data falling within 50 km from international boundaries / coastline are classified as restricted. Maps under this categories can only be issued to government departments / Non-Governmental Organizations (NGO) after completing formalities as laid down by MoD. Moreover, the digital data of all topographical maps are classified as restricted. To overcome such difficulties for end users, the Survey of India introduced two series of maps. One series of maps is on Everest spheroid datum with existing map projection and all existing details for use of defence forces only. And the second series of maps is on Universal Transverse Mercator (UTM) Projection with less detail for use by the public. The release of maps of Gujarat (restricted zone) for public use is just a beginning in this direction. Very soon the SOI is releasing the digital maps of entire country.

National Remote Sensing Agency (NRSA) is an autonomous organization under the DOS. It is mainly responsible for acquisition, processing and dissemination of satellite / aerial data and training of users in various applications. Space Application Centre (SAC), Ahmedabad of ISRO and a chain of Regional Remote Sensing Service Centres (RRSSC) are providing operational resources survey services to the users utilizing modern remote sensing techniques. Similarly, the state governments have established State Remote Sensing Application Centres (SRSAC) to meet the local needs and to provide services for various agencies utilizing the remote sensing data and GIS technology. In the present decade, many Academic Departments in Universities and Colleges, Indian Institute of Technology (IIT) and Engineering Colleges, Research Laboratories, Research Institutions, Surveying Agencies and spatial technology industries of our country are well equipped with Remote Sensing and GIS Laboratory infrastructure to promote quality research, training and services in various application areas.
The Department of Science and Technology (DST), Government of India launched a comprehensive programme in 1982 on the development of the Natural Resources Data Management System (NRDMS) by setting up computerized databases at micro-level taking district as a unit. The Indian Space Research Organization (ISRO) has programme through which financial support is provided for conducting research and development activities related to Space science, Space Technology and Space Applications in universities and academic institutions in India. This programme of research sponsored by ISRO is called RESPOND. The main objective of RESPOND Programme is to establish link with academic institutions to carry out quality research and development projects of relevance to space. Through this initiative many areas of space science and technology for national development has been explored and maximum benefit is reached to the people of India. The Integrated Missions for Sustainable Development (IMSD) was initiated in the year 1987 with a specific objective to find scientific and lasting solutions to mitigate drought following unprecedented drought in many parts of the country during 1985-87. The Department of Space (DOS) in close collaboration with respective State Remote Sensing Application Centres initiated the study for pilot demonstration in 21 districts of 13 states in India during 1988-89. As a part of these and many other such programmes research areas covering various geospatial modelling applications in resource management, agriculture, forestry, hydrology, soil science, oceanography, land use and land cover changes, infrastructure planning and management have been carried out in various states of India (Kasturirangan et al, 1996).

A nationwide programme under the DOS was launched during 1990s in our country, covering 174 districts distributed in 25 states in order to make geospatial applications at watershed levels (NRSA, 1995). For Assam, two districts viz. Kamrup and Karbi Anglong have been identified for generating action plans during the eighth plan period under the project direction of Professor D. C. Goswami (ARSAC, 1997). Subsequently, district and block level geospatial databases for resource management and planning were created by Assam Remote Sensing Application Centre (ARSAC) for various districts in Assam during the last five years. Presently, National Informatics Centre (NIC), Assam is also preparing such databases for geospatial applications at block level.
1.1.3 Organization of the Study

The present study of resources and infrastructure management and planning in Kathiatoli development Block, Nagaon District in Assam using GIS based spatial models has been organized into eight chapters with some innovative features in mind.

Firstly, the emphasis has been made to introduce the problem in various contexts of growing crises in resource management in relation to the increasing population, deteriorating social and physical environment in the world at regional and local level. Here, the options have been sought by taking advantage of the strides made by science and technology in dealing with the problems related to spatial decision-making, management and planning of the available resources and infrastructure for sustainable future.

Secondly, the core issues relating to management and planning of resources and infrastructure are viewed at local scale as elaborately as possible in a digital environment taking advantage of the geo-spatial tools and information technology available to day. The real world situations are analyzed in various perspectives with the help of geographic data matrix and geo-databases.

Thirdly, the real world situations are synthesized with specific purpose, in order to find alternative solutions of the identified problems at micro-level. In order to fulfill the targeted objectives of the study reference has been made to conventional data and tools including the kinds of works have already been done, using satellite data and modern tools of Geoinformatics. Hence, the world of data is visualized as spatial information models, thematically and in integrated manner.

The first four chapters provide the information on introductory part of the problem and the study area including the basic framework of whole study. The first chapter entitled ‘Introduction’ to deal with the statements of the problems undertaken for the study and its significance, the study of relevant works at global, national and regional levels with a reference to tools and technology available during various time periods. It gives an introduction to the present study, through the current discussion on the organization of the study. Similarly, a very brief summary of physical and cultural landscapes of the study area has been made as an introduction of the study area. The second chapter deals with the research hypotheses and objectives of the study. The third
chapter is devoted to describe the database used in the study including some conceptual and technical framework in designing database for geo-spatial applications. This chapter also gives a reference to various data sources and tools and technology involved. Brief discussions on general methodology on creation of spatial data models and their applications have been emphasized along with the description of methodology of data collection, ordering, processing and presentation. The fourth chapter is employed in this study specially to focus on database management and its environment in general way to specific manner, relevant to the data and tools used in the study. It describes shortly the evolution of database concepts, the environment of its creation, applications and advantages.

In Chapter-V, an evaluation of physical resources and environment, in terms of natural resources inventories for these have been prepared at GP level and regional level of the Kathiatoli Block for geology, geomorphology, physiography, water resources, soils and forest resources. Applying the geoinformatics tools of data visualization, the real world scenario is viewed nearly close to its reality by designing 2-dimensional and 3-dimensional spatial models. The various components of DEM such as slopes and aspects are examined at local level. Similarly, the status of water, soils and forest resources is evaluated and analyzed at GP level. Thematic representations, visualizations and analyses of natural resources and environment are the essence of this chapter. Similarly, Chapter-VI deals with the evaluation of cultural resources and infrastructure. This chapter proceeds with basic ideas and references on cultural resources initially and then the discussion on and evaluation of demographic structure, composition and distributitional characteristics, land uses, localization and influence of various amenities and infrastructure including community services using various spatial models.

Integration of physical and cultural information is attempted in Chapter-VII including the suggestion and formulation of action plans on some aspects of management and planning of these resources for sustainable rural development in Kathiatoli Development Block. On action plans the focus is made on population and their employment in various sectors, control measures of population growth, conservation of land and water resources and infrastructure development are mainly emphasized. Chapter-VIII is meant for SUMMARY AND CONCLUSIONS of whole study.
1.2 INTRODUCTION OF STUDY AREA

In introducing the study area, Kathiatoli Development Block of Nagaon District in Assam, several geographical aspects are remarkable. First of all, geographically it lies in the central part of the North Eastern Region (NER) of the country, stretching roughly between $88^\circ - 97^\circ$ E longitudes and $22^\circ - 30^\circ$ N latitudes (Fig. 1-1). Secondly, it is under the influence of the rain shadow zone of the region. The average annual rainfall is only 170 cm in this area. While Mowsynram (a small locality near Cherapunjee), the wettest place on Earth receives average annual rainfall of 1400 cm, is only 55 km away southward from Shillong city, the state capital of Meghalaya that receives average annual rainfall of 245 cm (Gopalakrishnan, 1989). Most remarkably, it is noted that Shillong is nearly 100 km away towards south-west of the study area. Therefore, within a very short distance (merely 155 km) the variation of average annual rainfall, no doubt, is the highest in the country; this variation within such a small area may be the highest in the world also. Thirdly, the drainage regime of this area belongs to the Kopili, one of the principal left bank tributaries in the central southern Brahmaputra valley. Significantly, the study area lies at the lower portion of the Kopili Basin. Naturally, the impact on overall environmental conditions of the study area, especially on soil formations, floods and hydrological and many other physical conditions is purely dependent on physical configuration and characteristics of the basin and the immediate surroundings of the study area. A short description of the salient features of the physical and social landscapes of the study area often referred to as Kathiatoli Block in this study is presented here. Detailed discussions and analyses on these aspects are to be done in subsequent and relevant chapters that follow.

1.2.1 Physical Landscape

1.2.1(a) Geographical location and situation

The study area comprises the Kathiatoli Development Block of Nagaon District of Assam, is physically situated in the lower Kopili basin that stretches between $25^\circ 00' - 26^\circ15'$ N latitudes and $92^\circ 00' - 93^\circ15'$ E longitudes (Fig. 1-1). It lies to the south of the Brahmaputra plain in Assam covering an area of 14,760 sq. km.
LOCATION OF THE STUDY AREA
KATHIATOLI DEVELOPMENT BLOCK
NAGAON DISTRICT (ASSAM)

Fig. 1-1: Location of the Study Area, Kathiatoli Development Block
The Kathiatoli Development Block area is situated at the extreme down stream segment of the Kopili River and its tributaries between 25°55' - 26°20' N latitudes and 92°30'- 92°50' E longitudes (Fig. 1-1 and Fig. 1-2). It is important to note that the study has been conducted for the block within the basin area and a comprehensive digital database for local area planning and management of resources and infrastructures at Gram Panchayat (GP) and revenue village level has been developed. It is significant that the villages and GPs are considered to be the lowest geographic units of local governance in our country. There are 156 revenue villages and 20 Gram Panchayats in the study area. Fig. 1-3 shows these local administrative units and major places of the block. The revenue villages are distributed in Kampur and Nagaon Revenue Circles of Nagaon district of Assam. The total reported area; available from the revenue records of the villages of the block is 369 km². But this area does not include some of the areas of revenue villages categorized as forest villages. Considering the mapped area of all the revenue villages including the forest area, the total area of the block is 381 km².

1.2.1(b) Geology

The Kopili basin, geologically, forms a part of the ancient landmass of Shillong plateau and Karbi Anglong, the tertiary sedimentary rock formations of hill ranges in North Cachar district of Assam, and the alluvial plains of Kopili and its tributaries in the south and south eastern part of the basin. The tertiary deposits resting over the weathered platforms of Archaean rocks are found in some parts of Kathiatoli Block mostly lying within Nagaon plain (GSI, 1869). The geological formations of Kathiatoli Block area comprise mainly of New and Old alluvium in the plain and foothill region of Karbi Anglong respectively and granite rocks towards North eastern and gneissic rock in the southwestern part of the area.

1.2.1(c) Geomorphology

The Kopili basin, geomorphologically, forms a part of Shillong plateau, Karbi Anglong, North Cachar hills, and Nagaon or Kopili plain. The geomorphic evolution of the basin was in progress for about two thousand million years (GSI, 1981). Geomorphologically, the Kathiatoli Development Block area falls within Nagaon or
Kopili plain including a part of Archaean plateau and piedmont zone bordering Daboka hills and western part of Karbi Anglong. The study area is mostly comprised of the alluvial plains and floodplains of Kopili, Borpani, Haria and Nanoi river systems. Some insignificant area is comprised of the older alluviums. Kondali and Borpani Tea Estates generally occupy these areas.

Fig. 1-2: Major Drainages and Physiography of the Kopili Basin
Fig. 1-3: Local Administrative Units and Major Places of Kathiatoli Block
1.2.1(d) *Physiography*

The physiography of the Kopili Basin is made up of the lofty hill ranges, plateau and alluvial plains (Fig. 1-4). The topography of the region is by and large uneven with about 61% of the total area covered by highlands of Meghalaya plateau, Karbi Anglong and tertiary hill ranges of North Cachar. Numerous tributaries of Kopili River Viz. Umium or Killing, Umkhen or Borpani, Diyung and Jamuna etc dissect these highlands. The Kopili or Nagaon Plain separates the Karbi Anglong from the main mass of Meghalaya Plateau.

![Fig. 1-4: Physiographic Divisions of Kathiatoli Block](image)

Similarly, the physiography of the Kathiatoli Development Block area is controlled by river systems, and most of the area comprises of alluvial plain of Kopili in the central part and its tributaries in the northern and northeastern part. The marginal areas in the north east of the block area belong to foothills of the Dabaka hills ranges and in the south-west to west Karbi Anglong plateau is located in Hamren sub-division of Karbi Anglong district of Assam. In the plain, the elevation varies from 60 m to 100 m and in the foothills it is about 150 m. The plateau part in the southwest varies between 150 m to 300 m.
1.2.1(e) Drainage

The Kopili drainage basin occupies about 14,760 sq. km. covering parts of Karbi Anglong, Nagaon plain, North Cachar hills of Assam and Khasi and Jaintia hills of Meghalaya (Fig. 1-2). The principal river of the basin, the Kopili rises at an altitude of 1525 m situated at Barail Hill range in North Cachar hills. The river fed by four major left bank rivers viz. Umium or Killing, Umkhen or Borpani, Myntang and Kharkar and three right bank tributaries viz. Diyung, Jamuna and Nanoi. Underlying geological structure in its upper reaches, which follow joints and faults etc, controls almost all the tributaries of Kopili flowing from Shillong plateau and Karbi Anglong. The streams of Kopili basin represent two distinct types of drainage pattern. The right bank tributaries of Kopili River represent trellis and rectangular pattern, while the left bank tributaries flowing down from North Cachar hills especially Diyung river represent dendritic pattern.

Lower reaches of the rivers like Kopili, Jamuna, Borpani, Nanoi, Haria, and Lutumari etc. drain the Kathiatoli Development Block area. These rivers follow the course almost parallel to the Kopili River in SW-NW direction except Borpani River situated in the southern part of the block tending N-S direction.

1.2.1(f) Climates

The Kopili Basin is situated in the humid subtropical belt and experiences subtropical monsoon climate with variations from east to west ranging from subtropical warm to cool temperate conditions. The average annual rainfall of the region is about 168 cm. The average annual temperature of the basin varies between 10 °C to 28 °C.

The climatic data for the Kopili basin is available from meteorological stations of Chaparmukh, Lumding, Diphu, Shillong, Garampani and Haflong. The rainfall amount is least towards Lumding and Chaparmukh but the variation in these areas is the least (16.7%) as compared to the rainfall variations in Haflong (23.2%) and Shillong (26.3%) for the last 32 years (Saikia, 1990). The climatic data especially on rainfall and temperature of the study area is available from two tea gardens – Kondali and Singimari situated within the area.
Fig. 1-5: Monthly Rainfall and Maximum - Minimum Temperatures of Kondali

Fig. 1-6: Mean Monthly Rainfall at Singimari
Similarly, the Kathiatoli Block area being situated in the northern part of the basin, the climatic scenario is slightly different from the basin as a whole. It experiences hot and humid climate during summer and cool and dry climate during winter. The climatic data available from Kondali Tea Estate for a period of 32 years (1968-1999), reveals that average annual rainfall is 170 cm and average monthly temperature varies from 17.9 °C in January to 30.6 °C (Fig. 1-5) during the months of June, July and August. The average annual rainfall amount increases gradually towards south up to 305 cm in Singimari area (Fig. 1-6). Relatively higher relief and dense vegetation cover of Borpani Reserve Forest in the southern and south-western parts of the Kathiatoli Block cause this local variation of rainfall.

1.2.1(g) Soils

Based on the interpretation of Soil Map of Assam prepared by National Bureau of Soil Survey and Land Use Planning (NBSSLUP), Nagpur, the soils of the area is broadly alluvial and loamy in character. Applying order level classification of soils in Kathiatoli Development Block area, it is found that there are five soil orders. They are – Alfisols or Red Soils (40%), Inceptisols or Old Alluvial Soils (37%), Entisols or Recent Alluvial Soils (20%), Ultisols or Red Soils (1.7%) and Histosols (1.6%). Considering the texture and structure, these soils may be further be classified into the three major groups- [i] Alluvial, [ii] Red loamy and [iii] Laterite soils. These soils are comprised mostly of recent alluvium in the plains and old alluvium in the foothill and highlands.

1.2.1(h) Natural Vegetation

In the Kopili basin, physiographic configuration, climates and soils have given rise to various types natural vegetation ranging from grass, bush to Evergreen coniferous forests. Forests occupy about 7390 Sq. km of this basin. Botanically, this basin may be termed as vegetal museum. Phytogeographically, it is of great interest, for nature of vegetation as well as floristic composition. The natural vegetation of the Kopili basin may be classed broadly into – Tropical Evergreen and Semi Evergreen forest in high altitude and heavy rainfall conditions in Khasi, Jaintia and North Cachar Hills in the
Barail Ranges, Mixed Deciduous forest and riverine forest in north-western, central south-eastern and eastern Kopili basin. The upper part of the basin being influenced by heavy rainfall, results in the growth of dense mixed deciduous and evergreen trees. Another zone with relatively less rainfall (less than 100 cm) and lower altitudes of central Kopili basin is dominated by open mixed deciduous forests with moist savannah type of grassy vegetation. The areas with higher temperature and relatively higher amount of rainfall, the predominant vegetation is deciduous broad leaved forests like Sal (Shorea robusta), Chapa (Artocarpus Chopalosha) mixed with bamboo, cane and other minor vegetation.

Kathiatoli Development Block area comprises of semi-evergreen and dense mixed deciduous forest in the south and southeastern part and riverine forests in the alluvial plains. The recent satellite data (IRS-1C, LISS-III, 2003) employed in this study shows that the coverage of forests is only 6% of the total geographical area and it is confined in the southern and south-western part of the block. The most commonly found species in this semi-evergreen vegetation zone are – Tita sopa (Talauna phellocarpa), Sopa (Maglantica isignis), Hollong (Diptero carpus), Makai (Shorea assamica) and Sal (Shorea robusta). The ‘Sal’ occupies the old alluvium tract with well-drained slopes, slightly acidic soils and areas of moderate rainfall. In these areas, the other species are – Makari Sal (Schima wallichii) and Sonaru (Cassia fistula). The deciduous forests mainly comprises of Udal (Stericola villosa) and Bonsum (Phoebe assamica). It is also covered by dense reserve of bamboos. Nearer to the alluvial tract of the block is commonly occupied by open mixed deciduous forests, scrubs and grasses. In the riverine alluvial tracts are covered by bamboos, thatches, grass and reeds. Simul (Bombax malaricum) and Koroi (Albizzia procera) occasionally occupy these areas.

1.2.2 Cultural Landscape

1.2.2 (a) Population Base

The total population of the Kathiatoli Development Block, (subsequently referred to as Kathiatoli Block) as per Census of India, 2001 is 193,395. This figure is 8.35% of the total population of Nagaon District. They are distributed in 156 villages and 20 Gram Panchayats of the block. No doubt, mainly the physical landscape, available resources
and means of communication and transportation influence the distribution pattern of population in this block.

The block has a total working population of 74,756. Hence, the share of working population to total population is 38.65%. Therefore, the dependency ratio is very high. Out of 74,756 workers in the block only 70.62% of them are main workers and the rest are marginal workers having only 90 days of employment within a year.

1.2.2 (b): Growth of Population

The decadal growth rate of population during 1991-2001 is 25.61%, which is very high in comparison to the national and state figures of 21.53% and 18.85% respectively. The average annual growth rates of population for various geographic units including the world, country, state and the district are computed, based on the model of cumulative growth of population, \( P_t = P_0 (1 + r)^t \), where, \( P_t \) = population in 2001 and \( P_0 \) = population in 1991, \( r \) = average annual growth rate and \( t \) = time period and the results are presented in the Table 1-1.

It is quite clear from the Table 1-1 that the national population growth is higher than the world’s growth rate of population. The regional growth rate is higher than the nation’s growth rate of population and the study area is experiencing very high annual rate of growth of population in comparison to any geographic unit larger than it in the last census decade. This signifies that the population problem at local level is very acute than the others. As a result the stress on land resources is very high.

<table>
<thead>
<tr>
<th>Geographic Unit</th>
<th>Period</th>
<th>Average Annual Growth Rate of Population (%)</th>
<th>Data Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>North East India</td>
<td>1991 - 2001</td>
<td>2.00</td>
<td>Census of India, 1991 and 2001</td>
</tr>
</tbody>
</table>

1.2.2 (c) Density of Population

The density of population in Kathiatioli Block is slightly lower than the district but it is far higher than the national, state and regional figures (Table 1-2).
Table 1-2: Population density in various geographic units

<table>
<thead>
<tr>
<th>Geographic Unit</th>
<th>Density of Population (persons / km²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>India</td>
<td>324</td>
</tr>
<tr>
<td>North East India</td>
<td>151</td>
</tr>
<tr>
<td>Assam</td>
<td>340</td>
</tr>
<tr>
<td>Nagaon District</td>
<td>604</td>
</tr>
<tr>
<td>Kathiatoli Block</td>
<td>507</td>
</tr>
</tbody>
</table>

Data Source: Census of India, 2001

It is significant that the density of population in Kathiatoli Block is more than three times in comparison to the regional figure of 151 persons / km² in the states of North Eastern India (excluding Sikkim) as a whole and it is 1.5 times the national and state’s figure. Thus, the study area is one of the very densely populated parts of the Kopili basin in Assam.

1.2.2 (d) **Literacy Levels of Population**

As it can be seen from the Fig. 1-7 and Table 1-3 that the literacy level among the populations in Kathiatoli Block is very low in comparison to national, state and district level geographic units. The literacy level in the male folks is higher than the females in all of the geographic units considered here but in Kathiatoli Block, nearly 50% of females are literate and this figure is far below the district, state and national level figure for the same. Observing the over all literacy, it can be said that 44% of the total population are illiterates in this block.

![Fig. 1-7: Literacy in the Block in Relation to National, State and District Level](image-url)
Table 1-3: Literacy levels of population

<table>
<thead>
<tr>
<th>Geographic Unit</th>
<th>Overall literacy (%)</th>
<th>Male literacy (%)</th>
<th>Female literacy (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>India</td>
<td>65.49</td>
<td>75.96</td>
<td>54.28</td>
</tr>
<tr>
<td>Assam</td>
<td>64.28</td>
<td>71.93</td>
<td>56.03</td>
</tr>
<tr>
<td>Nagaon District</td>
<td>62.28</td>
<td>68.52</td>
<td>55.57</td>
</tr>
<tr>
<td>Kathiatoli Block</td>
<td>57.41</td>
<td>64.10</td>
<td>50.3</td>
</tr>
</tbody>
</table>

Data Source: Census of India, 2001

This clearly indicates that the utilization of available resources in the area and the plans and programmes of developments are hindered due to low level of literacy, including many other factors of social and economic transformations.

1.2.2 (e) Social Composition of Population

Broadly, there are three social groups in the study area. They are – (a) Scheduled Castes (b) Scheduled Tribes and (c) General. Again, each of them belongs to a number of linguistic groups and communities. The Scheduled Castes (SCs) and the Scheduled Tribes (STs) are generally considered to be backward and special provisions are made in the constitution of our country for their upliftment in the social hierarchy. As per 2001 census records, in Kathiatoli Block, general population comprises of 82%, SCs 11% and STs 7% of the total population (Fig. 1-8).

Fig. 1-8: Social Composition of Population
The share of these two segments of populations will play vital role, while designing management plans, policies and in decision-making processes of their development and well being besides the development of the whole area with certain priority.

1.2.2 (f) Land use characteristics

This study area is representing a rural agricultural economy. The field survey data based on household land use indicates 82% of the total area under cultivated land excluding the settlement area. The land use map prepared from LISS II IRS -1B, 1998 data suggests that there is 84% of total area under Agricultural Land use (Area under Kharif, Rabi, Agriculture plantation and Tea Plantation), 7% under forests and 9% under waste lands. However, analyzing the IRS-1C, LISS-III satellite data of 2003, it is found that agricultural land use constitutes 85%, forests 9% and wastelands 6%. The detail discussion on this section will be made in a relevant chapter.
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Kathiatoli Market Centre