# CHAPTER – 1

# INTRODUCTION

## 1.0 Introduction

Agriculture forms the backbone of the regional economy of Uttar Dinajpur District. "Land use is the surface operation of all developed and not in use land on an exact point, at a particular time and space. This leads one backside to the village farm and the farmer to the fields, private grounds, pastures, fallow land, and forests to the isolated farmstead." (Freeman, 1968). The Uttar Dinajpur District came into existence on 1st April 1992, after the bifurcation of erstwhile West Dinajpur District (Governor of West Bengal, 1992). For administrative purposes, West Bengal has been divided into 23 Districts. Uttar Dinajpur is one of the most important agriculture prone Districts of West Bengal. The Dinajpur District was named after the King Danuj Dinaj. It ranks 16th among twenty-three West Bengal districts in terms of overall size with 3.5 per cent of the total land area of the state and 17th in terms of overall population with 3 per cent of the aggregate state population (Human Development Report, 2010). The responsibility of geographers becomes relevant to analyze the connection between different uses of land and planning for more meaningful as well as economically profitable use of land. Not only that, the study of land use has in recent times developed and it has become one of the most essential branches of economic geography because even today majority of the people have an intimate relationship with the primary activities which is concerned with agricultural land use (Kumar, 1986). In recent times, geographers are engaged to represent a more understandable picture of the potential of land use, conducive to successful planning for massive agricultural production with the help of geospatial technology.

Changes in agricultural land use are not a new phenomenon rather this is a constant process that has been continuously taking place over time and space. Changes in agricultural land use in all the revenue blocks in Uttar Dinajpur District are not uniform. As a result, land use investigation areas are grouped into different regions in much a similar way as has been discussed in criteria, such as the respective proportions of different classes of land use, including forest area, urban area, industrial area and unused land. They may coincide closely with the agricultural region, even exactly the criteria used for definition and delimitation are different - they are land use criteria (Symons, 1968). The structure of agricultural land use in any region is continuous processes of evaluation through inter play of ecological, technological and institutional influences (Lal, et al, 1987). It varies from one revenue block to another revenue block in accordance with the variation in the quality of land, its productivity potential

and availability of water resources. Most of the revenue blocks in the District are facing the problem of acute water shortage, increasing population and urbanization, large agricultural plots are fragmented into several small plots and encroachment of cultivated field leads to small land holding. For these reasons, day-by-day agricultural land use changes in Uttar Dinajpur District. Land use changes to fulfil man's needs. Man's needs can be classified into six major categories, viz. the need for wood, house, food, transport & communication, defence and recreation. To fulfil his needs, man utilizes the land into various forms.

Uttar Dinajpur District's total geographical area is 3,140 $km^2$ which accounts for 3.54 per cent of the total area of West Bengal (88,752 $km^2$) and 0.09 per cent of the total area of India (3,287,263 $km^2$). The general land use type of Uttar Dinajpur District can be classified into four groups - (i) Cultivable area (which includes - Net Sown Area, Current Fallow, Fallow and other than Current Fallow, Culturable Waste Land, Land under misc. tree crops and groves, Permanent pastures and other grazing lands), (ii) Barren and unculturable land, (iii) Net Cropped Area, and (iv) Forest Land (PAO, Uttar Dinajpur, 2015).

The agricultural sector has performed impressively in terms of increasing production, productivity and area of cultivation. It is a remarkable thing that the food grain availability per capita at the district level has increased to a high level over the last three decades. In the mean time, irrigation availability has doubled, there has been an increase in use of chemical fertilizers and pesticides and mechanization in agricultural fields, as a result of which crop production and productivity has increased significantly. Total paddy area rose from 2,651 hundred hectares in 1995-96 to 2,966.50 hundred hectares in 2015-16. The production of paddy decreased from 5,996.90 hundred metric tonnes to 5,733.53 hundred metric tonnes. But the productivity of paddy increased from 2,117 kg/ha to 2,490 kg/ha during the period. Area of wheat rose from 261 hundred hectares in 1995-96 to 533.30 hundred hectares in 2015-16. The production of wheat increased from 589.10 hundred metric tonnes to 893.24 hundred metric tonnes during the period. Similarly, the productivity of wheat per hectare increased from 2,200 kg/ha in 1995-96 to 2,383 kg/ha in 2015-16. Production of potato increased from 51.03 hundred metric tonnes in 1995-96 to 3,577.22 hundred metric tonnes in 2015-16. During the post-green revolution period, the area under major cereal crops would generally be changing substantially from year to year in the district.

All those areas which are under cultivation or under plough at a given time are said to be cultivated lands and placed in the category of net sown area in a year. This category covers all cultivated lands, which are suitable for agricultural use because of plain topography with fertile soil. Such lands are placed under cultivation at an affordable cost, whether such land is in

isolation or within cultivated holdings. In Uttar Dinajpur District it is reported that during 1991-92, about 82 percent area covered under net area sown lands. But in the year of 2015-16, it increased to 87.83 percent. In terms of the percent of the reported area, Raiganj Block has about 10.25 percent (the highest position in District) as cultivable area whereas Chopra Block has 4.03 percent (the lowest position in District) area under this category during the same period.

If any seeding area is not cropped in the same year, it is also treated as current fallow land. It is revealed that out of the total reporting area in the district, the share of current fallow was 1.85 percent during 1991-92 which further decreased to 0.07 percent during 2015-16; the land under current fallow was 5,780 hectares during 1991-92; and it decreased to 240 hectares during 2015-16. The block-wise percentage share of current fallow indicates that Raiganj Block with 23.88 percent land under current fallow was among the highest of vacant land during 1991-92 out of the total current fallow land and lowest current fallow land was in Kaliaganj Block with 4.37 per cent.

Fallow and other than current fallow is a types of land which remain uncultivated for a period of 1 to 5 years. It is noted that out of total reporting area in the district, the share of fallow land other than current fallow was 0.28 per cent during 1991-92 and it decreased to 0.009 per cent (very negligible) during 2015-16; the land under fallow land other than current fallow was 890 hectare during 1991-92 and it was decreased to 30 hectares during 2015-16. But in the three aforesaid Blocks of the district namely Chopra, Goalpokher-I and Kaliaganj there was no fallow land other than current fallow in the year.

The culturable waste land in the Uttar Dinajpur District is only 0.65 per cent of the reporting area during 1991-92 which is far lower than the national standard (4.60 per cent) and the state standard i.e., 3.17 per cent and it has decreased to 0.05 per cent (negligible) during 2015-16; If we consider the block-wise percentage share of culturable wasteland to the reporting area, during 1991-92, the highest is observed in Karandighi Block which has 21.09 per cent of the total culturable waste land and 1.52 per cent of the total reporting area. But during 2015-16, it has increased in Raiganj Block with 29.27 per cent of the total culturable land and 2.65 per cent of the reporting area.

In Uttar Dinajpur District it has been reported that during the year 1991-92 land under miscellaneous tree crops and groves is (not included in N.A.S) only 2,150 hectares which accounted for 0.69 per cent of the reporting area. But this category has increased from 215 to 2,210 hectares in 2015-16 which accounting about 0.71 per cent of the total reporting area in the district.

It is apparent that in Uttar Dinajpur District, the share of permanent pasture and other grazing land is very negligible. In terms of percentage share of permanent pastures and other grazing lands, it is noted that only 960 hectares land which accounts for 0.31 per cent of the total reporting area. The picture of permanent pastures and other grazing lands during 2015-16 shows that there is no space for this land in the district. These permanent pastures and other grazing lands are the most important for the cattle.

The present study combines the study of changes in agricultural land use scenario in Uttar Dinajpur District and its impacts which have influenced these. It provides the real trends of changes in agricultural land use and the role of different factors that Uttar Dinajpur District experienced.

### 1.0.a Organization of the thesis

The study of the changes in agricultural land use scenario in Uttar Dinajpur District is conducted with a geographical point of view. The study agricultural land use scenario is based on the overall observation, statistical information, some selected number of household surveys from all blocks, the status of soil condition and many other information. The study was completed after several field visits of the district and out of the district's offices and total 50 villages which cover 360 sample households for observation and necessary data collection. The whole things and findings are given in nine chapters which also include different information, tables, figures and cartographic representations of different amassed data. This research consists of all chapters and it's organized as follows:

**Chapter-I** includes an introductory part which includes overall concepts of the theme, location of the study area and sample villages, the purpose of the study, objectives, methodological descriptions.

**Chapter-II** is devoted to an analysis of physical aspects (relief character, drainage situation, vegetation presents and soil status, etc.) of the study area which are the most controlling factors for agricultural land use change in the district.

**Chapter-III** is devoted to an analysis of the levels of population distribution, density, growth, decadal variation that have been analyzed for the period from 1961 to 2011 on one side. On the other side, a brief analysis of ownership change between the farmers and others, expansion of urban area which is converted from the agriculture land and it is the negative impact of agricultural land, expansion of irrigation area which indicates the newly added area in the agriculture sector, soil fertility which is very important for crop growth.

**Chapter-IV** deals with the land evaluation which includes suitability and capability classes and sub-classes. It is related to crop growth knowledge of changes in the agricultural land use changes. Not only that, these situations giving the proper idea of suitable crop growth are discussed.

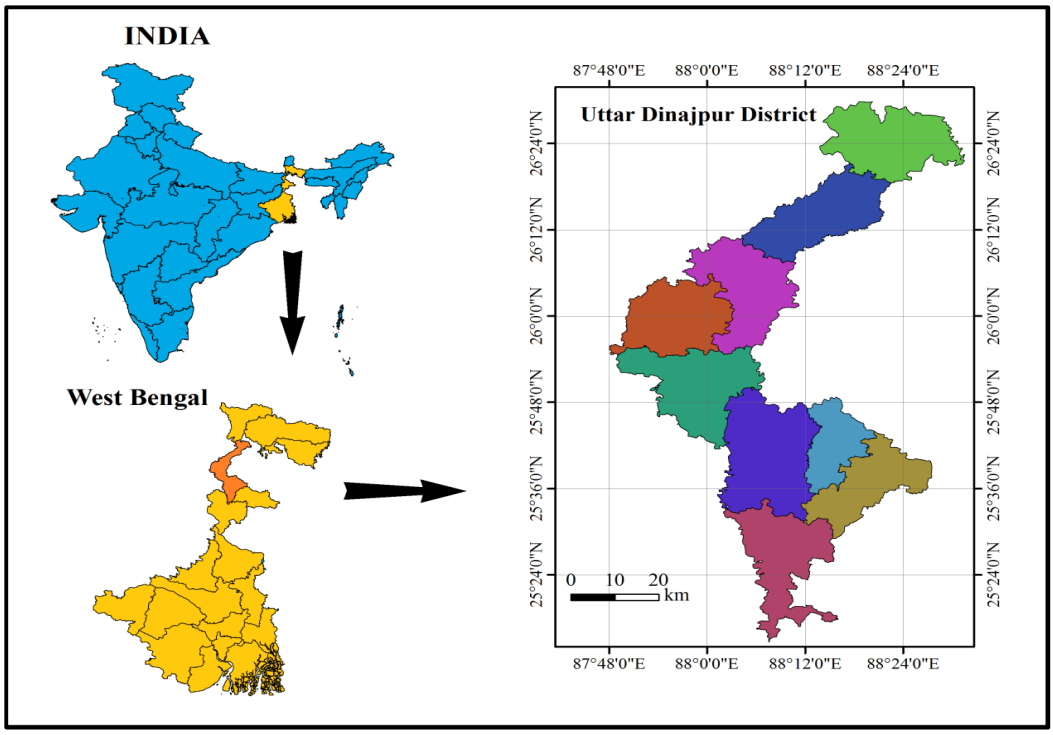
**Chapter-V** is devoted to an analysis of block-wise agricultural innovation and their potentialities which include the method of agriculture, the status of mechanization in agriculture, use of HYV seeds and chemical fertilizers, use of pesticides. The spread of new agricultural technology has been accounted for the district as a whole. These elements help in the increasing crop production and productivity that are the important factors for agricultural land use change. An effort is made to study the troubles of spatial variations in agricultural productivity and examine the association, among the levels of productivity and mechanization of farm inputs at the block level. Introduction and application of new agricultural technology applied for high production.

**Chapter-VI** deals with the block level investigation of the spatial pattern of infrastructure for agricultural practice. Mode and intensity of irrigation have been analyzed for the spatial pattern of levels and growth of agriculture. Brief analyses of agricultural seed farm, market situation, storage capacity in farmer's houses and in cold storage are highlighted. Not only that, the most important things for agricultural production are transport conditions and banking loaning facility are also considered in this chapter.

**Chapter-VII** is devoted to an analysis of the levels and growth rates of the area under major crops, production and productivity per hectare have been discussed for the overall period 1995-96 to 2015-16 (actual study period is 1991-92 to 2015-16, but lack of the proper data for the period of 1991-92 to 1995-96 is the reason for consideration of the period 1995-96 to 2015-16). As discussed earlier, the analysis of block-wise data is based on the actual area and out of the 7 crops (food grain and non-food grain crops). Changes of farm size year to year and cropping pattern change have been considered. Statistical, descriptive and observational and mapping accounts of different agricultural land use pattern and its trend over the study period (from 1991-92 to 2015-16) are discussed.

**Chapter-VIII** few impacts of changes in agricultural land use on agricultural families as findings of the present study have been accounted for. Besides analyzing the spatial pattern of status and present progress of per capita income, education, yield rate, unemployment, etc. for agricultural land use change have been analyzed.

**Chapter-IX** gives a brief summary, conclusions drawn from the study. It is also discussed besides this thesis contains some references




**Source:** Prepared by the researcher based on HDR, 2010, Uttar Dinajpur.

**Figure 1.1** Location map of the study area.

### 1.0.b Software used

In the preparation of this thesis design, figures, statistical calculations and algorithms of modelling were solved using the MS Excel v2010, SPSS v17.0 and MATLAB (Fuzzy logic) v7.12. The different mapping has done using the open-source GIS software QGIS v3.2.2 BONNA and ArcGIS.

## 1.1. The study area

For administrative purposes, West Bengal has been divided into 23 Districts. Uttar Dinajpur is one of the most important districts of West Bengal, comprising an area of about 3,140 $km^2$ and lying between latitudes 25°17'10'' N to 26°35'15'' N and 87°48'37'' E to 88°33'10'' E longitudes.

The District consists of 9 C.D. Blocks covering 1,577 villages, 3 statutory towns and 5 Census towns with accommodation of 30,07,134 inhabitants and an average population density of 956 persons per $km^2$. Not only that, Uttar Dinajpur District occupies 15$^{th}$ position in terms of total population of West Bengal. (Census of India, 2011). In the district, about 67 per cent of the population still depends on agriculture for their livelihood and out of 3,12,466 hectares geographical area of the district 2,72,564 hectares (i.e. 87.23 per cent) area is under cultivation (PAO, Uttar Dinajpur). Agriculture Scientists are applying new technologies and instruments

for growing crops. Uttar Dinajpur District is situated in the northern tract of Bengal Plain lying North of the Ganga River. The district is divided into two sub-micro regions i.e., a) Islampur-Goalpokhar plain, b) Sudhani-Mahananda-Gamari plain and it is bound by Darjeeling and Jalpaiguri in the North and North-East, on the east by Bangladesh and Dakshin Dinajpur, on the south by Malda and the West by Bihar. Normally this district does not exceed 32 m above mean sea level and there is no hill in the district.

Climatically, this region falls under the subtropical monsoon climatic zone, oppressive hot summer (38$^{o}$C in May) and monsoon rainfall, dry and cold winter season (15$^{o}$C in January) are some of the typical characteristics. The area is drained generally by the River Mahananda, Nagar, Sui, Gamari, Chhiramati (Srimati) and Tangan flowing from North to South (Human Development Report, 2010).

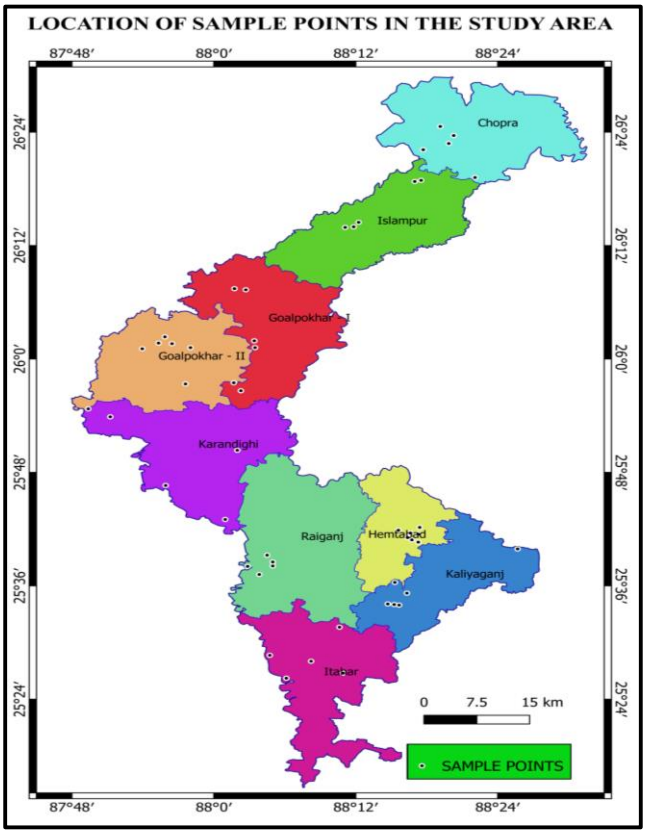



**Figure 1.2** Location of sample sites (sample villages) for fuzzy application.

## 1.2 The objective of the study

The study of land use has developed and it has become one of the most important things because even today the majority of the rural people have a close relationship with the land. Human behaviors in recent times have accelerated the changes in land use. The present study

is an attempt to present an integrated study on changes in agricultural land use scenario of Uttar Dinajpur District, West Bengal.

Therefore, the main objectives of the present study are

1. To study factors responsible for changes in agricultural land use.
2. To assess the land resources and their potentialities for the development and their proper use.
3. To study the general infrastructural facility of agricultural practices.
4. To highlight Block-wise changing trends of agricultural land use in the district.
5. To study the different problems arising from the changing agricultural land use pattern and its result in the study area.

### 1.3. Purpose of the study

The District accommodates 30,07,134 persons of which 26,44,906 persons of the total are (87.95 per cent) inhabiting the rural areas and 3,62,228 persons of the total (12.05 per cent) reside in the urban areas. The density of the population is worked out as 958 persons per $km^2$ in 2011. And the average size of holdings in the district is 0.88 hectare (District Statistical Hand Book, 2015) which is far below of West Bengal which is 1.10 hectares (Agricultural Census Division, 2015) and in India it is 1.08 hectare (Agricultural Census, 2015) per holding.

The chief purpose of the study is to know about the changes in agricultural land use scenario in the study area. The District selected for the study draws its significance for the subsequent reasons:

With the growth of rice factories during the last four decades, a large area that was previously under non-food grains is being devoted to paddy, thereby leading to changes in the use of agricultural land. Large scale changes are taking place in the land use scenario of the study area due to the growth in population, use and misuse of land, as large number of the inhabitants has migrated from different districts as well as from the neighboring state as well as countries (Mukhopadhyay, 2011).

Agricultural activities depend on the physical factors which play a vital role in land use change in a region. In respect to this disparity in micro relief, slope conditions, soil properties, drainage systems, natural plant life, etc. have been taken into consideration.

The study of land use has established a relationship with the study of rural settlements, agricultural science & technology and geomorphology. In fact, rural and urban land uses have become two clear cut aspects of land use study. Large scale unexpected expansion of urban areas leads to an encroachment into the agrarian field which is adversely creating difficulties for future design.

Agriculture is the chief backbone of the study area. The majority of the agrarian farm is infirm due to lack of appropriate scientific methods generally, poverty and illiteracy.
All these considerations have motivated the author to turn his attention to this district and its agricultural land use changes within.

### 1.3.1 Previous works

The title of the proposed research work intends to deal with the dynamic elements of some primary and secondary data based on district-level studies. There are in fact various works on agricultural land use both interdisciplinary and multivalent which was done by many research scholars, authors, Government organizations, etc. The geographer by applying these techniques of survey, mapping, tabulation, analysis and interpretation would provide the correct base to evolve a rational scheme of land use planning (Ali, 1978). Over the decades we came across the huge titles related to agricultural land use like

M, Shafi., 1966 in his paper entitled "*Technique of Rural Land Use Planning with Reference to India'*, was of the judgment that land use survey of a vast country like India is easier to be conducted on the origin of sampling as it is extremely complicated to procure data for all the villages to be surveyed. Moreover, there is an enormous similarity in the land use pattern of an exacting area comprising of several villages, so a model village would do the needful. The author has brought out a plan based on the sampling techniques used for land use survey of India. He has chosen the purposive sampling for relating the trend in the study of land use.

Davis, K. P., 1976 in his book entitled "*Land Use*" highlights the Urban and Nonurban areas are deeply interdependent in land use. Although land use situations and problems often differ widely in specifics, they all have much in common, as is emphasized in this book. In land use, one is consequently working with a complex and changing human-land relationship and balance, and few problems are susceptible to technological solutions only. Lastly, he emphasizes the application of the principle in many different land use contexts in his book.

Kumar, J., 1986 in his book entitled "*Land Use Analysis: A Case Study of Nalanda District, Bihar",* states that the role of land use studies in this way highlights the land use changes which have taken place due to socio-economic transformation and administrative set-up to suggest measures to increase production by the proper uses of the land in a region and to use the improved agricultural methods and crops etc. He also discussed that land use studies reveal the potentialities of the land. Lastly, he mentions the scientific methods in cultivation, improvement of irrigation facilities, electrification in rural areas, the pressure of huge population on the land and many others have also caused the changes of land use in this district.

Grigg. D., 1986 in his book "An Introduction to Agricultural Geography" discussed in part one the demand of the agricultural product, the economic behavior of the farmers, market and transport facilities and population pressure (growth and density) on agriculture can force the change of land use pattern in agriculture. Part two presents the biological individuality of crops and livestock, and the techniques by which the physical environment influences the farmer's selection of crops and animals. But in the last part of this book, it deals with institutional and social influences of agricultural geography. The role of the state, farm size, innovation diffusion and religion are discussed. Lastly, he concluded that the remarkable diversity of the world's major industry requires an equal breadth of mind and its spatial variety is to be understood.

Mandal, R. B., 1990 in his book entitled *"Land Utilization: Theory and Practice*", highlights the basic concepts and methods of land use studies with particular reference to the factors, principles, different approaches of the study, land use models, carrying capacity of the land, land utilization classification, technique of land capability classification, agricultural efficiency, remote sensing and aerial photograph interpretation, agricultural regions and land use planning from different parts of the globe. It is also indicated in this book that a consequence of spatial analysis and developing in an area for economic improvement and social impartiality.

Morepatil. K. S., 1995 in his book "*Studies in Agricultural Land Use*" the study is primarily concerned with the changing agricultural land use pattern in South Maharashtra's Kolhapur district. In his book the general land use and cropping pattern through the maps in the view of the physical and socio-economic situation are analyzed. The changes in agricultural land use which have taken place from 1951 is also highlighted in this book. How new technological inputs can change agricultural land use is also discussed. This is shown by the result which measures the correlation of land capability and land use pattern by making the case study of the district. He concluded that as far as the use of agricultural inputs is concerned, the application of chemical fertilizers and pesticides has strengthened and co-operative agricultural credit societies have forced to change the agricultural land use of the region.

Singh J. Dillon. S. S., 2005 in their book "*Agricultural Geography*" discussed the essential principles, concepts and methods of agricultural geography and contain newer models pertaining to agricultural planning and development. In their book, the first two chapters introduce the cover abiotic and biotic factors which influence agricultural attributes and development at a spatio-temporal scale. Chapter 3$^{rd}$ and 4$^{th}$ present techniques and methods of regionalization of agricultural patterns and examine the agricultural systems of the world and

India. The last two chapters are devoted to the field studies and surveys in agricultural geography, and give a detailed account of models used in agriculture as an activity.

Kispotta. J., 2007 in his research work "*Urban Impact on Changing Pattern of Agricultural Land Use in East Singhbhum District*" examines the agricultural land use and changing pattern of agricultural land use and urban impacts that have influenced these. He discussed that in this thesis the increase in urban area extent for the population pressure and newly origin of industry. It also identifies in his thesis the framework of importance as well as comparatively profitability of the land using by the primary data to analyze the cost and profits of the urban land and agricultural land both. It is noticed that agricultural land is less profitable than urban land because of the location of industry and many other important offices. The pattern of agricultural land and their changes are shown in his work during 2004-05 and how many areas of land were put on non-agricultural uses during 2004-05. He analyzed the impact of industrialization and urban growth on land use and new agricultural technology adoption, process and spread rate was also highlighted.

Th. Phajabi Devi; 2008 She mentioned in her work a future plan for the evolution of existing land use patterns into a second Green Revolution and taking up cultivation in the marshy wetlands and uncultivable areas by application of modern scientific agronomic and information technologies.

S. Mishra and S. Patnaik., 2008 They discussed in their article about the importance of land use pattern which is considered as a primary requisite for formulating development planning in perennially drought-prone areas where the economy is agro-based, hence proper planning of land use is a must for developmental proposals, etc. has contributed much in exploring various dimensions of land use studies.

Aspinall, J. and Hill, J., 2008 in their book "*Land Use Change: Science, Policy and Management",* consider the basic science questions that underpin the study of land use change and focuses on issues that influence the analysis of dynamics of land change. It also examines several issues relevant to successful communication and cooperation between scientists and practitioners accountable for decision-making, whichever policy or management regarding the land use change. The improvement of spatially dependent measures and models for such responses and patterns connected with land use change to simpler significant metrics. These are based on the use of both quantitative and qualitative procedures of patterns and trends and investigation of spatial patterns. He fulfilled that the findings of the prospective developments in spatial methods necessary advancing integrated modeling of land use change and improving

the connection between the systematic study of land use change at the local, countrywide and global level.

V. Singh and B. N. Singh., 2010 The main theme of their article shows that whether the present pattern is in some sort of static harmony or adjustment with the other main characteristics of the economy of Chakia Development Block. An interesting aspect of the analysis of the paper is that how socio-economic and technical organizational factors are interacting with one another over time and again for maintaining the continuity of such process and the result of which is reflected in the land use pattern.

A. M. Siddique, 2010 has shown in his paper that land use change in relation to its driving forces provides essential information for land use planning and sustainable management of resources. It also focuses on the causes behind these changes and the consequences in his study area.

Talukdar, M and Singh. S., 2010 "*Land use changes in Tinsukia District"* they discuss in their paper about the significant change in land use pattern and conversion of land from the categories of the forest, barren and waste land to the Net Sown Area. Such fast changes in land use of the district show that the expansion and intensification processes of agricultural land use have been accelerated by the intensification of the technological inputs. Not only that, they also discussed in their paper the effects of market forces and expansion of road network in the district works to facilitate agriculture practices in its intensive manner.

A. Mukhopadhyay., 2011 in his paper he highlighted to identify the basic causes of land use changes and its inevitable effect on the environment and society of Dubrajpur Block of Birbhum District. The most disquieting features are that growth in agricultural output that has occurred has not come from any extension of cultivated area and the benefit of irrigation is mostly enjoyed by the big landholders which in turn bring an imbalance in the cultivator's agricultural laborer ratio of the area.

### 1.4 Methodology

From the foregoing discussion in order to fulfill the purposes, objectives and hypothesis, the following methodology has been adopted. The whole work of this study has been completed on the basis of two sets of data i.e. primary and secondary. The methodology of the present work includes the following:

### 1.4.1 Primary Data

Required primary data and information have been collected from the household survey like-land ownership data, agricultural method used related data, extent of use of chemical fertilizers and pesticides, use of HYV seeds, per capita income, education status of farmer families, yield rate data, etc., soil-related data and many other unpublished official records. To analyse infrastructural facilities related to agriculture, character and quality of land the researcher has conducted field visits in different cropping seasons in the district. The impact of changes in agricultural land use has to be shown with the help of primary data. For this purpose the researcher has been engaged in direct field observation and collected above related data. All the processed data and information has been tabulated and analyzed by using suitable cartograms.

Primary data has been collected from the household survey of 360 sample farmers' families which is covering all nine blocks of the district with the help of a pre-printed questionnaire (Appendix I). In this way, a total of 50 villages were chosen as sample villages within the district and the present study was carried out on the basis of random sampling in the study area. In order to fulfill 40 households of each block, the researcher selected 5 or 7 villages in a block. Because researcher found the variability of the farmers (small & marginal farmers). Detailed plot to plot land use maps was prepared by using the cadastral map and this map is cross-checked with the field visits and met the senior persons of the respective village for each C.D. Blocks of the district. Block-wise the name and location code (As per 2011 Census) of sample villages are presented in table 1.1.

### 1.4.2 Secondary Sources

After the primary source of data, the secondary data source is very important for the completion of the thesis. Data related to the meteorological were collected from the office of the Principal of Agricultural Officer (PAO, Uttar Dinajpur), Regional meteorological centre, India meteorological department, Kolkata 700027, Deputy Directorate of Agriculture (administration), Government of West Bengal and District Statistical Hand Book published by the Bureau of Applied Economics & Statistics, Government of West Bengal, Kolkata. Different factors of changing agricultural land use patterns like, increase in population, expansion of the urban area, and changes in land ownership, expansion of irrigation area, soil fertility and productivity have been considered.

**Plate 1.1** Field survey at Khamrua mouza, Itahar Block, 2017

**Table 1.1** Block-wise sample villages and their location code.

| Name of the C.D. Blocks | Name (As per 2011 Census) of the sample villages | Location code of sample villages (As per 2011 Census) | The total number of sample villages within the Block |
|---|---|---|---|
| **CHOPRA** | Bhagabati | 308851 | 5 |
| | Dakshin Damorgachh | 308852 | |
| | Uttar Damorgachh | 308864 | |
| | Thuthipakar | 308865 | |
| | Rampur | 308906 | |
| **ISLAMPUR** | Chaprajhar | 309005 | 5 |
| | Ghoramara | 309006 | |
| | Dumrulla | 309008 | |
| | Phulhara | 308950 | |
| | Ramganj | 308951 | |
| **GOALPOKHER-I** | Intia | 309127 | 6 |
| | Purbba Gati | 309124 | |
| | Goagaon | 309184 | |
| | Bhagabanpur | 309183 | |
| | Ibrahimpur | 309092 | |
| | Kamalpur | 309093 | |

| | | | |
|---|---|---|---|
| **GOALPOKHER-II** | Kahata | 309223 | 6 |
| | Chakulia | 309224 | |
| | Ghordhappa | 309227 | |
| | Sagarpur | 309264 | |
| | Baligura | 309339 | |
| | Samaspur | 309360 | |
| **KARANDIGHI** | Paschim Goalgaon | 309384 | 5 |
| | Bhagabanpur | 309386 | |
| | Gospur | 309455 | |
| | Baijuar | 309542 | |
| | Bilaspur | 309575 | |
| **RAIGANJ** | Jhitkai | 309651 | 5 |
| | Chapduar | 309683 | |
| | Madhupur | 309684 | |
| | Ekar | 309685 | |
| | Sankarpur | 309688 | |
| **HEMTABAD** | Beltore | 309865 | 7 |
| | Bazitpur | 309864 | |
| | Minapara | 309866 | |
| | Samaspur | 309874 | |
| | Rotibati | 309867 | |
| | Rampur | 309856 | |
| | Anantakota | 309863 | |
| **KALIAGANJ** | Chandgaon | 309965 | 6 |
| | Kashidanga | 310026 | |
| | Rautgaon | 310069 | |
| | Hatpara | 310073 | |
| | Kunore | 310075 | |
| | Mukundapur | 310076 | |
| **ITAHAR** | Chabhat | 310206 | 5 |
| | Churamon | 310262 | |
| | Dakshinal | 310143 | |
| | Gulandar | 310253 | |
| | Khamrua | 310225 | |

Source: Census of India, 2011

The researcher has collected the aforesaid population-related data and information from the Census of India for different census years, expansion of urban centers related data for the region were collected from the municipality offices and Census of India, expansion of irrigation area

related data were collected from the Office of the bureau of Applied Economics and Statistics, Government of West Bengal, Karnojora, Uttar Dinajpur and Department of Minor Irrigation, Government of West Bengal, Karnojora, Raiganj, Uttar Dinajpur; Aquifer related data and information has collected from the office of the Central Ground Water Board, Eastern Zone, Kolkata; soil fertility and productivity data collected from the different offices like NBSS and LUP, Salt Lake (under ICAR), Government of India, Kolkata; Office of the Agricultural Chemist, Soil testing laboratory, Raiganj; Department of Geography and Applied Geography, North Bengal University, Darjeeling, Soil Conservation Wings, Government of West Bengal, Raiganj, Uttar Dinajpur and Office of the PAO, Raiganj, Uttar Dinajpur. Altitudes, Slope maps are prepared from the ASTER DEM, USGS and soil pH, CEC, clay, silt and sand etc. maps are arranged from the soil grid, ISRIC. The data on area, production and productivity rate of different crops were taken from the published report (Annual report of the Bureau of Applied Economics & Statistics, Government of West Bengal, Kornojora, Uttar Dinajpur; Sub-divisional agricultural office, Karnojora, Uttar Dinajpur and Office of the Principal Agricultural Officer, Karnojora, Uttar Dinajpur). Data related to agricultural land use in different years which includes Net Sown Area, Current Fallow, Fallow and other than Current Fallow, Culturable Waste Land, Land under Misc. tree crops and groves, Permanent pastures and other grazing lands (Spelling as per Evaluation Wings, Directorate of Agriculture, 1960) were collected from B.L. & L.R.O, District Statistical Hand Book published by the Bureau of Applied Economics & Statistics, Government of West Bengal.

The study was carried out from the Survey of India topographical sheets on 1:50,000 scale bearing nos. 78C/1, 78C/2, 78C/3, 78C/6, 78C/7, 78B/3, 78B/4, 78B/7, 78B/8, 78B/11, 72O/13, 72O/14 and 72N/16 to prepare the base map, Slope map, Drainage map, Soil map, Vegetation map, etc. Elevation extracted data regarding slope analysis and slope aspect map (DEM, DTM & TIN) were collected from the Survey of India Topographical sheet, GPS points handling and Satellite imageries which published by USGS Global Visualization Viewer (GloVis).

### 1.4.3 Statistical Tool

The whole primary data has been collected from the primary household survey and direct intensive fieldwork in the study area, which is verified by the secondary sources from the office of the Principal of Agricultural Officer and District Statistical Hand Book. All the amassed primary data and information were processed, tabulated and summarized at first. Thereafter, it was tested followed by the different appropriate statistical methods like; Mean, Standard deviation, Linear and non-linear regression, Choropleth maps, Radar diagram, Isopleths map

were prepared. Suitable cartographic techniques were also applied and are used to support the discussion. A sample point map of the sample villages is also prepared. In this regards the coordinates of all the surveyed villages in the district (will be mentioned as 'sites' in the following part of the theses) were recorded with the help of receiver GPS handheld for the purpose of plotting data (Latitudinal and Longitudinal location) with GIS software platforms (figure 1.2).

Secondary data and information were collected from different authentic sources. Then data and information were summarized and tabulated by suitable statistical methods. Factors for changing the agricultural land use of the study area are analyzed and prepared different maps. The fertility maps have been prepared by Parker's Nutrient Index process. Hence, the nutrient index value (NIV) introduced by (Parker, et al, 1951) is useful and describes the fertility status of soils for the purpose of mapping. The percentage of samples in each of the four classes; low, medium, high and very high is multiplied by 1, 2, 3 and 4 respectively. The summation of the figures thus obtained is divided by a total number of samples and it is computed as:

$$\mathbf{NIV = (N_L x1 + N_M x\ 2 + N_H x\ 3.....) / (N_L + N_M + N_H .....)}$$

Where,

$N_L$= Number of samples falling in the low category of nutrient status.

$N_M$ = Number of samples falling in the medium category of nutrient status.

$N_H$ = Number of samples falling in the high category of nutrient status.

Land capability classification map has been prepared based on USDA method. To measure the land capability map was prepared by MATLAB (fuzzy logic). Measure of capability map total three sets of variables have been considered viz; Soil profile characteristics variables: soil texture, available nutrients status (NPK), Climate variables: annual rainfall, temperature, and external variables: type of terrain, irrigation, drainage, slope and availability of soil moisture. Each and every sub-variable is represented as a determinant of land capability classification. A score (1 to 3) has been allotted to each sub-class of a variable separately on the basis of their importance for determining the capability class for growth of crops. After establishing variables, the variable is presented in the form of information layers represented by the separate map (layer map) in which a degree of capability with respect to those particular variables. This degree of capability then needs to be rated according to the relative importance of the contribution made by that particular variable. In the district, paddy is the major food dominating crop. So, score assign of the land capability class depends on the basis of the paddy. Land suitability evaluation has been prepared followed by FAO methods presented in the

existing literature (A. Satish, 2010; Vargahan, 2011; FAO, 1993; FAO, 1976; De La Rosa and Van Diepen, 2002 and Chang and Burrough, 1987) and lastly final output of the land suitability map was prepared by the MATLAB (fuzzy logic). To measure the land suitability index, total ten variables have been considered i.e. altitudes, slope, drainage, water availability, workability, CEC, sand, silt, clay and $p^H$. A total of 50 land units define according to the topography and soil were selected for this study (Sinthurahat, 1992). Each component plays an important role in finding suitable for agricultural crops in the district. Availability of nutrients has been assessed with regard to the cation exchange capacity (CEC), pH measured in soil. Oxygen availability has been assessed according to the drainage conditions. Water availability has been evaluated according to effective rainfall taking into account the storage capacity of soil (Sinthurahat, 1992). Workability has been assessed according to the texture, structure, moisture of the top soil (0-20 cm). The overall suitability of land was determined based on the degree and the number of limitation for a particular unit. The final land suitability was based on the number and degree of limitation. This map is cross checked with the map of land survey wings department of the district. Pre-field and post field ground truth verification for the thematic maps were cross checked; updated and final output was derived. Different types of layer maps (different variables map like; altitude, slope, $P^H$, CEC, sand, silt, clay etc.) were prepared in GIS database using QGIS 3.2, BONNA, 2018.

The level of agriculture modernization has been prepared by the Composite Index of Level (CIL) which was arrived at by summing different location quotients values. The summed up location quotients were divided by the number of components of modern farm technology considered and multiplied by 100 (Singh and Dhillon, 2005). The equation may be written as:

$$\mathbf{CI_{mo}} = \frac{\mathbf{Trb}}{\mathbf{Trd}} + \frac{\mathbf{Ipsb}}{\mathbf{Ipsd}} + \frac{\mathbf{Hyvb}}{\mathbf{Hyvd}} + \frac{\mathbf{Chfb}}{\mathbf{Chfd}} + \frac{\mathbf{Hib}}{\mathbf{Hid}} \ldots\ldots\ldots\ldots$$

Where, $CI_{mo}$ = the composite index level of modernization in agriculture.

Tr = tractors per 1,000 hectares of cultivated area

Ips = irrigation pump set used per 1,000 hectares of cultivated area

Hyv = the area under HYVs as a percentage of the total cropped area

Chf = use of chemical fertilizers in kg per hectare of the cropped area

Hi = harvester used per hectare of the cropped area

n = the number of factors of modern farm technology used in the district

b and d indicate the symbolize subscripts the enumeration unit (block) and the whole region (district).

Degree of modernization in agriculture = **ΣLQs / n x100**

Where, ΣLQs = Summing up the location quotients values.

n = the number of factors of modern farm technology used in the district.

100 = gives the degree of the coefficient of localization.

The crop productivity index (Yang's method 1965) has been adopted for the determination of different crops yield index of Uttar Dinajpur District. The agricultural productivity indices of selected crops were calculated. His method represents the yield rate of various crops in a block compared to the average crop yield of the district. Firstly, the average yield of each crop grown in the whole region is determined. And secondly, the value of each crop is divided by the yield of the whole region then multiplied by 100 and get the value in per cent. By considering the area devoted to each crop as weight and multiplying it with the percentage value, a product is obtained. By adding and dividing the sum of the products by the total crop area (hectares). The procedure for calculating 'crop yield index' shown in table 5.28. Changes in agricultural productivity of cereal, pulses, cash crops and miscellaneous crops are shown by the choropleth map. The per annum change of crop productivity is also shown by the shading method.

Temporal and spatial variation in changes in cropping pattern (area, production and productivity) of Uttar Dinajpur District are analyzed by the geometric progression method. Changes of major crops are shown by the shading method on which the changing trends of area, production and productivity have been recognized by winning the triennium ending crop year 1995-96 as the base year with an allocated value of 100 per cent and the percentage changes of the year 2015-16. Changing agricultural land use maps are prepared based on supervised and unsupervised classifications by using satellite data and the relevant statistics have been extracted for different years. To find out land use change, change exposure procedure mainly based on two date classification was used. This method has been effectively used in some studies. Overlaying is a good technique in finding changes for establishing connection between the two data sets. This method is very helpful in diverse applications as land use change investigation, monitoring of urban area extension and irrigation area extension. Mouza-wise (two mouza each block) and Block-wise proportions of area under different land use categories have been calculated, tabulated, interpreted and show the changes in land use (supervised classification method) on map by QGIS that has taken place during both the periods of 2001 and 2016. IRS LISS-III images was used for preparing the land use map (Both years) of the study area which were collected from Bhuban (IIRS) database.

**Image Classification techniques are-**

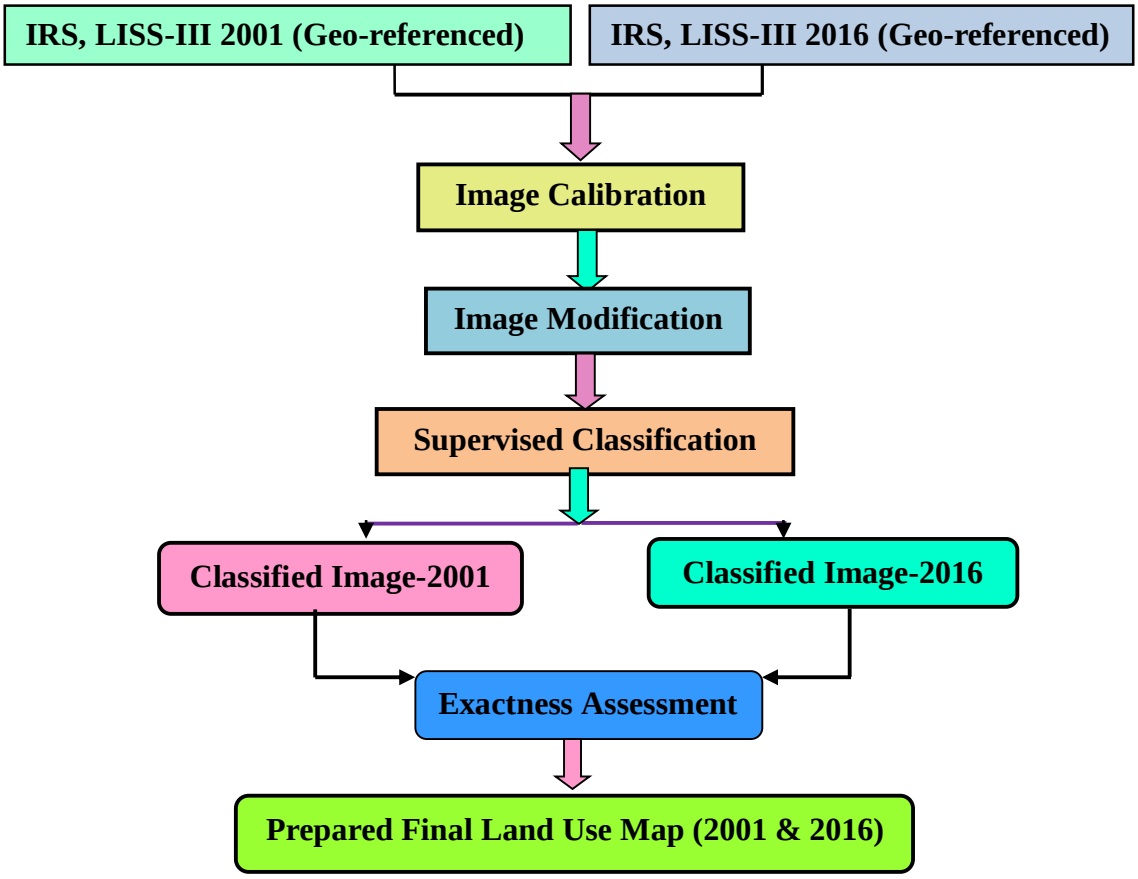



**Figure 1.3** Flow chart of image classification.

Per capita income of the farmers is shown by the bar diagram and educational status of the district's farmers is also shown by the radar diagram. Change of yield rate and agricultural unemployment are shown by using suitable cartograms.

### 1.5 Hypothesis

Following hypothesis is to be tested by the researcher in the proposed study:

1. There is an intricate relationship between the increase of population and agricultural land use practices.
2. The man-land ratio is inversely related to the growth of population.
3. Successful agricultural practices are related to scientific soil analysis.
4. The yield rate is directly related to the extent of modernization in the agricultural sector.
5. Cropping intensity is directly related to the extent of irrigation practices.
6. Labour surplus in the agricultural sector is directly related to the growth of the population.

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