UGC Major Research Project

Ref. No: F.41-1075/2012(SR)

Dated: 26.07.2012

Project Title: "R.S and G.I.S application in spatial dynamics of agriculture and industry along Sealdah-Maldah Transact, West Bengal"

Project Report

(2012-2014)

Submitted By

Prof. Kanan Chakrabarti (Chatterjee).

Principal. Investigator

Department of Geography

University of Calcutta

Kolkata

West Bengal

Project Report - (2012-2014)

U.G.C. Major Research Project

Ref. No: F.No.41-1075/2012(SR), dated: 26.07.2012

PROJECT TITLE : ***R.S and G.I.S application in spatial dynamics of agriculture and industry along Sealdah-Maldah Transact, West Bengal***

Submitted by

Prof. Kanan Chakrabarti (Chatterjee).

Principal Investigator
Department of Geography
University of Calcutta
Kolkata
West Bengal

CONTENTS

CHAPTER 1: Introduction **Page No. 1-19**

- Background
- Aims and objectives
- Methodology
- Study area
- Sealdah-Maldah Transact
- District wise details (area in sq. km.)
- Study area District wise
- Percentage of Study area to total area of the district
- Data Acquisition
- Image Registration
- Image Classification
- The data flow in a classification process
- Adaptation of the land cover classification scheme for County or a small city
- Database Design
- View of Reality
- Conceptual Design
- Logical Design
- Physical Design
- Software used in the research project
- Database Creation
- Database Management
- Method of data analysis
- Land Cover and Land use

CHAPTER 2: Results and discussion – Case Studies **Page No. 20-137**

Case Study: A
Eastern Railway Line extends from Sealdah to Maldah via Nabadwip (Sealdah, Tribeni, Nabadwip, Salar, Azimganj, Nimta and Old Maldah).

Case Study: B
Eastern Railway also extends from Sealdah to Maldah via Bardhaman
(Begampur, Chanchai, Guskara, Sainthia, Chatra and Bonidanga).

Case Study: C
National Highway (NH34) runs through Barasat, Pramanic, Bethuadahari, Sargachhi , Jangipur and PTS Bus Stop etc.

CHAPTER 3: Conclusion **Page No.138-147**

List of Figures

Figure:

1. Methodology
2. Location Map
3. Sealdah-Maldah Transact
4. District wise details
5. Kolkata
6. Haora
7. Hugli
8. Bardhaman
9. Nadia
10. Birbhum
11. Maldah
12. North 24 –Parganas
13. Murshidabad
14. Jharkhand
15. Percentage of Study area to total area of the district
16. The data flow in a classification process
17. Sample study area
18. Sampling Zone: Sealdah and its Surrounding areas ,Kolkata District, WB
19. Google Image of Sealdah (1 sq km)
20. Google Image of Sealdah (78.51 sq km)
21. RGB Values
22. Google Image 78.51 sq km Land Use and land cover Map
23. FCC Classification of Sealdah
24. Probable Industrial Zone
25. Communication Map
26. Actual prospective Industrial area
27. Visual interpretation of land use in Sealdah
28. Land Use and land cover Map Sealdah Railway Station (Kolkata, West Bengal)
29. Google Image 1 sq km Land Use and land cover Map
30. Land use and Land cover - Changing Pattern
31. Land Use and land cover Map Tribeni Railway Station (Hugli, West Bengal)
32. Land Use and land cover Map Nabadwip Railway Station (Nadia, West Bengal)
33. Sampling Zone: Palsa and its Surrounding areas , Palsa station Birbhum District,WB
34. Google Images 1 sq km
35. Google Images 78 sq km
36. RGB values

37. Vectorization layer
38. Google Image 78.51 sq km Land Use and land cover Map
39. FCC Classification
40. Probable Industrial Zone
41. Communication Map
42. Actual prospective Industrial area
43. Google Images ¼ th sq. km.
44. Google Image 1 sq km Land Use and land cover Map
45. Land use and Land cover - Changing Pattern
46. Land Use and land cover Map Salar Railway Station (Murshidabad, West Bengal)
47. Land Use and land cover Map Azimgang Railway Station (Murshidabad, West Bengal)
48. Land Use and land cover Map Nimta Railway Station (Murshidabad, West Bengal)
49. Sampling Zone: Maldah and its Surrounding areas , Maldah District, WB
50. Google Image 1sq km
51. Google Image 78.51 sq km
52. RGB values
53. Vectorization layer
54. Google Image 78.51 sq km Land Use and land cover Map
55. FCC Classification
56. Probable Industrial Zone
57. Communication Map
58. Actual prospective Industrial area
59. Google Images ¼ th sq. km.
60. Land Use and land cover Map Old Maldah Railway Station (Maldah, West Bengal)
61. Google Image 1 sq km Land Use and land cover Map
62. Land use and Land cover - Changing Pattern
63. Zone: Porabazar and its Surrounding areas, Hugli District, WB
64. Google Images 1 sq km
65. Google Images 78.51sq.km
66. RGB values
67. Vectorization layer
68. Google Image 78.51 sq km Land Use and land cover Map
69. FCC Classification
70. Probable Industrial Zone
71. Communication Map
72. Actual prospective Industrial area
73. Google Images ¼ th sq. km.
74. Google Image 1 sq km Land Use and land cover Map
75. Land use and Land cover - Changing Pattern
76. Land Use and land cover Map Begampur Railway Station (Hugli, West Bengal)

77. Sampling Zone: Bardhaman and its Surrounding areas , Bardhaman District, WB
78. Google Images 1sq km
79. Google Images 78 sq km
80. RGB values
81. Vectorization layer
82. Google Image 78 sq km Land Use and land cover Map
83. FCC Classification
84. Probable Industrial Zone
85. Communication Map
86. Actual prospective Industrial area
87. Google Images ¼ th sq. km.
88. Google Image 1 sq km Land Use and land cover Map
89. Land use and Land cover - Changing Pattern
90. Land Use and land cover Map Chanchai Railway Station (Bardhaman, West Bengal)
91. Land Use and land cover Map Guskara Railway Station (Bardhaman, West Bengal)
92. Sampling Zone: Bolpur and its Surrounding areas ,Birbhum District, WB
93. Google Images 1 sq Km
94. Google Images 78.51 sq Km
95. RGB values
96. RGB values
97. Google Image 78.51 sq km Land Use and land cover Map
98. FCC Classification
99. Probable Industrial Zone
100. Communication Map
101. Actual prospective Industrial area
102. Google Images ¼ th sq. km.
103. Google Image 1 sq km Land Use and land cover Map
104. Land use and Land cover - Changing Pattern
105. Land Use and land cover Map Sainthia Railway Station (Birbhum, West Bengal)
106. Land Use and land cover Map Chatra Railway Station (Birbhum, West Bengal)
107. Land Use and land cover Map Bonidanga Railway Station (Jharkhand)
108. Sampling Zone: Fatehpur and its Surrounding areas, North 24 Parganas District, WB
109. Google Images 1 sq Km
110. Google Images 78.51 sq Km
111. RGB values
112. RGB values
113. Google Image 78.51 sq km Land Use and land cover Map
114. FCC Classification
115. Probable Industrial Zone
116. Communication Map

117. Actual prospective Area
118. Google Images ¼ th sq. km.
119. Google Image 1 sq km Land Use and land cover Map
120. Land use and Land cover - Changing Pattern
121. Land Use and land cover Map Pramanic Bus Stop (24 Parganas, West Bengal)
122. Land Use and land cover Map Bethuadahari Bus Stop (Nadia, West Bengal)
123. Sampling Zone: Tildanga and its Surrounding areas, Murshidabad District, WB
124. Google images 1sq km
125. Google Images 78.51sq.km
126. RGB values
127. Vectorization Map
128. Google Image 78.51 sq km Land Use and land cover Map
129. FCC Classification
130. Probable Industrial Zone
131. Communication Map
132. Actual prospective Industrial area
133. Google Images ¼ th sq. km.
134. Google Image 1 sq km Land Use and land cover Map
135. Land use and Land cover - Changing Pattern
136. Land Use and land cover Map Sargachhi Bus Stop (Murshidabad, West Bengal)
137. Land Use and land cover Map Jangipur Bus Stop (Murshidabad, West Bengal)
138. Land Use and land cover Map PTS Bus Stop (Maldah, West Bengal)
139. Land Use and land cover Sample Area (Sealdah-Maldah Transact)
140. Land Use and land cover Sample Area (Sealdah-Maldah Transact)
141. Land Use and land cover Sample Area (Sealdah-Maldah Transact)

List of Tables

Table:

1. The study area covers
2. Percentage of Study area to total area of the district
3. Adaptation of the land cover classification scheme for County or a small city
4. Attribute table for the Land cover classes
5. Software used in the research project
6. Land use in the sample study areas-along Sealdah–Maldah Eastern Railway via Nabadwip
7. Land use in the sample study areas-along Sealdah–Maldah Eastern Railway via Bardhaman
8. Land use in the sample study areas-along National Highway 34 (NH-34)

CHAPTER 1: Introduction

Background

The primary purpose of this project is to show R S and G I S application in spatial dynamics of agriculture and industry along Sealdah-Maldah Transact leading to predictions of programme effectiveness. Dynamic modeling uses a computer programme, in this case Quantum GIS (1.8.0), TNTmips V 7.4 and Arc View 3.2a. are used to develop and stimulate existing systems which are able to predict future actions and trends.

As major agricultural producer, West Bengal is the sixth-largest contributor to India's production. In 2009–10, the tertiary sector of the economy(service industries) was the largest contributor to the gross domestic product of the state, contributing 57.8% of the state domestic product compared to 24% from primary sector(agriculture, forestry, and fishing) and 18.2% from secondary sector (industrial and manufacturing). Agriculture is the leading occupation in West Bengal. Rice is the state's principal food crop. Rice, potato, jute, sugarcane and wheat are the top five crops of the state.

The area of study covers the districts of West Bengal namely, **Kolkata, Haora, Hugli, Bardhaman, Birbhum, North-24 Parganas, Murshidabad, Nadia, and Maldah** Industrial and agricultural use of land monitoring through Remote Sensing and Geographical Information System has been carried out in this study. The project work stretches on Railway Line and National Highway- Railway line (Seldah to Maldah via Bardhaman , Sealdah to Maldah via Nabadwip-**Eastern Railway**) and **NH-34.** Spatial indicators to trace the use of land have been selected as follows: (a) Built up areas. (b) Water Bodies, (c) Areas covered by crops, vegetation or forests and (d) Wet land, Waste land, vacant land, fallows etc. which are preferred by industries. Observation of these indicators can be broadly traced and distinctly understood by RS and GIS data. Analysis of digital Remote Sensing data and field work is quite obvious.

The present study is an explanatory one and endeavours to explain and interpret interrelations between various aspects of industrial and agricultural development along

Sealdah-Maldah Transact, West Bengal in a geographical context. Field Work and sample survey will be followed by compilation and analysis of data as well as their presentation through maps and diagrams using techniques of RS and GIS, supported by interpretation. The research work aims at exploring the causes and effects of changing uses of land for agriculture and industry and it attempts to provide a geo-economic analysis of the same. Herein, lies the significance of further research work.

Sealdah-Maldah transacts stretches for about 300kms. 5kms on both sides of Eastern Railway line and National Highway (NH-34) have been taken into consideration. Sample surveys of major study area of 1sq km and ¼ th sq. km. each at an interval of 50 kms have been worked out and the spatial dynamics of Agriculture and Industry have been sorted out through compilation of field survey, R.S and G.I.S data.

Aims and objectives

The objective of this study is to examine the integration of GIS and Remote sensing for application in spatial dynamics of agriculture and industry along Sealdah-Maldah Transact. The following objectives were pursued to achieve the aim defined above.

- To map out the different land use / land cover and their spatial distribution
- To identity, quantify and map out the agricultural and industrial activities during 2003 - 2013 using Google Earth images.
- To examine the specific agricultural and industrial activity types responsible for the changes.
- To demonstrate the capabilities of GIS in the area of classification and overlay in the study of agriculture and industry.
- To model / predict possible future changes.

Methodology

The study has been carried out adopting the methodology given in fig. 1.

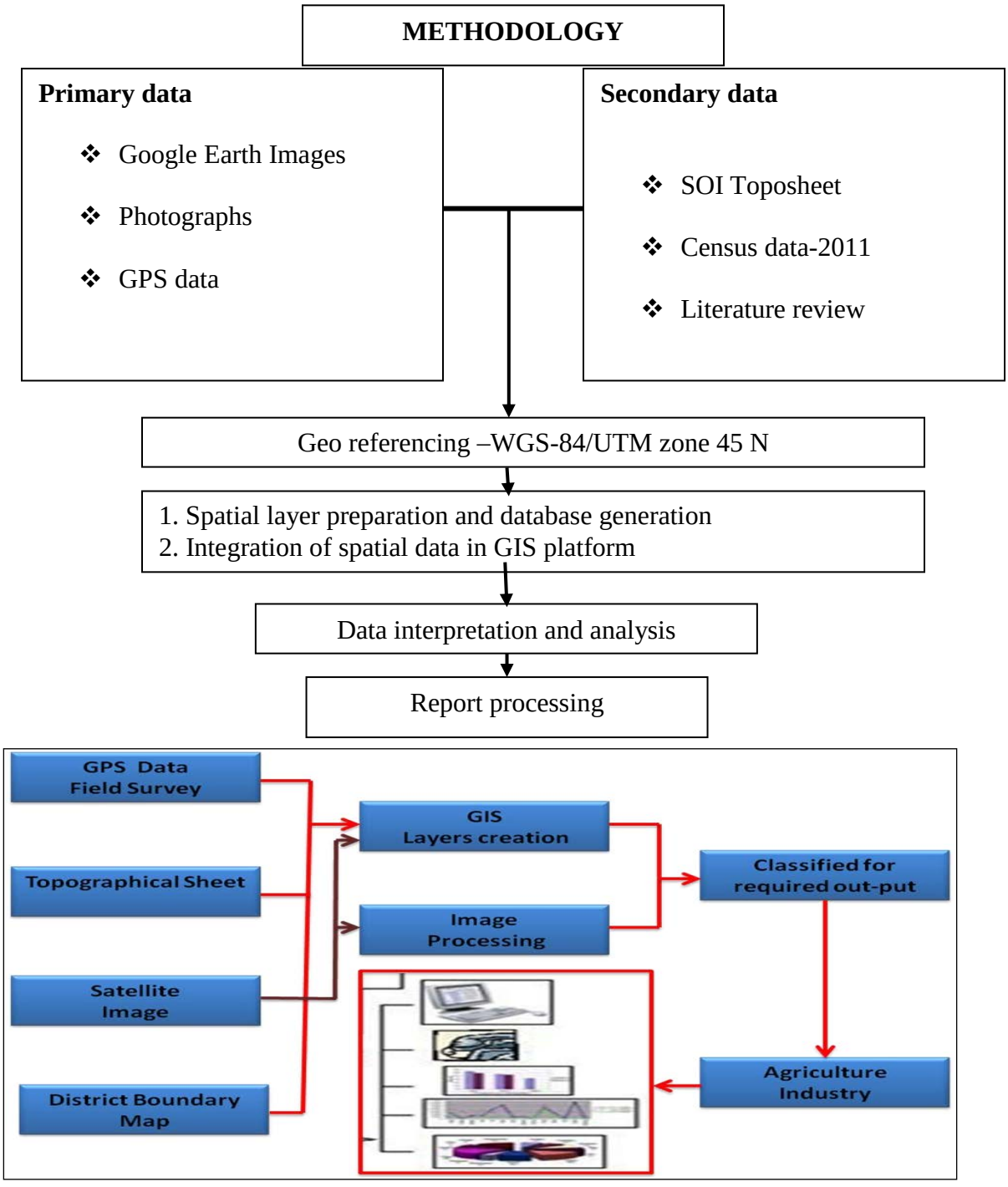
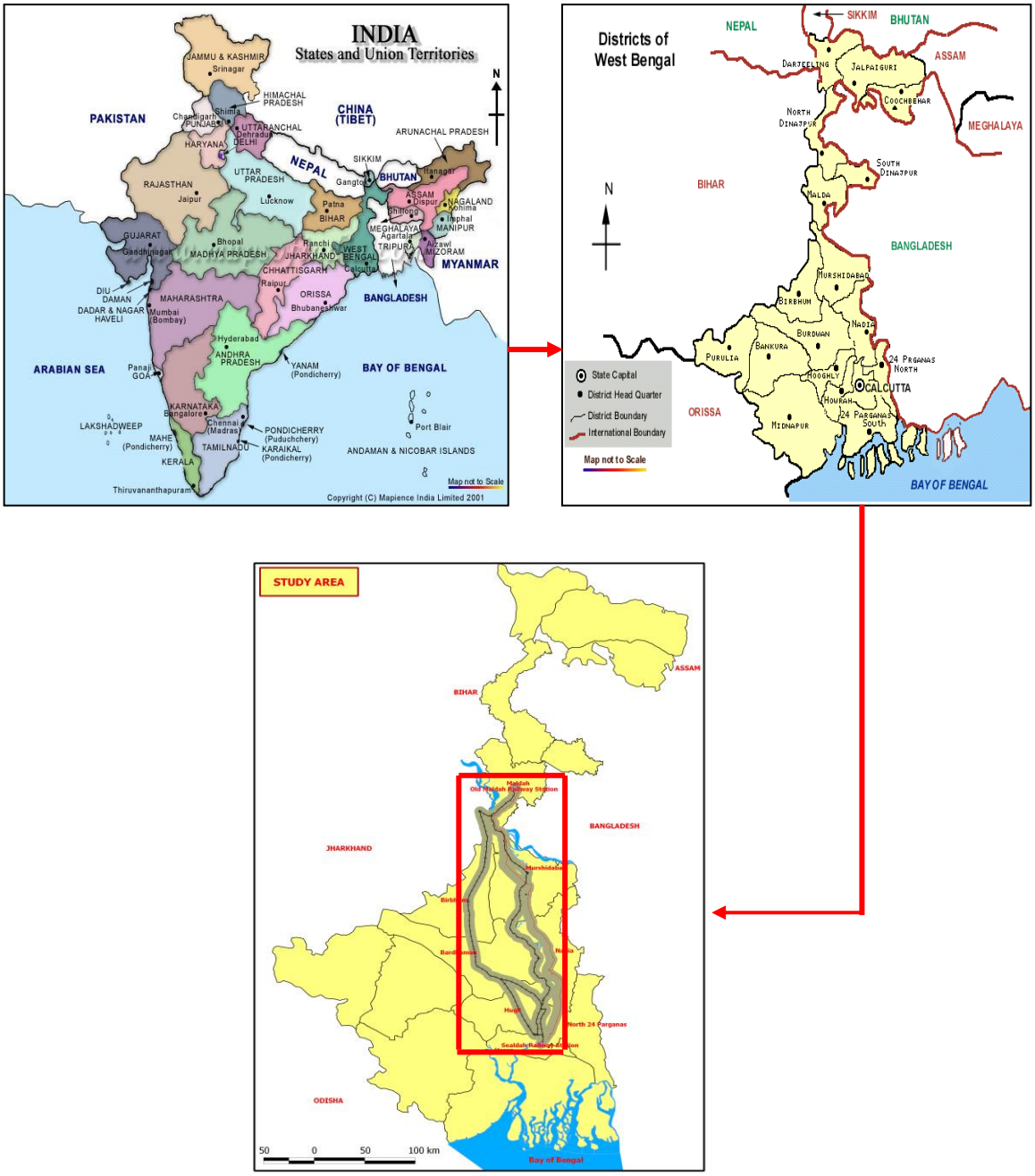


Fig.1

STUDY AREA



Location map Fig.2

Sealdah-Maldah Transact

The project work stretches on Railway Line and National Highway. The Railway line

runs through Sealdah to Maldah via Nabadwip (Sealdah , Tribeni, Nabadwip, Salar, Azimganj Farakka and Old Maldah)

Eastern Railway also extends from Sealdah to Maldah via Bardhaman (Sealdah,Begampur, Chanchai,Guskara, middle of Bataspur and Gadadharpur, Bonidanga, Old Maldah)

National Highway NH34 runs through(Barasat,Krishnanagar ,Berhampur,English Bazar) etc.

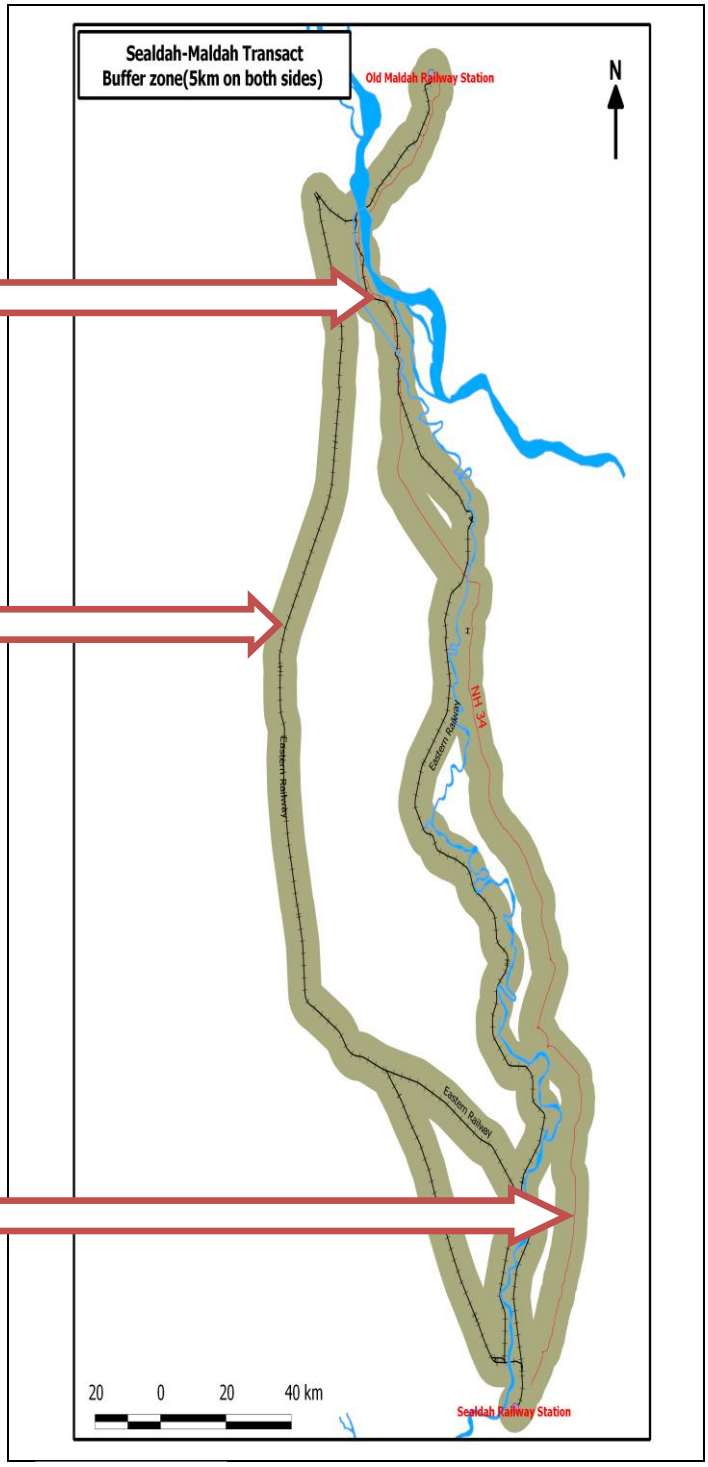


Fig.3

District wise details (area in sq km,)
The study area covers approximately 8,642.066 sq km

Study area		
SL.no	**DISTRICT**	**AREA in sq km**
1	Kolkata	62.163
2	Haora	61.968
3	North 24 parganas	637.727
4	Hugli	1,225.237
5	Bardhaman	1,362.678
6	Birbhum	1,091.938
7	Murshidabad	1,924.801
8	Maldah	478.607
9	Nadia	1,437.744
10	Others	359.203
Total		8,642.066

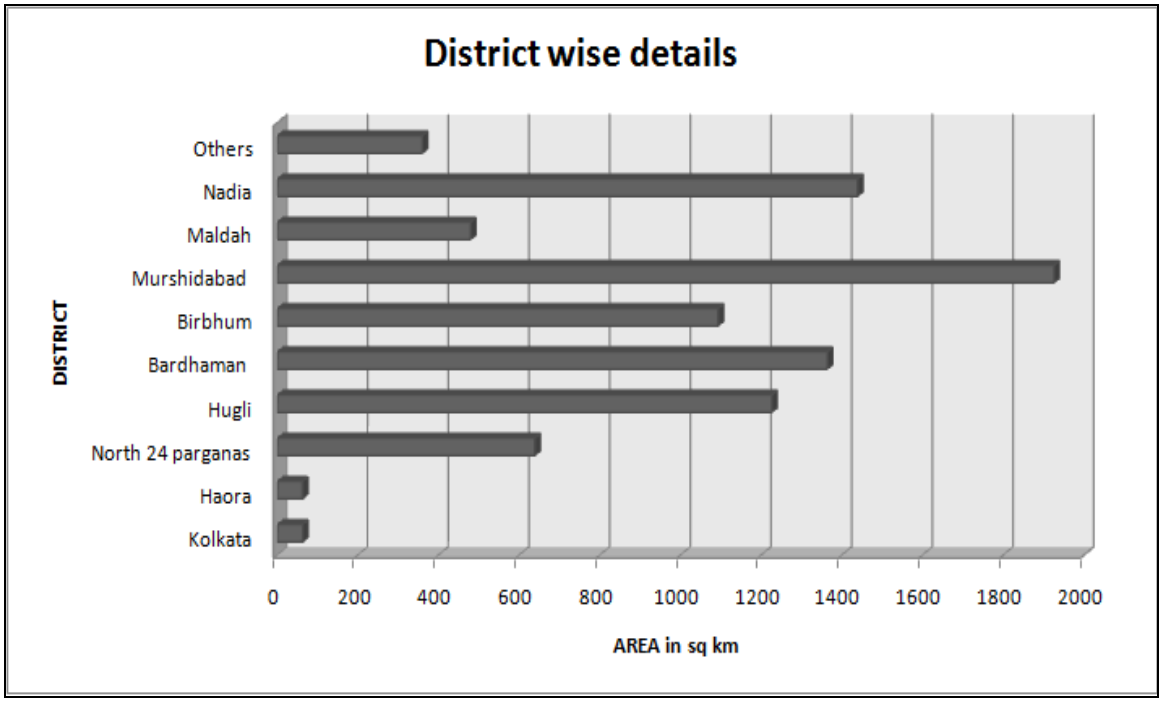


Fig.4

STUDY AREA - DISTRICT WISE

Kolkata

Kolkata is located in the eastern part of India at 22.82°N 88.20°E. It has spread linearly along the banks of the Hugli River. The Kolkata Municipal Corporation has an area of 185 square kilometers. The city is near sea level, with the average elevation being 17 feet. The whole area is in the Ganges Delta and is monotonously plain. The Bay of Bengal coastline is about 60 miles to the south. The Sundarban National Park starts within 100 km south to the city. Most of the city was originally marshy wetlands, remnants of which can still be found especially towards the eastern parts of the city where the remaining wetlands have been converted to fish farming centres. Human habitation has led to the establishment of mature trees and shrubs. The original marshland has been changed to a primarily moist deciduous habitat which flourishes under the high rainfall and sunny humid climate. As in most of the Indo-Gangetic plain, the soil type is predominantly alluvial.

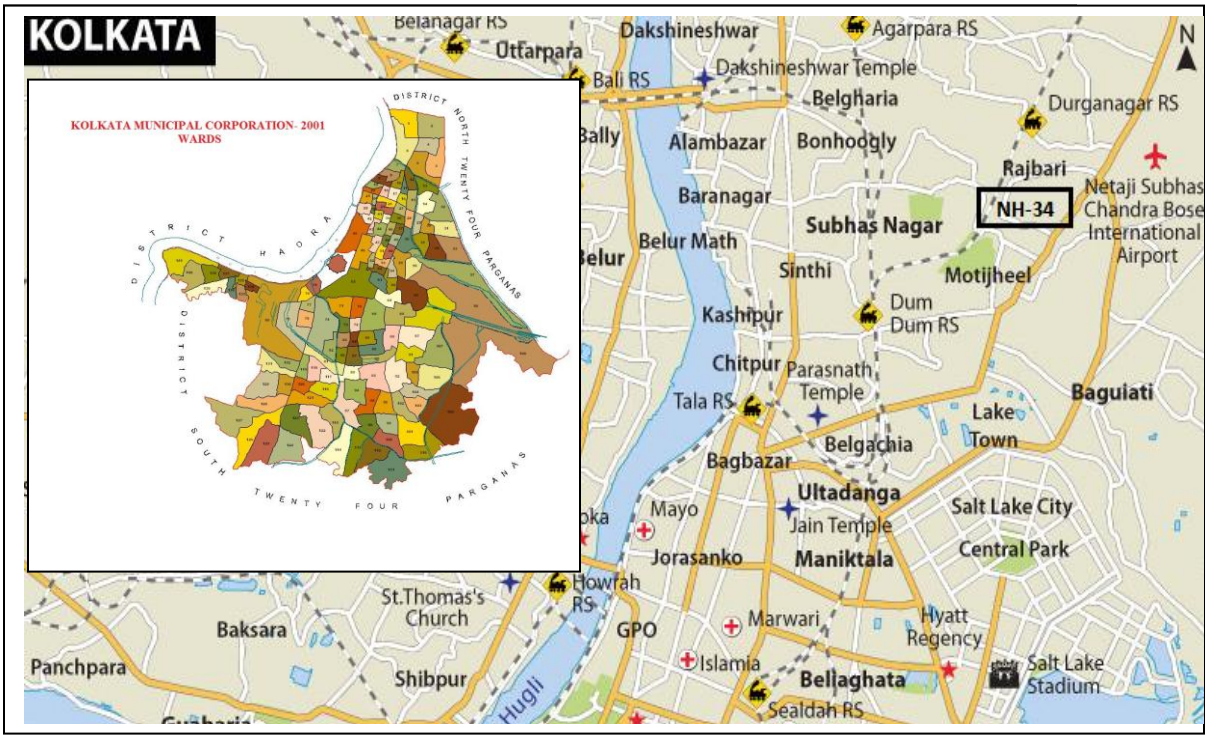


Fig.5

Haora

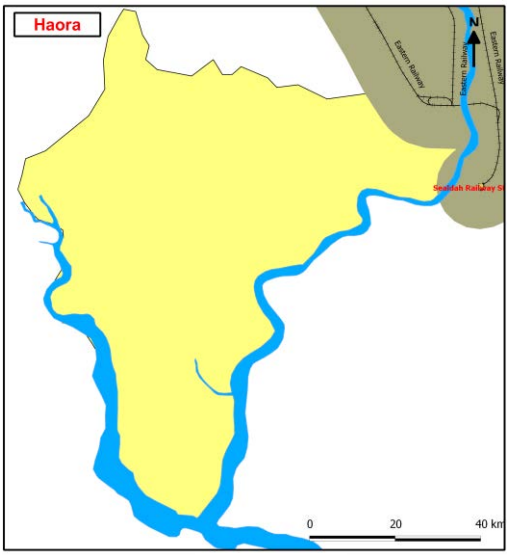


Fig.6

The Haora district lies between 22°48′ N and 22°12′ N latitudes and between 88°23′ E and 87°50′ E longitudes.The district is bounded by the Hugli River on the north. North 24 Parganas and South 24 Parganas districts on the east,on the north by the Hooghly River and on the south by Purba Medinipur district on the south. The total population (as of 2011 Census) was recorded at 4,841,638 persons.

Hugli

The district is a completely flat land with no place having more than an elevation of 200 meters. The river Hooghly borders it to the east. Another major river is 'Damodar'. The district is bordered by Haora District to the south, Bardhaman District to the north, and to the east by the river Hugli. Bankura District lies to the north-west, with Medinipur District on the south-west. The total population (as of 2011 Census) was recorded at 55,20,389 persons.

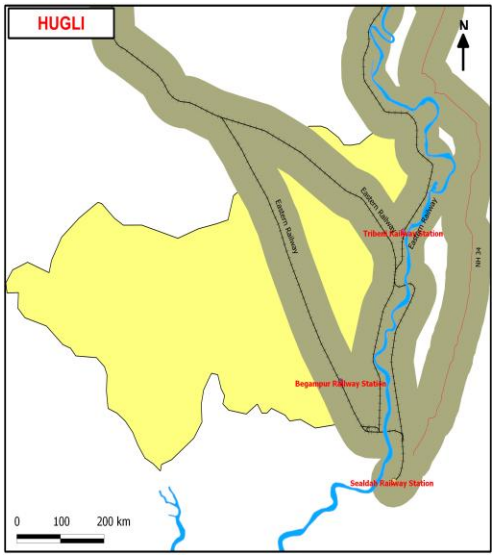


Fig.7

Bardhaman

Bardhaman District has an area of 7,024 sq km, and a population of 6,895,514 (2011 census). It is bounded on the north by Birbhum and Murshidabad districts, on the east by Nadia District, on the southeast by Hugli District, on the southwest by Bankura and Purulia districts, and on the northwest by Dhanbad district of Jharkhand.

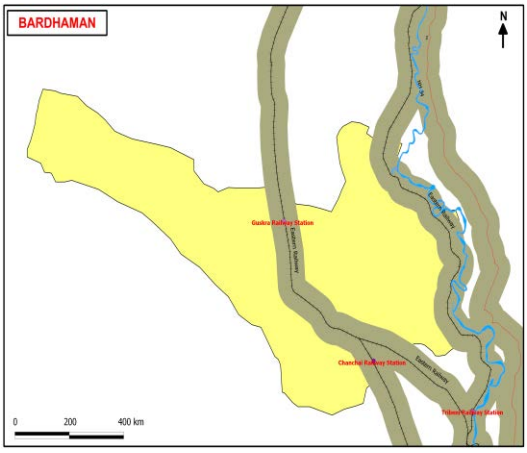


Fig.8

Nadia

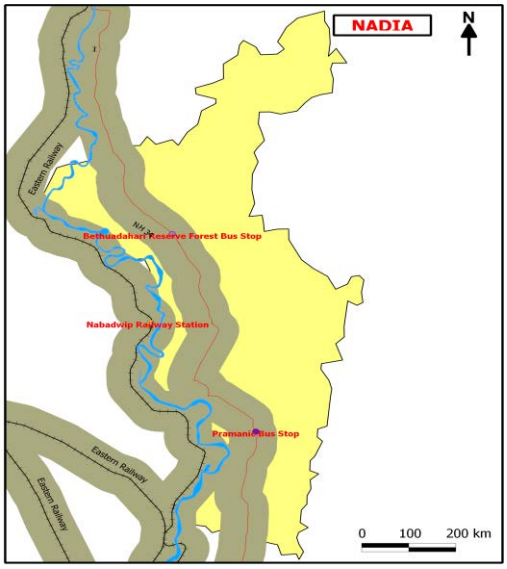


Fig.9

Nadia is situated between 22º53″ and 24º11″ North latitude and 88º09″ and 88º48″ East longitudes and has about 390027 Sq Kms. in area, this Ditrict is linear in shape with orientation of North-South. The District is approximately 46 ft. above the mean sea level. The Tropic of Cancer divides the district in two parts.

Birbhum

Situated between 23° 32' 30" (right above the tropic of cancer) and 24° 35' 0" north latitudes and 87° 5' 25" and 88° 1'40" east longitudes, with 4,545 square kilometers in area, this district is triangular in shape. The total population (as of 2011 Census) was recorded at 3,502,387 persons.

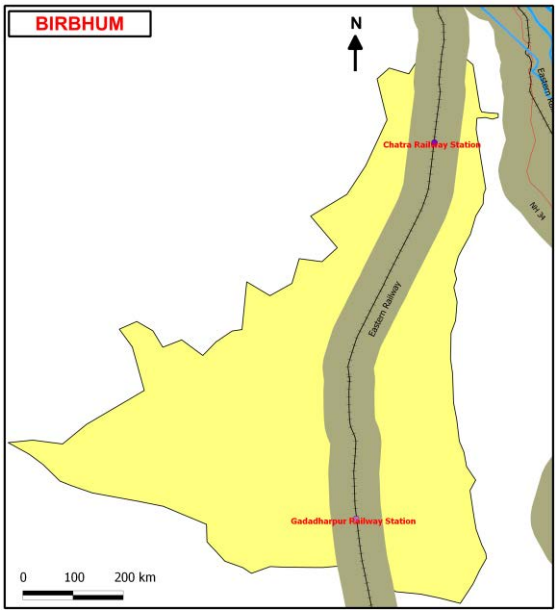


Fig.10

Maldah

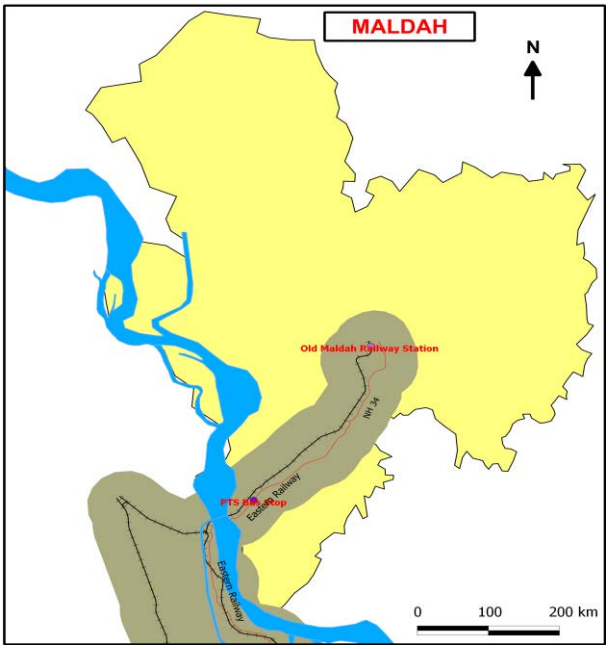


Fig.11

The District extends from 24°40′20" N to 25°32′08" N latitudes, and 87°45′50" E to 88°28′10" E longitudes it is surrounded by Bangladesh and Dakshin Dinajpur in the east, Santal Parganas of Jharkhand state in the west, Uttar Dinajpur in the north and Murshidabad in the south. Maldah, the southern most of the North Bengal districts comprises of Jalpaiguri Division.The district covers an area of 3,733.66 square kilometres. The total population (as of 2011 Census) was recorded at 3,997,970 persons.

North 24 –Parganas

The district lies within the Ganges-Brahmaputra delta. River Ganga flows along the entire west border of the district. Other rivers, include Ichhamati, Jamuna, and Bidyadhari. The latitudinal range is 23°15'North - 22°11' North, and the longitudinal range is 89°5'East - 88°20' East. The total population (as of 2011 Census) was recorded at 3,502,387 persons.

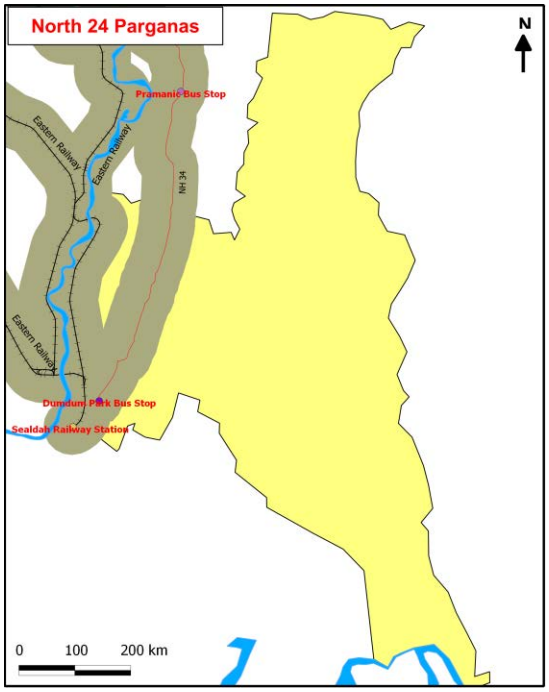


Fig.12

Murshidabad

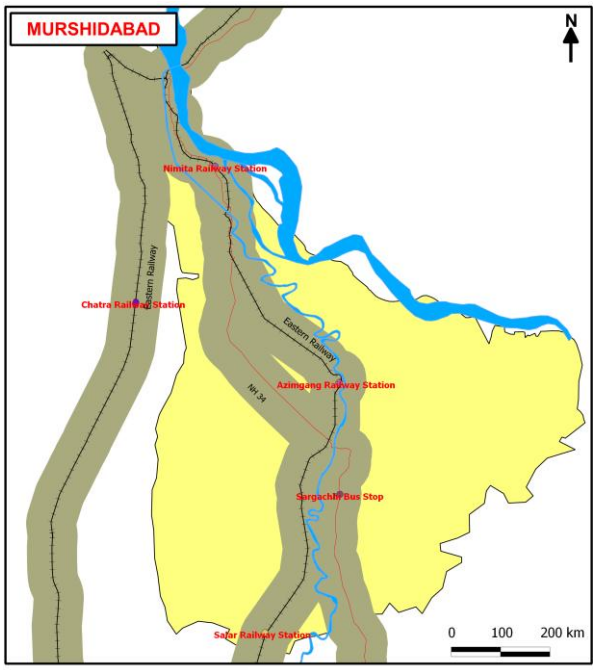


Fig.13

It borders Maldah district to the north, Jharkhand's Sahebganj district and Pakur district to the north-west, Birbhum to the west, Bardhaman to the south-west and Nadia district to the south. The international border with Bangladesh's Rajshahi division is on the east. The total population (as of 2011 Census) was recorded at 3,502,387 persons.

Bonidanga Railway Station

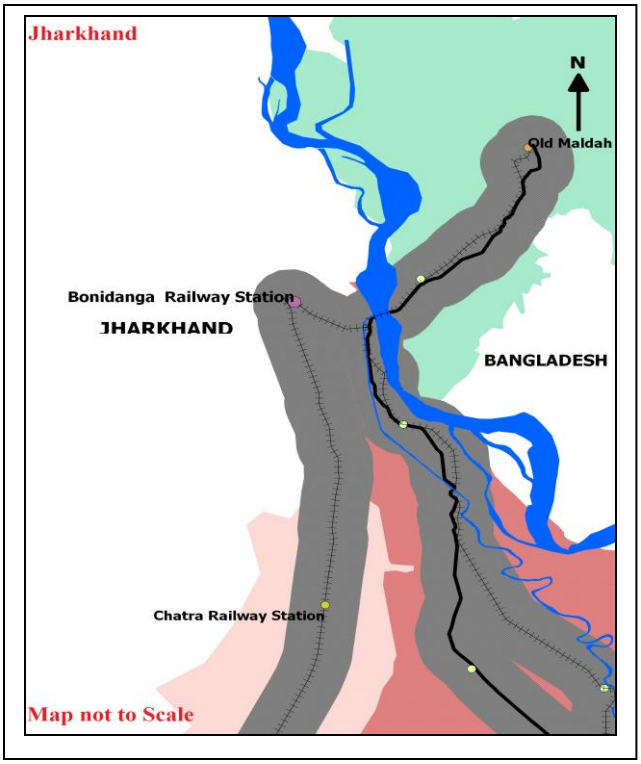


Fig.14

Percentage of Study area to total area of the district:

Percentage of Study area to total area of the district				
SL.no	**DISTRICT**	**Area of District**	**Study area sq km**	**Per centase**
1	Kolkata	185	62.163	0
2	Haora	1,467	61.968	4
3	North 24 parganas	4,094	637.727	12
4	Hugli	3,149	1,225.24	9
5	Bardhaman	7,024	1,362.68	20
6	Birbhum	4,545	1,091.94	13
7	Murshidabad	5,324	1,924.80	15
8	Maldah	3,733.66	478.607	11
9	Nadia	3,927	1,437.74	11
10	Other(Jharkhand,Pakur)	1,805	359.203	5
Total		35,253.66	8,642.07	100

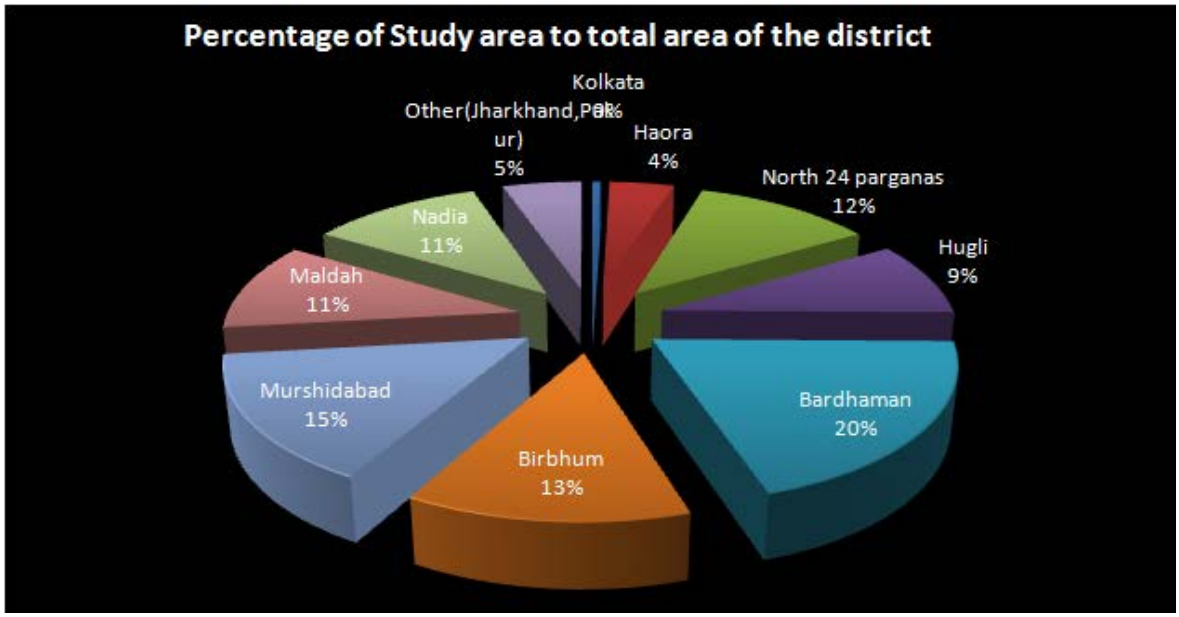


Fig.15

Data Acquisition:

Data can be said to be the live wire of any study most especially in Remote Sensing and Geographical Information System. For this study, data are acquired from a number of sources. Since the nature of land cover monitoring requires images of different time period, and that change detection analysis is carried out most effectively with not less than 3 images of the study area, three LANDSAT ETM Satellite images of Oyo state are acquired. - 1993, 2003 and 2013 with spatial resolution of 1000m. Other ancillary data like topographical map are also used.

Image Registration:

The images are scanned and imported into Arc View 3.2a. for registration .The image reader extension (Tiff images) was activated to allow the software to read Tiff image files. The images have been geo-referenced in Arc View due to its flexibility. Subsequently the study area was cut from the whole image for the four-time period. The images are broken into subsets in Arc View and saved as Tiff images.

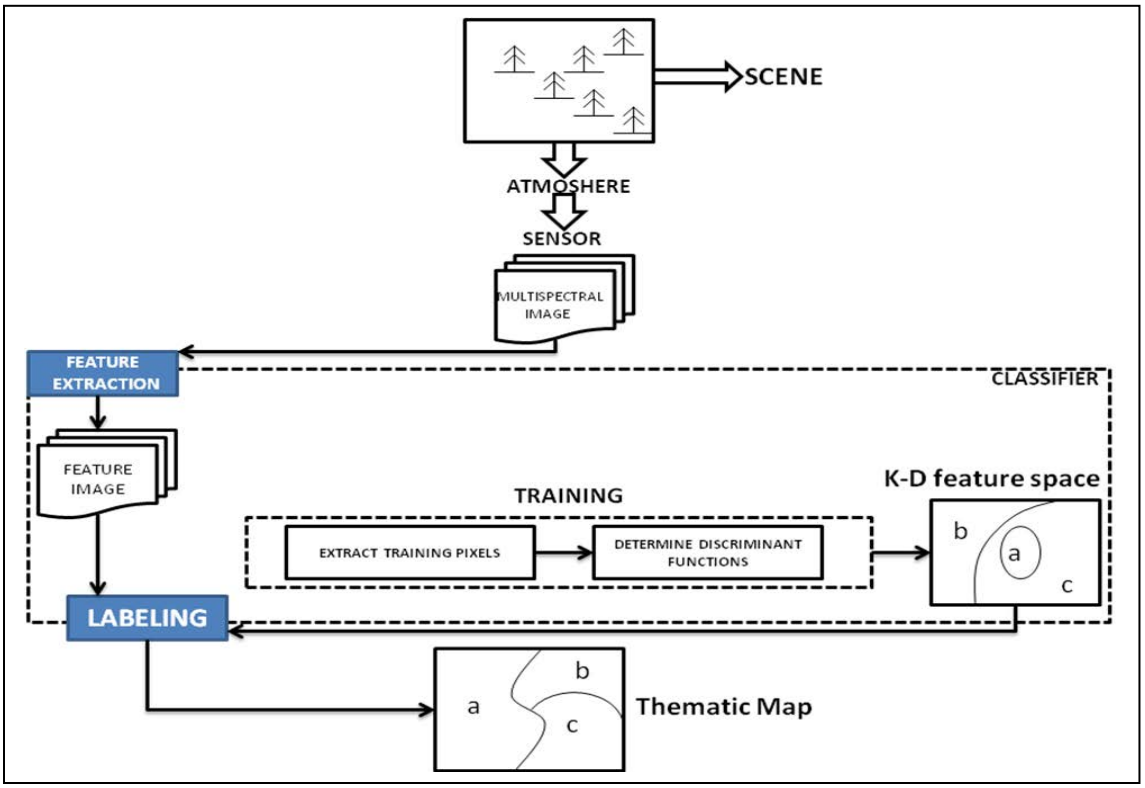
Reference system is WGS 84 / UTM zone 45N.

Image Classification:

The images were imported into TNTmips V 7.4 for classification i.e. the process of extraction of differentiated classes or theme from raw remotely sensed digital satellite data (Meyer, 1994). Each cluster of observations is a class. A class occupies its own area in the feature space i.e. a specific part of the feature space corresponds to a specific class. Once the classes have been defined in the feature space, each image pixel observation can be compared to these classes and assigned to the corresponding class. Classes to be distinguished in an image classification need to have different spectral characteristics, which can be analyzed by comparing spectra reflectance curve. The only limitation of image classification is that classes do not have distinct clusters in the feature space. Such image classification does not give reliable results. Training sites were generated on the images by on-screen digitizing for each land cover classes derived from image of different band combination. A supervised (full Gaussian) maximum likelihood classification was implemented for the four images. This was due to the fact that the operator has familiarized himself with the study area through

dedicated field observation, whereby the spectra characteristics of the classes in the sampled area has been identified. Ground truth information was used to assess the accuracy of the classification.

The data flow in a classification process:



Adaptation of the land cover classification scheme for County or a small city

URBAN	Residential	Low-density
		Medium-density
		High-density
	Commercial	Mixed-use (commercial/residential)
		General retail (central business district)
		Professional services and office
	Industrial	Light industry/warehousing
		Heavy industry
		Industrial/Research park
	Other Urban	(Open space, Transportation)
Non URBAN	Agriculture	Cropland
		Orchard
	Forest	Deciduous
		Evergreen
	Protected Areas	

Fig.16

Database Design:

A database system is essentially a computerized record-keeping system. It is an electric filing cabinet, that is, a repository for collection of computerized data files. In any GIS application, there must be a well structured spatial database. The process of designing database is referred to as data modeling. Kufoniyi (1998) defined data modeling as the process by which real world entities and their relationship are analyzed and modeled in a way that maximum benefits are derived while utilizing minimum amount of data. It should be noted that an improper database design often leads to implementation problems. There are two main phases in obtaining a GIS database; these are the design phase and construction or implementation phase. The design phase, otherwise known as data modeling consists of three stages; while the construction phase is made up of the spatial database proper. The three main phases of database design are: Conceptual, Logical and Physical design phases.

View of Reality:

Reality refers to the phenomenon as it actually exists, including all aspects which may or may not be perceived by individuals. The view of reality is the mental abstraction of the reality for a particular application or group of application. In this project, this refers to agriculture and industry in the study area.

Conceptual Design:

Conceptual design is a conceptual data modeling and it is a human conceptualization of reality. In this phase, we decide how the view of reality will be represented in a simplified manner to satisfy the information requirement of the project at hand. This phase also deals with the identification of the basic features and the spatial relationship that exist between them. The vector data model was widely used here.

Logical Design:

This phase deals with the logical representation of data model with regard to the way they are actually stored in a computer environment. Relational data structure is adopted for this project. The following datasets as well as their attributes were identified.

Physical Design:

This is a tabular representation of the entities and their attributes into the implementation software. It is the first stage of database creation when the attribute data are mapped into the implementation software. The software used is the Quantum GIS(1.8.0) which uses number, string, Boolean and date for declaration of data types.

Software used in the research project:

SOFTWARE USED IN THE RESEARCH PROJECT		
S/N	Software	Used for
1	Arc view 3.2a	Image registration and enhancement. Carving out of the study area
2	Quantum GIS(1.8.0)	Querying and hot linking
3	TNTmips V 7.4	Change detection and Image classification and training site selection
4	MS Excel	Pie graphical presentation

Attribute table for the Land cover classes:

Attributes of Study Locations

FID	Shape *	ID	LOCATION	X_COORD	Y_COORD	IMAGE
2	Point	1	WATER_BODY	3.86	7.42	C:\IMAGES\WATER_BODY.tif
3	Point	2	BUILT-UP_AREA	3.87	7.44	C:\IMAGES\BUILT-UP_AREA.tif
4	Point	3	VEGETATION	3.87	7.43	C:\IMAGES\VEGETATION.tif
5	Point	4	PLANTATION	3.85	7.43	C:\IMAGES\PLANTATION.tif
6	Point	5	FARMLAND	3.86	7.4	C:\IMAGES\FARMLAND.tif

Database Creation:

Digital data are used in GIS analysis. But most often, the available data is usually in analog format. The preprocessing involves converting the analog map into digital format through scanning, geo-referencing and digitizing.

The data processing in this study involves conversion of analog maps of the project area into digital. One this was done by scanning the maps and vectorizing the maps through on-screen digitizing and this was done using Arc view 3.2a.

Q GIS was used in creating the database. The relations/tables in the database are: Agriculture, Industry, Settlement Vacant land, Forest, Plantation, Built-up-Areas, Farmland, Vegetation, and Water body within the study area. The semantic data of each

entity was entered into the tables for spatial query and other spatial analyses that will be carried out in the next section.

Database Management:

This involves the use of implementation software to organize information in a database. This is the collection of software for creating, storing, updating, manipulating, retrieving, analyzing and organizing information in the database. The database must be properly managed to ensure that the data stored in the database are correct, consistent and measured.

Method of data analysis:

Seven main methods of data analysis were adopted in this study.

- Calculation of the area in sq km of the resulting land use/land cover types for each study year and subsequently comparing the result.
- Overlay operations. – i.e. mathematical and logical operation between two raster layers on a pixel to pixel basis.
- Image differencing – to provide for change analysis through differencing of images pairs.
- Cross tab. – to deter′ e all unique combinations of value in two qualitative images and calculate similarity statistics
- Database query and hot linking
- Markovian transition estimator for predicting future change.
- Normalized difference land used and land covered index.

SAMPLE STUDY AREA

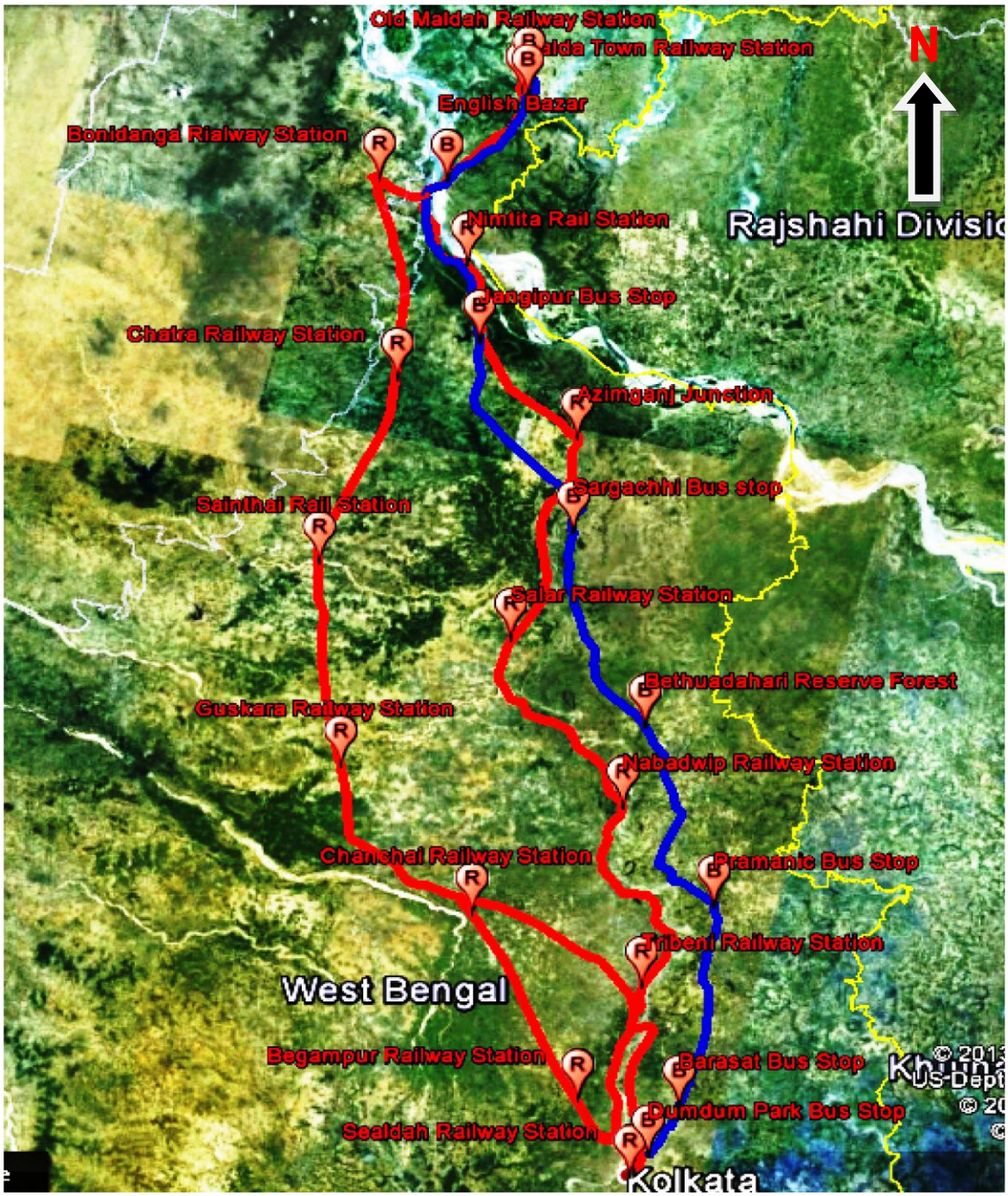


Fig.17

Land Cover and Land use:

Although the terms ‘Land cover′ and ‘Land use′ are often used interchangeably their actual meanings are quite distinct. It is important to distinguish this difference and the information may be ascertained from each source.

Land cover mapping is one of the most important and typical applications of Remote sensing data Land cover corresponds to the physical conditions of the ground surface, for example forest, grassland, etc. Land use reflects human activities such as the use of the land for Industrial Zone, Residential zone, Agricultural Field etc. Land cover refers to features of land surface, which may be natural, semi natural managed or manmade. They are directly observable by a remote sensor land use, such as residential, urban, rural, etc.

CHAPTER 2: Results and discussion – Case Studies

Case Study: A

Eastern Railway Line extends from Sealdah to Maldah via Nabadwip (Sealdah, Tribeni, Nabadwip, Salar, Azimganj, Nimta and Old Maldah).

"R.S and G.I.S application in spatial dynamics of agriculture and industry along Sealdah-Maldah Transact, West Bengal"

Sampling Zone: Sealdah and its Surrounding areas ,Kolkata District, WB

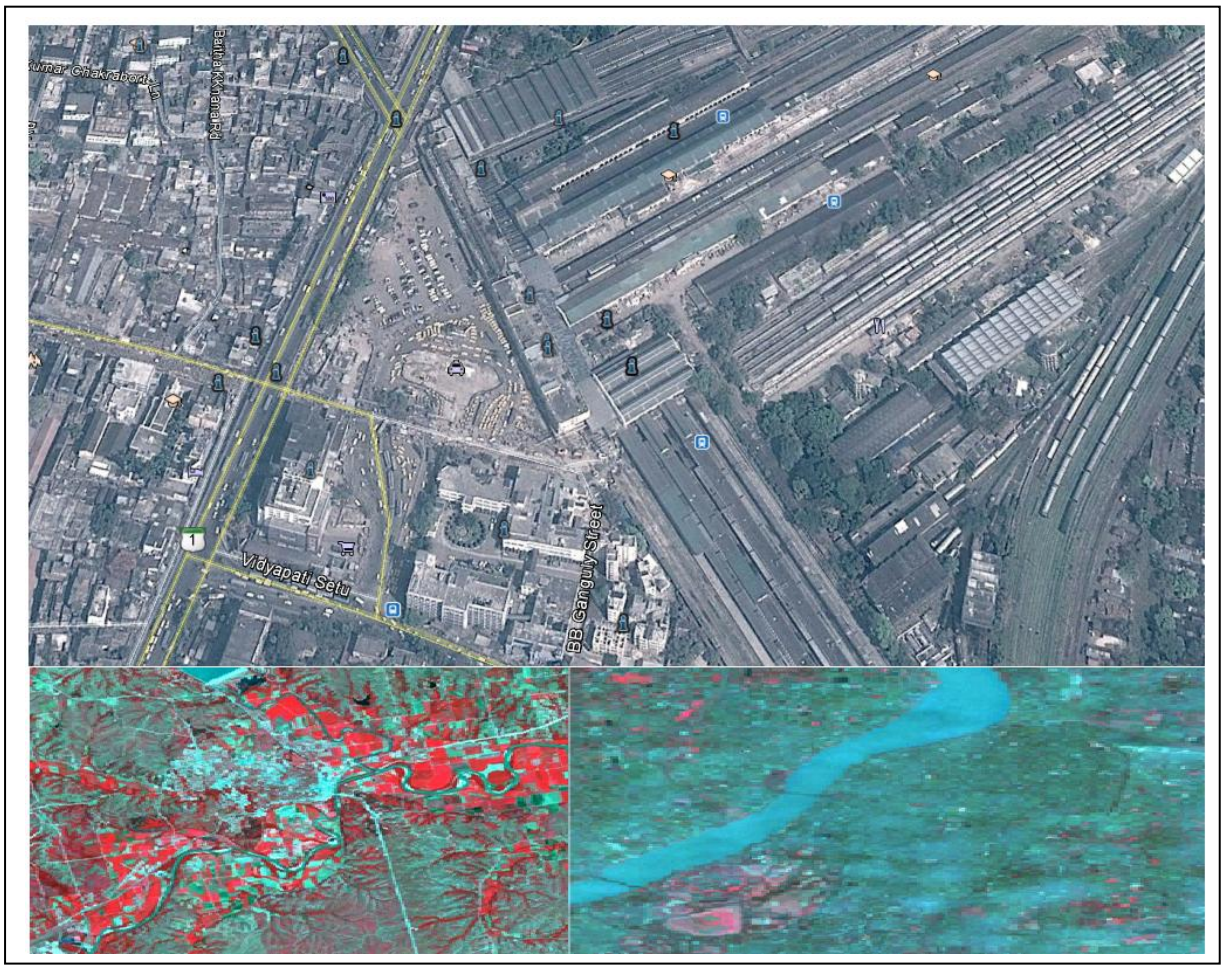


Fig.18

Objective: Economic development and population growth have triggered rapid changes to Earth's land cover over the last two centuries, and there is every indication that the pace of these changes will accelerate in the future. The present study shows the utility of remote sensing techniques integrated with GIS to study the spatial dynamics of Agriculture and Industry in the selected specified study area and its surroundings in Sealdah, Kolkata District. Various satellite image data were analyzed within a digital image processing system to provide up-to-date information of the whole area. The extracted information from remotely sensed data was then integrated with visually interpreted information and field inputs in a GIS to create a comprehensive spatial database. This permitted the integration of several layers of information with the remotely sensed data in both temporal and spatial dimensions.

Background: Remote sensing technology has been recognized as a useful means of supplying up to date information and have the potential to respond to the growing and urgent demand for timely and accurate land cover information over large areas. In the recent past, land cover mapping from satellites has come of age, Through research on various issues regarding data pre-processing, classification and accuracy assessment, new and unique data / land cover products are being generated which could not be produced by earlier techniques. Various data set of the area were used for interpreting and unifying them within GIS and Image Processing environment for analysis and interpretation.

Data Available: The following data were used for this project work:

- Landsat satellite image having 28.5m spatial resolution.
- IRS Cartosat multispectral satellite image having 5m spatial resolution.
- Digital Globe high resolution image (0.5m) from Open Source Google
- Earth repository for Visual interpretation and as a supplementary data for interpretation.

Software Used: TNTmips Pro 2014, the integrated GIS and Image Processing platform were used in the present study.

Workflow:

- Satellite Images were imported in a project file within TNTmips Pro platform.

- The Images were geometrically rectified with the GCP by using Geographic co-ordinate system and World Geodetic System 1984 (WGS 84) as Datum. Affine transformation model has been deliberately selected for this sapling area to maintain the geometric area and shape accuracy.
- The sampling location extends from North 22°33′50.720″ to North 22°34′ 23.234″ and East 88°22′04.958 ″ to East 88° 22′39.968″ .
- As per the present scope of study to meet the temporal data requisite two different year data has been collected.
- Image preprocessing was implemented on both the images to improve the quality and interpretability
- Extraction model was implemented on the scenes to get the 1 sq km sampling area as decided to process with in the buffer zone of 5 kilometer both of the railway track from Sealdah to Maldah at the location of Sealdah station to get the surrounding bird's eye view.

The sampling location extends from North 22°33′50.720″ to North 22° 34′23.234″ and East 88° 22′04.958 ″ to East 88° 22′39.968″ .

Google Image 1 sq km

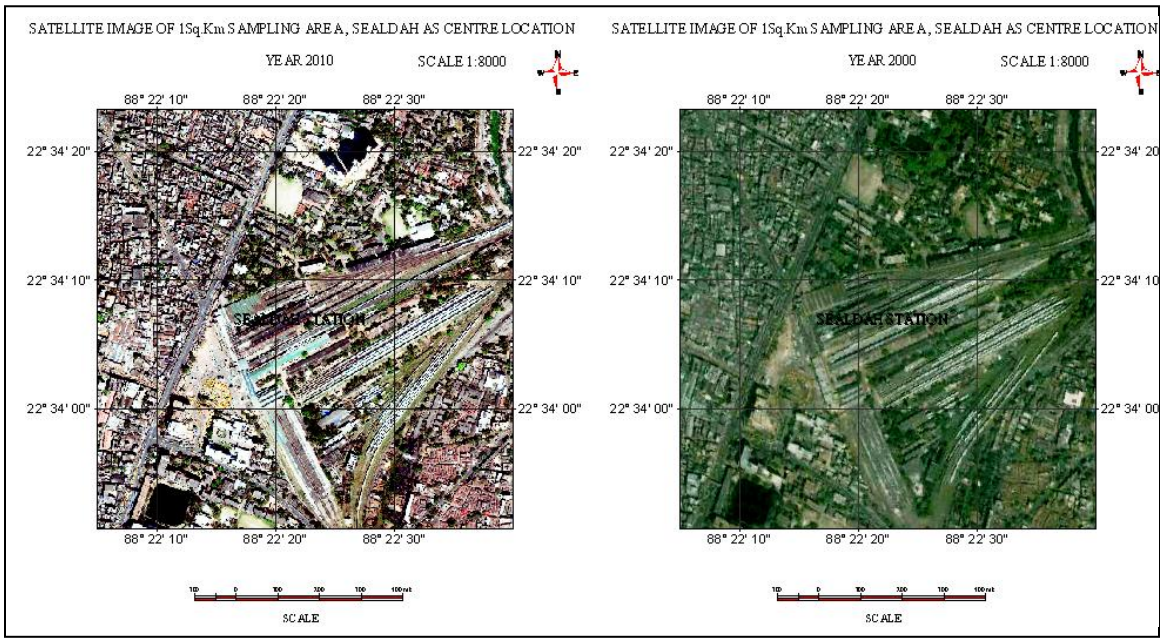


Fig.19

The given area extends from North 22°31′37″ to North 22°36′36″ and East 88°19′41″ to East 88°25′04″ . The area of interest is shown below:

Google Image 78.51 sq km

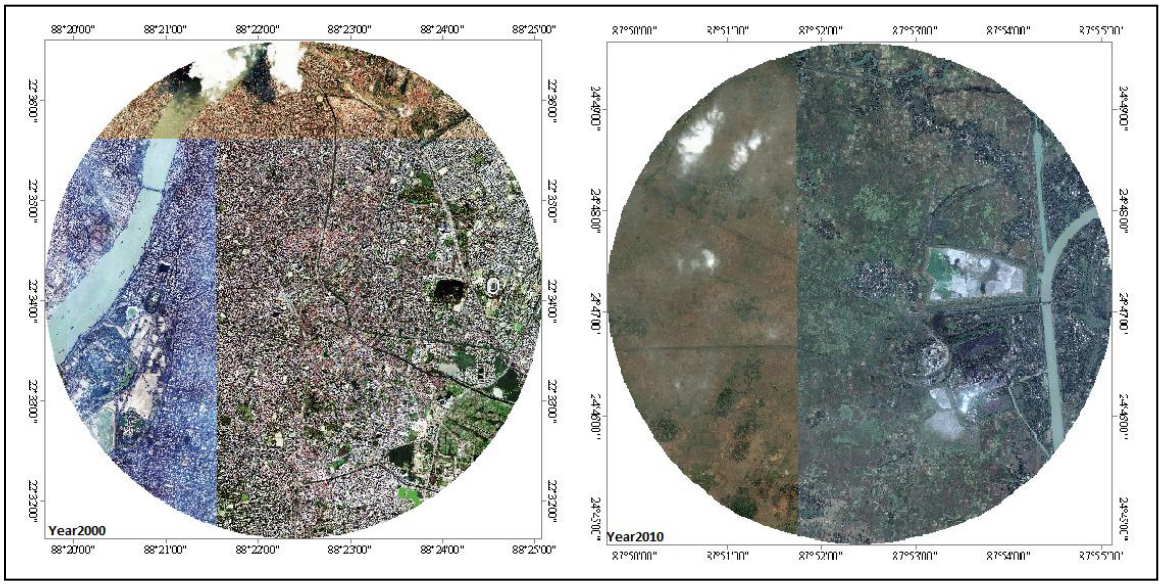


Fig.20

Once we have the processed image for both the years the remarkable change between reflectance values were quite obvious study though this factor is highly dependent on the solar illumination of that particular time and date. Here is a comparative diagram of those values of particular location:

RGB values

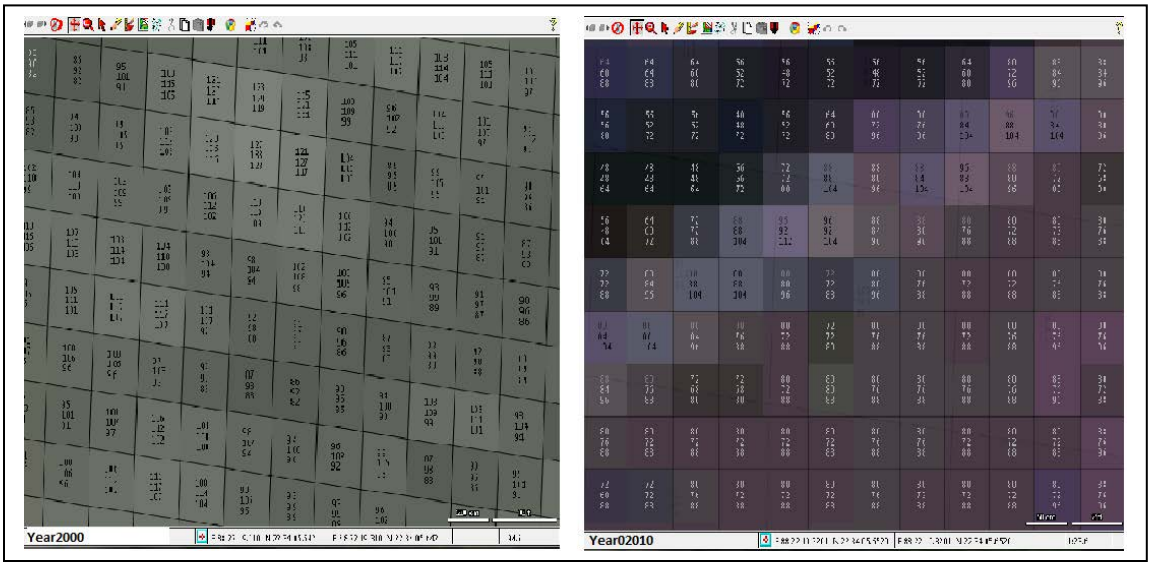


Fig.21

As a part of visual interpretation the important land-cover patterns have been delineated by using manual vectorization followed by building of topology between the spatial feature. The platform used through-out the process flow is a topology inbuilt system where no we have achieved the optimum vector statistics for further comparison with digital interpreted result.

The implementation of the visual image interpretation technique, the areas having proper land use differentiation had been delineated. Areas are shown below:

Google Image 78.51 sq km Land Use and land cover Map

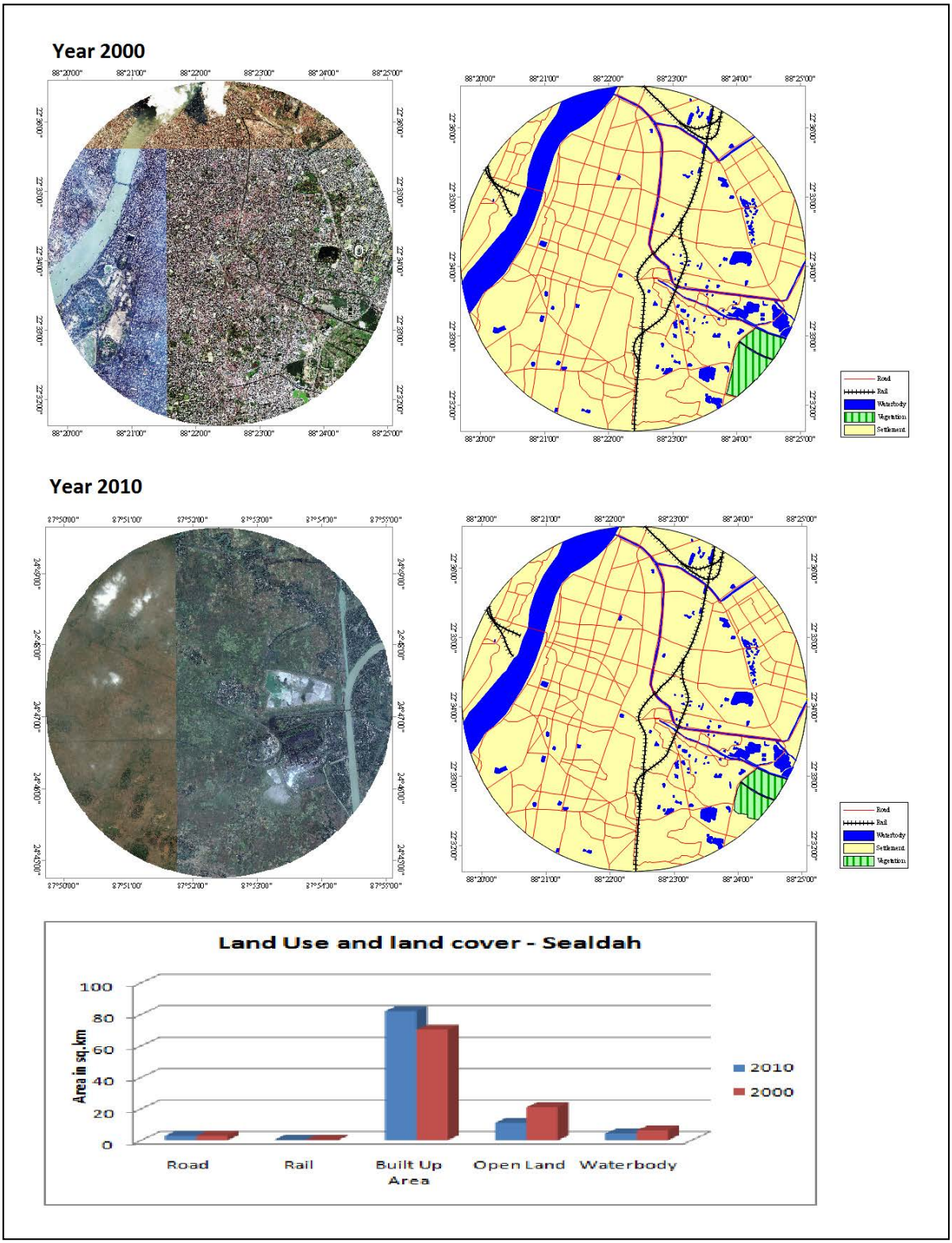


Fig.22

Factors Considered: Following factors were taken into consideration for delineating the zones of interest:

- In order to create a balanced and sustainable industrial growth in any zone and maximize use of uncultivable land in any area, it is felt that some parts of this zone can be identified as industrial growth poles, because of such factors such as availability of non-agricultural land, historical industrial presence and availability of good infrastructure. This will mean optimal use of the existing industrial infrastructure and up gradation of infrastructure where required and create new industrial infrastructure for project in backward areas.
- During land use classification habitation, vegetation and open land areas have been merged into a single category as in this scope of study we are trying to demarcate the land which can be acquired for industrial.
- From the observation of study area, most of the area covered by agricultural land. So there is high prospect in producing crop. Then it′s not healthy to create an industry in this particular area. There must have some social and political issues.

Major criteria for industrial development is communication condition. In this area we can observed that Highway and Railway tracks are passing almost centre portion of this area.

FCC Classification of Sealdah

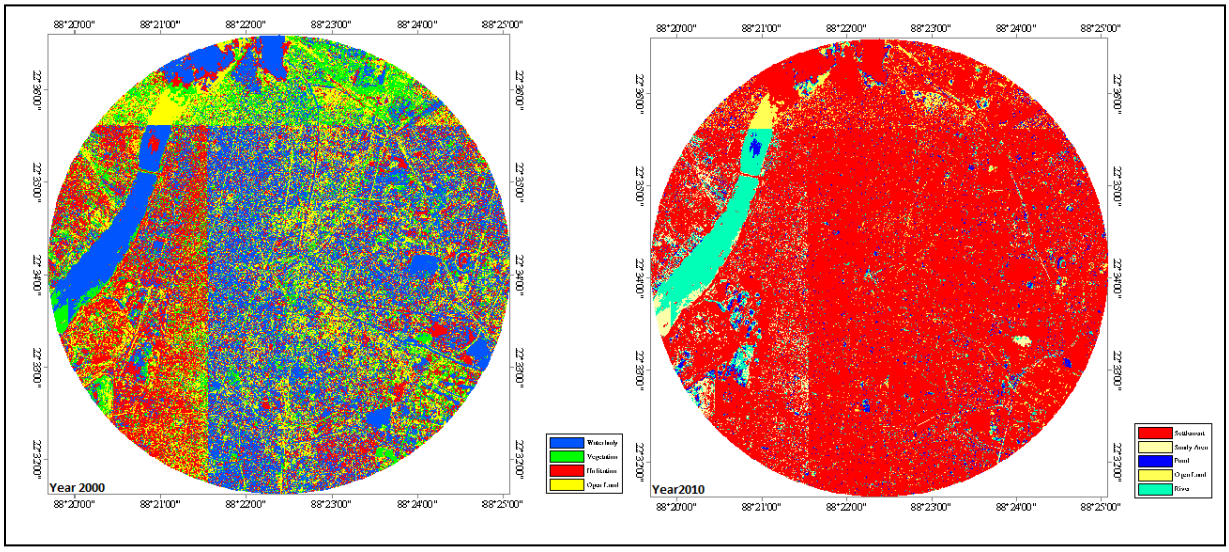


Fig.23

As we compare the FCC Classification image data of the desired area between the year 2000 and 2010 we can clearly see that the agricultural land has decreased to some extent due to the significant increase in settlement area and the decrease of water bodies. Also though there is potential industrial zones scattered throughout the aforementioned area, but scattered area are not healthy for built up an proper industrial zone. At least 1sq. km. continuous area is feasible for actual industrial zonation. So here setting up large or small scale factories may not be viable.

Another issue arises up with settlement area. Here we can observe that, in the year 2010, the percentage of population is very much higher than the year 2000. So the scope of industrial expansion is not possible in this heavy population zone, so pollution issues are common.

In the next map the potential industrial zones are depicted for the area of interest.

Probable Industrial Zone

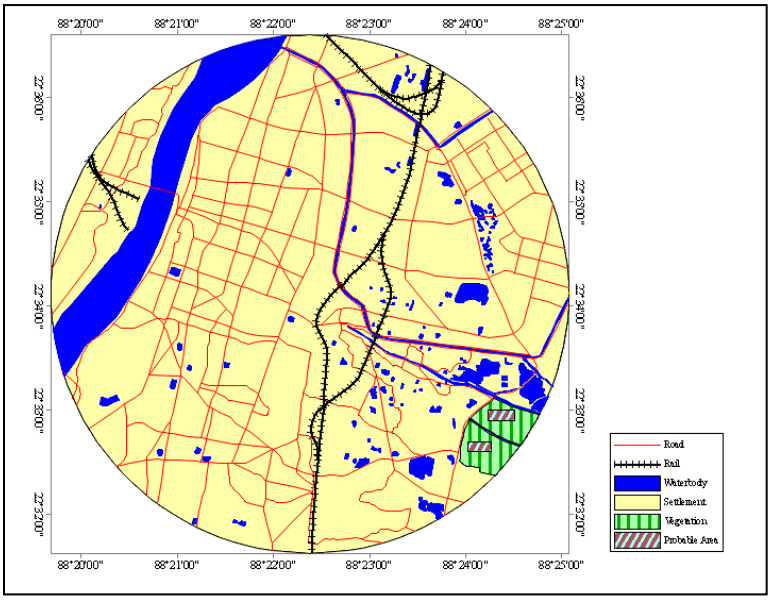


Fig.24

From this map we can clearly visualize that these two probable zones are ideal for industrial area due to proper communication and availability of water. Areas of this prospective zones are 0.15sq.km and 0.10Sq.km receptively. These two zones are under fallow land area, so it cannot hamper the agricultural growth of this particular area. Due to good communication network and availability of water resource most of the areas are

densely populated and prosperity of agricultural growth are very high. So only these identified zones are feasible for industrial within our region of interest.

Communication Map

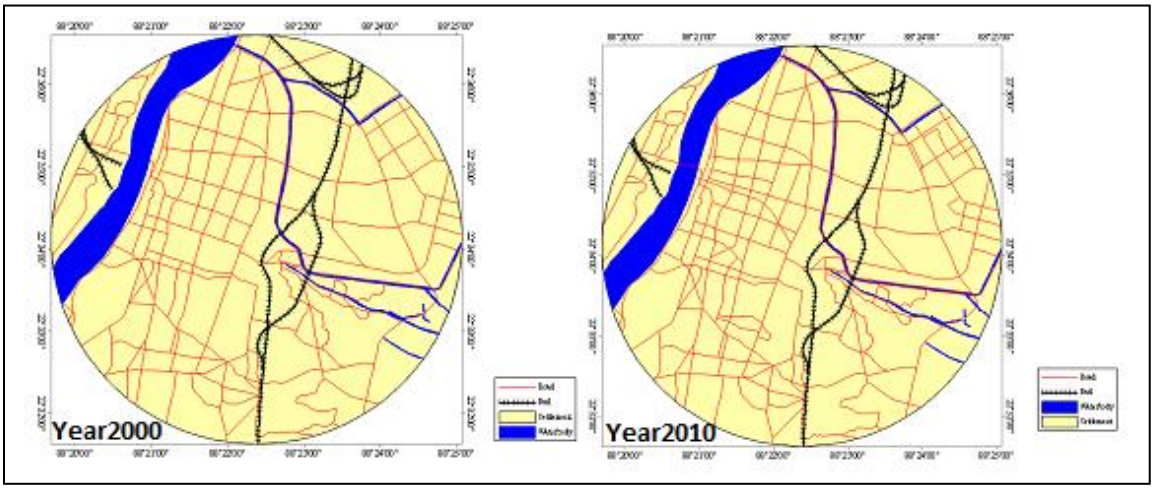


Fig.25

From this above two maps we can interpret that the communication system has been drastically change from 2000 to 2010 due to increase in population. So probability of industrial zone is maximum in this zone.

In spite of other social issues it can be concluded that this zone is superior for industrial growth.

Considering all these factors, the actual suggested area for industrial area is shown below:

Actual prospective Industrial area

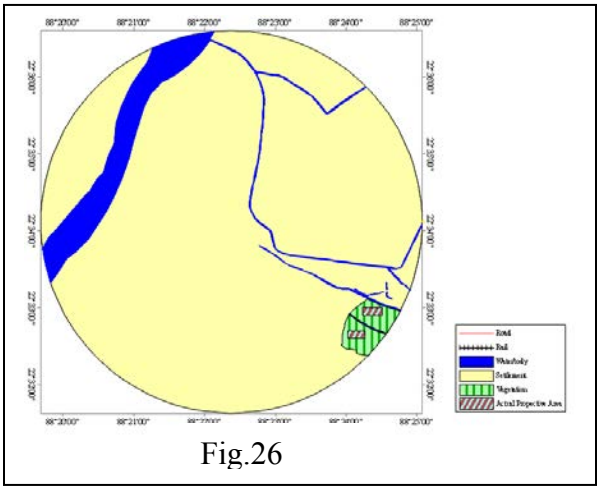


Fig.26

Conclusion: In the present status of study all the parameters related to industrial suitability had not been considered. The zones, which had been delineated as prospective

area, should be verified using the field data. So, the delineated zones are the probable prospective area.

So using the same manual interpretation technique both the images were visually classified to get the spatial changes between the years-

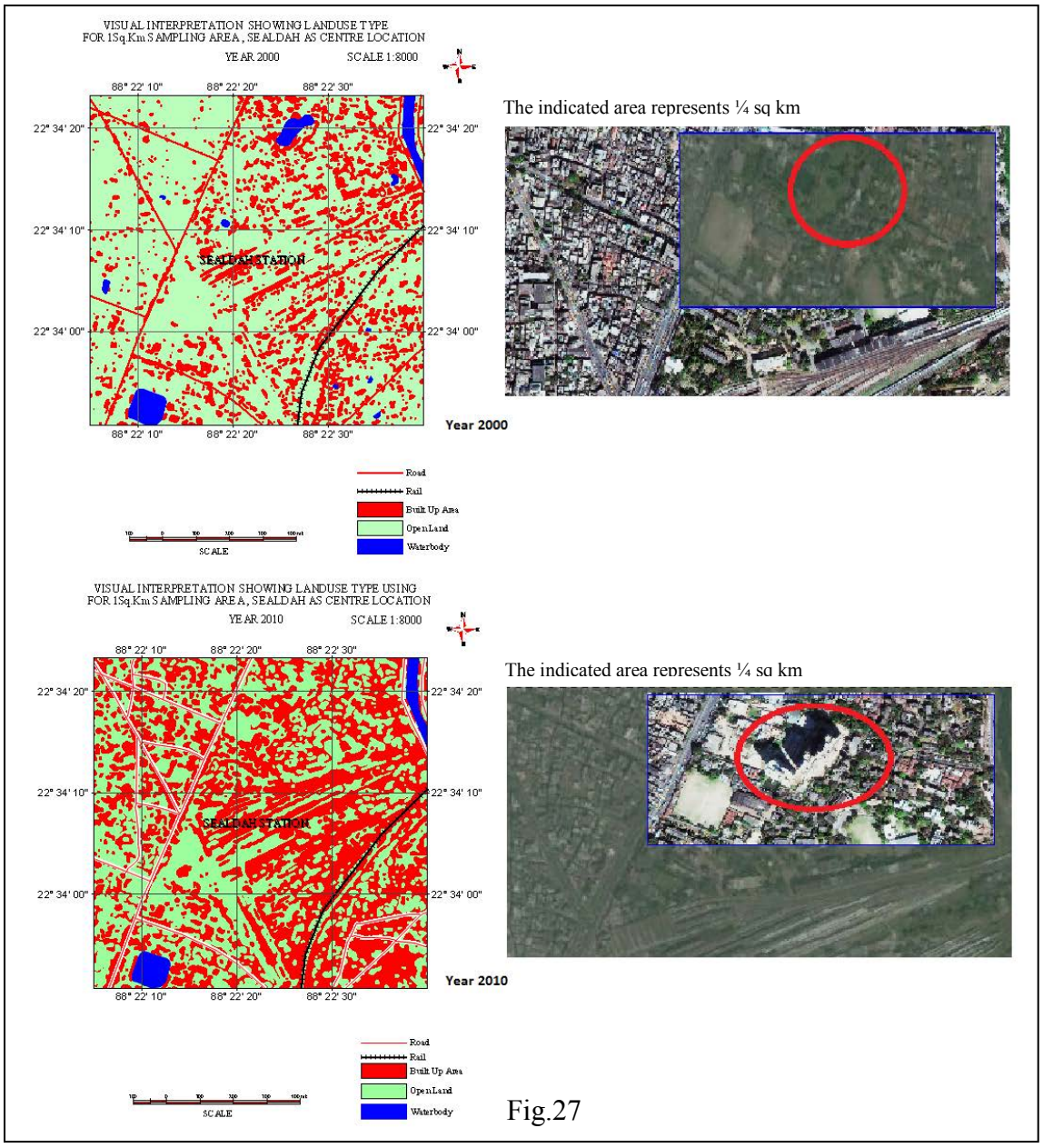


Fig.27

At the other hand same images have been used for digital image classification. The study area has been passed through hybrid classification technique, where the unsupervised classification has been followed by supervised classification method and finally the spurious classes were deliberately merged to get the intended result.

Land Use and land cover Map

Sealdah Railway Station (Kolkata, West Bengal)

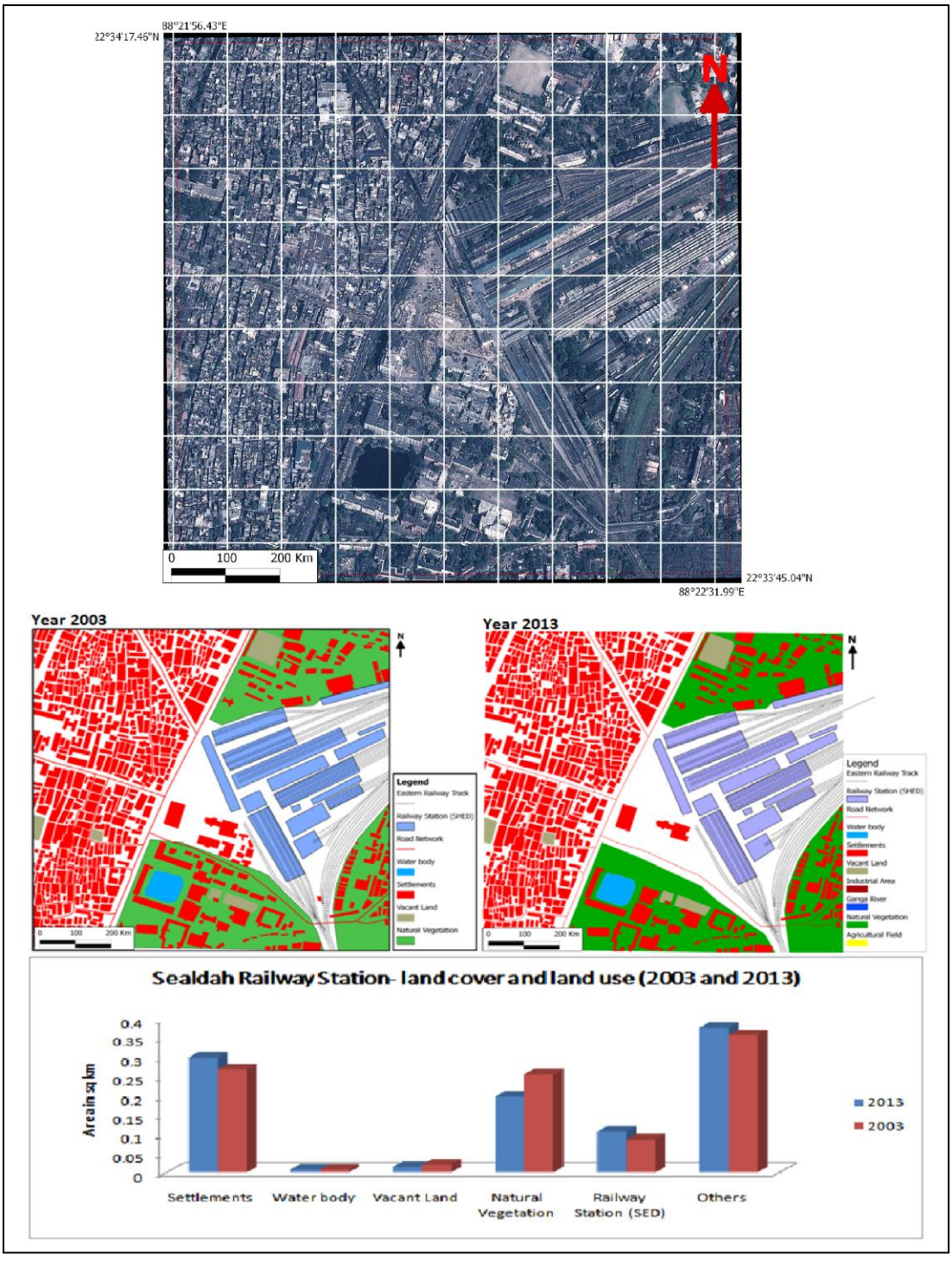


Fig.28

At Sealdah Railway Station, there is increase in station area and settlement and decrease is noticed in water body, vacant land, natural vegetation in the year 2013 compared to 2003.

Google Image 1 sq km Land Use and land cover Map

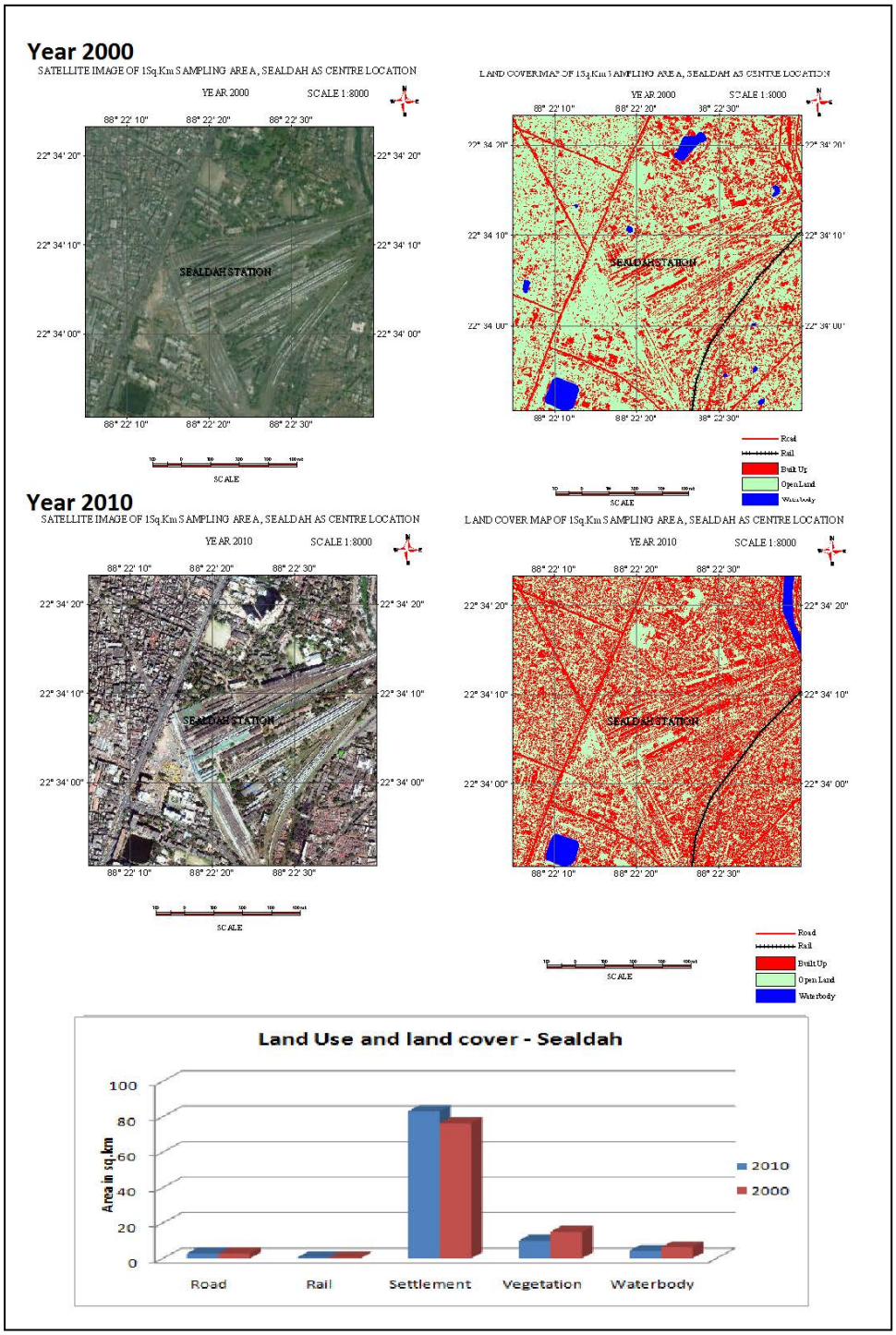


Fig.29

Cartographical map preparation with suitable scale. Throughout the mapping we have tried to use A4 page where maps were fitted with 1:8000 scale.

Interpretation and discussion

So, the procedural steps with the rigorous interpretation with both visual and digital technique for the study area between the years 2000 and 2010 this can be clearly interpreted that the '*Open Land*' has decreased to huge extent due to the significant increase in 'built-up' area and the decrease of water bodies is quite obvious. As this zone is belongs to the one of the impotent industrial city of West Bengal naturally the population is dramatically increased during last 10 years.

Land use and Land cover - Changing Pattern

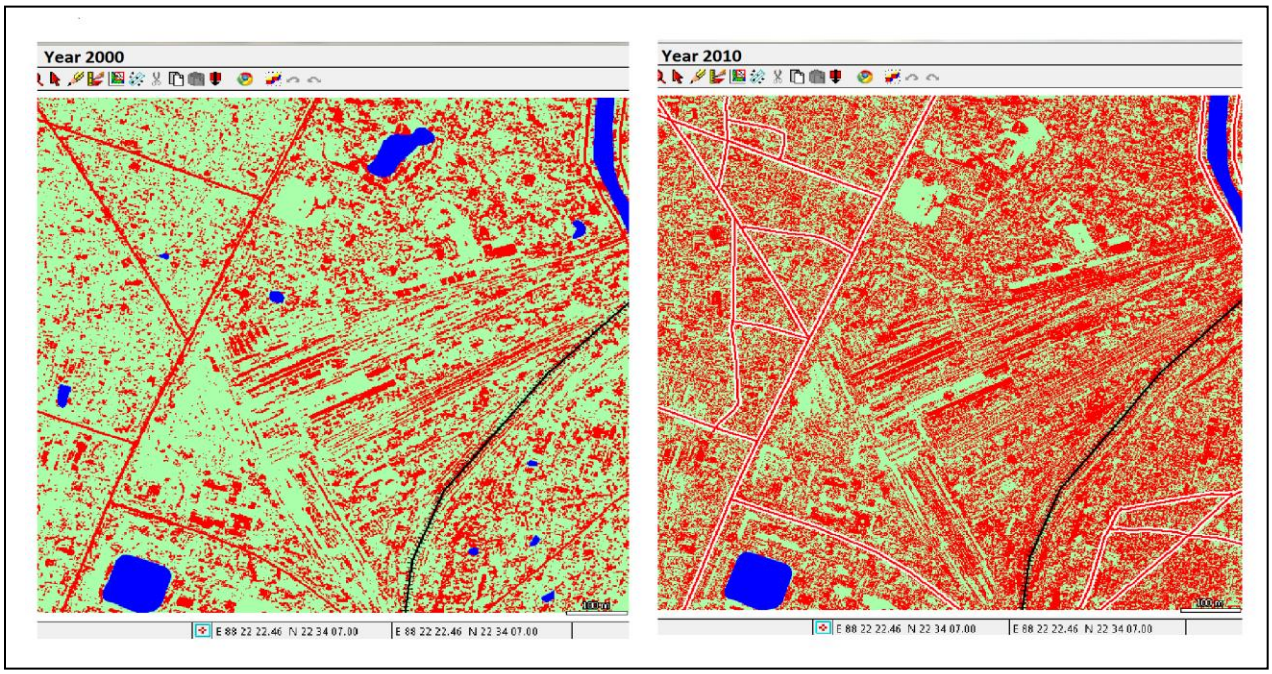


Fig.30

So, spatial dynamics has dramatically changed during last 10 years where the population change is quite significant in the quest of earning and lively hood. Naturally there is notable increase in small scale industry as well as large industries to the circumferences of this sampling study area. Though agricultural land has not been noticed with in this zone but in sequel the general observation is 'Agricultural land' has been occupied throughout the year to accommodate the increased population pressure in this zone and its surroundings.

Land Use and land cover Map

Tribeni Railway Station (Hugli, West Bengal)

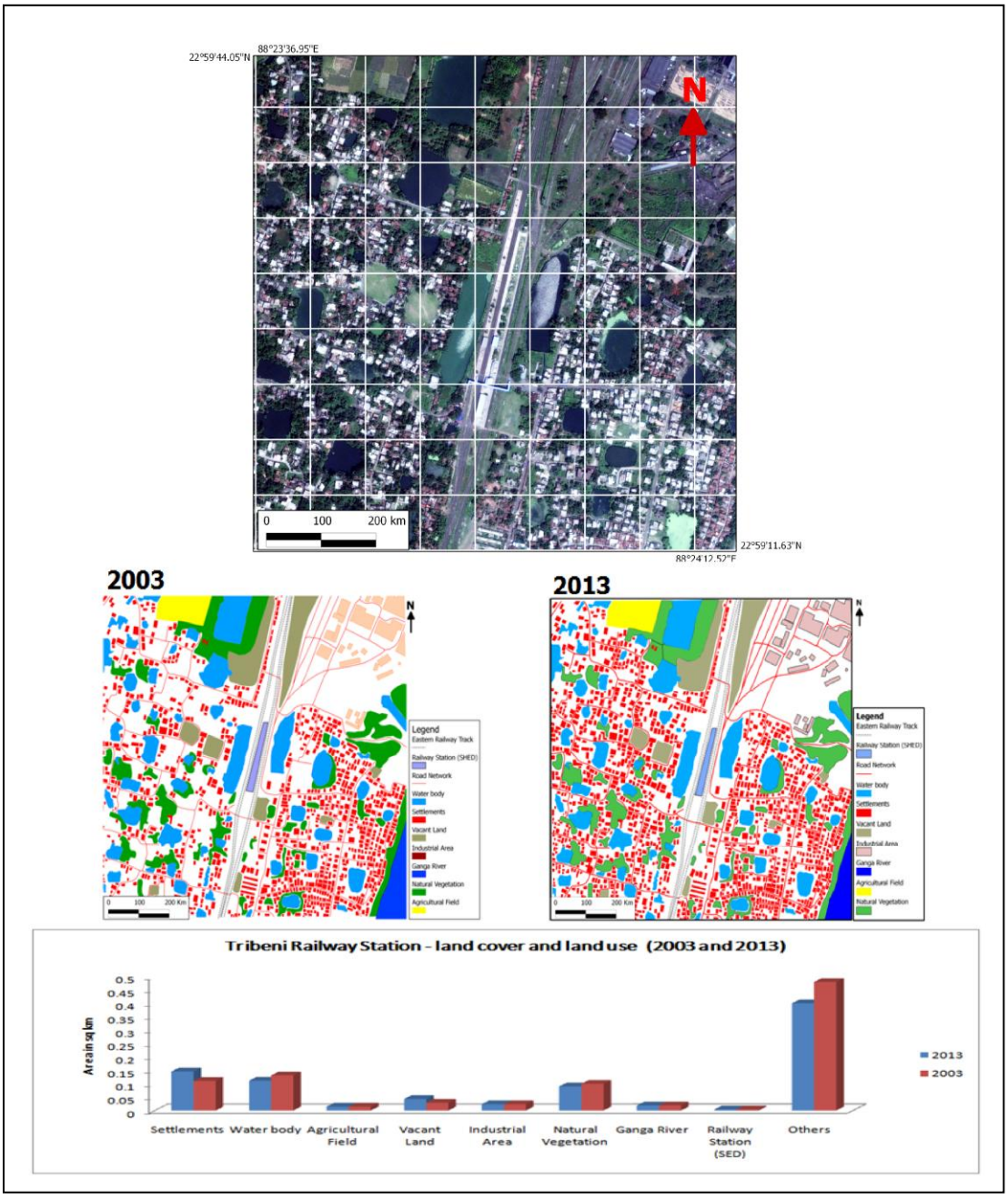


Fig.31

At Tribeni Railway Station, there is increase in settlement and vacant land and decrease is noticed in water body, natural vegetation and others in the year 2013 compared to 2003.

Land Use and land cover Map
Nabadwip Railway Station (Nadia, West Bengal)

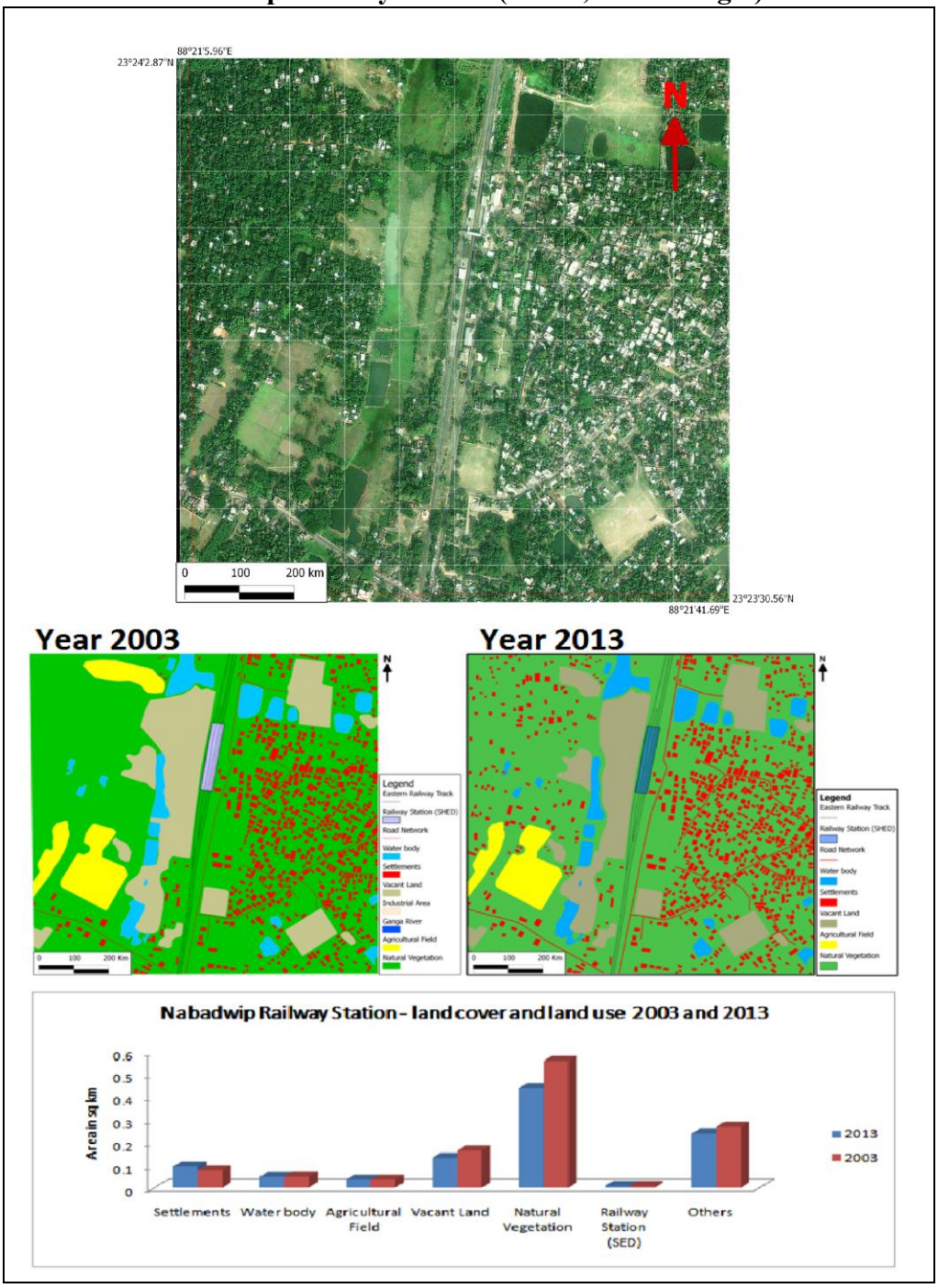


Fig.32

At Nabadwip Railway Station, there is increase in settlement and decrease is noticed in Water body, Vacant Land, Natural Vegetation and others in the year 2013 compared to 2003.

Sampling Zone: Palsa and its Surrounding areas , Palsa station Birbhum District,WB

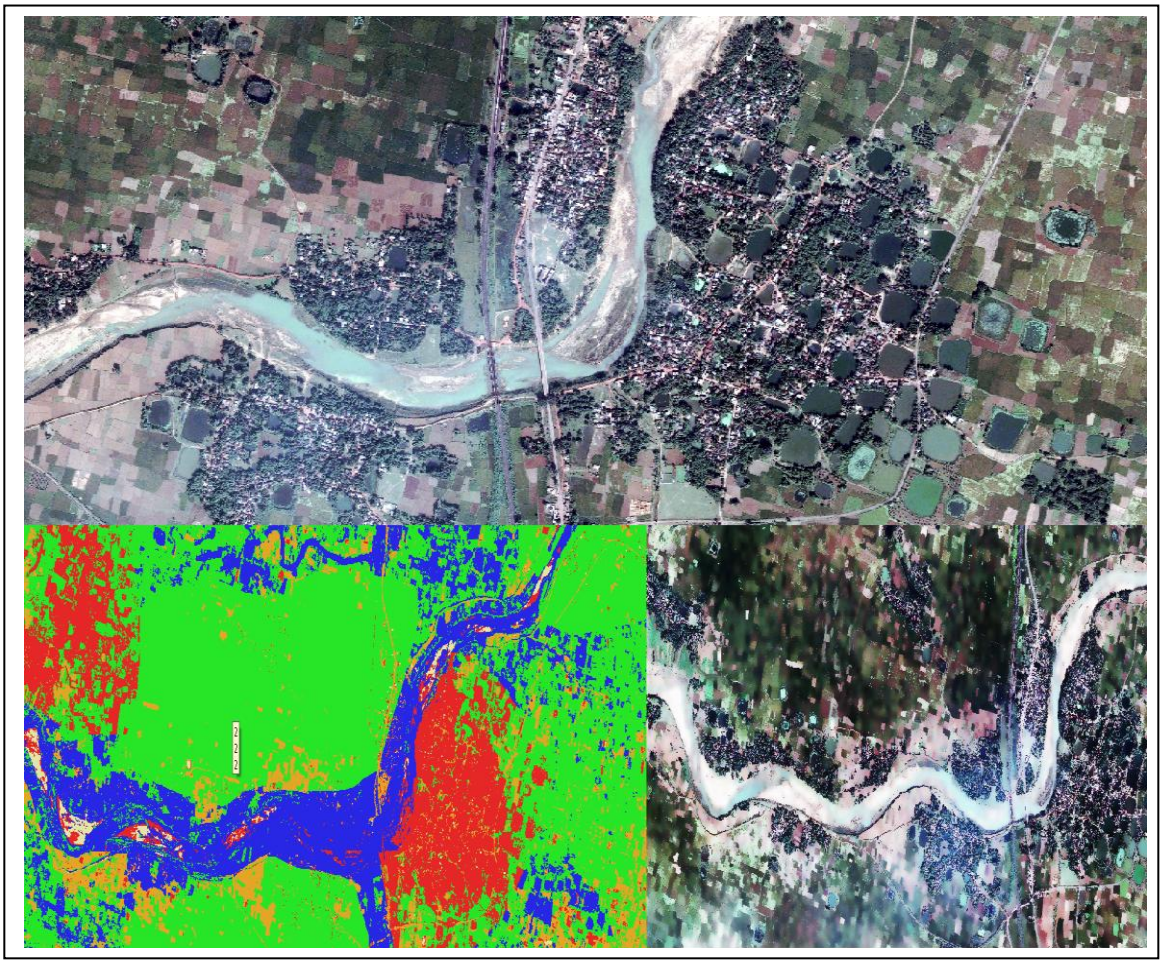


Fig.33

Objective: Economic development and population growth have triggered rapid changes to Earth′s land cover over the last two centuries, and there is every indication that the pace of these changes will accelerate in the future. The present study shows the utility of remote sensing techniques integrated with GIS to study the spatial dynamics of agriculture and industry in the selected specified study area and its surroundings in Palsa, Birbhum District. Various satellite image data were analyzed within a digital image processing system to provide up-to-date information of the whole area. The extracted information from remotely sensed data was then integrated with visually interpreted information and field inputs in a GIS to create a comprehensive spatial database. This permitted the integration of several layers of information with the remotely sensed data in both temporal and spatial dimensions.

Background: Remote sensing technology has been recognized as a useful means of supplying up to date information and have the potential to respond to the growing and urgent demand for timely and accurate land cover information over large areas. In the recent past, land cover mapping from satellites has come of age, Through research on various issues regarding data pre-processing, classification and accuracy assessment, new and unique data / land cover products are being generated which could not be produced by earlier techniques. Various data set of the area were used for interpreting and unifying them within GIS and Image Processing environment for analysis and interpretation.

Data Available: The following data were used for this project work:

- Landsat satellite image having 28.5meter spatial resolution.
- IRS Cartosat multispectral satellite image having 5 meter spatial resolution.
- Digital Globe high resolution image (0.5m) from Open Source Google Earth repository for Visual interpretation and as a supplementary data for interpretation.

Software Used: TNTmips Pro 2014, the integrated GIS and Image Processing platform were used in the present study.

Workflow:

- Satellite Images were imported in a project file within TNTmips Pro platform.
- The Images were geometrically rectified with the GCP by using Geographic co-ordinate system and World Geodetic System 1984 (WGS 84) as Datum. Affine transformation model has been deliberately selected for this sapling area to maintain the geometric area and shape accuracy.
- The sampling location extends from North 23°39′14.563″ to North 23°39′ 44.192″ and East 87°41′39.356 ″ to East 87°42′11.705″ .
- As per the present scope of study to meet the temporal data requisite two different year data has been collected.
- Image preprocessing was implemented on both the images to improve the quality and interpretability
- Extraction model was implemented on the scenes to get the 1 sq km sampling area as decided to process with in the buffer zone of 5 kilometer both of the railway track from Sealdah to Maldah at the location of Palsa station to get the surroundings bird′s eye view.

The sampling location extends from North 23° 39′ 14.563″ to North 23° 39′ 44.192″ and East 87° 41′ 39.356 ″ to East 87° 42′ 11.705″ .

Google Images 1 sq km

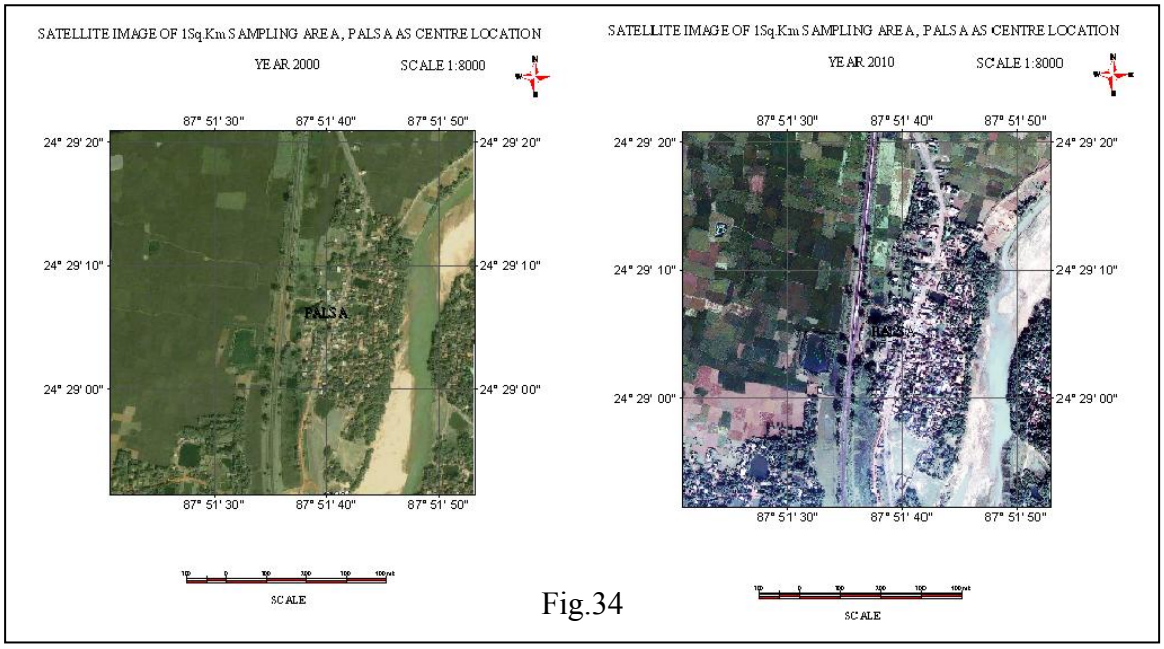


Fig.34

The given area extends from North 22°31′ 37″ to North 22°36′ 36″ and East 88°19′41″ to East 88°25′ 04″ . The area of interest is shown below:

Google Images 78 sq km

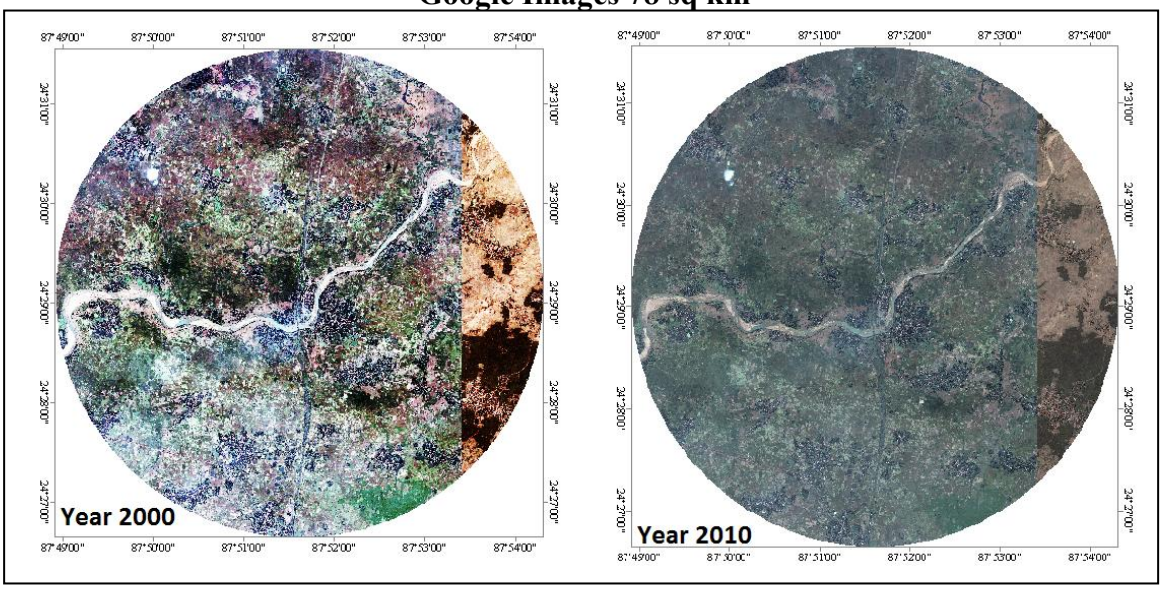


Fig.35

- The study area is about 78 sq.km.

Once we have the processed image for both the years the remarkable change between reflectance values were quite obvious study though this factor is highly dependent on the solar illumination of that particular time and date. Here is a comparative diagram of those values of particular location:

RGB values

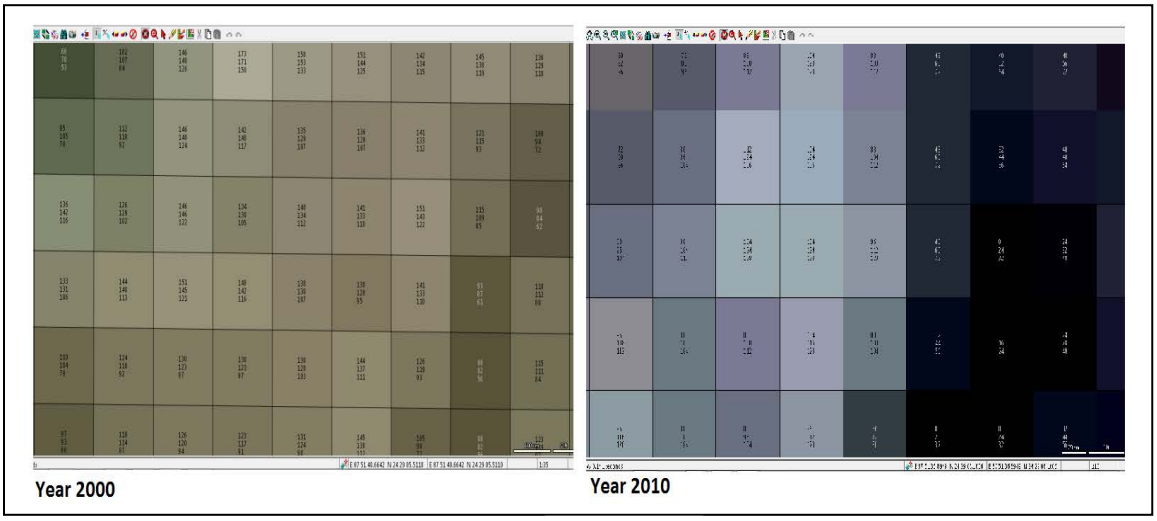


Fig.36

As a part of visual interpretation the important land-cover patterns have been delineated by using manual vectorization followed by building of topology between the spatial features. The platform used through-out the process flow is a topology inbuilt system where we have achieved the optimum vector statistics for further comparison with digital interpreted result.

Vectorization layer

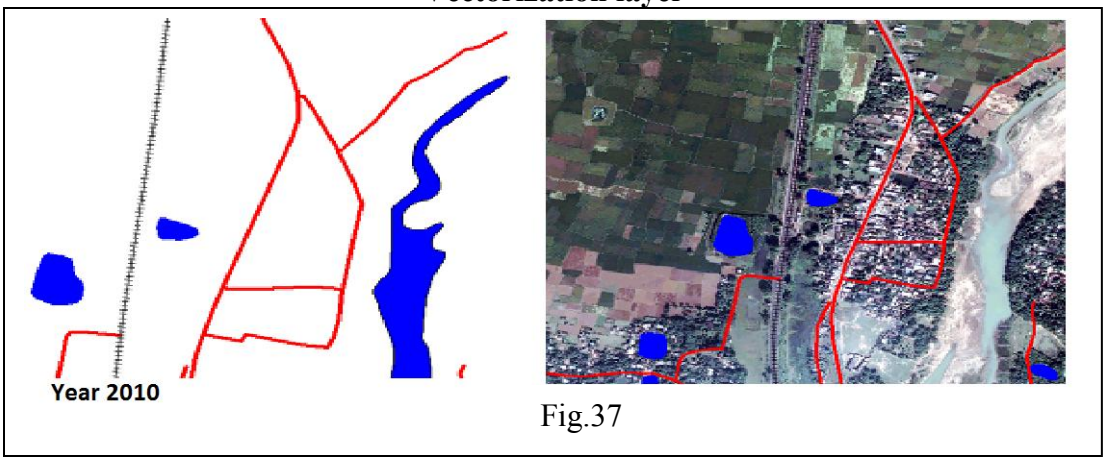


Fig.37

The implementation of the visual image interpretation technique, the areas having proper

Land use differentiation had been delineated. Areas are shown below:

Google Image 78.51 sq km Land Use and land cover Map

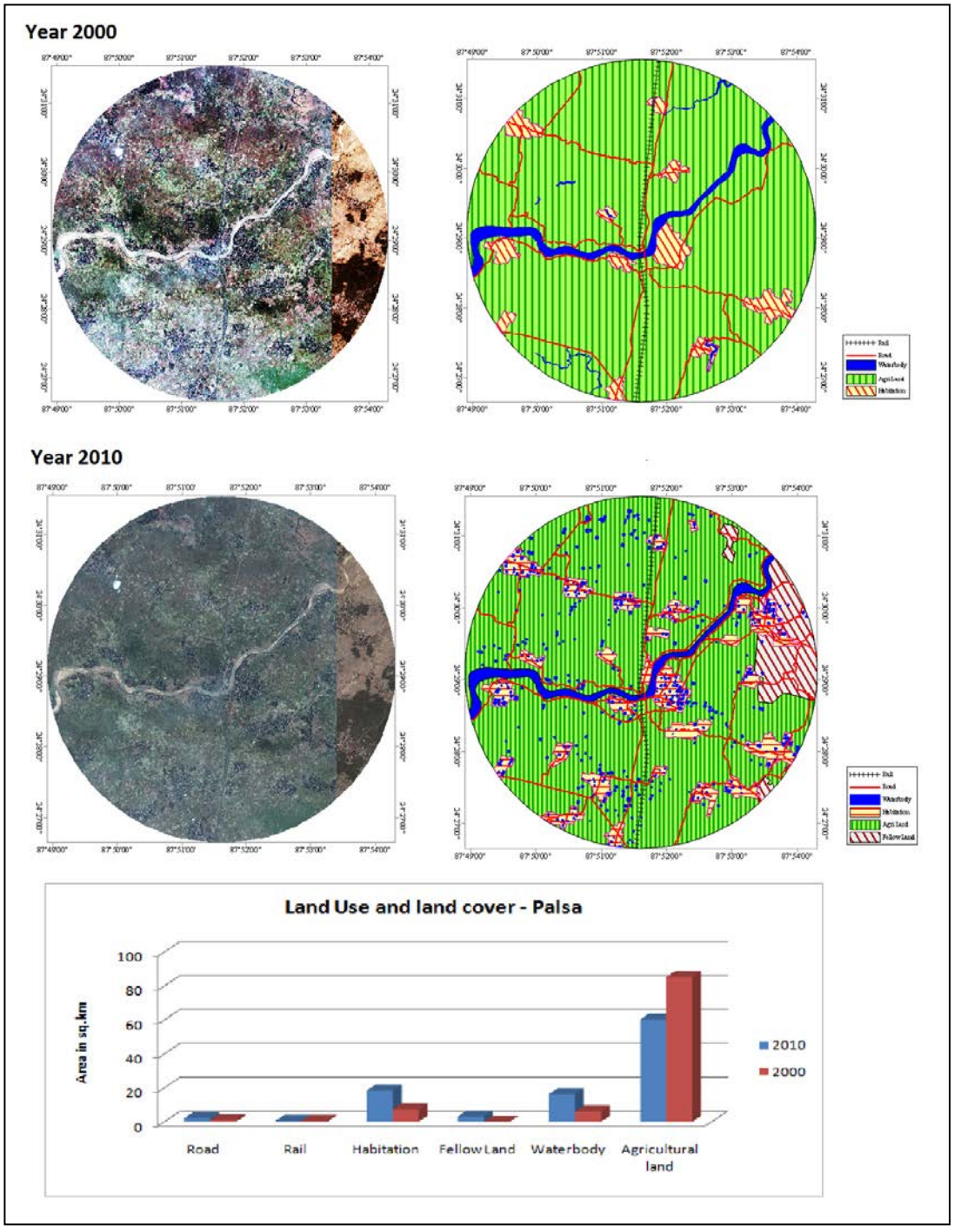


Fig.38

Factors Considered: Following factors were taken into consideration for delineating the zones of interest:

- In order to create a balanced and sustainable industrial growth in any zone and maximize use of uncultivable land in any area, it is felt that some parts of this zone can be identified as industrial growth poles, because of such factors such as availability of non-agricultural land, historical industrial presence and availability of good infrastructure. This will mean optimal use of the existing industrial infrastructure and up gradation of infrastructure where required and create new industrial infrastructure for project in backward areas.
- During land use classification habitation, vegetation and open land areas have been merged into a single category as in this scope of study we are trying to demarcate the land which can be acquired for industrial.area,
- From the observation of study area, most of the area covered by agricultural land. So there is high prospect in producing crop. Then it′s not healthy to create an industry in this particular area. There must have some social and political issues.
- Major criteria for industrial development is communication condition. In this area we can observe that Highway and Railway tracks are passing almost through central portion of this area.

FCC Classification

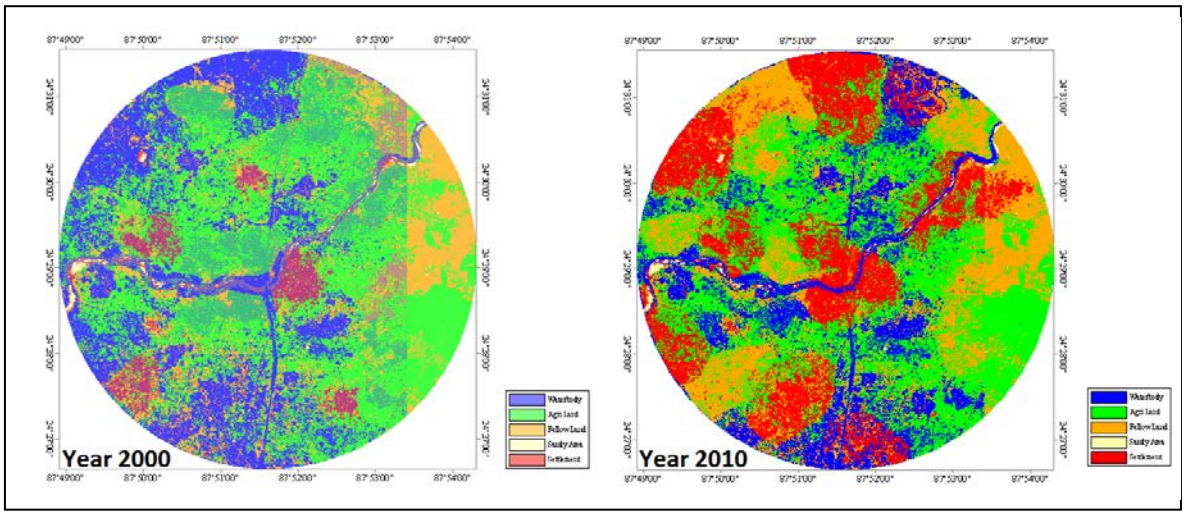


Fig.39

As we compare the FCC Classification image data of the desired area between the year 2000 and 2010 we can clearly see that the agricultural land has decreased to some extent

due to the significant increase in settlement area and the decrease of water bodies. Also though there is potential industrial zones scattered throughout the aforementioned area, but scattered area are not healthy for built up a proper industrial zone. At least 1sq. km. continuous area is feasible for actual industrial zonation. So here setting up large or small scale factories may not be viable.

Another issue rises up with settlement area. Here we can observe that, in the year 2010, the percentage of population is very much higher than the year 2000. So the scope of industrial zone is not possible in this heavy population zone, so pollution issues are arise.

In the next map the potential industrial zones are depicted for the area of interest.

Probable Industrial Zone

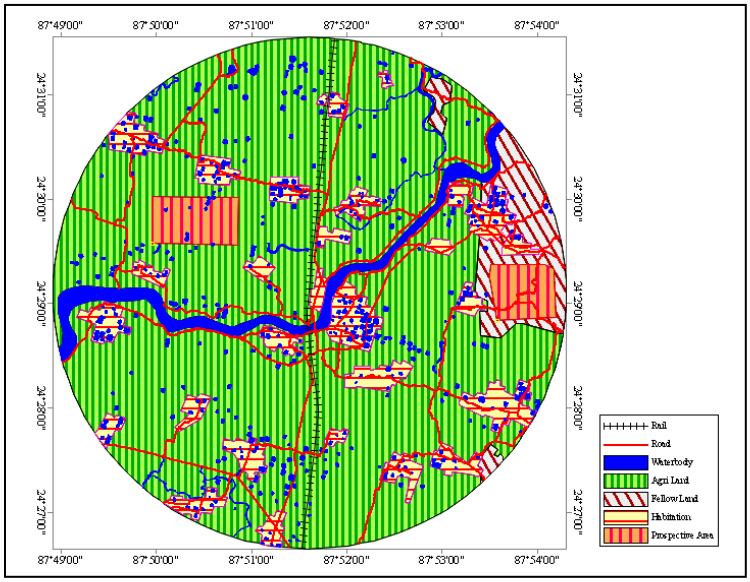


Fig.40

From this map we can clearly visualize that these two probable zones are ideal for industrial due to proper communication and availability of water. Areas of these prospective zones are 1.52 sq.km. and 1.30 sq.km receptively. These two zones are under fellow land area, so it can't be hamper the agricultural growth of this particular area. Due to good communication network and availability of water resource most of the areas are densely populated and prosperity of agricultural growth are very high. So only these identified zones are feasible for industrial within our region of interest.

Communication Map

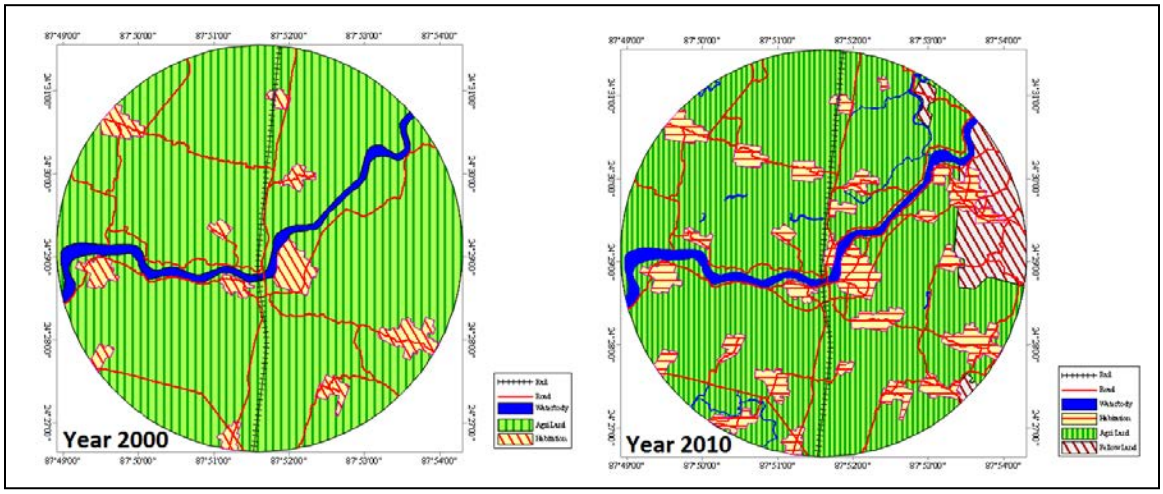


Fig.41

From this above two maps we can interpret that the communication system has been drastically change from year 2000 to year 2010 due to increase in population. So probability of industrial is maximum in this zone.

In spite of other social issues it can be concluded that this zone is superior for industrial.

Considering all these factors, the actual suggested area for industrial has shown below:

Actual prospective Industrial area

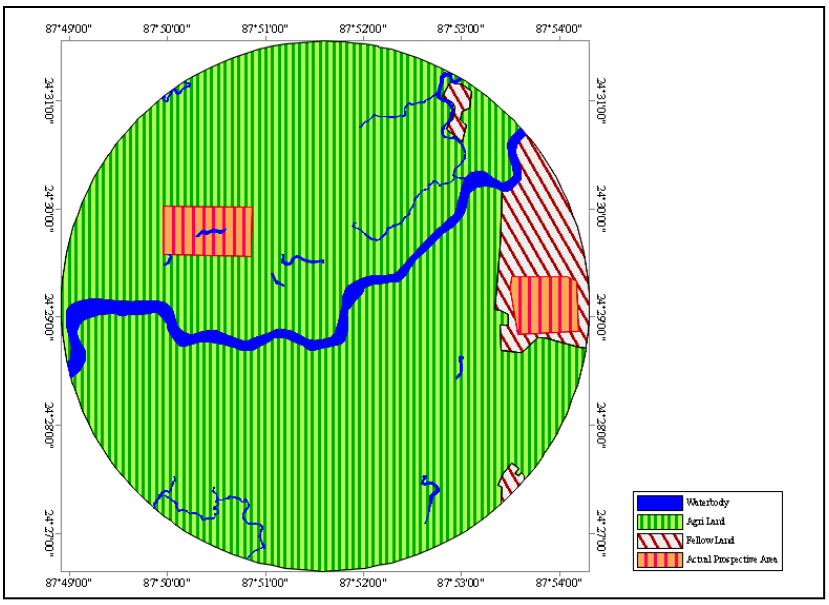


Fig.42

Conclusion: In the present status of study all the parameters related to industrial suitability had not been considered. The zones, which had been delineated as prospective area, should be verified using the field data. So, the delineated zones are the probable prospective area. So using the same manual interpretation technique both the images were visually classified to get the spatial changes between the years-

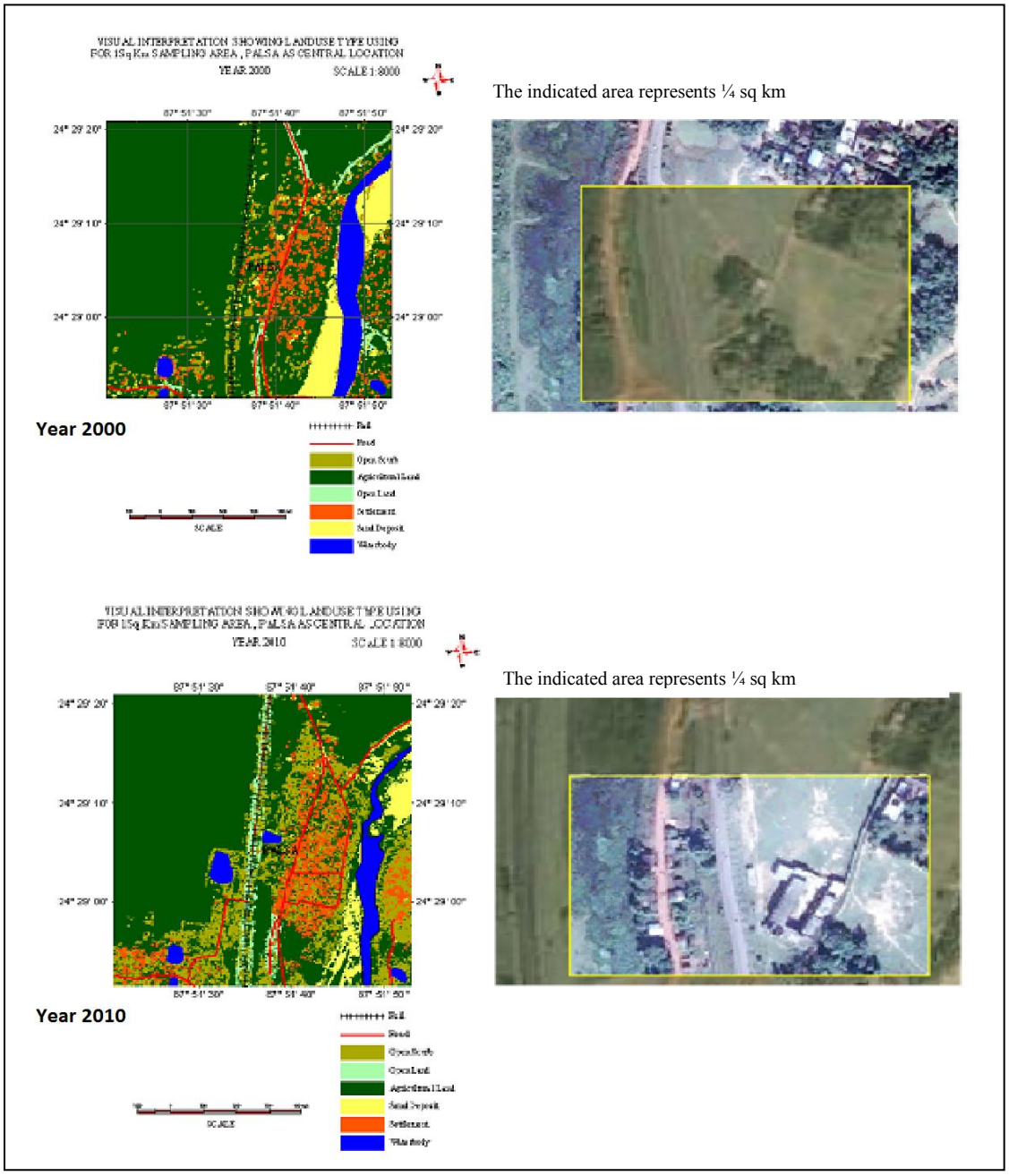


Fig.43

Same images have been used for digital image classification. The study area has been passed through hybrid classification technique, where the unsupervised classification has been followed by supervised classification method and finally the spurious classes were deliberately merged to get the intended result.

Google Image 1 sq km Land Use and land cover Map

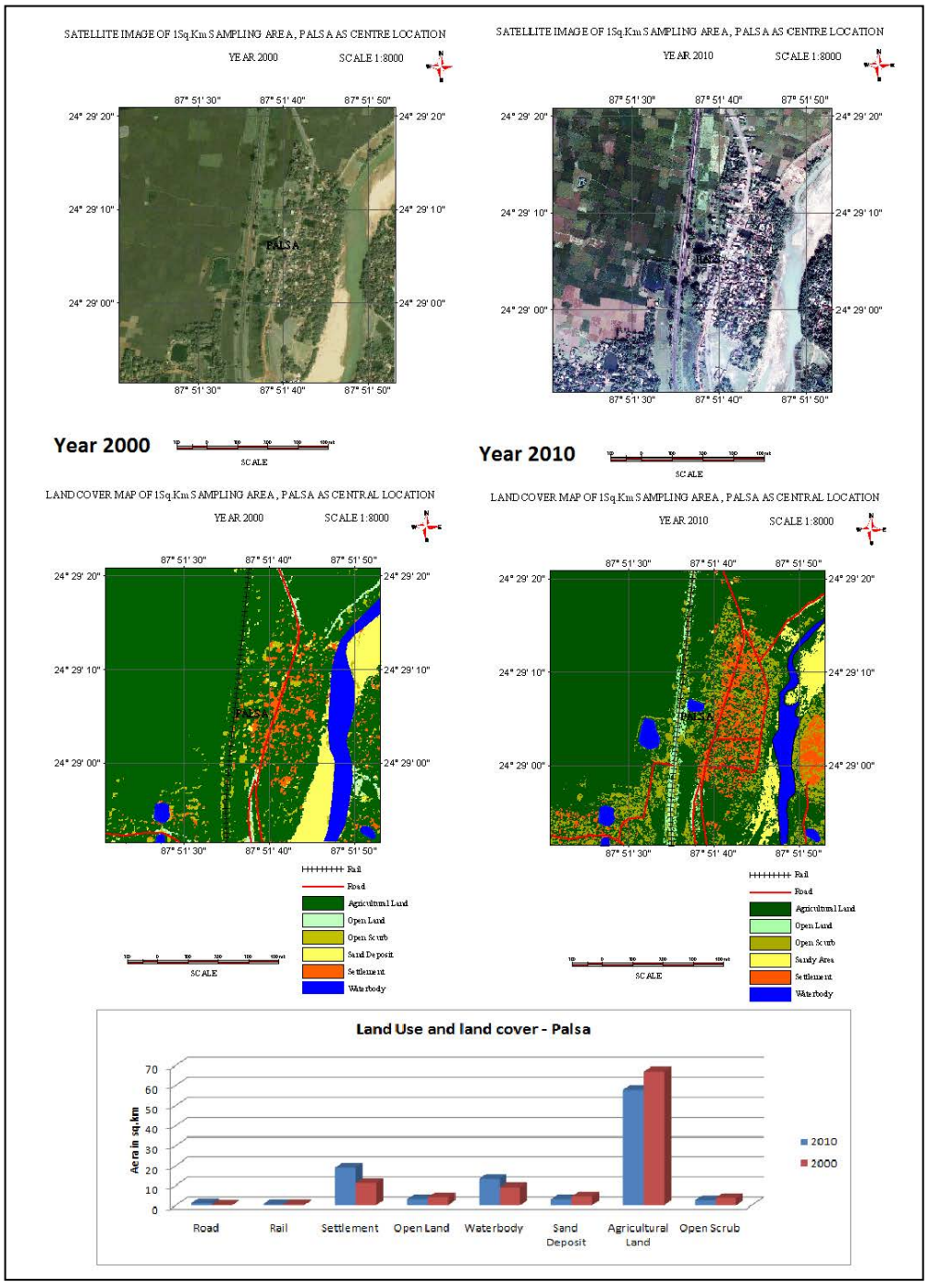


Fig.44

Cartographical map preparation with suitable scale. Throughout the mapping we have tried to use A4 page where maps were fitted with 1:8000 scale.

Interpretation and discussion:

So, the procedural steps with the rigorous interpretation with both visual and digital technique for the study area between the years 2000 and 2010 this can be clearly interpreted that the '*Agricultural Land'* has decreased to huge extent due to the significant increase in 'settlement' area. As this zone belongs to one of the important urban centres of Birbhum district, naturally the population increased during last 10 years.

Land use and Land cover - Changing Pattern

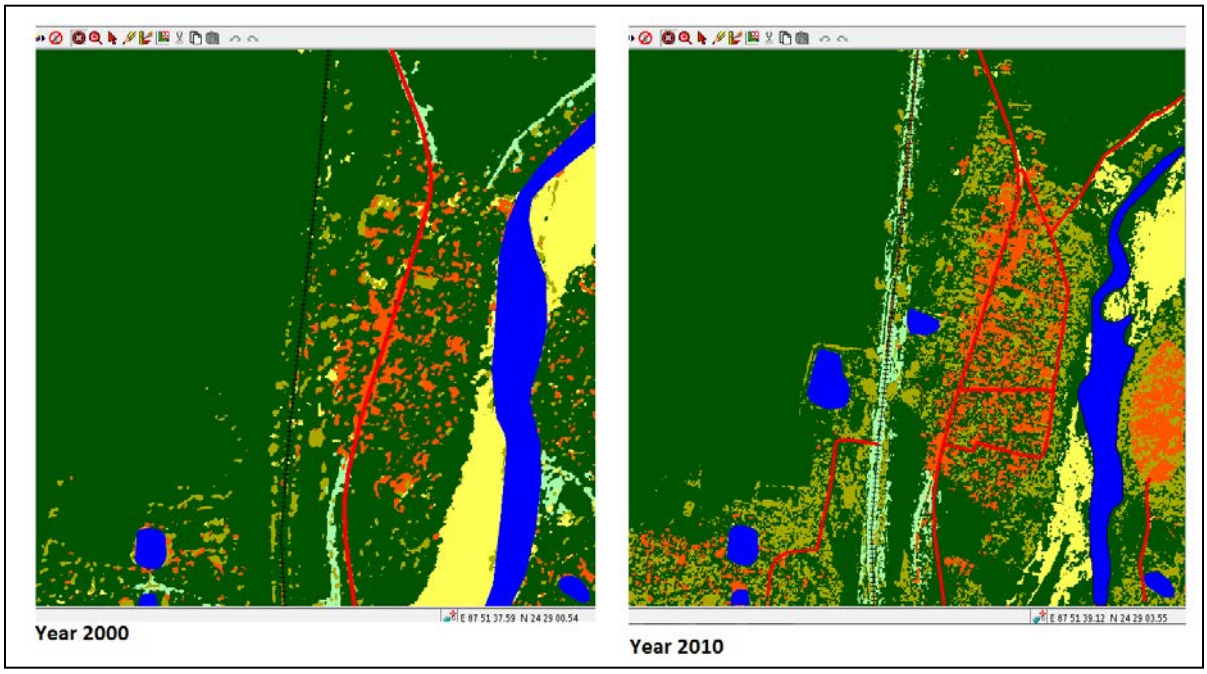


Fig.45

So, spatial dynamics has changed during last 10 years where the population change is quite significant in the quest of earning and lively hood. Naturally there is notable increase in small scale industry as well as large industries to the circumferences of this sampling study area. Though agricultural land is not noticed with in this zone but in sequel the general observation is 'Agricultural land has been occupied throughout the year to accommodate the increased population pressure in this zone and its surroundings.

Land Use and land cover Map

Salar Railway Station (Murshidabad, West Bengal)

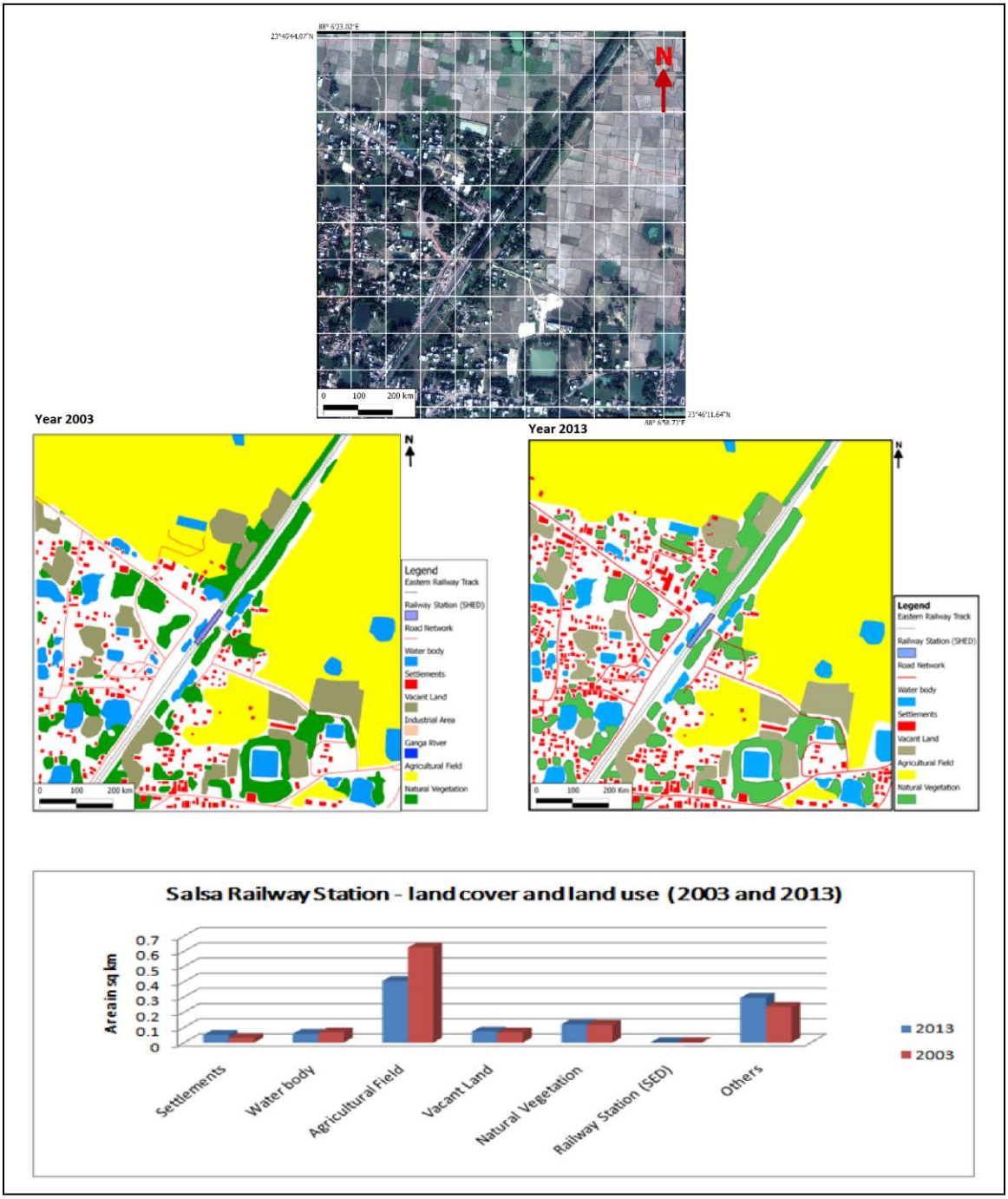


Fig.46

At Salar Railway Station, there is increase in settlement, water body, vacant land, natural vegetation and others and decrease is noticed in agricultural field in the year 2013 compared to 2003.

Land Use and land cover Map
Azimgang Railway Station (Murshidabad, West Bengal)

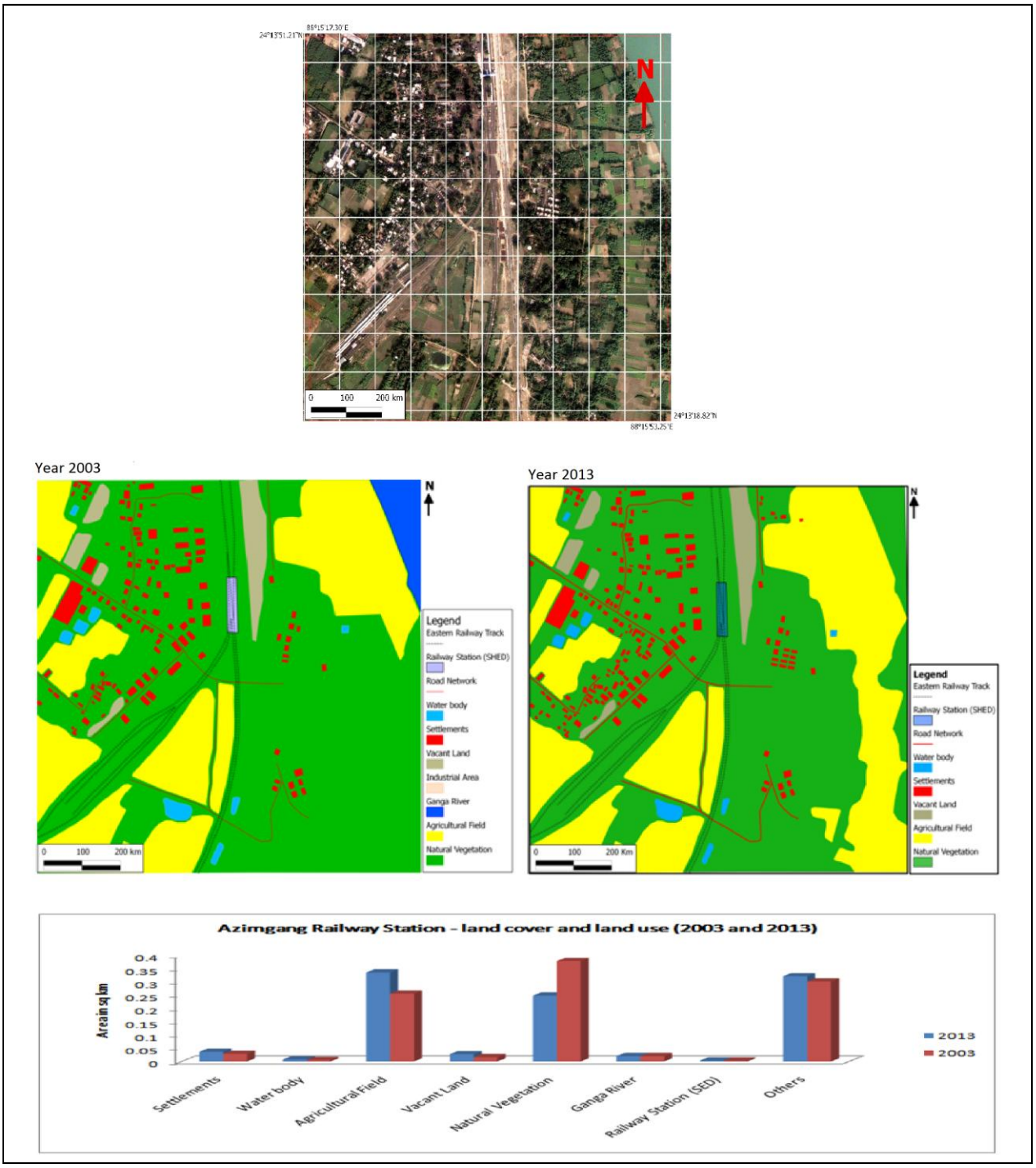


Fig.47

At Azimgang Railway Station, there is increase in settlement, water body, agricultural Field, vacant land and others and decrease is noticed in natural vegetation in the year 2013 compared to 2003.

Land Use and land cover Map
Nimta Railway Station (Murshidabad, West Bengal)

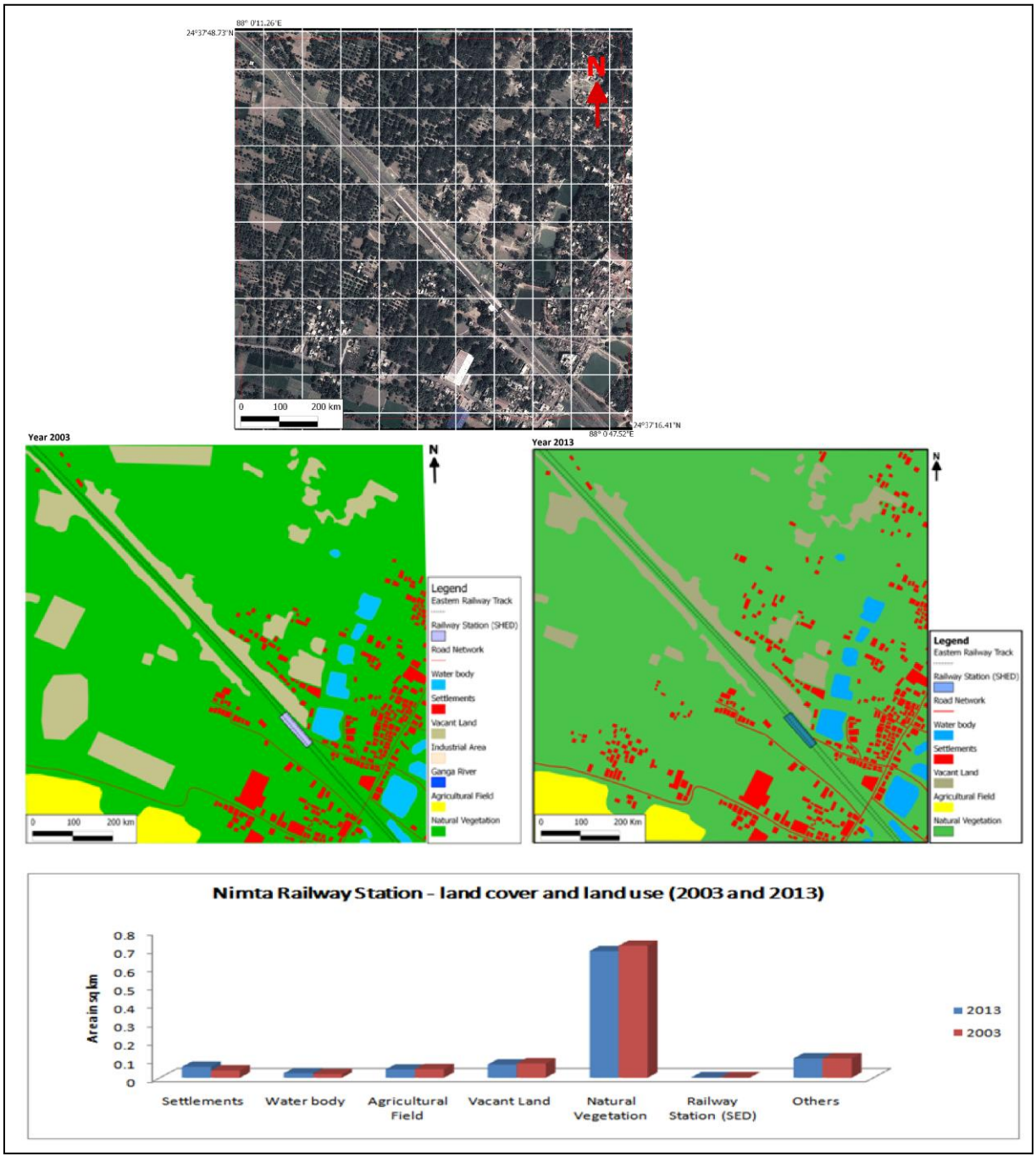


Fig.48

At Nimta Railway Station, there is increase in settlement , water body, vacant Land, natural vegetation and decrease is noticed in agricultural field and industrial area in the year 2013 compared to 2003.

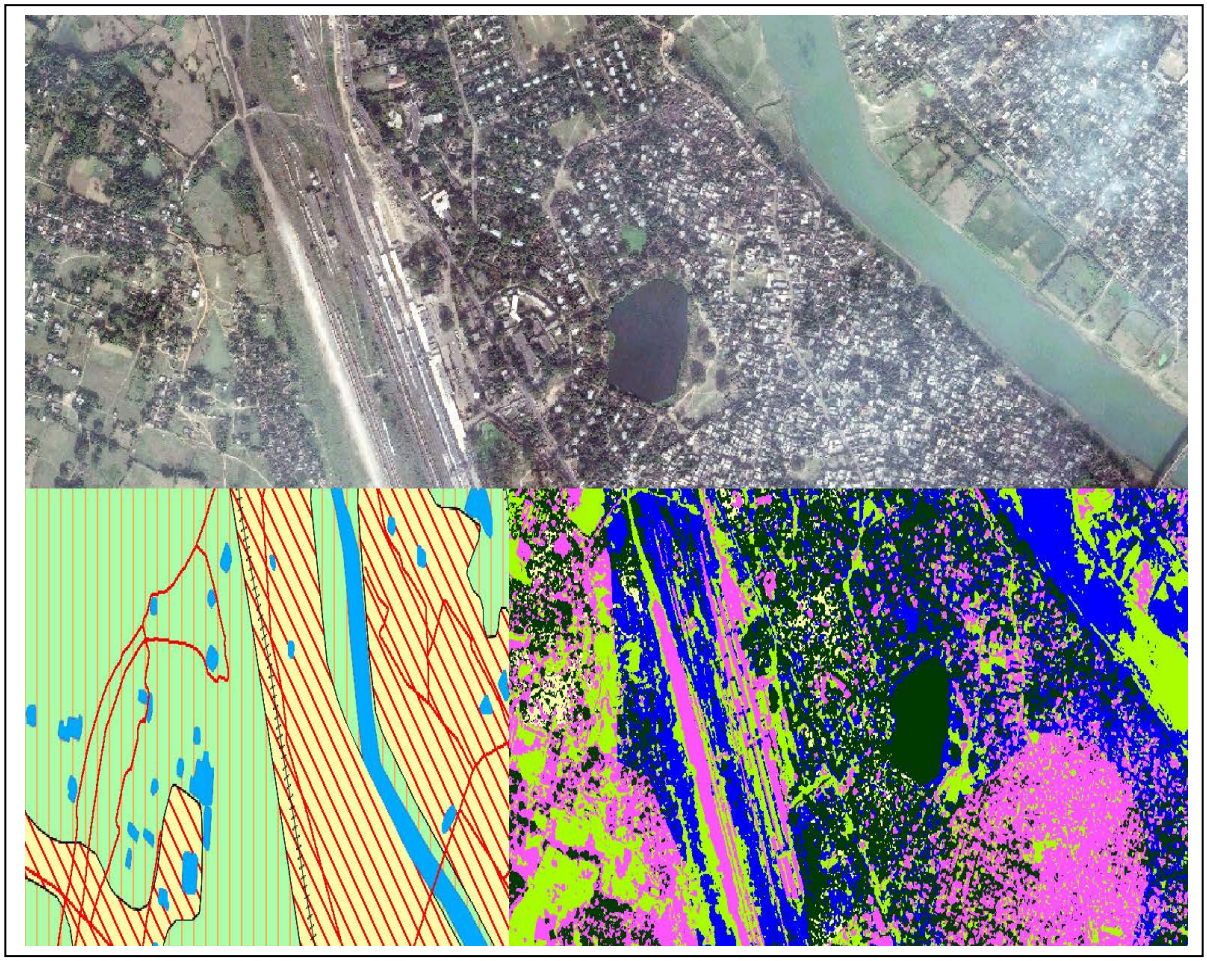


Fig.49

Objective: Economic development and population growth have triggered rapid changes to Earth's land cover over the last two centuries, and there is every indication that the pace of these changes will accelerate in the future. The present study shows the utility of remote sensing techniques integrated with GIS to study the spatial dynamics of Agriculture and Industry in the selected specified study area and its surroundings in Maldah, of Maldah District, West Bengal. Various satellite image data were analyzed within a digital image processing system to provide up-to-date information of the whole area. The extracted information from remotely sensed data was then integrated with visually interpreted information and field inputs in a GIS to create a comprehensive spatial database. This permitted the integration of several layers of information with the remotely sensed data in both temporal and spatial dimensions.

Background: Remote sensing technology has been recognized as a useful means of supplying up to date information and have the potential to respond to the growing and urgent demand for timely and accurate land cover information over large areas. In the recent past, land cover mapping from satellites has come of age, Through research on various issues regarding data pre-processing, classification and accuracy assessment, new and unique data / land cover products are being generated which could not be produced by earlier techniques. Various data set of the area were used for interpreting and unifying them within GIS and Image Processing environment for analysis and interpretation.

Data Available: The following data were used for this project work:

- Landsat satellite image having 28.5meter spatial resolution.
- IRS Cartosat multispectral satellite image having 5metre spatial resolution.
- Digital Globe high resolution image (0.5m) from Open Source Google Earth repository for Visual interpretation and as a supplementary data for interpretation.

Software Used: TNTmips Pro 2014, the integrated GIS and Image Processing platform were used in the present study.

Workflow:

- Satellite Images were imported in a project file within TNT mips Pro platform.
- The Images were geometrically rectified with the GCP by using Geographic co-ordinate system and World Geodetic System 1984 (WGS 84) as Datum. Affine transformation model has been deliberately selected for this sampling area to maintain the geometric area and shape accuracy.
- The sampling location extends from North 25°00′08.741″ to North 25° 01′ 12.776″ and East 88°07′33.068 ″ to East 88°08′08.741″ . The area of interest is shown below :
- As per the present scope of study to meet the temporal data requisite two different year data has been collected.
- Image preprocessing was implemented on both the images to improve the quality and interpretability
- Extraction model was implemented on the scenes to get the 1 sq km sampling area as decided to process with in the buffer zone of 5 kilometer both of the railway track from Sealdah to Maldah at the location of Maldah railway station to get the surroundings bird's eye view.

The sampling location extends from North 25°00′ 08.741″ to North 25°01′12.776″ and East 88°07′33.068 ″ to East 88°08′08.741″ .The area of interest is shown below:

Google Image 1sq km

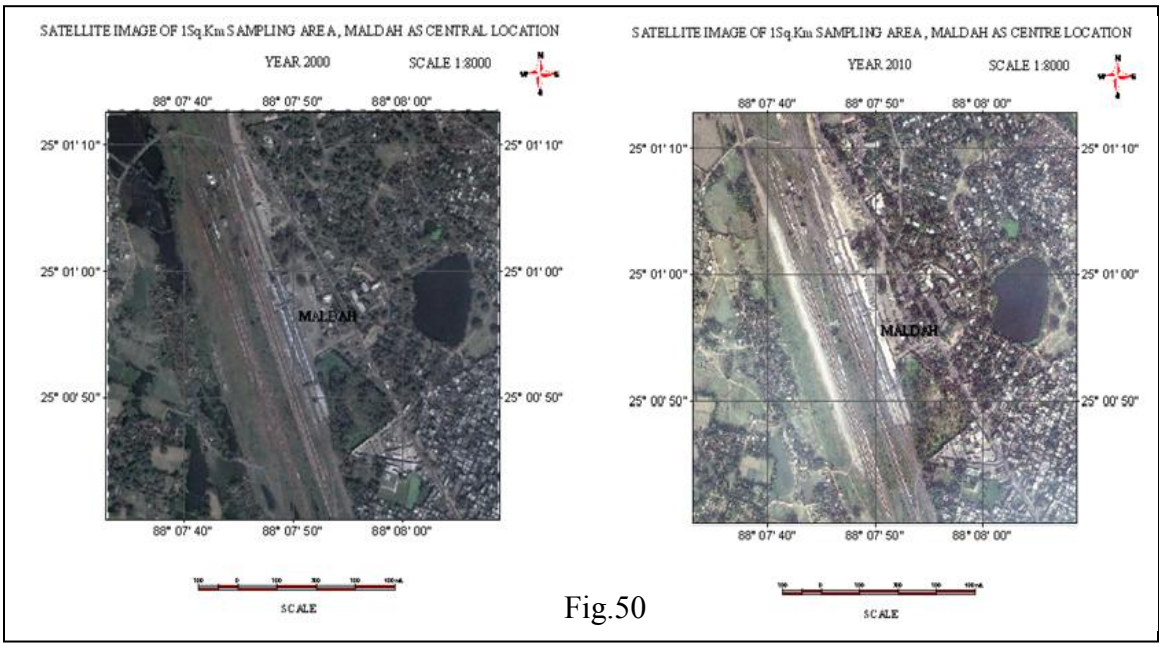


Fig.50

The given area extends from North 24° 58′ 29″ to North 25° 03′ 22″ and East 88°05′08″ to East 88°10′ 32″ . The area of interest is shown below:

Google Image 78.51 sq km

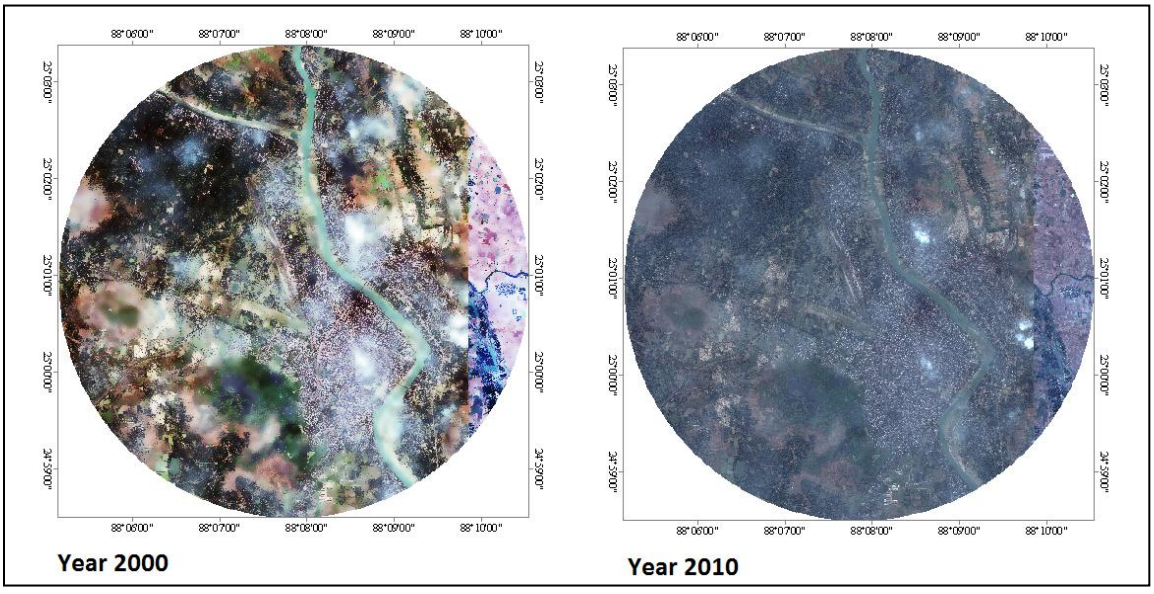


Fig.51

- The study area is about 78.51sq.km.

Once we have the processed image for both the years the remarkable change between reflectance values were quite obvious study though this factor is highly dependent on the solar illumination of that particular time and date. Here is a comparative diagram of those values of particular location.

RGB values

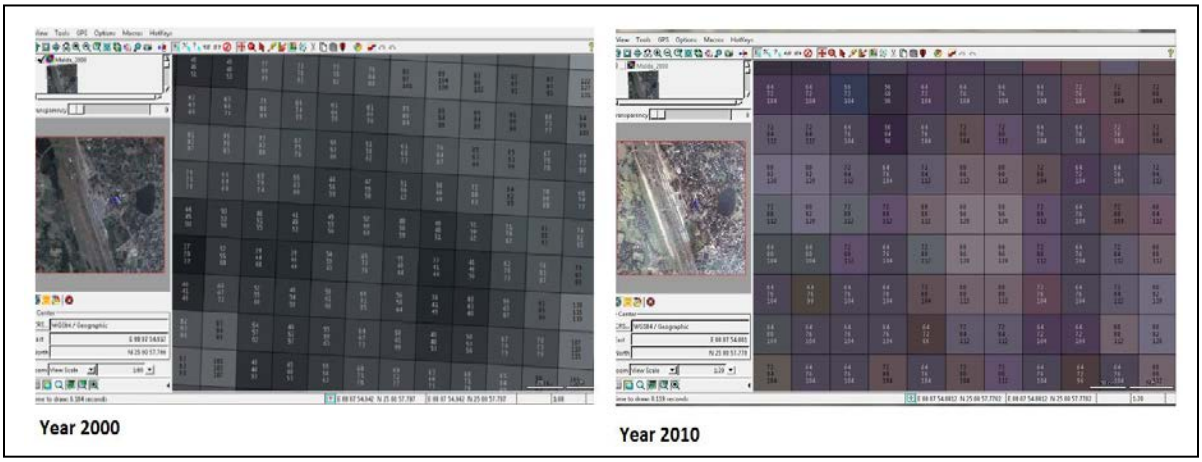


Fig.52

As a part of visual interpretation the important land-cover patterns have been delineated by using manual vectorization followed by building of topology between the spatial features. The platform used through-out the process flow is a topology inbuilt system where we have achieved the optimum vector statistics for further comparison with digital interpreted result.

Vectorization layer

Fig.53

The implementation of the visual image interpretation technique, the areas having proper land use differentiation had been delineated. Areas are shown below.

Google Image 78.51 sq km Land Use and land cover Map

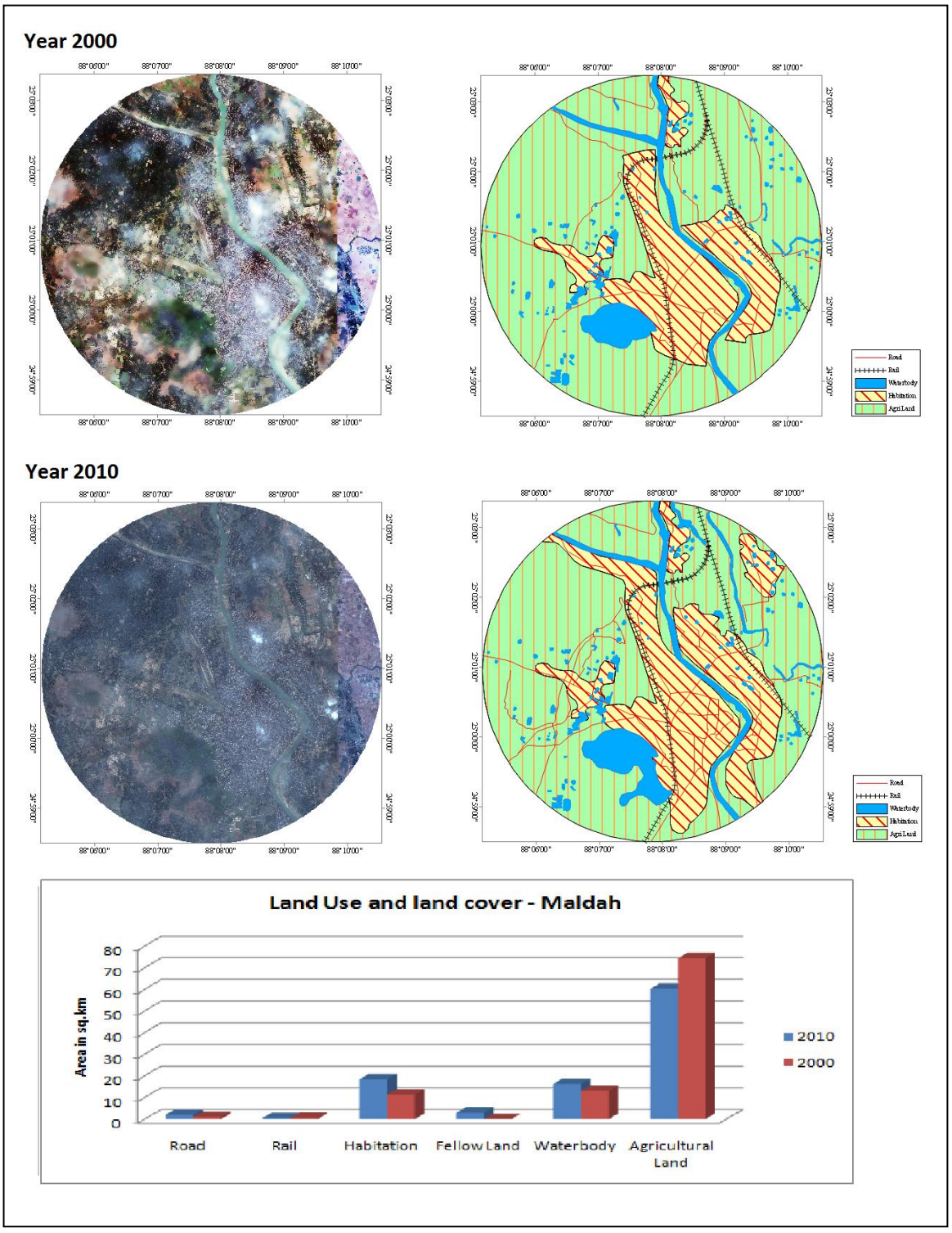


Fig.54

Factors Considered: Following factors were taken into consideration for delineating the zones of interest-

- In order to create a balanced and sustainable industrial growth in any zone and maximize use of uncultivable land in any area, it is felt that some parts of this zone can be identified as industrial growth poles, because of such factors such as availability of non-agricultural land, historical industrial presence and availability of good infrastructure. This will mean optimal use of the existing industrial infrastructure and up gradation of infrastructure where required and create new industrial infrastructure for project in backward areas.
- During land use classification habitation, vegetation and open land areas have been merged into a single category as in this scope of study we are trying to demarcate the land which can be acquired for industrial.
- From the observation of study area, most of the area covered by agricultural land. So there is high prospect in producing crop. Then it′s not healthy to create an industry in this particular area. There must have some social and political issues.
- Major criteria for industrial development are communication condition. In this area we can observed that Highway and Railway tracks are passing almost centre portion of this area.

FCC Classification

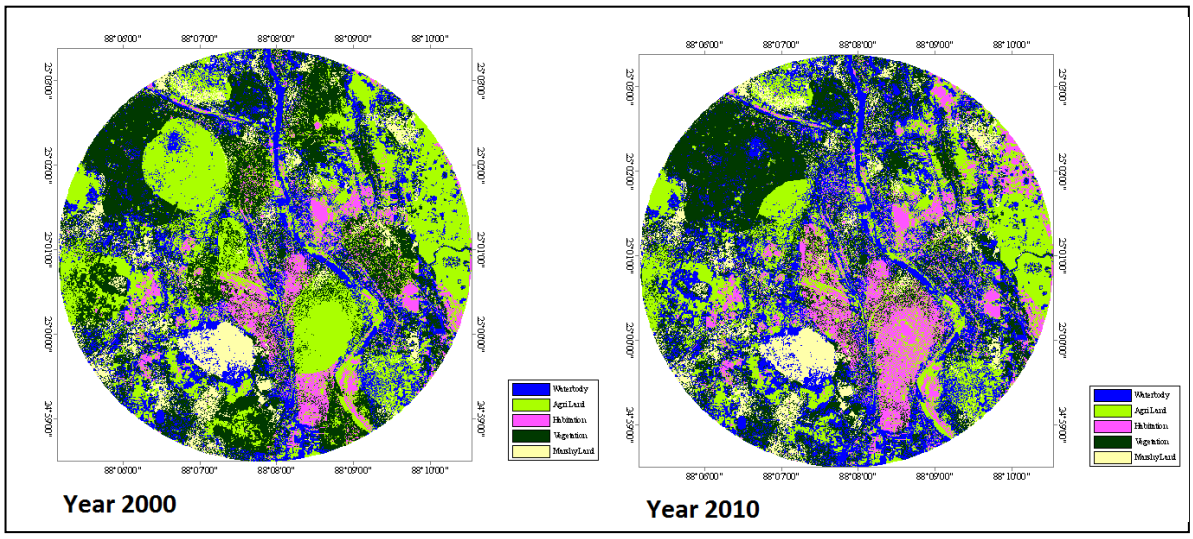


Fig.55

As we compare the FCC Classification image data of the desired area between the year 2000 and 2010 we can clearly see that the agricultural land has decreased to some extent due to the significant increase in settlement area and the decrease of water bodies. Also though there is potential industrial zones scattered throughout the aforementioned area, but scattered area are not healthy for built up a proper industrial zone. At least 1sq. km. continuous area is feasible for actual industrial zonation. So here setting up large or small scale factories may not be viable.

Another issue is rises up with settlement area. Here we can observe that, in the year 2010, the percentage of population is very much higher than the year 2000. So the scope of industrial is not possible in this heavy population zone, so pollution issues are arise.

In the next map the potential industrial zones are depicted for the area of interest.

Probable Industrial Zone

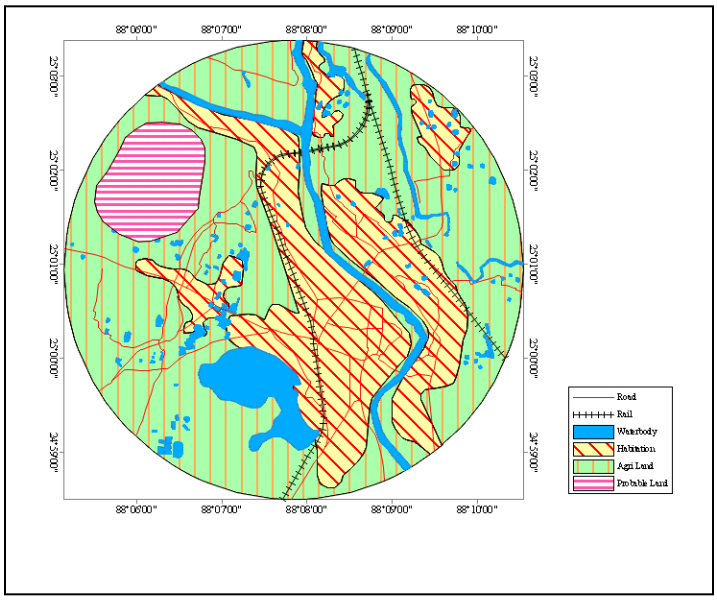


Fig.56

From this map we can clearly visualize that these two probable zones are ideal for industrial due to proper communication and availability of water. Areas of this prospective zone is 4.70 km. This is more healthy for built up an industrial zone. Due to good communication network and availability of water resource most of the areas are densely populated and prosperity of agricultural growth are very high. So only this identified zone are feasible for industrial within our region of interest.

Communication Map

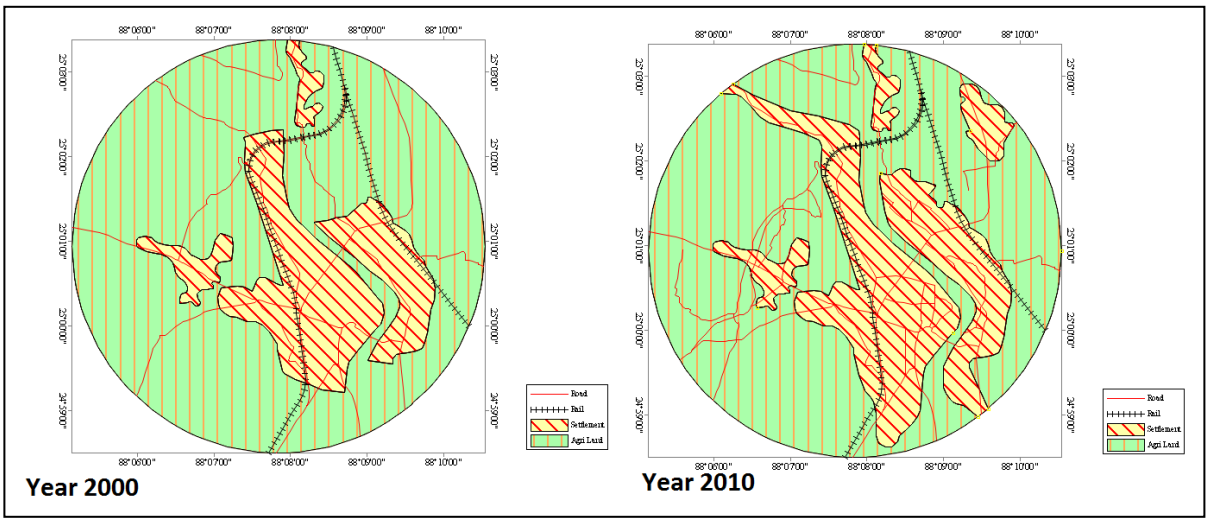


Fig.57

From this above two maps we can interpret that the communication system has been drastically change from year 2000 to year 2010 due to increase in population. So probability of industrial is maximum in this zone.

In spite of other social issues it can be concluded that this zone is superior for industrial.

Considering all these factors, the actual suggested area for industrial has shown below:

Actual prospective Industrial area

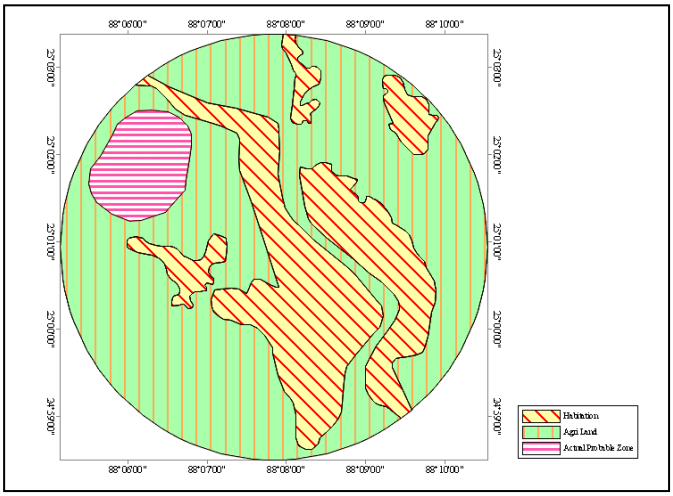


Fig.58

Conclusion: In the present status of study all the parameters related to industrial suitability had not been considered. The zones, which had been delineated as prospective

area, should be verified using the field data. So, the delineated zones are the probable prospective area.

So using the same manual interpretation technique both the images were visually classified to get the spatial changes between the years-

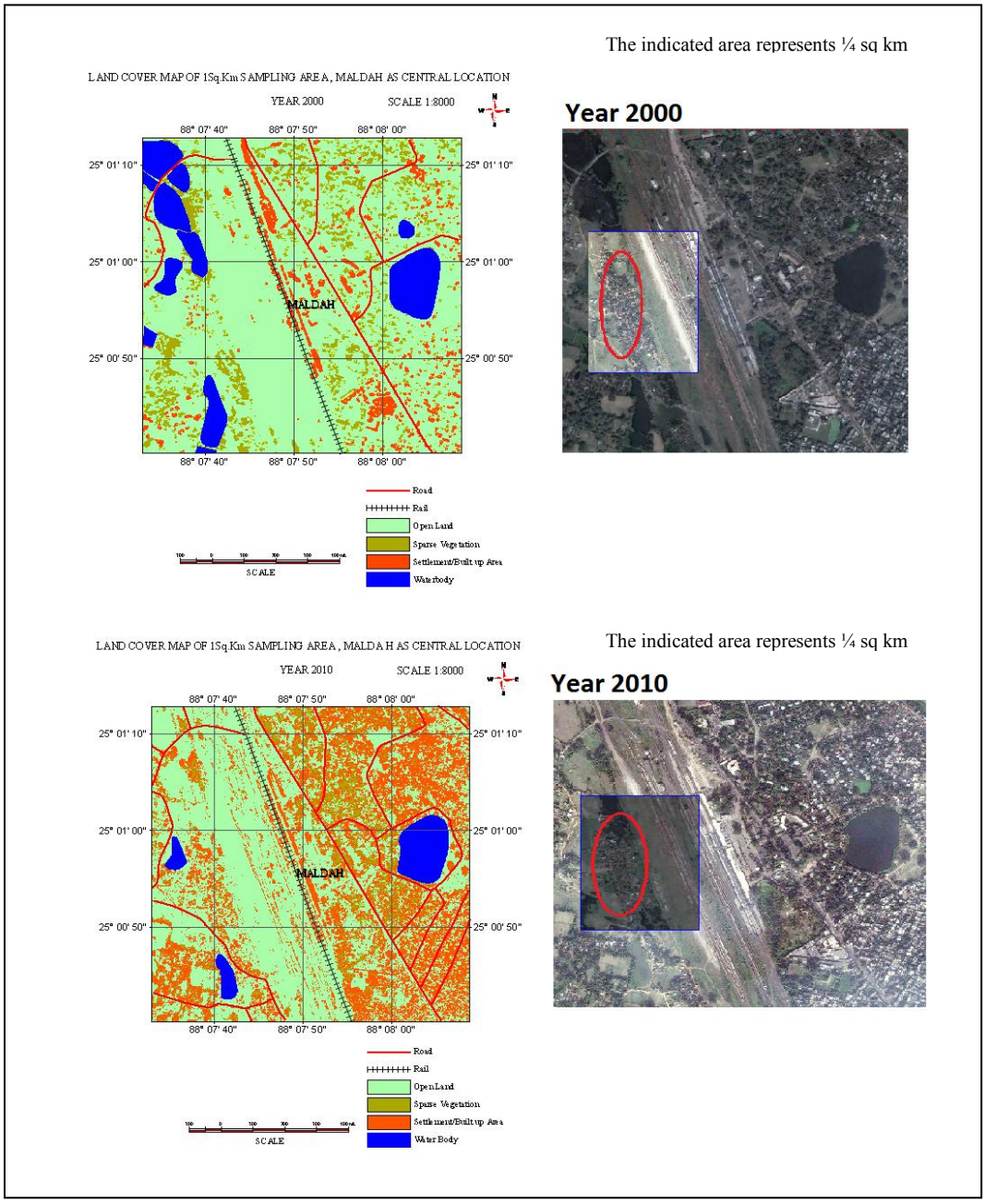


Fig.59

Land Use and land cover Map

Old Maldah Railway Station (Maldah, West Bengal)

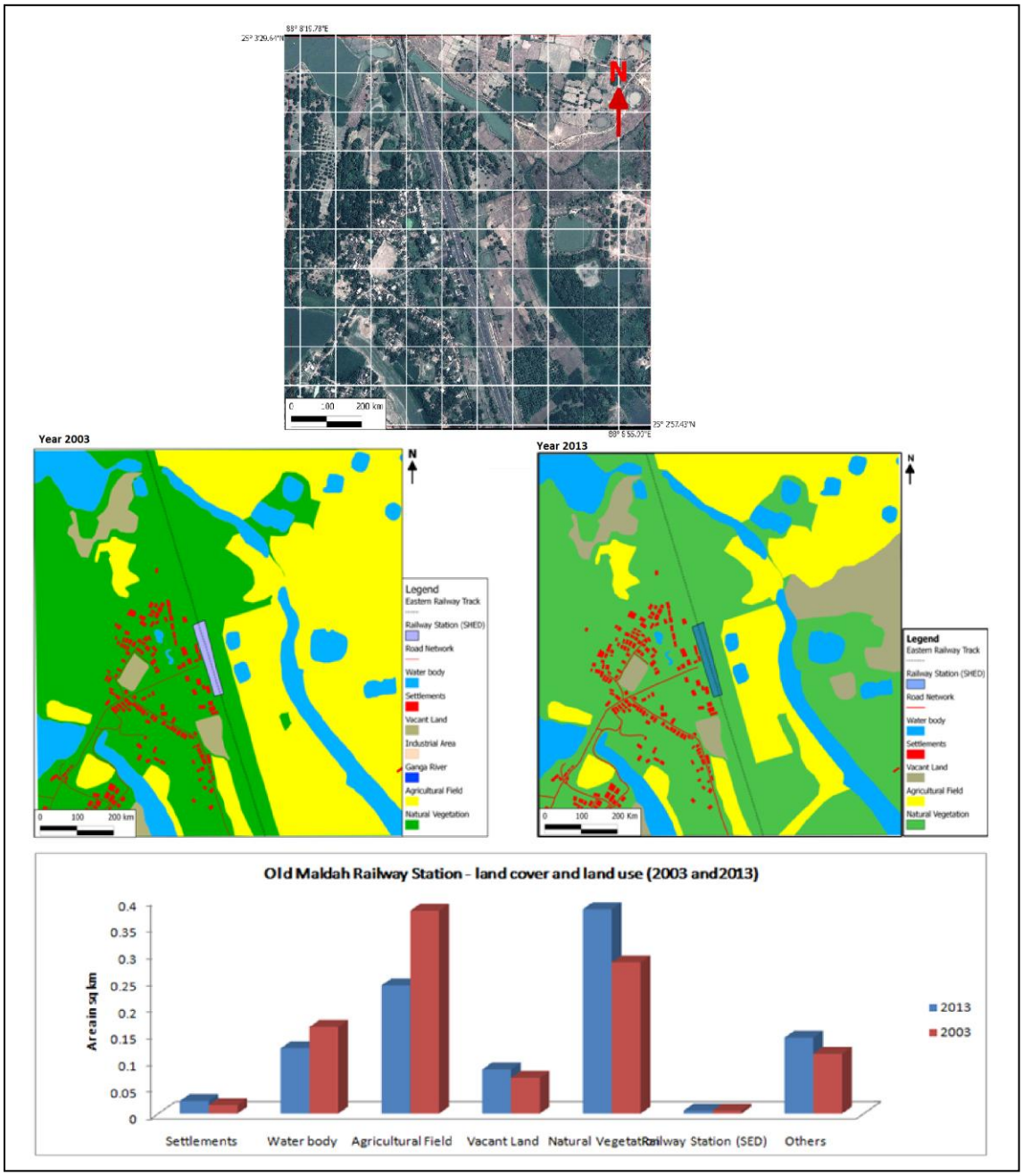


Fig.60

At Old Maldah Railway Station, there is increase in Settlement, vacant land, natural vegetation and decrease is noticed in Water body and agricultural fields in the year 2013 compared to 2003.

At the other hand same images have been used for digital image classification. The study area has been passed through hybrid classification technique, where the unsupervised classification has been followed by supervised classification method and finally the spurious classes were deliberately merged to get the intended result.

Google Image 1 sq km Land Use and land cover Map

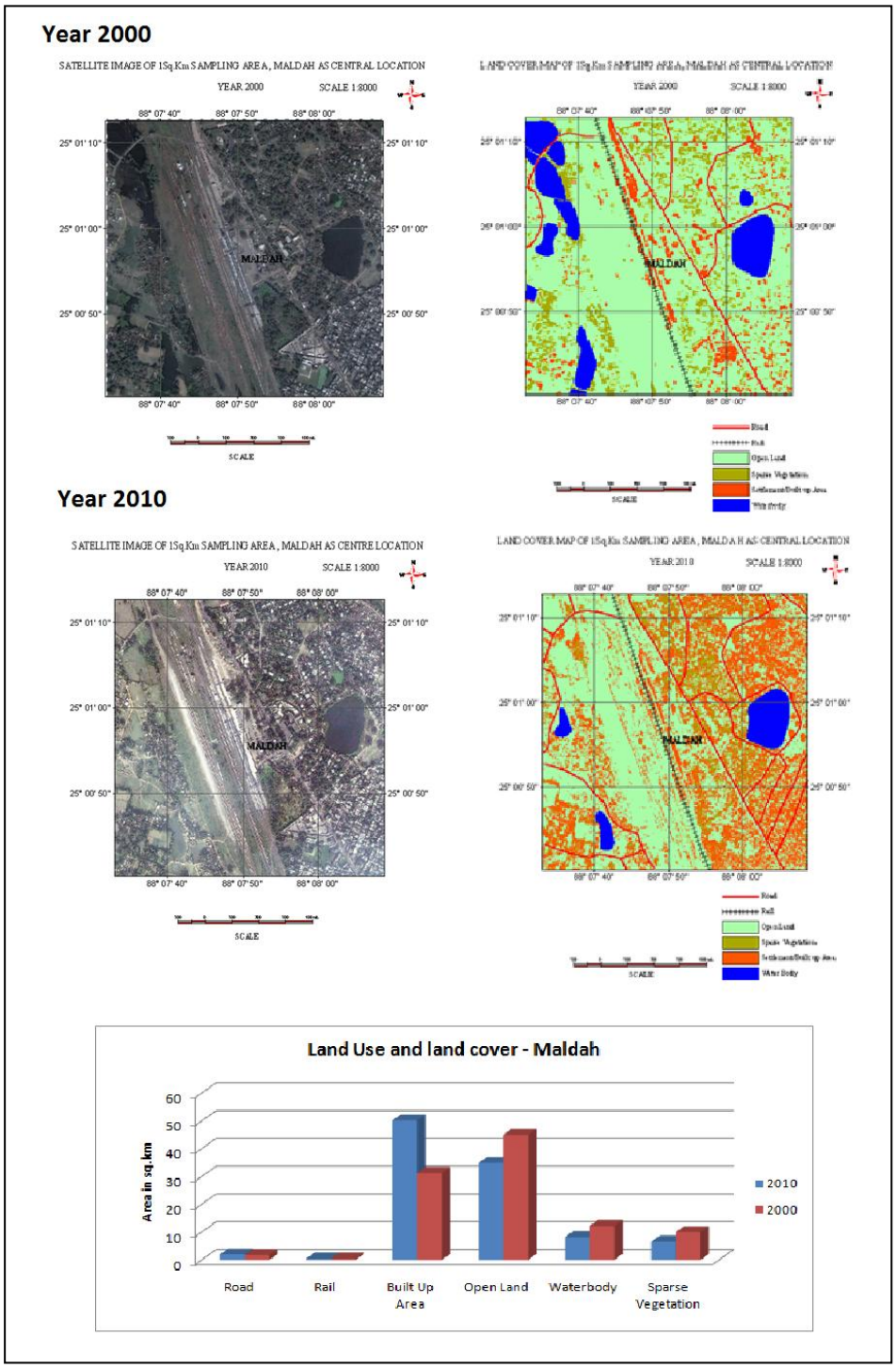


Fig.61

Cartographical map preparation with suitable scale. Throughout the mapping we have tried to use A4 page where maps were fitted with 1:8000 scale.

Interpretation and discussion:

Though the study area is concentrated with-in the periphery of Maldah station in context to the spatial dynamics study this sampling zone is noticed to go through huge change for the landcover type over the year of 2000 to 2010 where settlement and water body is the prime land cover type noticed to be changed. But within this buffer zone there is no existence of agricultural field so agricultural dynamics has not been considered here as mapable land cover which does not mean that no changes occur over the agricultural landcover type through-out the years for this zone. In obvious reason with increase of population pressure the open land, water body and agricultural land area has gone through massive tress and ‘Agricultural land′ has been occupied throughout the year to accommodate the increased population pressure in this zone and its surroundings

Land use and Land cover - Changing Pattern

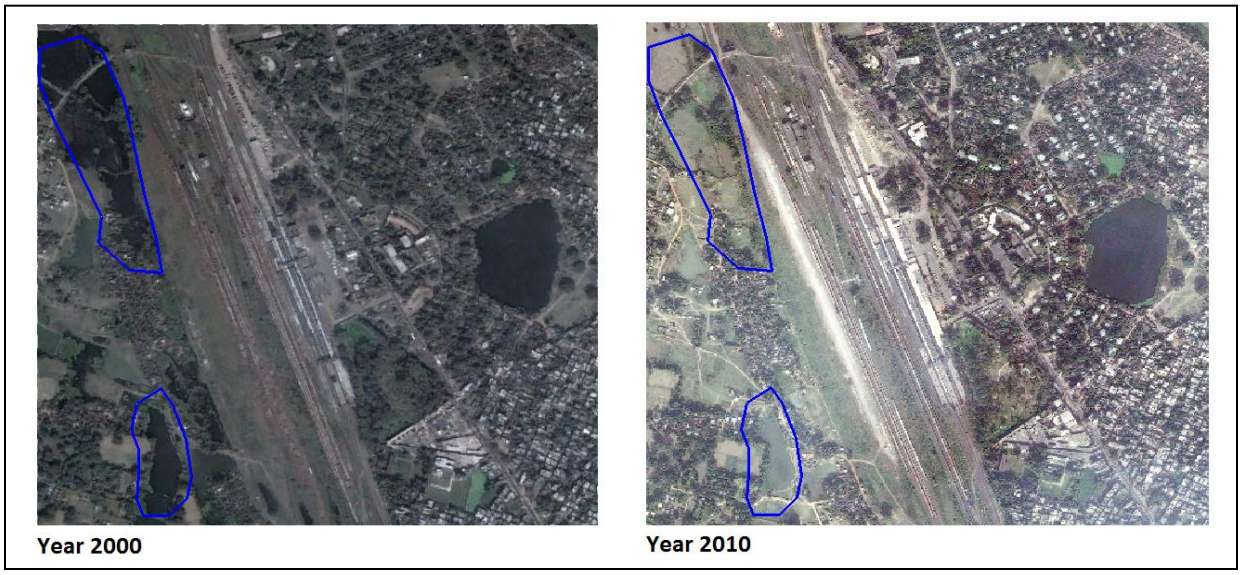


Fig.62

On the other hand still this zone has sufficient open land which can be considered for utilizing small scale industrial establishment because this zone is equipped with other necessary amenities of industrial development like communication, human resource, water body etc.

Case Study: B

Eastern Railway also extends from Sealdah to Maldah via Bardhaman (Begampur, Chanchai, Guskara, Sainthia, Chatra and Bonidanga).

Fig.63

Objective: Economic development and population growth have triggered rapid changes to Earth's land cover over the last two centuries, and there is every indication that the pace of these changes will accelerate in the future. The present study shows the utility of remote sensing techniques integrated with GIS to study the spatial dynamics of Agriculture and Industry in the selected specified study area and its surroundings in Porabazar, Hooghly District. Various satellite image data were analyzed within a digital image processing system to provide up-to-date information of the whole area. The extracted information from remotely sensed data was then integrated with visually interpreted information and field inputs in a GIS to create a comprehensive spatial database. This permitted the integration of several layers of information with the remotely sensed data in both temporal and spatial dimensions.

Background: Remote sensing technology has been recognized as a useful means of supplying up to date information and have the potential to respond to the growing and urgent demand for timely and accurate land cover information over large areas. In the recent past, land cover mapping from satellites has come of age, Through research on various issues regarding data pre-processing, classification and accuracy assessment, new and unique data / land cover products are being generated which could not be produced by earlier techniques. Various data set of the area were used for interpreting and unifying them within GIS and Image Processing environment for analysis and interpretation.

Data Available: The following data were used for this project work:

- Landsat satellite image having 28.5 meter spatial resolution.
- IRS Cartosat multispectral satellite image having 5 meter spatial resolution.
- Digital Globe high resolution image (0.5m) from Open Source Google Earth repository for Visual interpretation and as a supplementary data for interpretation.

Software Used: TNTmips Pro 2014, the integrated GIS and Image Processing platform were used in the present study.

Workflow:

- Satellite Images were imported in a project file within TNTmips Pro platform.
- The Images were geometrically rectified with the GCP by using Geographic co-ordinate system and World Geodetic System 1984 (WGS 84) as Datum. Affine transformation model has been deliberately selected for this sapling area to maintain the geometric area and shape accuracy.
- The sampling location extends from North 22°54′08.074″ to North 22°54′ 46.603″ and East 88°09′ 33.229 ″ to East 88°10′ 08.332″ .
- As per the present scope of study to meet the temporal data requisite two different year data has been collected.
- Image preprocessing was implemented on both the images to improve the quality and interpretability

Extraction model was implemented on the scenes to get the 1 sq km sampling area as decided to process with in the buffer zone of 5 kilometer both of the railway track from Sealdah to Maldah at the location of Porabazar station to get the surroundings

The sampling location extends from North 22° 54′ 08.074″ to North 22° 54′ 46.603″ and East 88° 09′ 33.229 ″ to East 88° 10′ 08.332″ .

Google Images 1 sq km

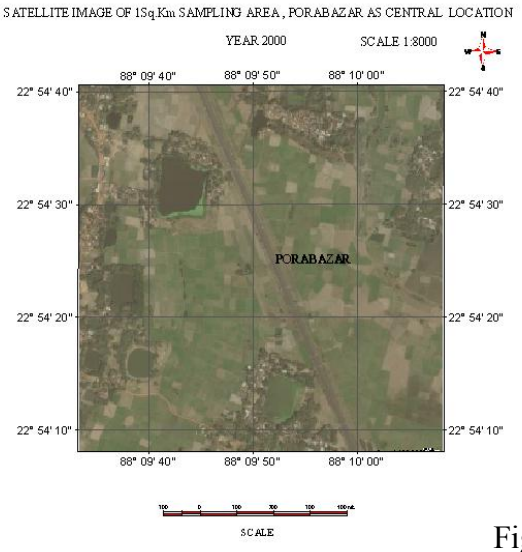


Fig.64

The given area extends from North 22° 51′ 55″ to North 23° 56′ 53″ and East 88° 07′09″ to East 88° 12′ 32″ . The area of interest is shown below:

Google Images 78.51sq.km

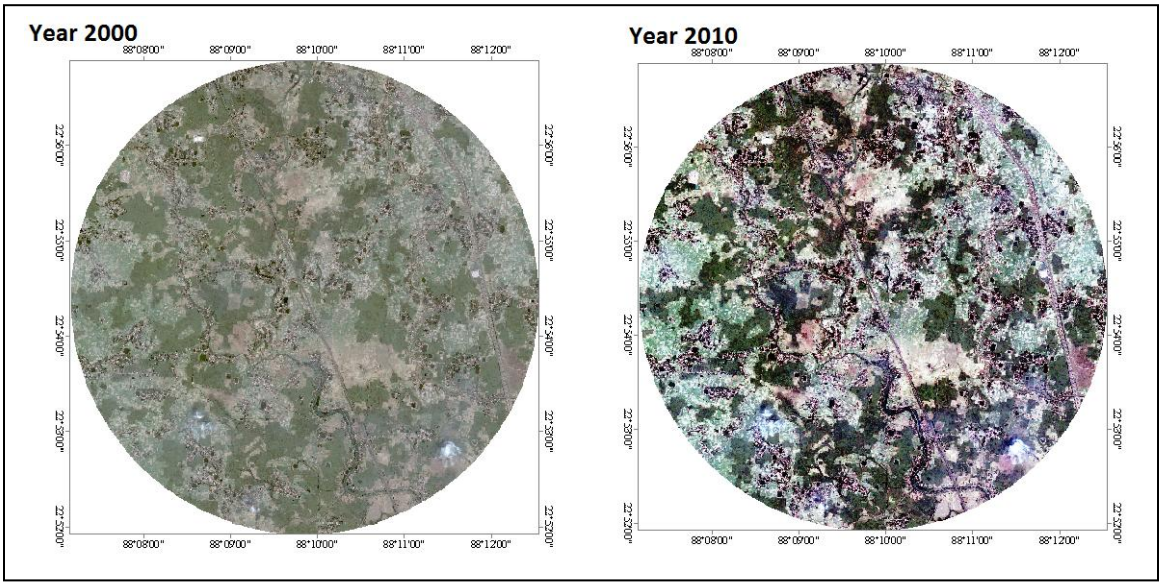


Fig.65

The study area is about 78.51sq.km

Once we have the processed image for both the years the remarkable change between reflectance values were quite obvious study though this factor is highly dependent on the solar illumination of that particular time and date. Here is a comparative diagram of those values of particular location-

RGB values

Fig.66

As a part of visual interpretation the important land-cover patterns have been delineated by using manual vectorization followed by building of topology between the spatial feature. The platform used through-out the process flow is a topology inbuilt system where we have achieved the optimum vector statistics for further comparison with digital interpreted result.

Vectorization layer

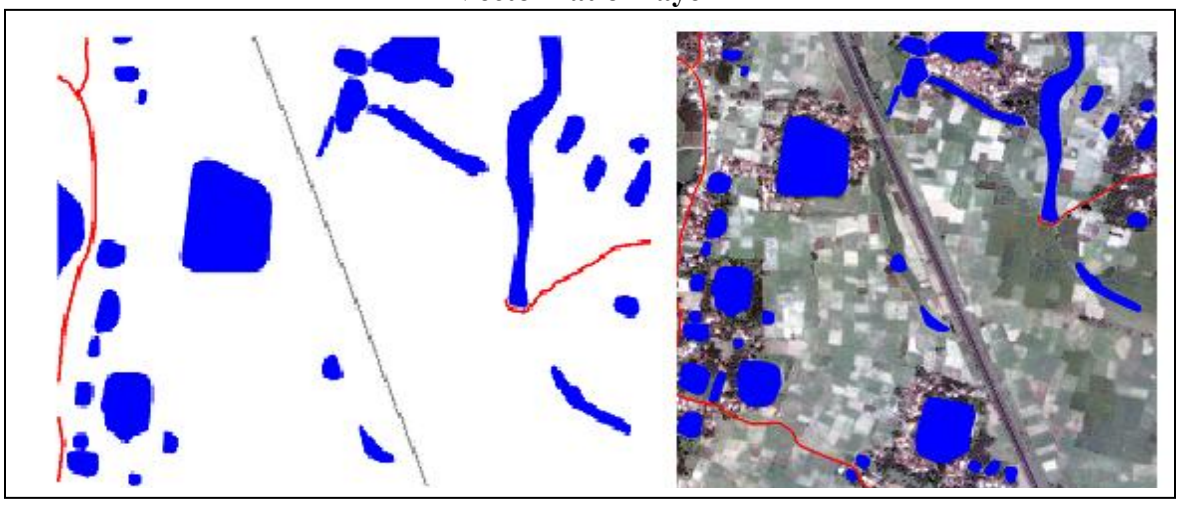


Fig.67

The implementation of the visual image interpretation technique, the areas having proper land use differentiation had been delineated. Areas are shown below**:**

Google Image 78.51 sq km Land Use and land cover Map

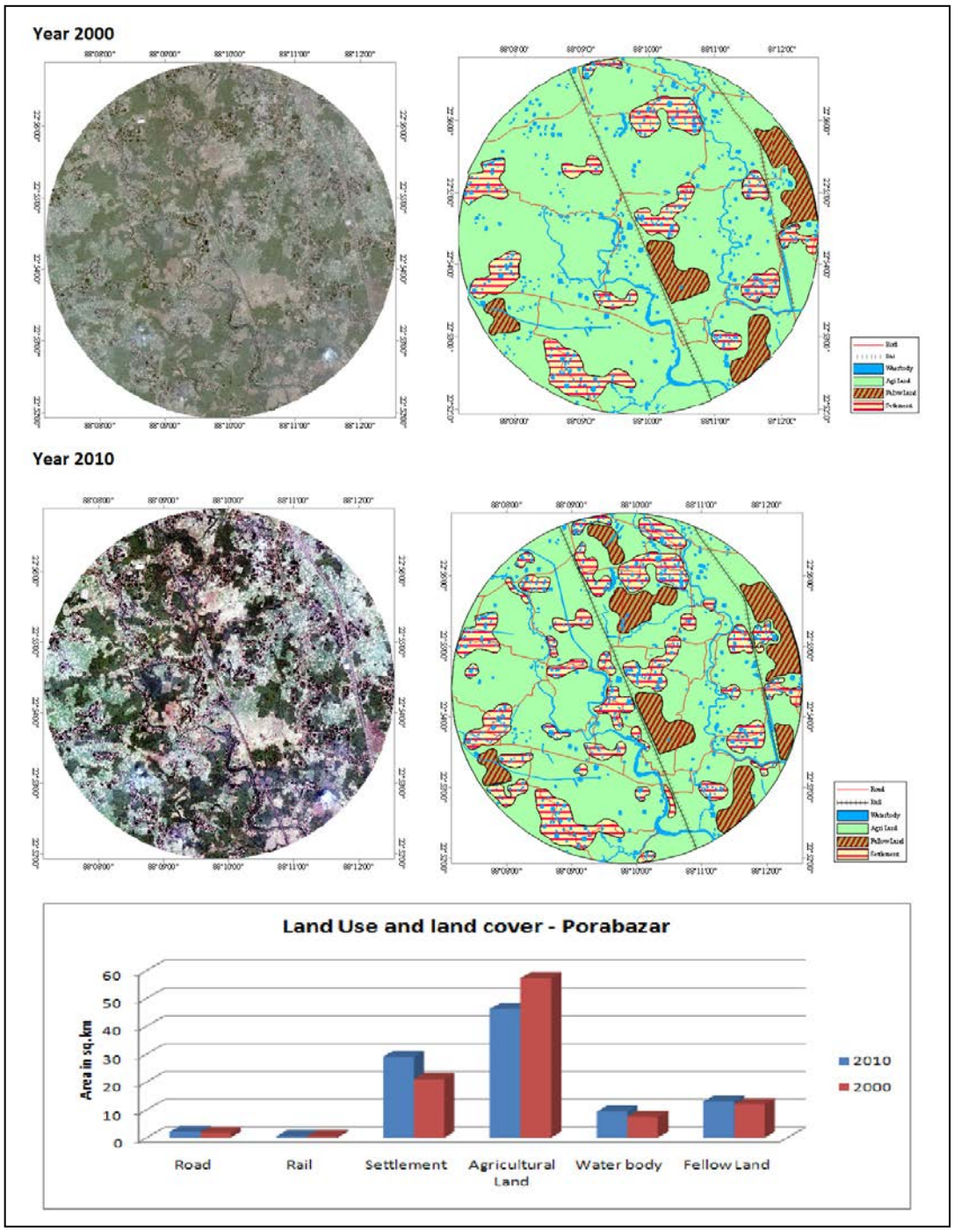


Fig.68

Factors Considered: Following factors were taken into consideration for delineating the zones of interest-

- In order to create a balanced and sustainable industrial growth in any zone and maximize use of uncultivable land in any area, it is felt that some parts of this zone can be identified as industrial growth poles, because of such factors such as availability of non-agricultural land, historical industrial presence and availability of good infrastructure. This will mean optimal use of the existing industrial infrastructure and up gradation of infrastructure where required and create new industrial infrastructure for project in backward areas.
- During land use classification habitation, vegetation and open land areas have been merged into a single category as in this scope of study we are trying to demarcate the land which can be acquired for industrial.
- From the observation of study area, most of the area covered by agricultural land. So there is high prospect in producing crop. Then it's not healthy to create an industry in this particular area. There must have some social and political issues.
- Major criteria for industrial development are communication condition. In this area we can observed that Highway and Railway tracks are passing almost centre portion of this area.

FCC Classification

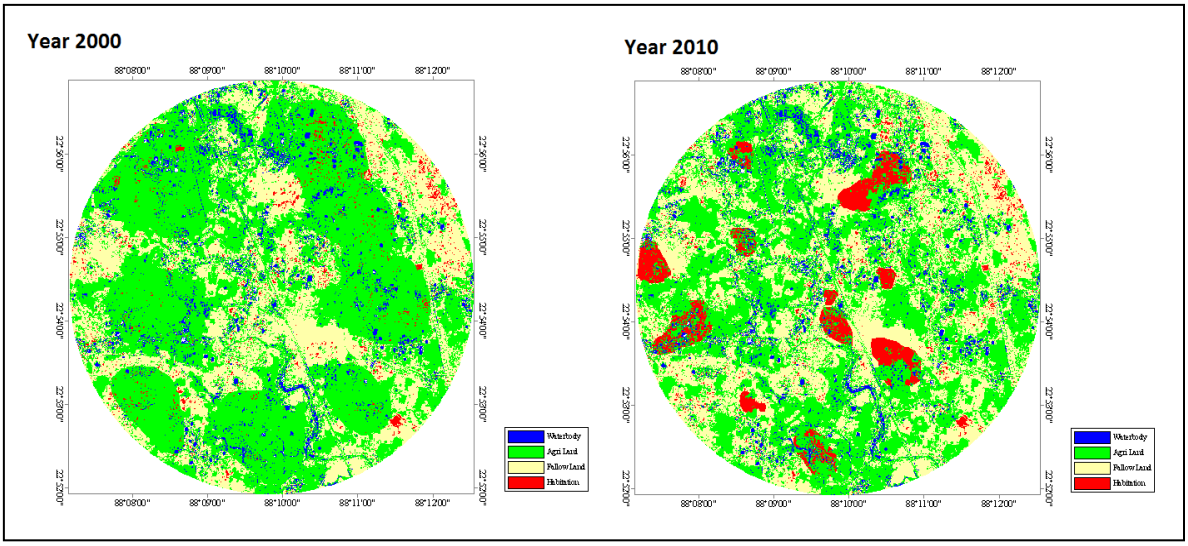


Fig.69

As we compare the FCC Classification image data of the desired area between the year 2000 and 2010 we can clearly see that the Agricultural land has decreased to some extent

due to the significant increase in settlement area and the decrease of water bodies. Also though there is potential industrial zones scattered throughout the aforementioned area, but scattered area are not healthy for built up a proper industrial zone. At least 1sq. km. continuous area is feasible for actual industrial zonation. So here setting up large or small scale factories may not be viable.

Another issue is rises up with settlement area. Here we can observe that, in the year 2010, the percentage of population is very much higher than the year 2000. So the scope of industrial is not possible in this heavy population zone, so pollution issues are arise.

In the next map the potential industrial zones are depicted for the area of interest.

Probable Industrial Zone

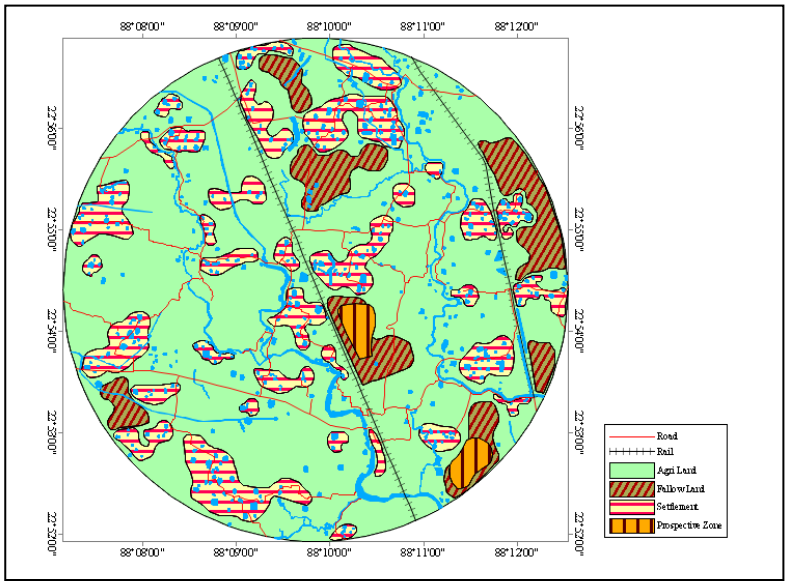


Fig.70

From this map we can clearly visualize that these two probable zones are ideal for industrial due to proper communication and availability of water. Areas of these prospective zones are 0.57sq.km and 0.54Sq.km receptively. These two zones are under fallow land area, so it can't be hamper the agricultural growth of this particular area. Due to good communication network and availability of water resource most of the areas are densely populated and prosperity of agricultural growth are very high. So only these identified zones are feasible for industrial within our region of interest.

Communication Map

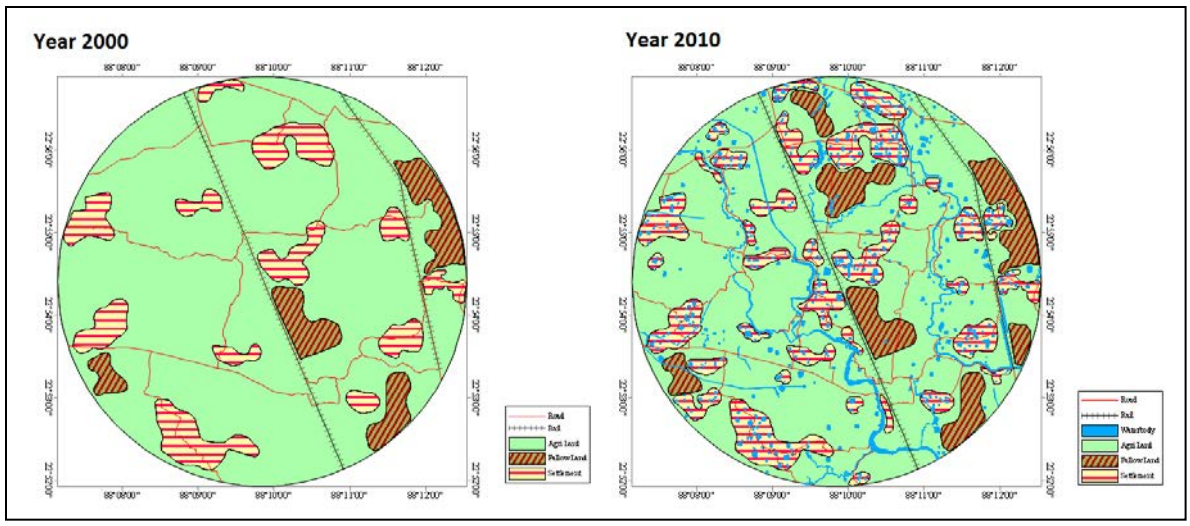


Fig.71

From this above two maps we can interpret that the communication system has been drastically change from year 2000 to year 2010 due to increase in population. So probability of industrial is maximum in this zone.

In spite of other social issues it can be concluded that this zone is suitable for industrial growth.

Considering all these factors, the actual suggested area for industries is shown below:

Actual prospective Industrial area

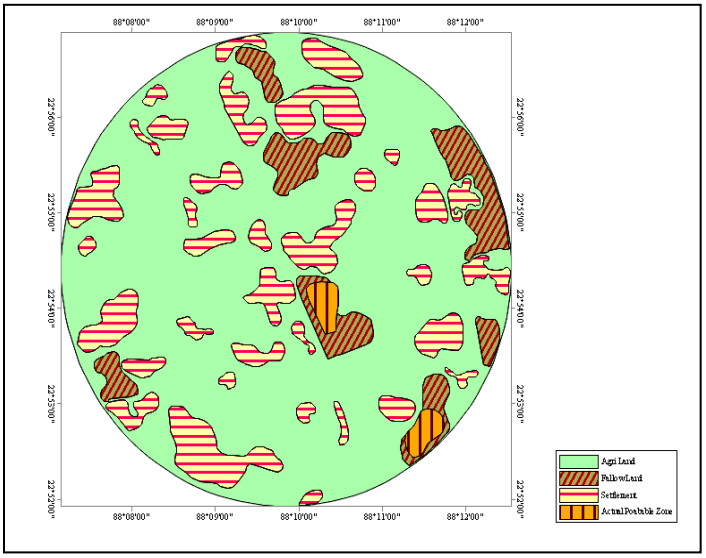


Fig.72

Conclusion: In the present status of study all the parameters related to industrial suitability had not been considered. The zones, which had been delineated as prospective area, should be verified using the field data. So, the delineated zones are the probable prospective area.

So using the same manual interpretation technique both the images were visually classified to get the spatial changes between the years-

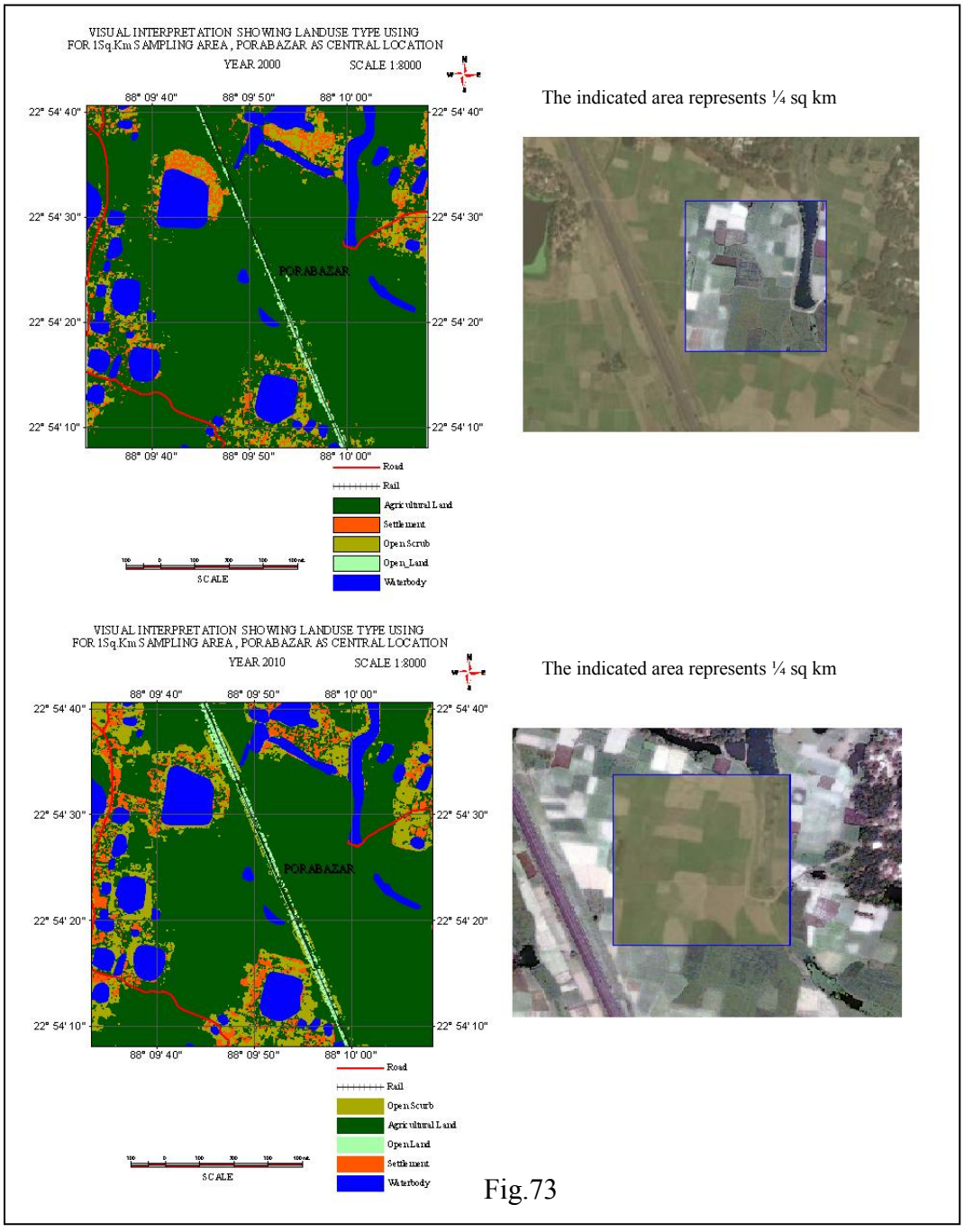


Fig.73

At the other hand same images have been used for digital image classification. The study area has been passed through hybrid classification technique, where the unsupervised classification has been followed by supervised classification method and finally the spurious classes were deliberately merged to get the intended result.

Google Image 1 sq km Land Use and land cover Map

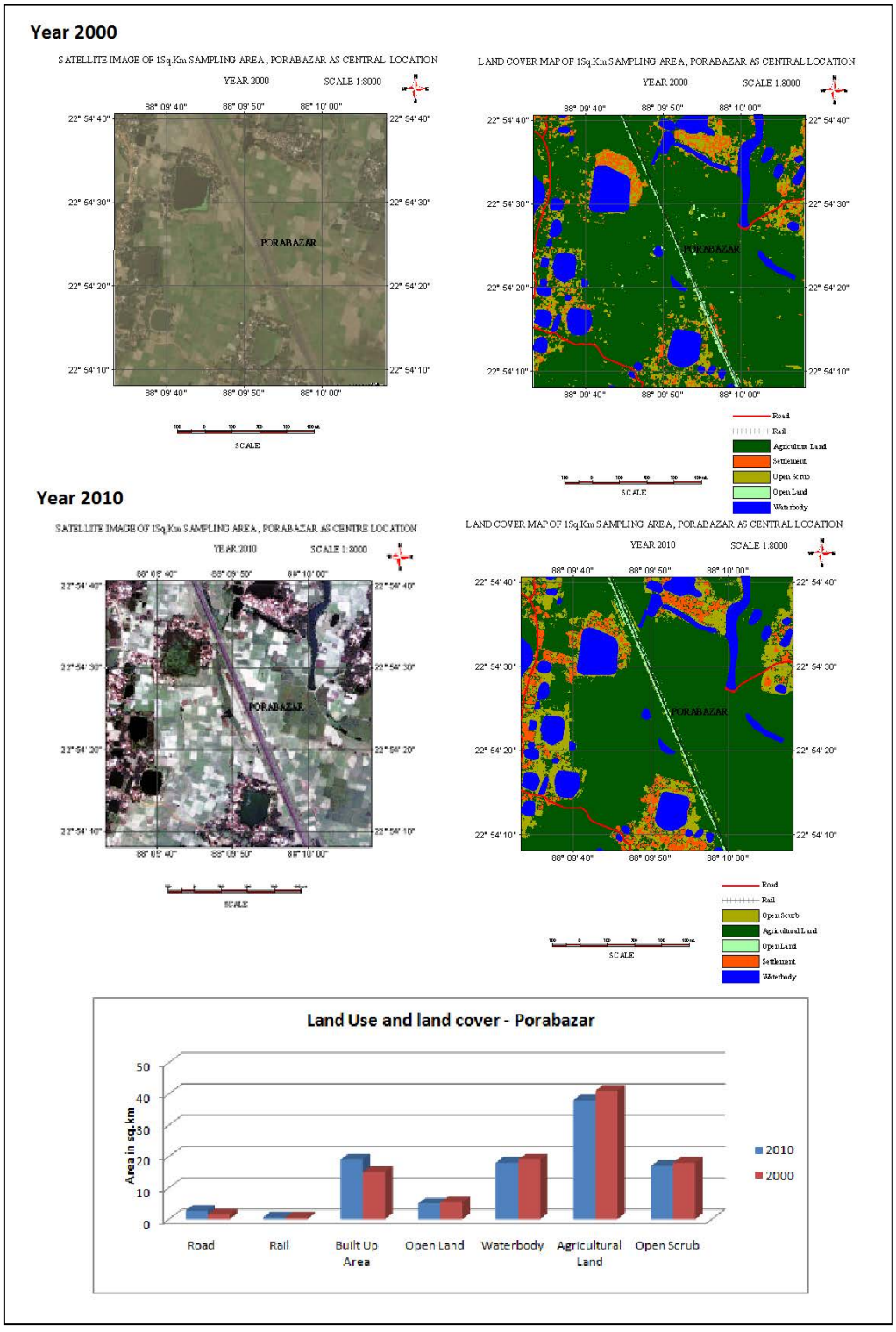


Fig.74

Cartographical map preparation with suitable scale. Throughout the mapping we have tried to use A4 page where maps were fitted with 1:8000 scale.

Interpretation and discussion

During last 10 years the notable spatial dynamics can be depicted as follows- there is improvement in agricultural practice by converting the agricultural fallow into agricultural land but in terms of area, agricultural land decreases due to increase of population pressure. The present sampling area is dotted by agricultural land so there is a scope of development agro-based industry.

Land use and Land cover - Changing Pattern

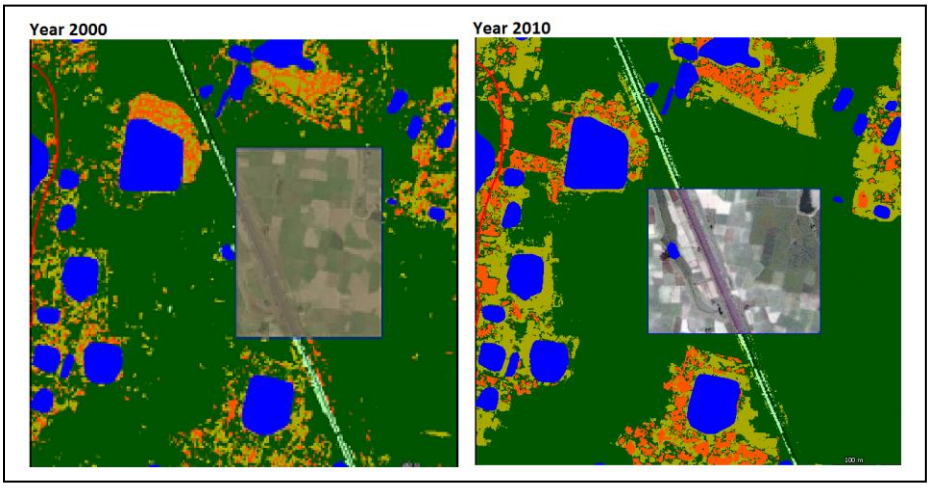


Fig.75

Land Use and land cover Map
Begampur Railway Station (Hugli, West Bengal)

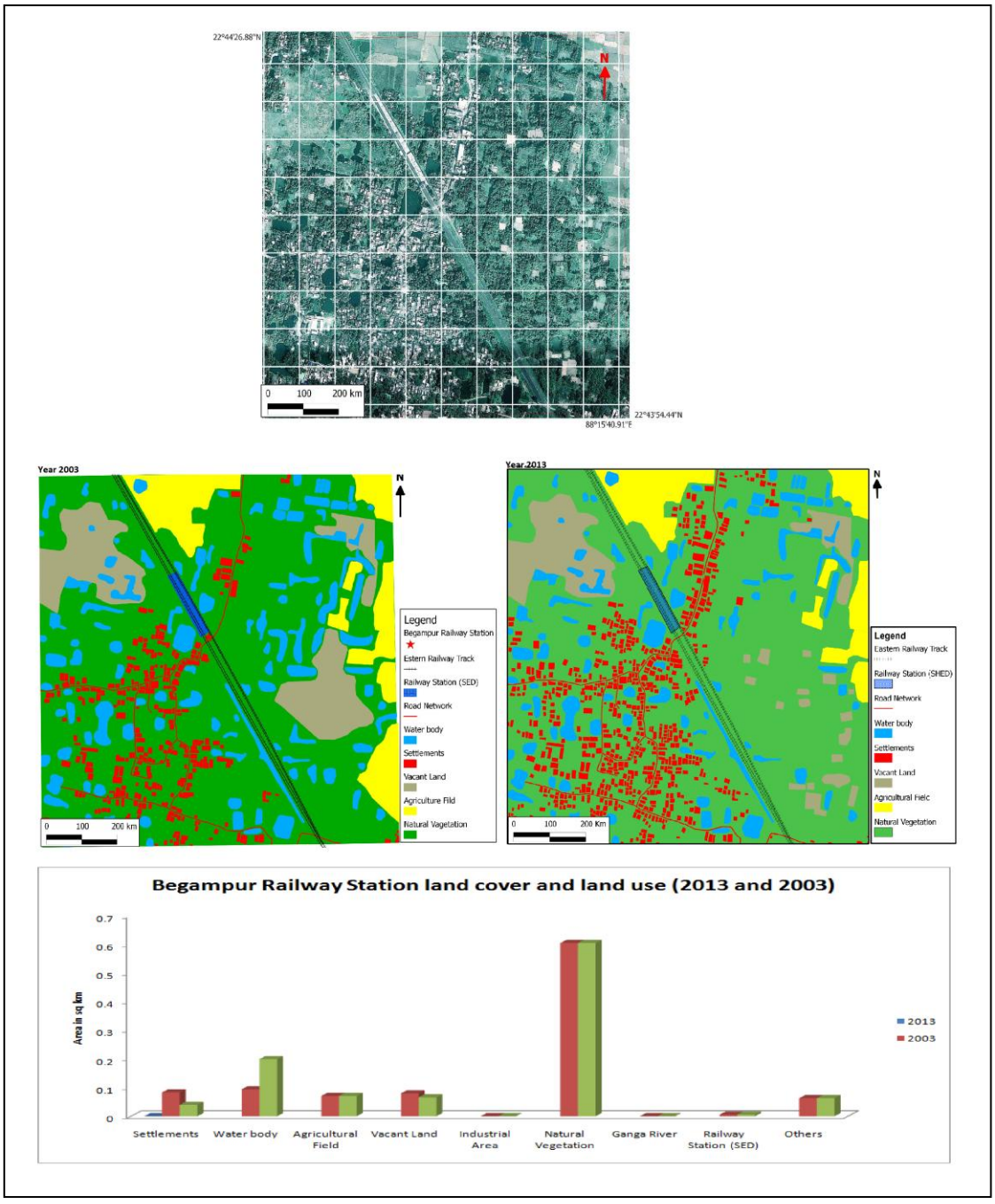


Fig.76

At Begampur Railway Station, there is increase in Settlement, Water body, Natural Vegetation and decrease is noticed in vacant Land and agricultural fields in the year 2013 compared to 2003.

"R.S and G.I.S application in spatial dynamics of agriculture and industry along Sealdah-Maldah Transact, West Bengal"

Sampling Zone: Bardhaman and its Surrounding areas , Bardhaman District, WB

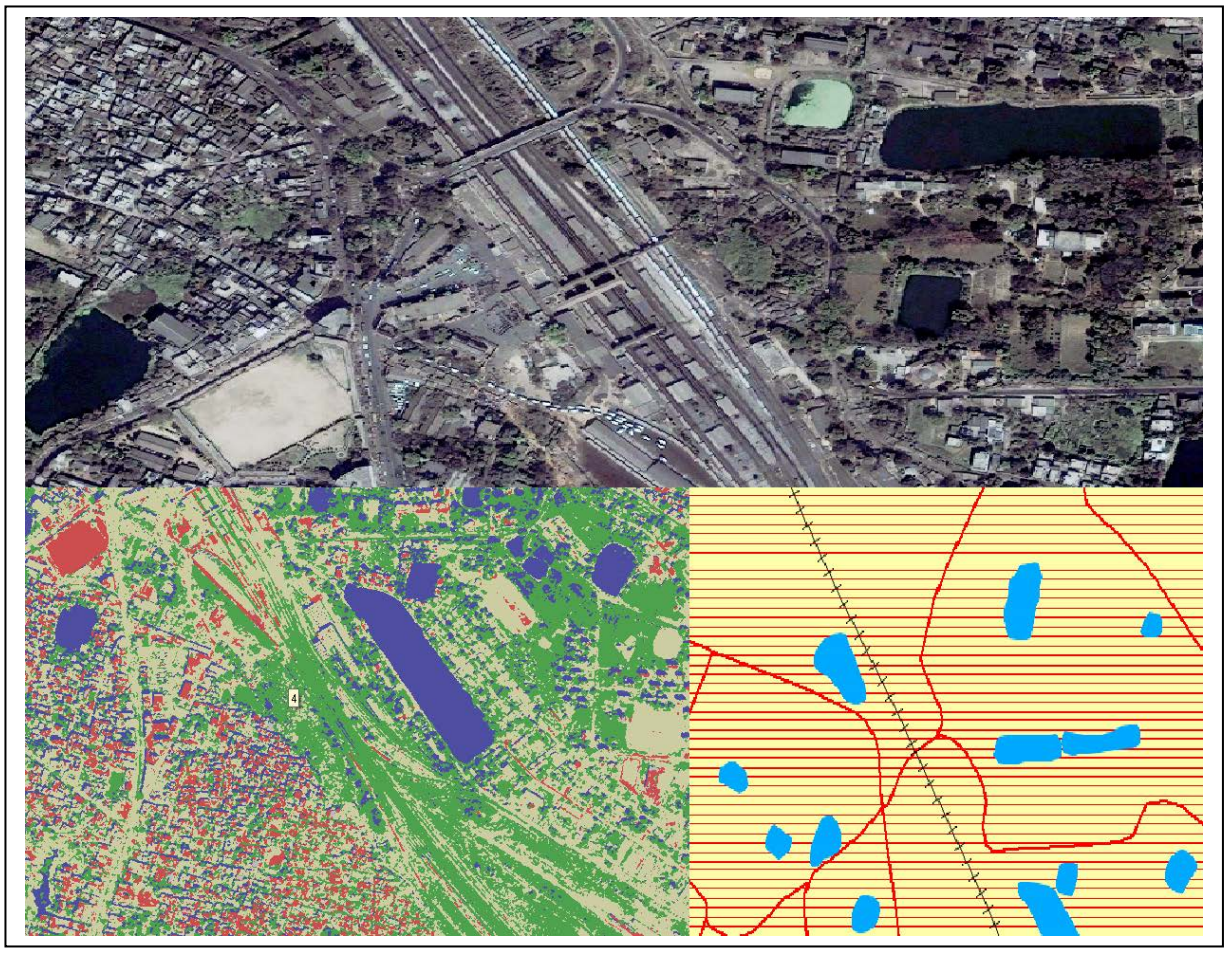


Fig.77

Objective: Economic development and population growth have triggered rapid changes to Earth's land cover over the last two centuries, and there is every indication that the pace of these changes will accelerate in the future. The present study shows the utility of remote sensing techniques integrated with GIS to study the spatial dynamics of Agriculture and Industry in the selected specified study area and its surroundings along Bardhaman station, Bardhaman District. Various satellite image data were analyzed within a digital image processing system to provide up-to-date information of the whole area. The extracted information from remotely sensed data was then integrated with visually interpreted information and field inputs in a GIS to create a comprehensive spatial database. This permitted the integration of several layers of information with the remotely sensed data in both temporal and spatial dimensions.

Background: Remote sensing technology has been recognized as a useful means of supplying up to date information and have the potential to respond to the growing and urgent demand for timely and accurate land cover information over large areas. In the recent past, land cover mapping from satellites has come of age, Through research on various issues regarding data pre-processing, classification and accuracy assessment, new and unique data / land cover products are being generated which could not be produced by earlier techniques. Various data set of the area were used for interpreting and unifying them within GIS and Image Processing environment for analysis and interpretation.

Data Available: The following data were used for this project work:

- Landsat satellite image having 28.5 metre spatial resolution.
- IRS Cartosat multispectral satellite image having 5 metre spatial resolution.
- Digital Globe high resolution image (0.5m) from Open Source Google Earth repository for Visual interpretation and as a supplementary data for interpretation.

Software Used: TNTmips Pro 2014, the integrated GIS and Image Processing platform were used in the present study.

Workflow:

- Satellite Images were imported in a project file within TNTmips Pro platform.
- The Images were geometrically rectified with the GCP by using Geographic co-ordinate system and World Geodetic System 1984 (WGS 84) as Datum. Affine transformation model has been deliberately selected for this sampling area to maintain the geometric area and shape accuracy.
- The sampling location extends from North 23°14′ 55.398″ to North 23°14′ 25.670″ and East 87° 52′ 09.921″ to East 87°52′ 42.268″ .
- As per the present scope of study to meet the temporal data requisite two different year data has been collected.
- Image preprocessing was implemented on both the images to improve the quality and interpretability
- 2Extraction model was implemented on the scenes to get the 1 sq km sampling

an area as decided to process with in the buffer zone of 5 kilometer both of the railway track from Sealdah to Maldah at the location of Bardhaman station to get the surroundings bird′s eye view.

The sampling location extends from North 23° 14′ 55.398″ to North 23° 14′ 25.670″ and East 87° 52′ 09.921″ to East 87° 52′ 42.268″ .

Google Images 1sq km

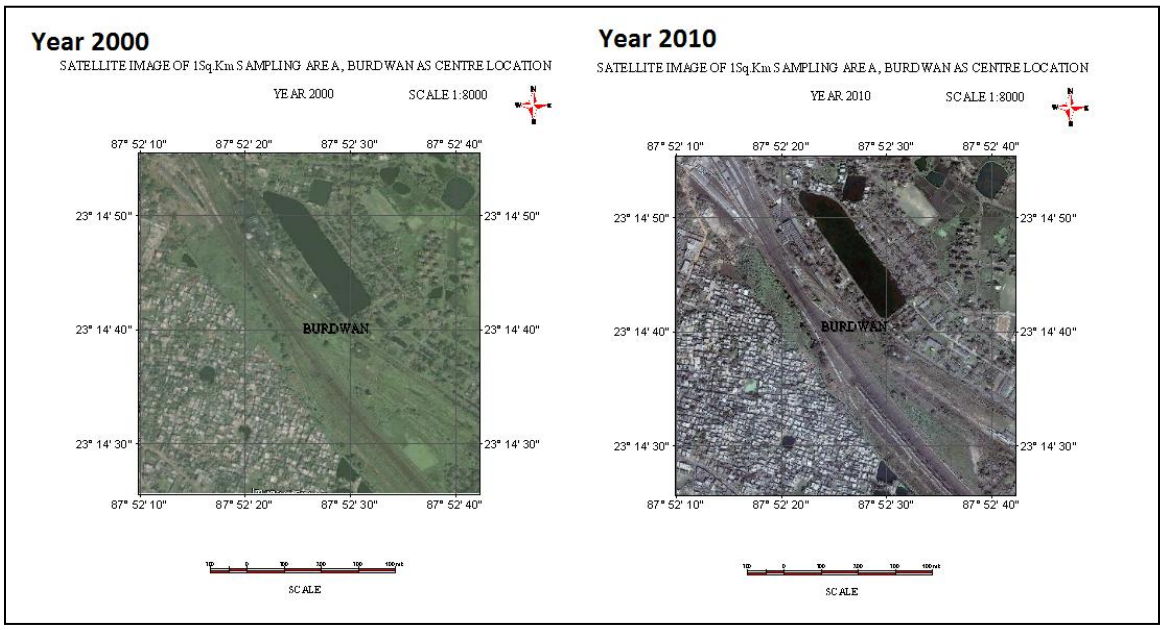


Fig.78

The given area extends from North 23° 12′ 11″ to North 23°17′ 09″ and East 87°55′ 07″ to East 87° 49′ 44″. The area of interest is shown below:

Google Images 78 sq km

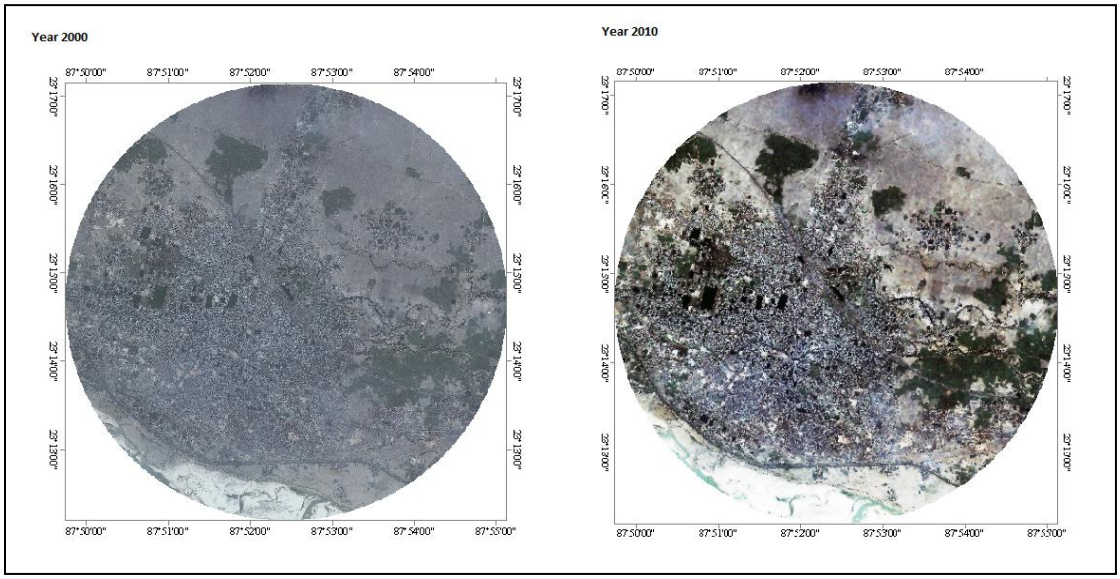


Fig.79

Once we have the processed image for both the years the remarkable change between reflectance values were quite obvious study though this factor is highly dependent on the solar illumination of that particular time and date. Here is a comparative diagram of those values of particular location-

RGB values

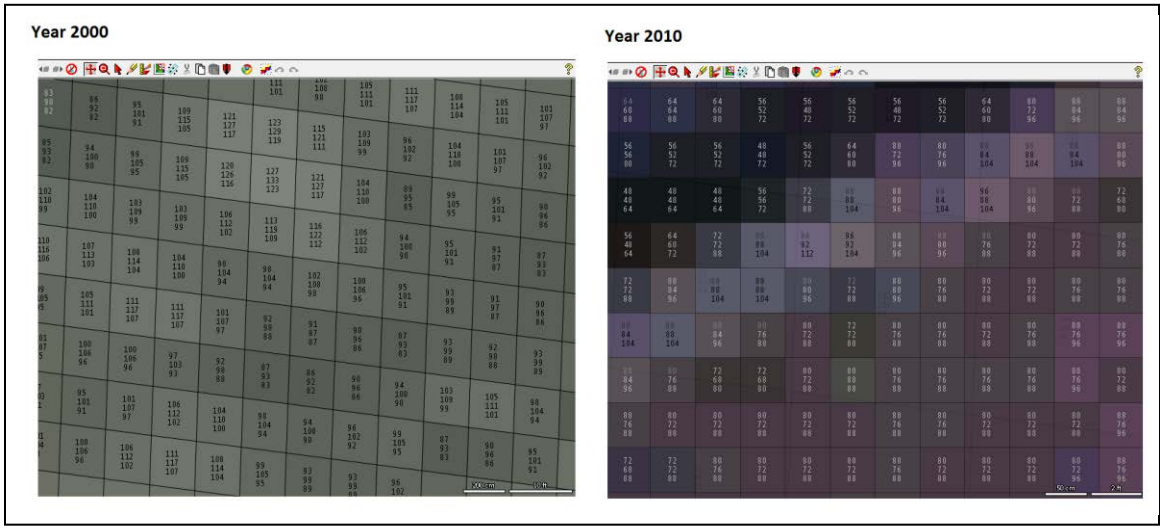


Fig.80

As a part of visual interpretation the important land-cover patterns have been delineated by using manual vectorization followed by building of topology between the spatial features. The platform used through-out the process flow is a topology inbuilt system where we have achieved the optimum vector statistics for further comparison with digital interpreted result.

Vectorization layer

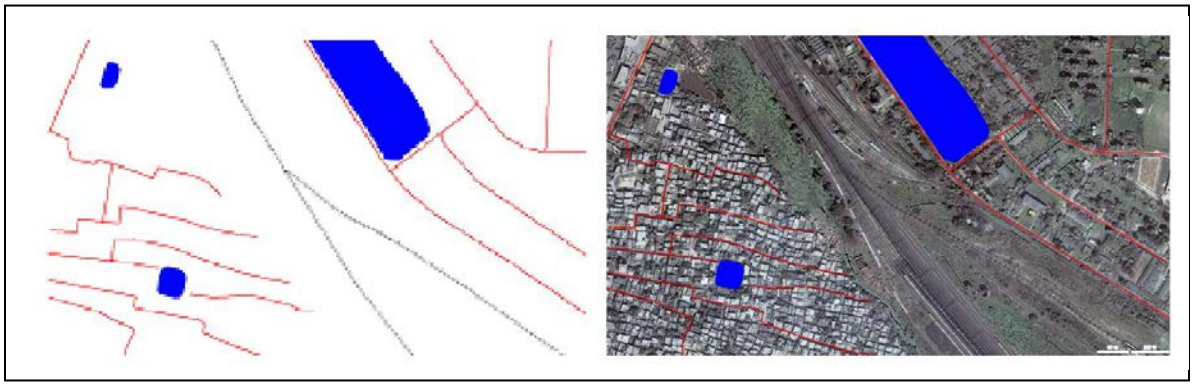


Fig.81

So using the same manual interpretation technique both the images were visually classified to get the spatial changes between the years-

The implementation of the visual image interpretation technique, the areas having proper land use differentiation had been delineated. Areas are shown below:

Google Image 78 sq km Land Use and land cover Map

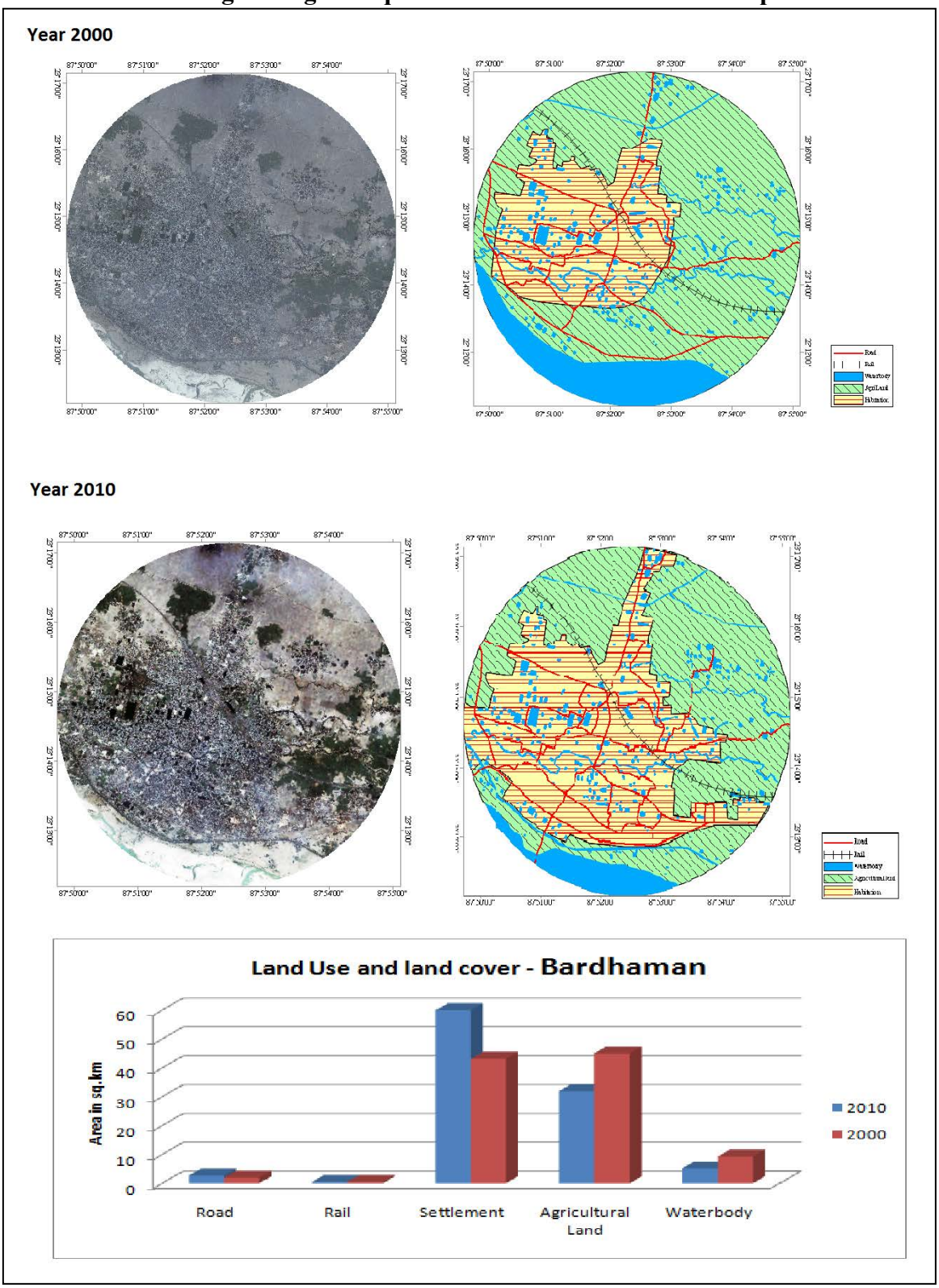


Fig.82

- In order to create a balanced and sustainable industrial growth in any zone and maximize use of uncultivable land in any area, it is felt that some parts of this zone can be identified as industrial growth poles, because of such factors such as availability of non-agricultural land, historical industrial presence and availability of good infrastructure. This will mean optimal use of the existing industrial infrastructure and up gradation of infrastructure where required and create new industrial infrastructure for project in backward areas.
- During land use classification habitation, vegetation and open land areas have been merged into a single category as in this scope of study we are trying to demarcate the land which can be acquired for industrial.
- From the observation of study area, most of the area covered by agricultural land. So there is high prospect in producing crop. Then it's not healthy to create an industry in this particular area. There must have some social and political issues.
- Major criterion for industrial development is communication system. In this area we can observe that Highway and Railway tracks are passing almost centre portion of this area.

FCC Classification

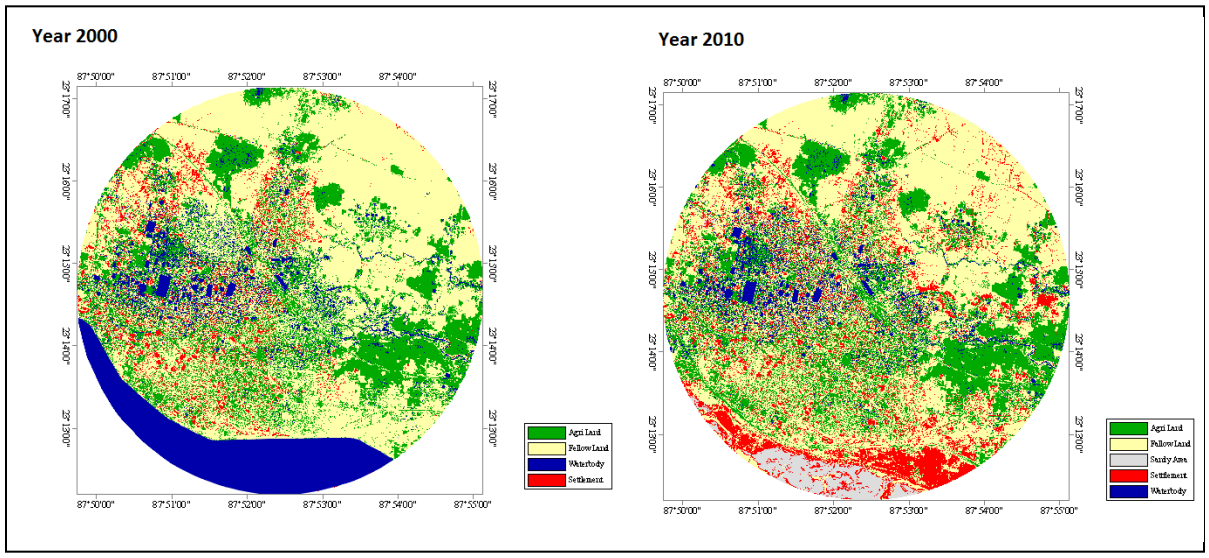


Fig.83

As we compare the FCC Classification image data of the desired area between the year 2000 and 2010 we can clearly see that the agricultural land has decreased to some extent due to the significant increase in settlement area and the decrease of water bodies. Also

though there is potential industrial zones scattered throughout the aforementioned area, but scattered area are not healthy for built up a proper industrial zone. At least 1sq. km. continuous area is feasible for actual industrial zonation. So here setting up large or small scale factories may not be viable.

Another issue is rises up with settlement area. Here we can observe that, in the year 2010, the percentage of population is very much higher than the year 2000. So the scope of industrial is not possible in this heavy population zone, so pollution issues are arise.

In the next map the potential industrial zones are depicted for the area of interest.

Probable Industrial Zone

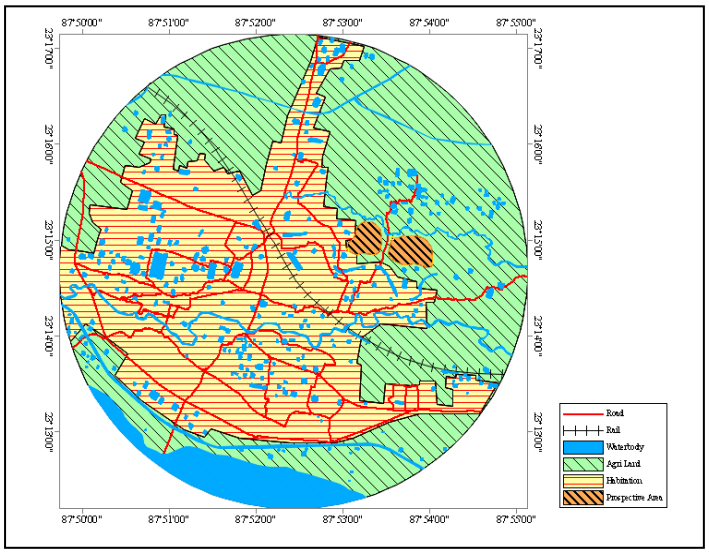


Fig.84

From this map we can clearly visualize that these two probable zones are ideal for industrial due to proper communication and availability of water. Areas of these prospective zones are 0.40 sq.km and 0.51 sq.km receptively. Due to good communication network and availability of water resource most of the areas are densely populated and prosperity of agricultural growth are very high. So only these identified zones are feasible for industrial within our region of interest.

Communication Map

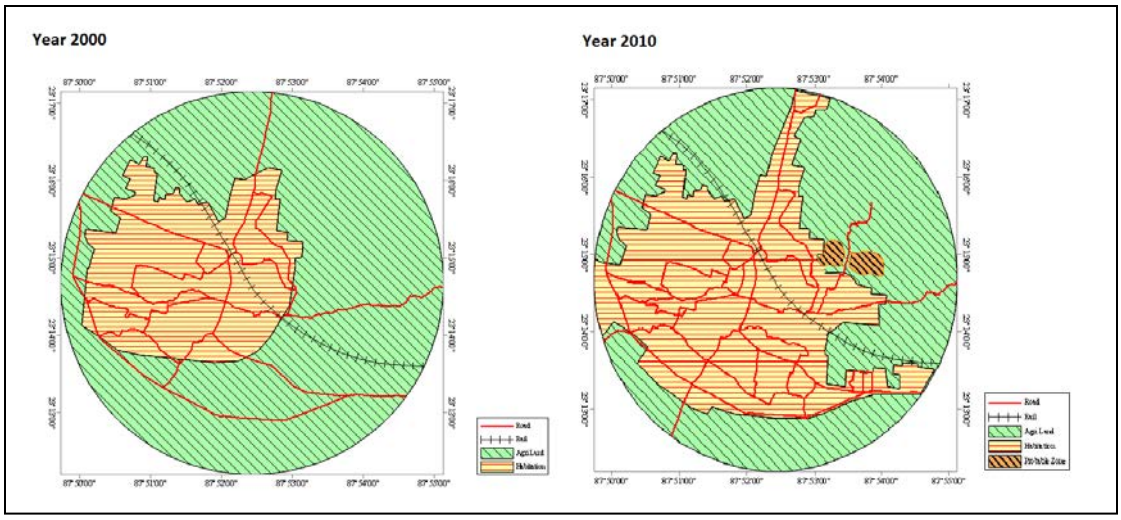


Fig.85

From this above two maps we can interpret that the communication system has been drastically change from year 2000 to year 2010 due to increase in population. So probability of industrial is maximum in this zone.

In spite of other social issues it can be concluded that this zone is superior for industrial.

Considering all these factors, the actual suggested area for industrial has shown below:

Actual prospective Industrial area

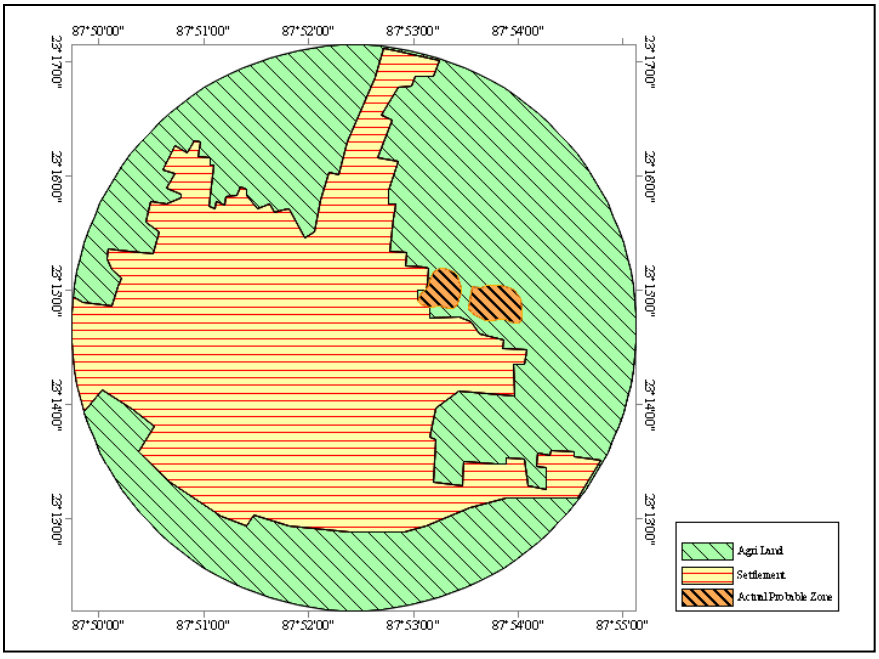


Fig.86

Conclusion: In the present status of study all the parameters related to industrial suitability had not been considered. The zones, which had been delineated as prospective area, should be verified using the field data. So, the delineated zones are the probable prospective area.

So using the same manual interpretation technique both the images were visually classified to get the spatial changes between the years-

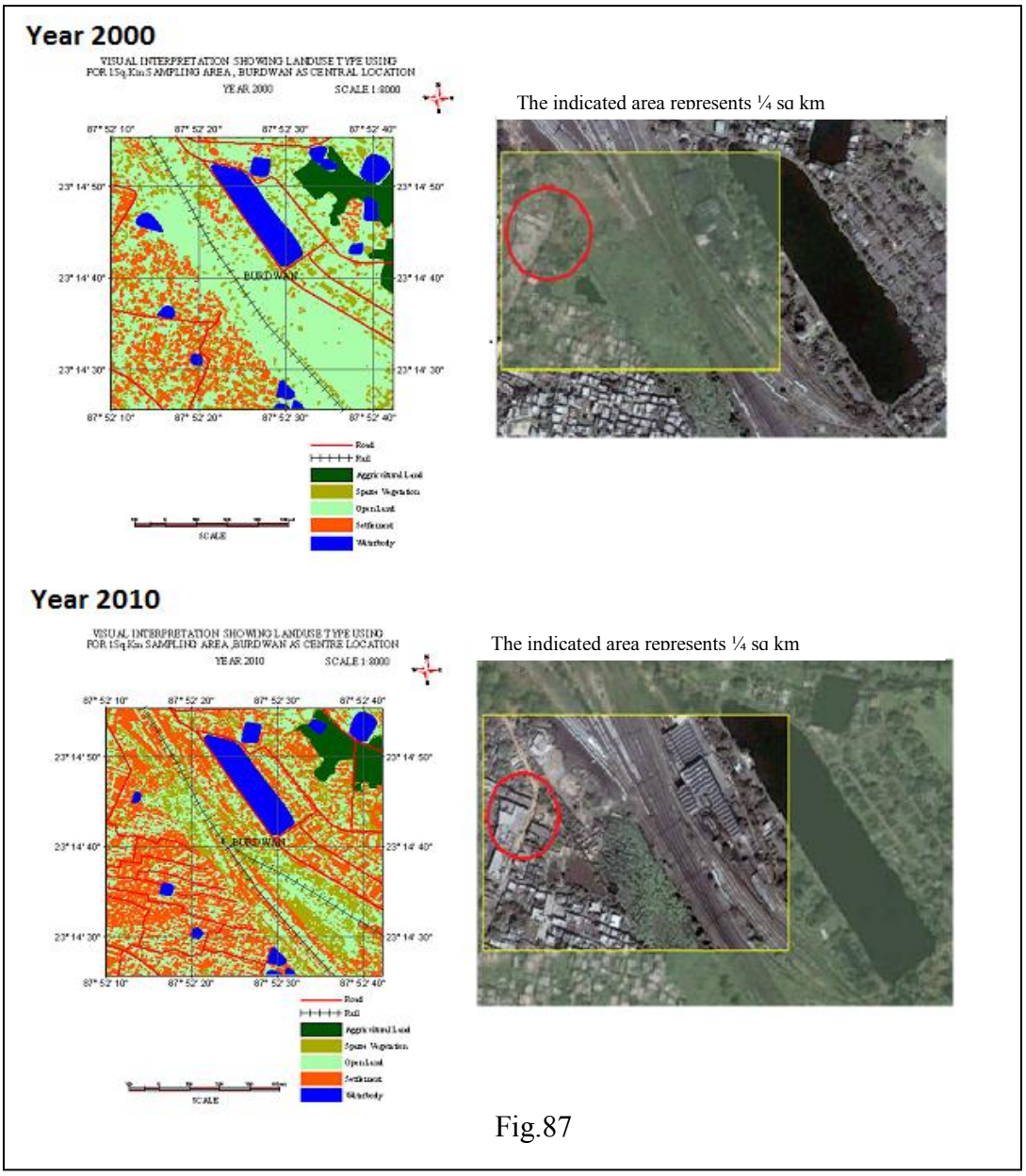


Fig.87

At the other hand same images have been used for digital image classification. The study area has been passed through hybrid classification technique, where the unsupervised

classification has been followed by supervised classification method and finally the spurious classes were deliberately merged to get the intended result.

Google Image 1 sq km Land Use and land cover Map

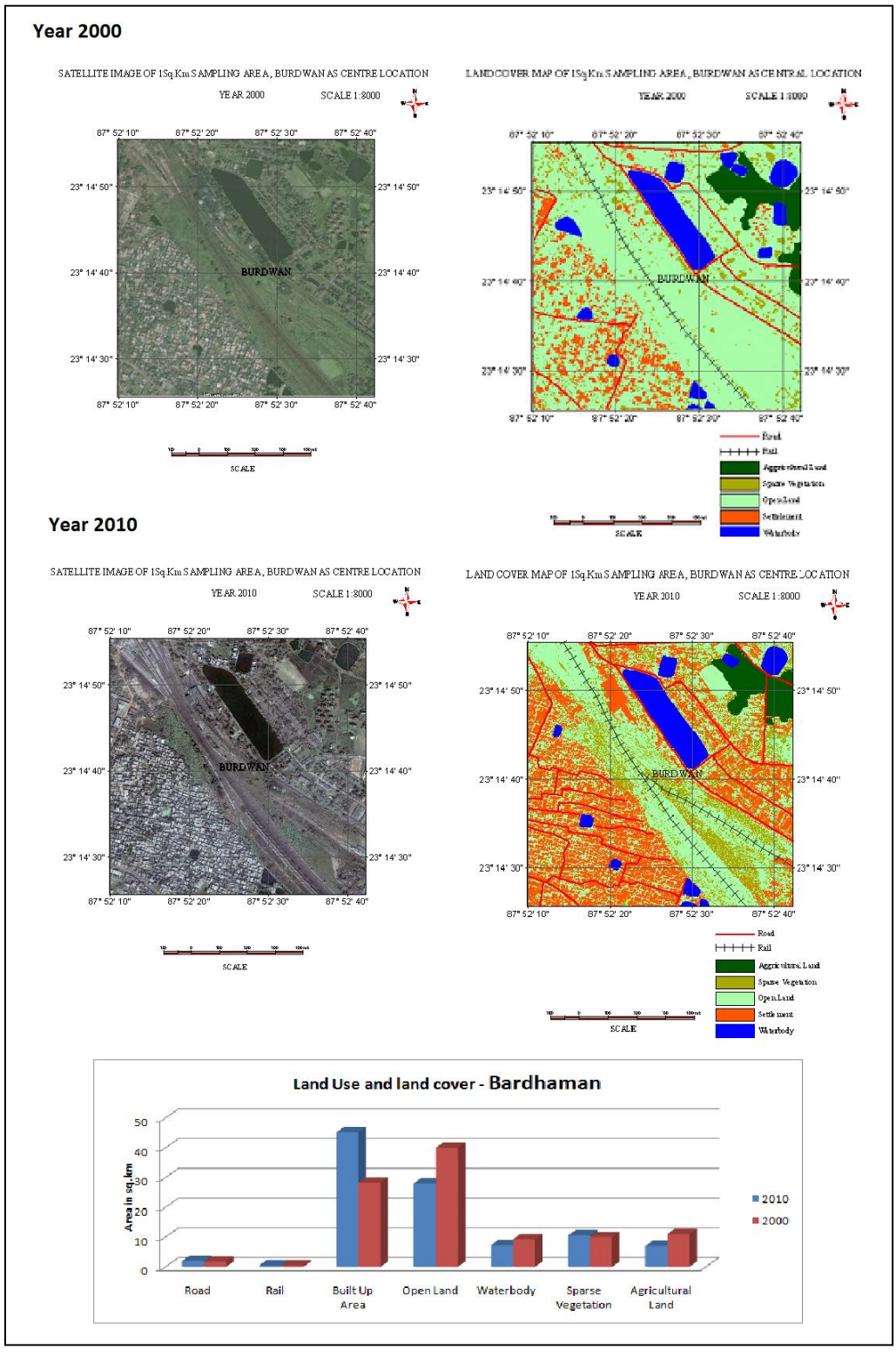


Fig.88

Cartographical map preparation with suitable scale. Throughout the mapping we have tried to use A4 page where maps were fitted with 1:8000 scale.

Interpretation and discussion

So, the procedural steps with the rigorous interpretation with both visual and digital technique for the study area between the years 2000 and 2010 this can be clearly interpreted that the '*Open Land*' has decreased to huge extent due to the significant increase in 'built-up' area and the decrease of water bodies is quite obvious. As this zone belongs to one of the important industrial cities of West Bengal naturally the population has dramatically increased during last 10 years.

Land use and Land cover - Changing Pattern

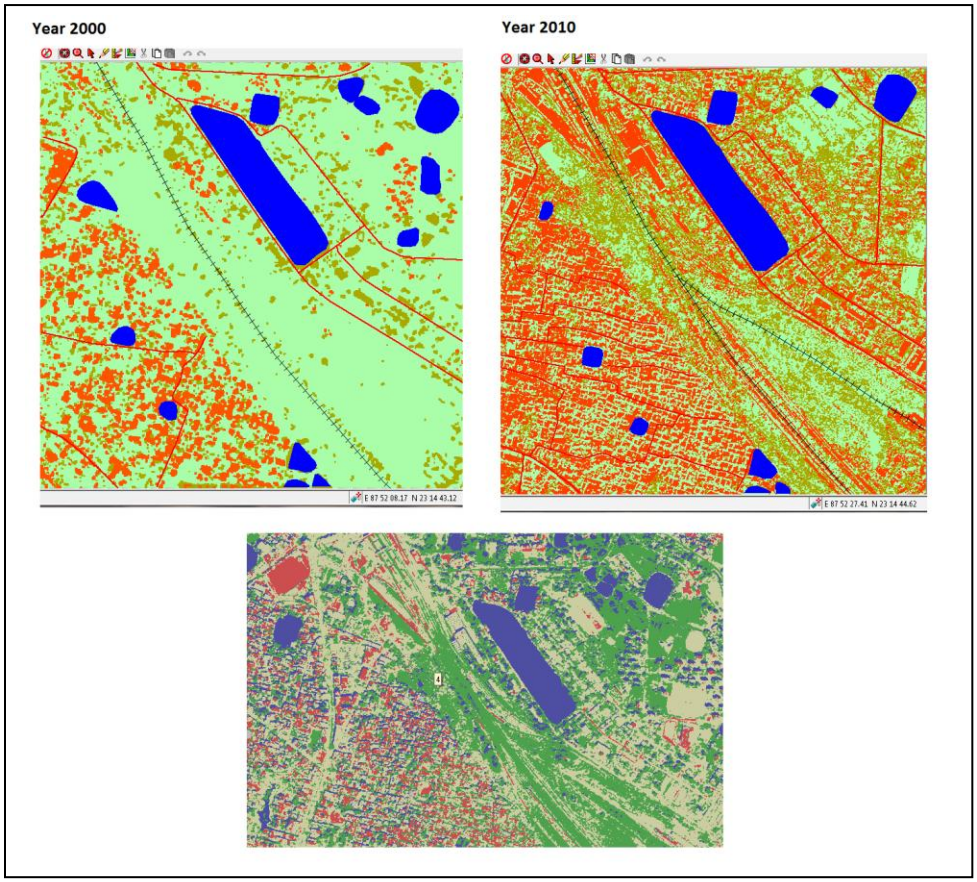


Fig.89

So, spatial dynamics has dramatically changed during last 10 years where the population change is quite significant in the quest of earning and lively hood. Naturally there is notable increase in small scale industry to the circumferences of this sampling study area. The sampling area does not reveal agricultural as one of the prime land use type, as this is the surrounding of Bardhaman station but study of adjacent areas confirm that agricultural land is the prime land use type in these areas. The land is fertile and used for 2 or even 3 times crop cultivation. So in the near future, agro-based industries might get a boom in this zone.

Land Use and land cover Map

Chanchai Railway Station (Bardhaman, West Bengal)

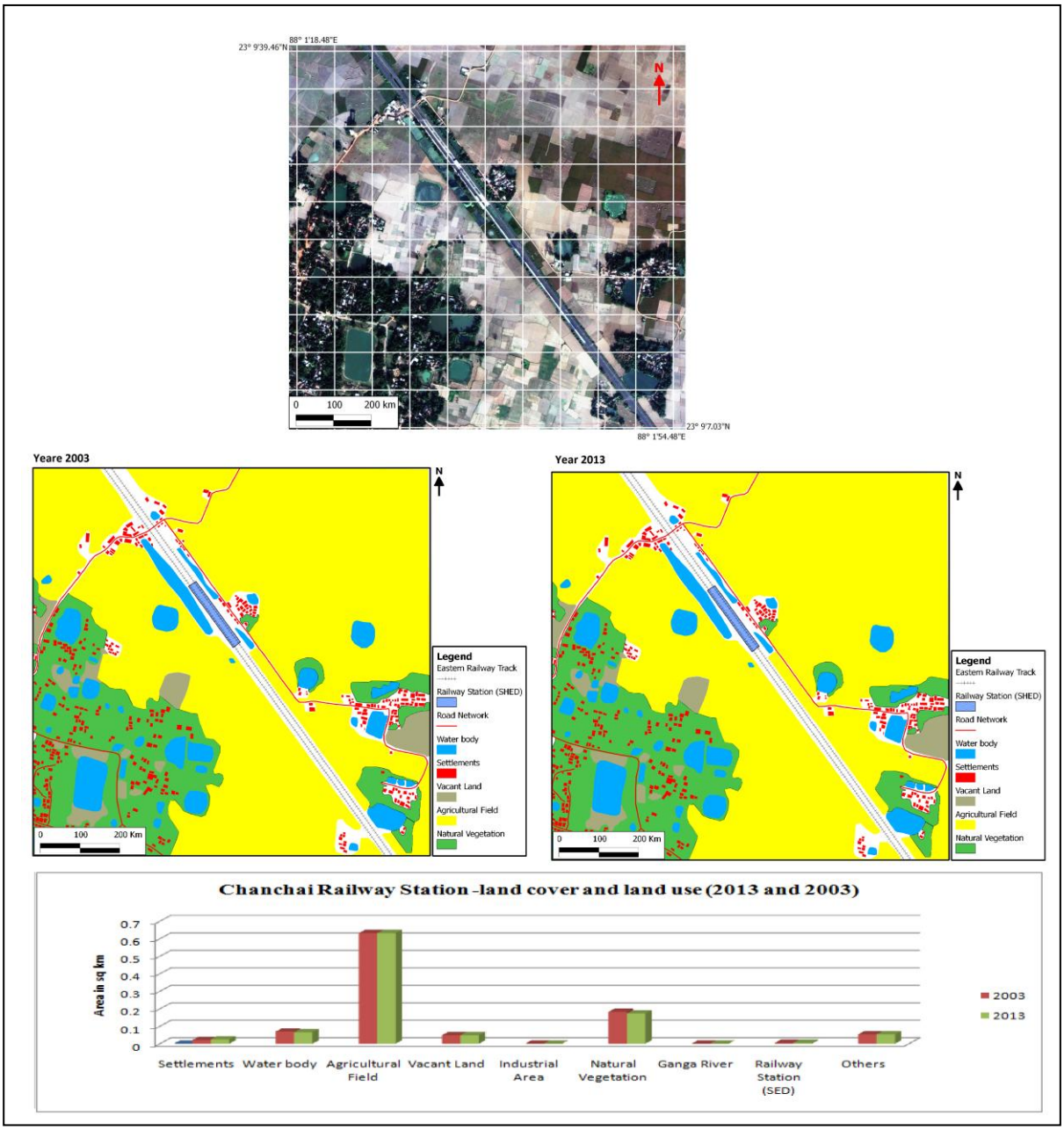


Fig.90

At Chanchai Railway Station, there is increase in settlement, water body, vacant land, natural vegetation and others and decrease is noticed in agricultural field in the year 2013 compared to 2003.

Land Use and land cover Map

Guskara Railway Station (Bardhaman, West Bengal)

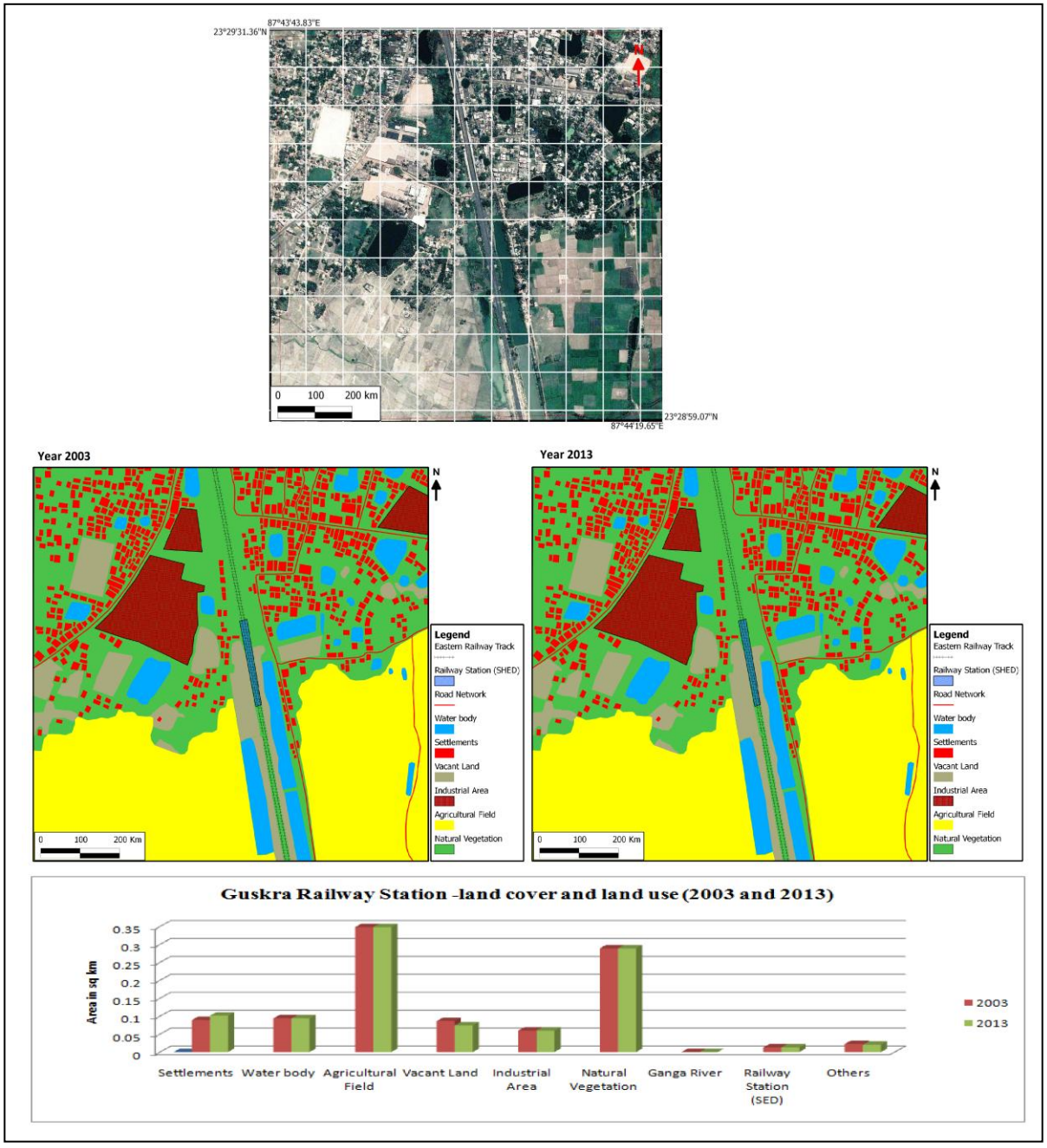


Fig.91

At Guskara Railway Station, there is increase in settlement, water body, vacant land, natural vegetation and others and decrease is noticed in agricultural field in the year 2013 compared to 2003.

"R.S and G.I.S application in spatial dynamics of agriculture and industry along Sealdah-Maldah Transact, West Bengal"

Sampling Zone: Bolpur and its Surrounding areas ,Birbhum District, WB

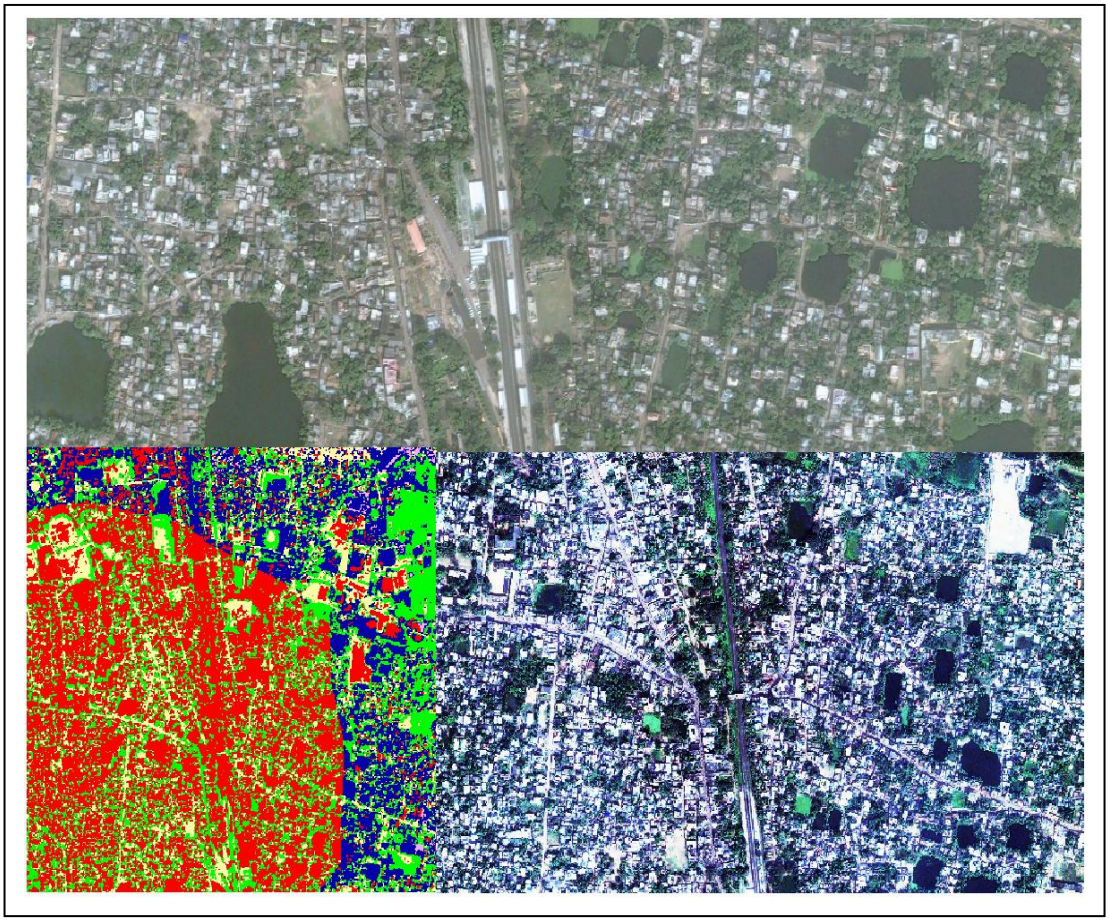


Fig.92

Objective: Economic development and population growth have triggered rapid changes to Earth's land cover over the last two centuries, and there is every indication that the pace of these changes will accelerate in the future. The present study shows the utility of remote sensing techniques integrated with GIS to study the spatial dynamics of agriculture and industry in the selected specified study area and its surroundings in Bolpur, Birbhum District. Various satellite image data were analyzed within a digital image processing system to provide up-to-date information of the whole area. The extracted information from remotely sensed data was then integrated with visually interpreted information and field inputs in a GIS to create a comprehensive spatial database. This permitted the integration of several layers of information with the remotely sensed data in both temporal and spatial dimensions.

Background: Remote sensing technology has been recognized as a useful means of supplying up to date information and have the potential to respond to the growing and urgent demand for timely and accurate land cover information over large areas. In the recent past, land cover mapping from satellites has come of age, Through research on various issues regarding data pre-processing, classification and accuracy assessment, new and unique data / land cover products are being generated which could not be produced by earlier techniques. Various data set of the area were used for interpreting and unifying them within GIS and Image Processing environment for analysis and interpretation.

Data Available: The following data were used for this project work:

- Landsat satellite image having 28.5 meter spatial resolution.
- IRS Cartosat multispectral satellite image having 5 meter spatial resolution.
- Digital Globe high resolution image (0.5m) from Open Source Google Earth repository for Visual interpretation and as a supplementary data for interpretation.

Software Used: TNTmips Pro 2014, the integrated GIS and Image Processing platform were used in the present study.

Workflow:

- Satellite Images were imported in a project file within TNTmips Pro platform.
- The Images were geometrically rectified with the GCP by using Geographic co-ordinate system and World Geodetic System 1984 (WGS 84) as Datum. Affine transformation model has been deliberately selected for this sampling area to maintain the geometric area and shape accuracy.
- The sampling location extends from North 23°39′14.563″ to North 23°39′ 44.192″ and East 87°41′39.356 ″ to East 87°42′11.705″.
- As per the present scope of study to meet the temporal data requisite two different year data has been collected.
- Image preprocessing was implemented on both the images to improve the quality and interpretability
- Extraction model was implemented on the scenes to get the 1 sq km sampling area as decided to process with in the buffer zone of 5 kilometer both of the railway track from Sealdah to Maldah at the location of Bolpur station to get the surroundings bird′s eye view.

The sampling location extends from North 23° 39′14.563″ to North 23°39′ 44.192″ and East 87°41′39.356 ″ to East 87° 42′11.705″ .

Google Images 1 sq Km

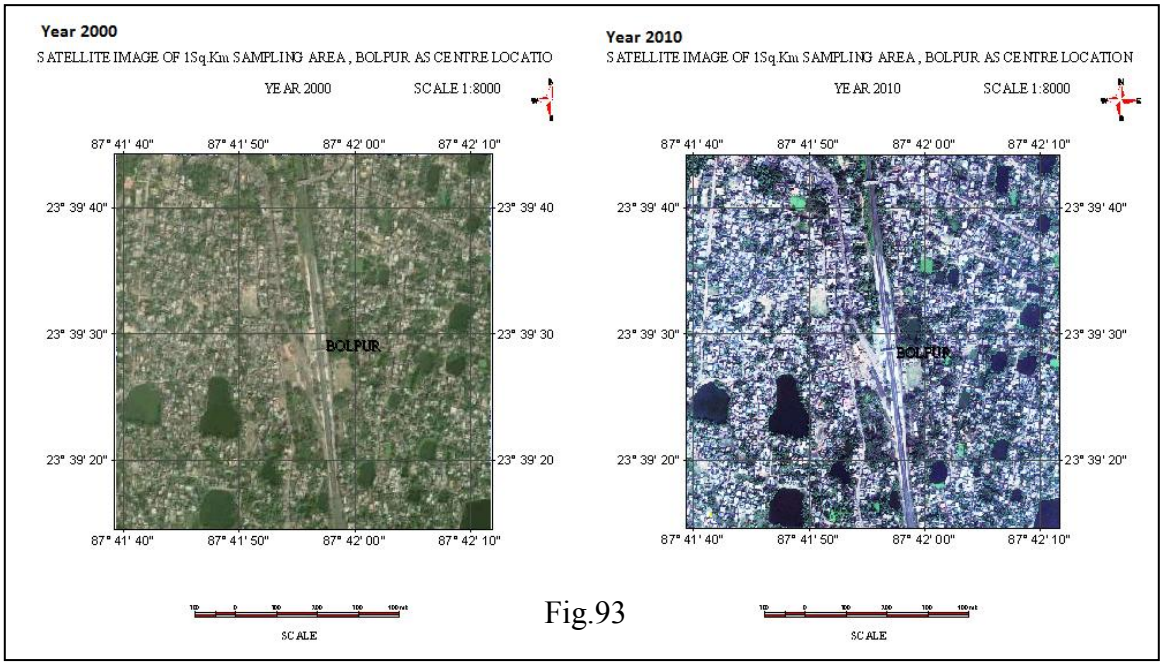
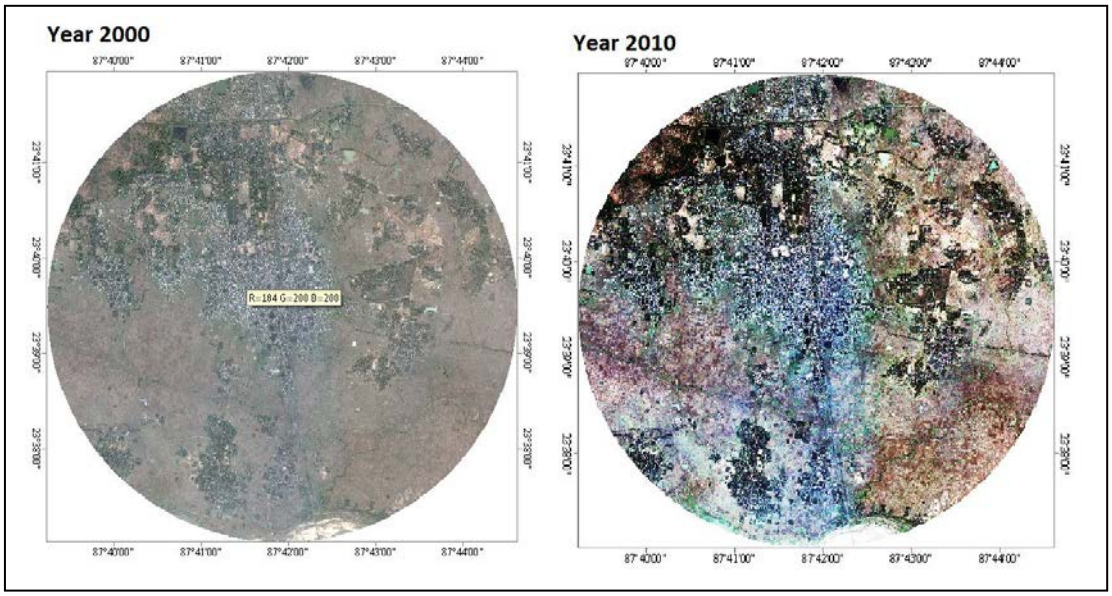


Fig.93

The given area extends from North 23°37′01″ to North 23°41′57″ and East 87°39′13″ to East 87°44′37″ . The area of interest is shown below:

Google Images 78.51 sq Km



The study area is about 78.51sq.km. Fig.94

RGB values

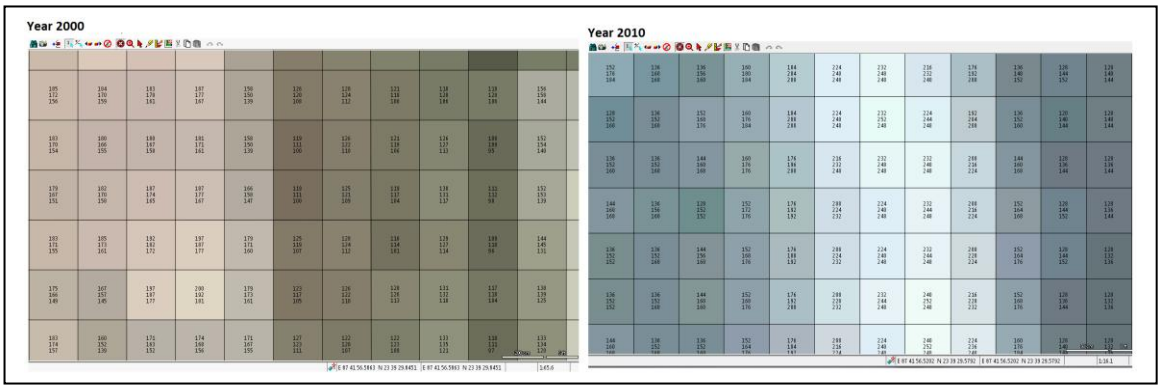


Fig.95

As a part of visual interpretation the important land-cover patterns have been delineated by using manual vectorization followed by building of topology between the spatial feature. The platform used through-out the process flow is a topology inbuilt system where we have achieved the optimum vector statistics for further comparison with digital interpreted result.

Vectorization layer

Fig.96

With the implementation of the visual image interpretation technique, the areas having proper land use differentiation has been delineated. Areas are shown below:

Google Image 78.51 sq km Land Use and land cover Map

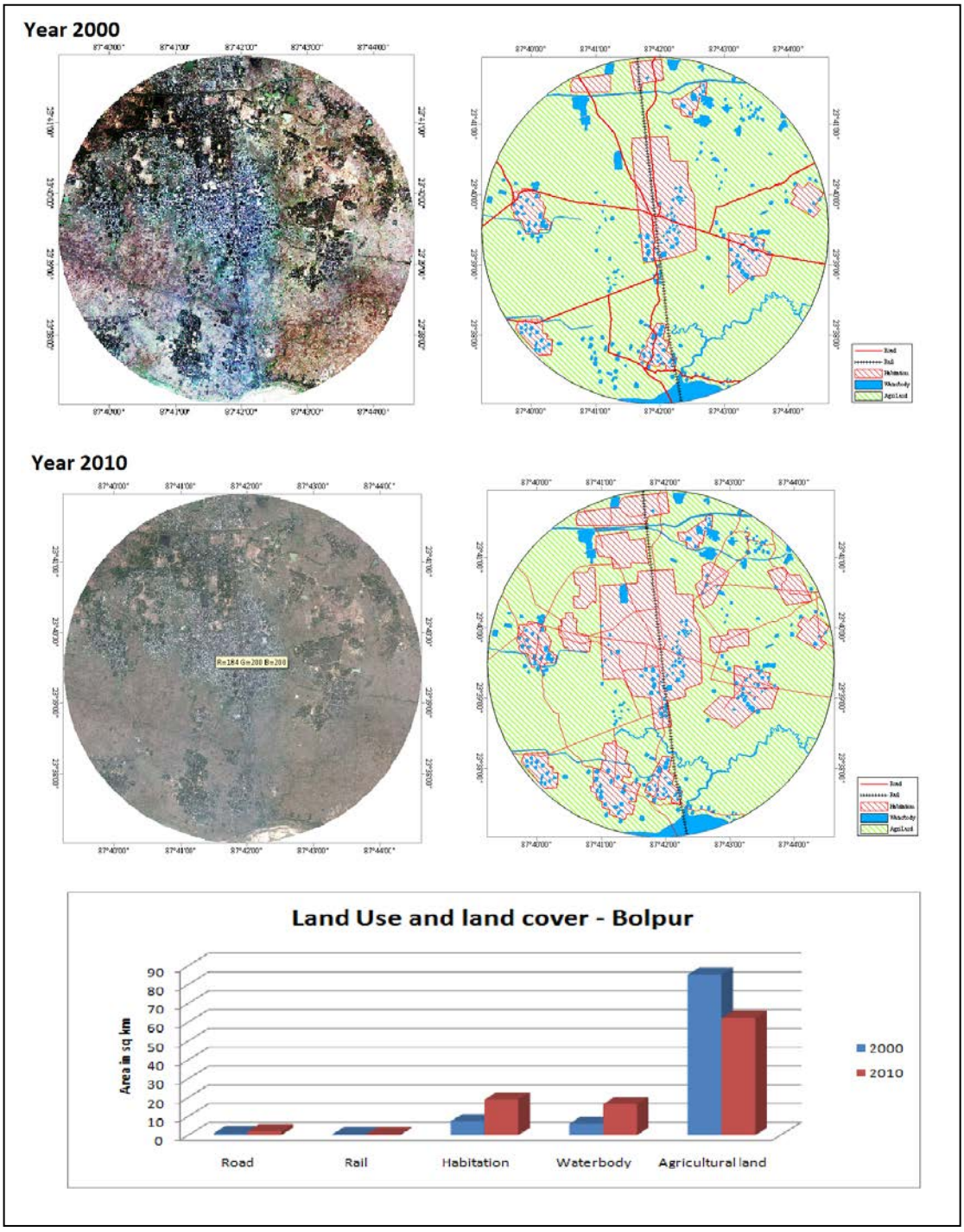


Fig.97

Factors Considered: Following factors were taken into consideration for delineating the zones of interest-

- In order to create a balanced and sustainable industrial growth in any zone and maximize use of uncultivable land in any area, it is felt that some parts of this zone can be identified as industrial growth poles, because of such factors such as availability of non-agricultural land, historical industrial presence and availability of good infrastructure. This will mean optimal use of the existing industrial infrastructure and up gradation of infrastructure where required and create new industrial infrastructure for project in backward areas.

- During land use classification habitation, vegetation and open land areas have been merged into a single category as in this scope of study we are trying to demarcate the land which can be acquired for industrial.

- From the observation of study area, most of the area covered by agricultural land. So there is high prospect in producing crop. Then it′s not healthy to create an industry in this particular area. There must have some social and political issues.

- Major criteria for industrial development is communication condition. In this area we can observed that Highway and Railway tracks are passing almost centre portion of this are.

FCC Classification

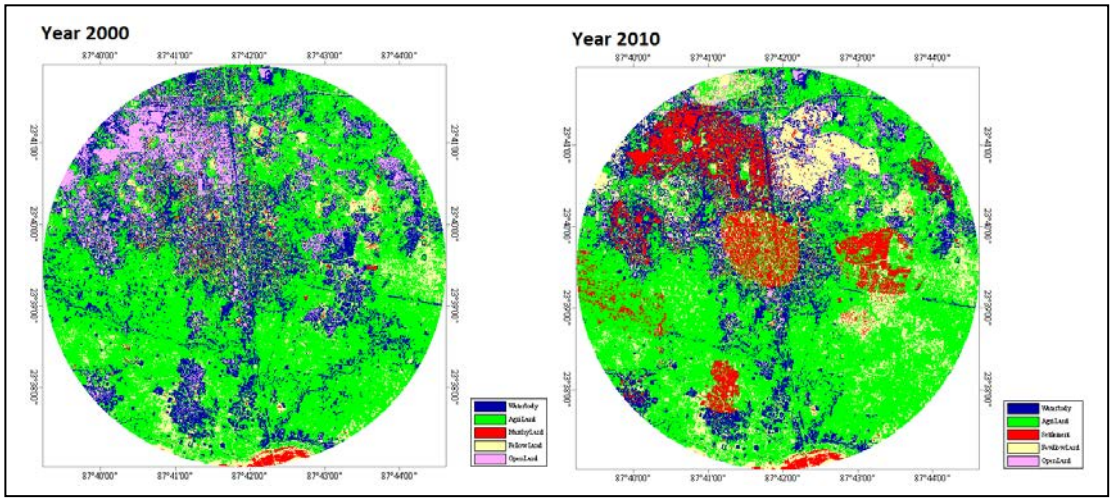


Fig.98

As we compare the FCC Classification image data of the desired area between the year 2000 and 2010 we can clearly see that the Agricultural land has decreased to some extent due to the significant increase in settlement area and the decrease of water bodies. Also though there is potential industrial zones scattered throughout the aforementioned area, but scattered area are not healthy for built up a proper industrial zone. At least 1sq. km. continuous area is feasible for actual industrial zonation. So here setting up large or small scale factories may not be viable.

Another issue is rises up with settlement area. Here we can observe that, in the year 2010, the percentage of population is very much higher than the year 2000. So the scope of industrial is not possible in this heavy population zone, so pollution issues are arise.
In the next map the potential industrial zones are depicted for the area of interest.

Probable Industrial Zone

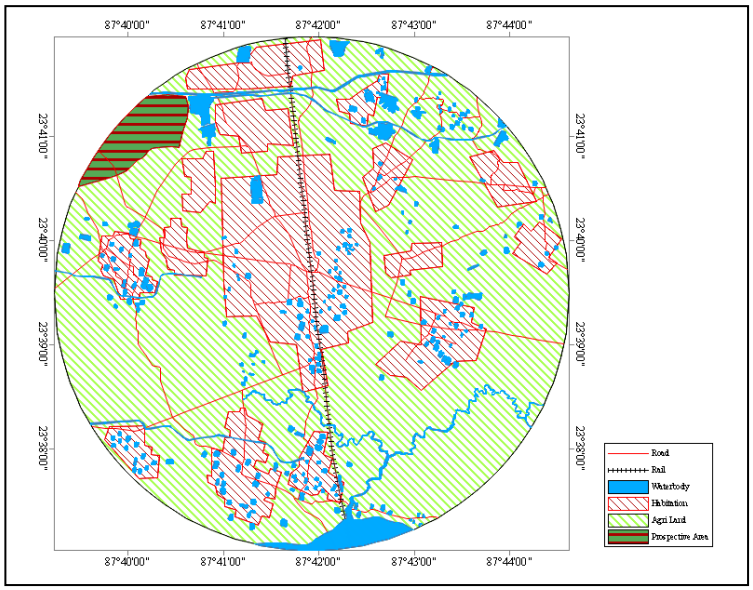


Fig.99

From this map we can clearly visualize that these two probable zones are ideal for industrial due to proper communication and availability of water. Areas of this prospective zone is 1.79 km. This is more healthy for built up an industrial zone. Due to good communication network and availability of water resource most of the areas are densely populated and prosperity of agricultural growth are very high. So only this identified zone are feasible for industrial within our region of interest.

Communication Map

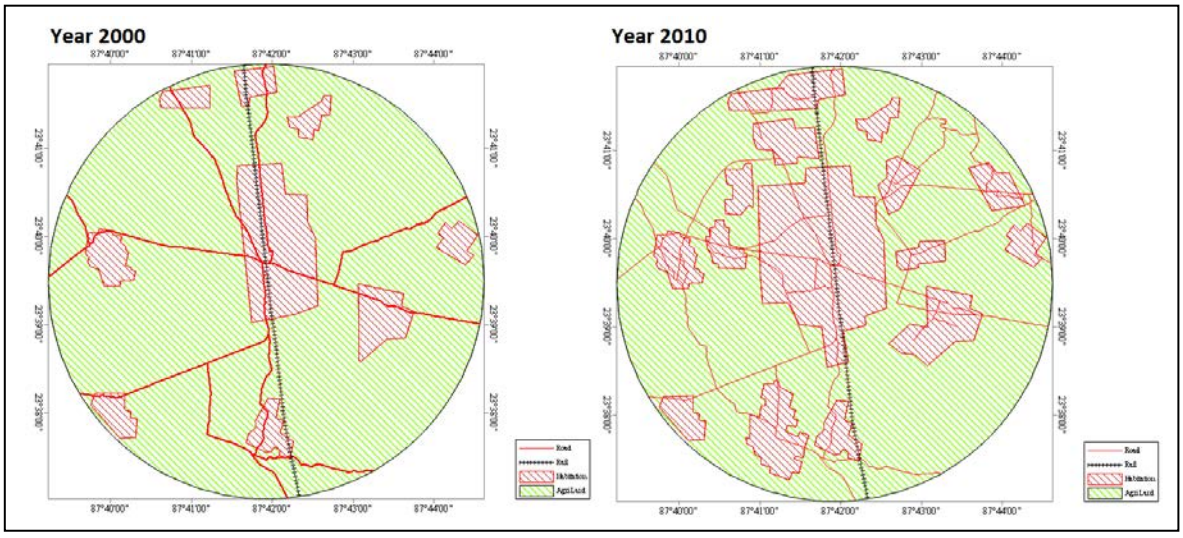


Fig.100

From this above two maps we can interpret that the communication system has been drastically change from year 2000 to year 2010 due to increase in population. So probability of industrial is maximum in this zone.

In spite of other social issues it can be concluded that this zone is superior for industrial. Considering all these factors, the actual suggested area for industrial has shown below:

Actual prospective Industrial area

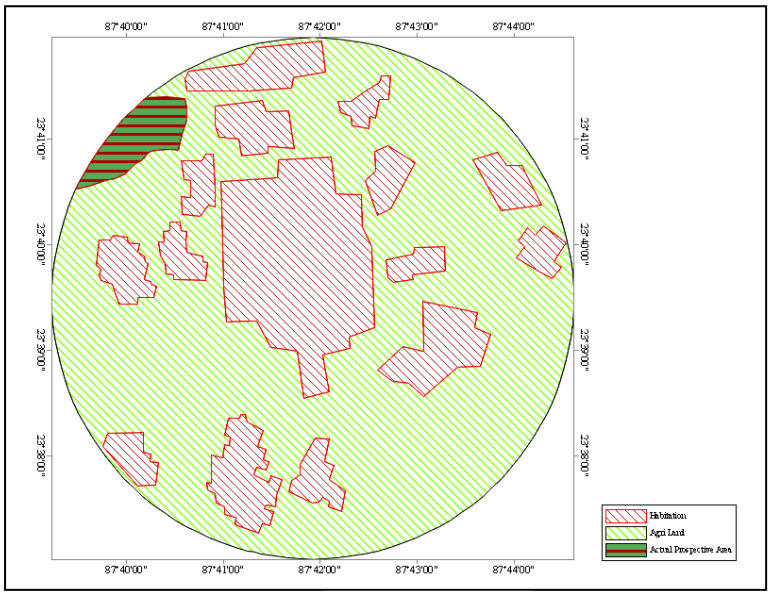


Fig.101

Conclusion: In the present status of study all the parameters related to industrial suitability had not been considered. The zones, which had been delineated as prospective

area, should be verified using the field data. So, the delineated zones are the probable prospective area.

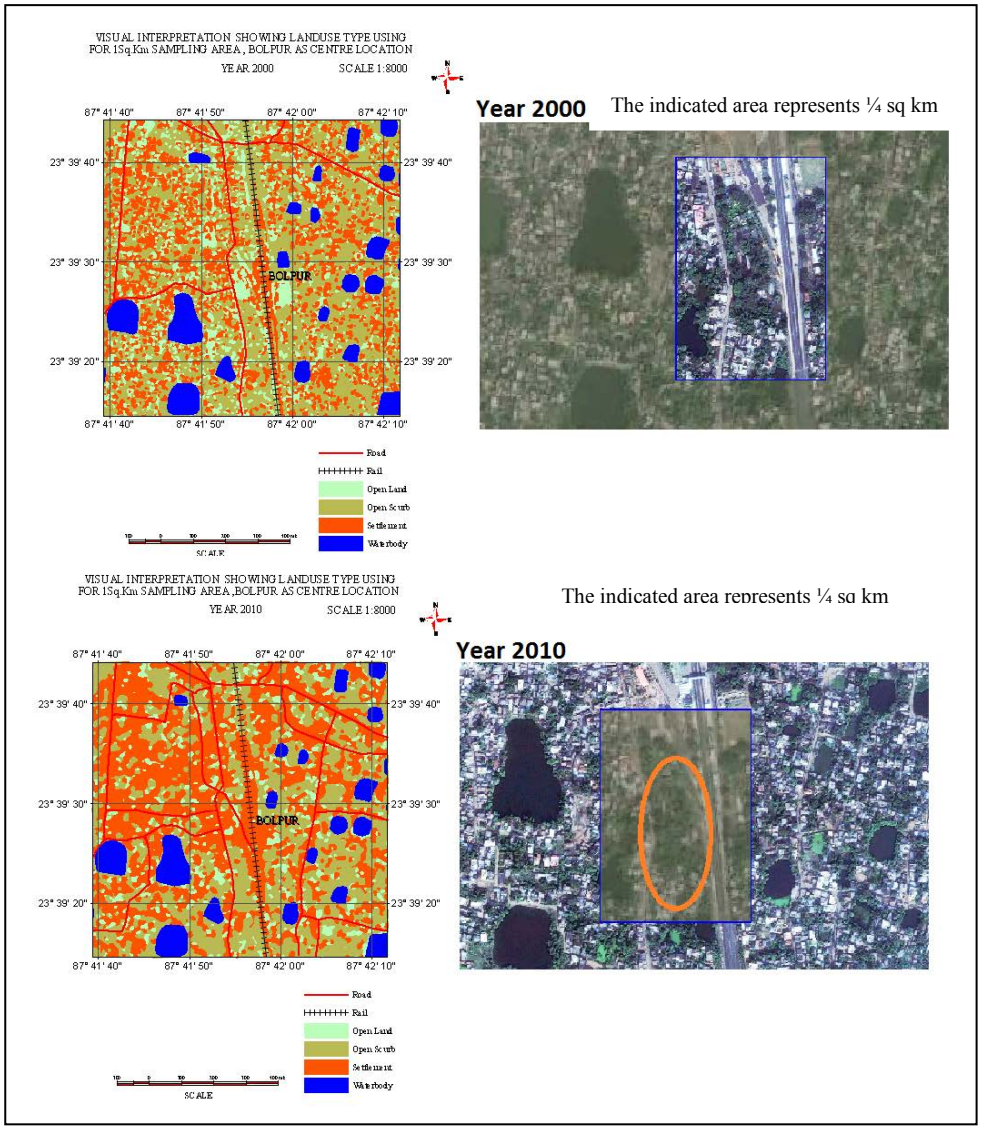


Fig.102

At the other hand same images have been used for digital image classification. The study area has been passed through hybrid classification technique, where the unsupervised classification has been followed by supervised classification method and finally the spurious classes were deliberately merged to get the intended result.

Google Image 1 sq km Land Use and land cover Map

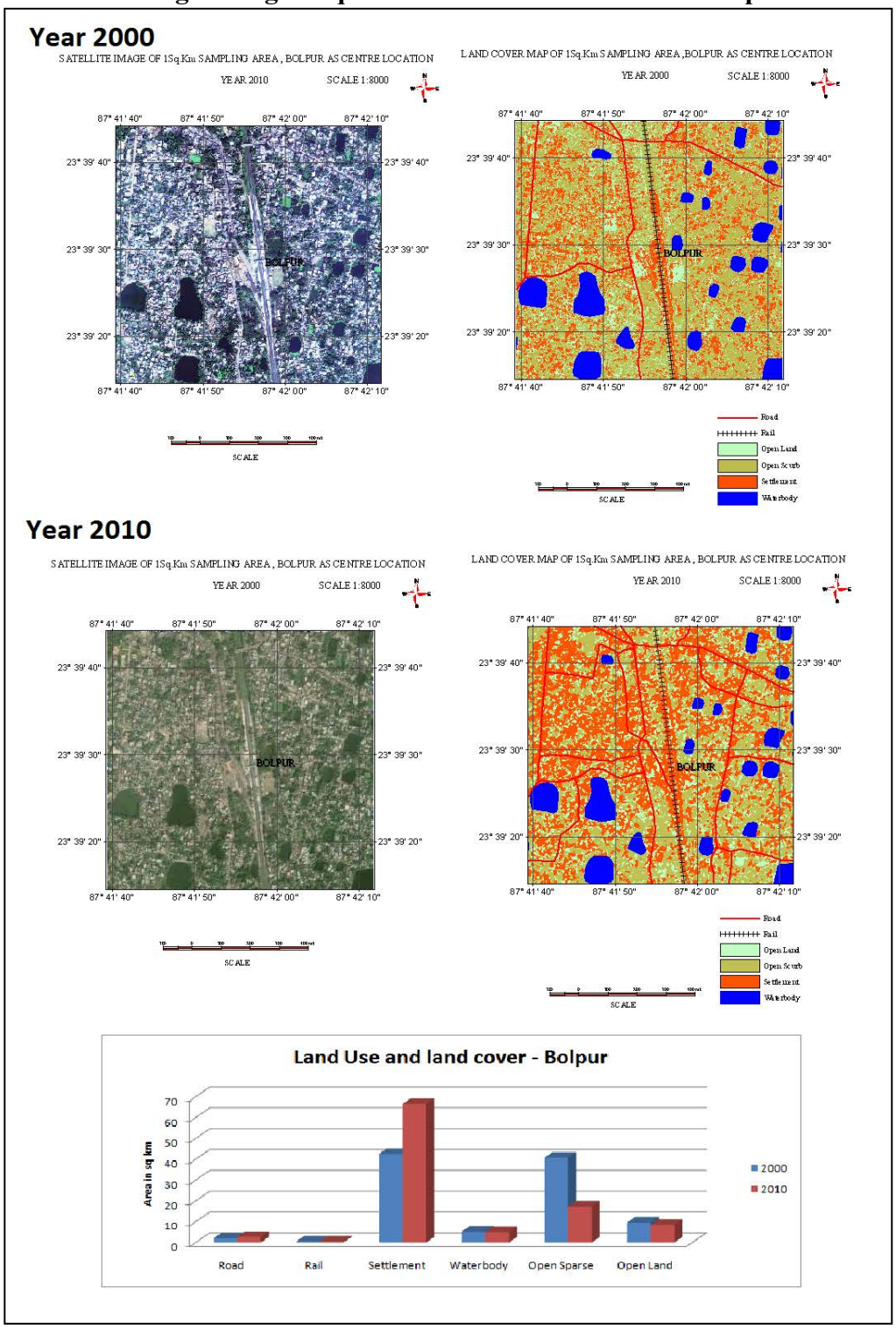


Fig.103

Cartographical map preparation with suitable scale. Throughout the mapping we have tried to use A4 page where maps were fitted with 1:8000 scale.

Interpretation and discussion

So, the procedural steps with the rigorous interpretation with both visual and digital technique for the study area between the years 2000 and 2010 this can be clearly interpreted that the '*Open Land'* and *'Open Scurb'* has decreased due to the significant increase in 'settlement' area. As this zone belongs to the one of the impotent cultural city of Birbhum district, naturally the population increased during last 10 years. The another importance of this sampling zone is the presence of Santinikatan/Bisva Bharati University which primarily leads to increase in population presser surrounding Bolpur. The sampling zone is strictly restricted with in the 1 sq. km keeping Bolpur Station in center so no agricultural land is visible with in this sampling zone but as per the observation of this field agricultural land has been decreased surrounding the station periphery to accommodate the population pressure but agricultural practice has been improved to its quality with increasing productivity.

Land use and Land cover - Changing Pattern

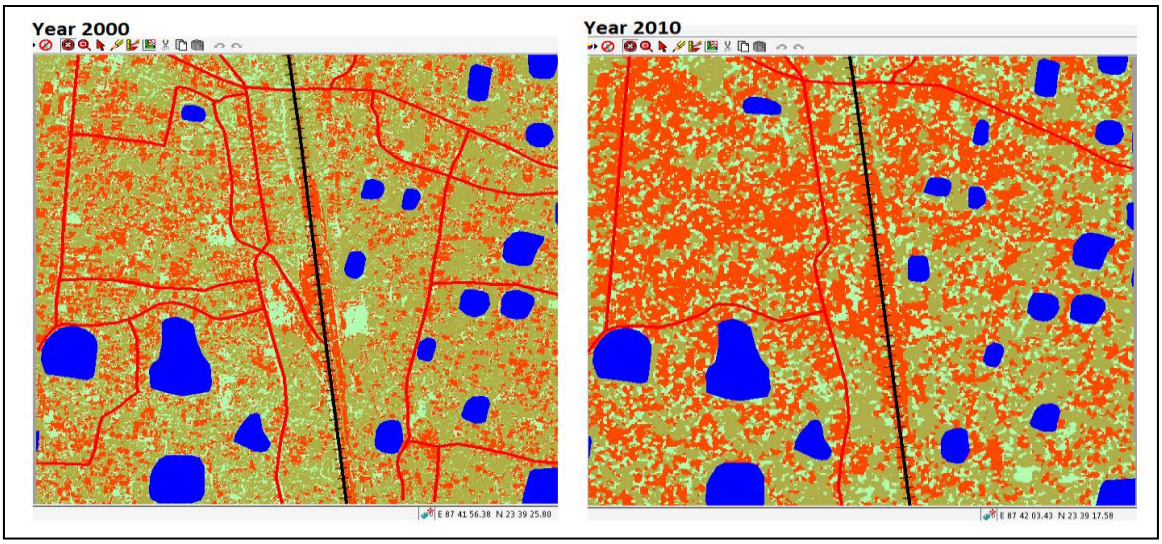


Fig.104

Especially this sampling zone has not been traced with any industry and the location is popular for its pleasant environment. As a part of suggestion and future planning this zone can be viable of small scale industry to improve the lively hood of the people which will lead to development of employment opportunity.

Land Use and land cover Map

Sainthia Railway Station (Birbhum, West Bengal)

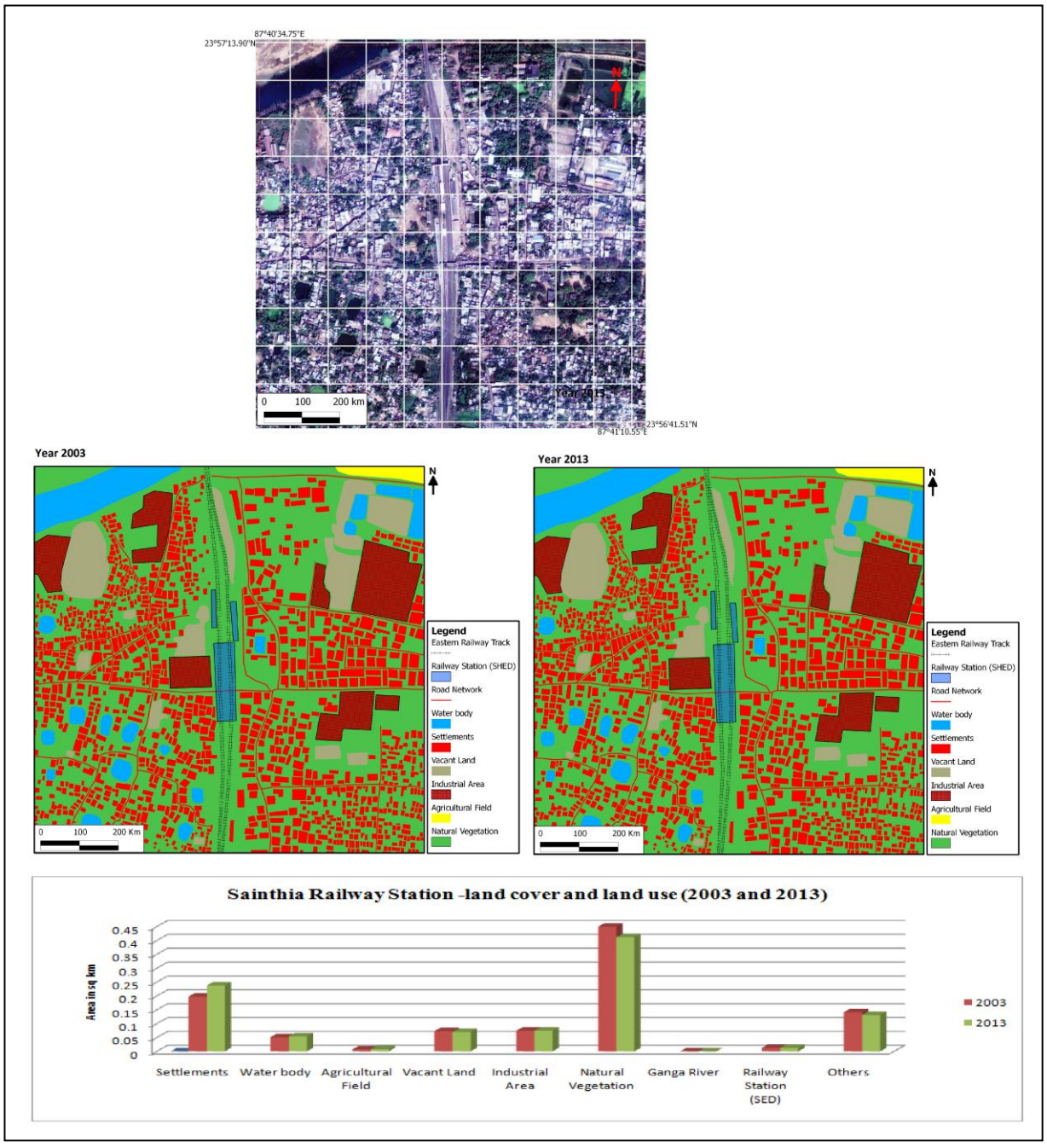


Fig.105

At Sainthia Railway Station, there is increase in settlement, water body, vacant land, natural vegetation and others and decrease is noticed in agricultural field in the year 2013 compared to 2003.

Land Use and land cover Map

Chatra Railway Station (Birbhum, West Bengal)

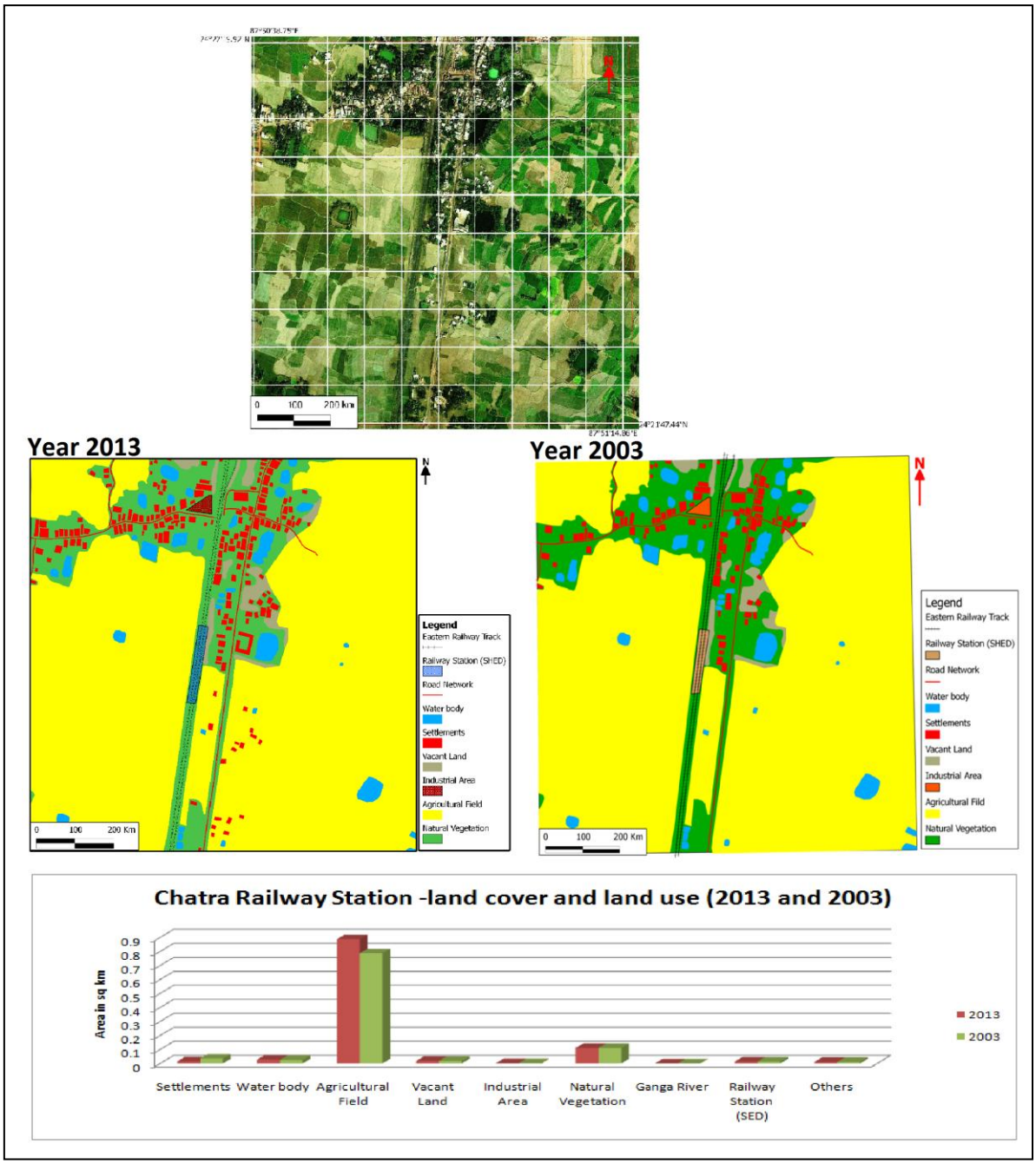


Fig.106

At Chatra Railway Station, there is increase in settlement, water body, vacant land, natural vegetation and others and decrease is noticed in agricultural field in the year 2013 compared to 2003.

Land Use and land cover Map
Bonidanga Railway Station (Jharkhand)

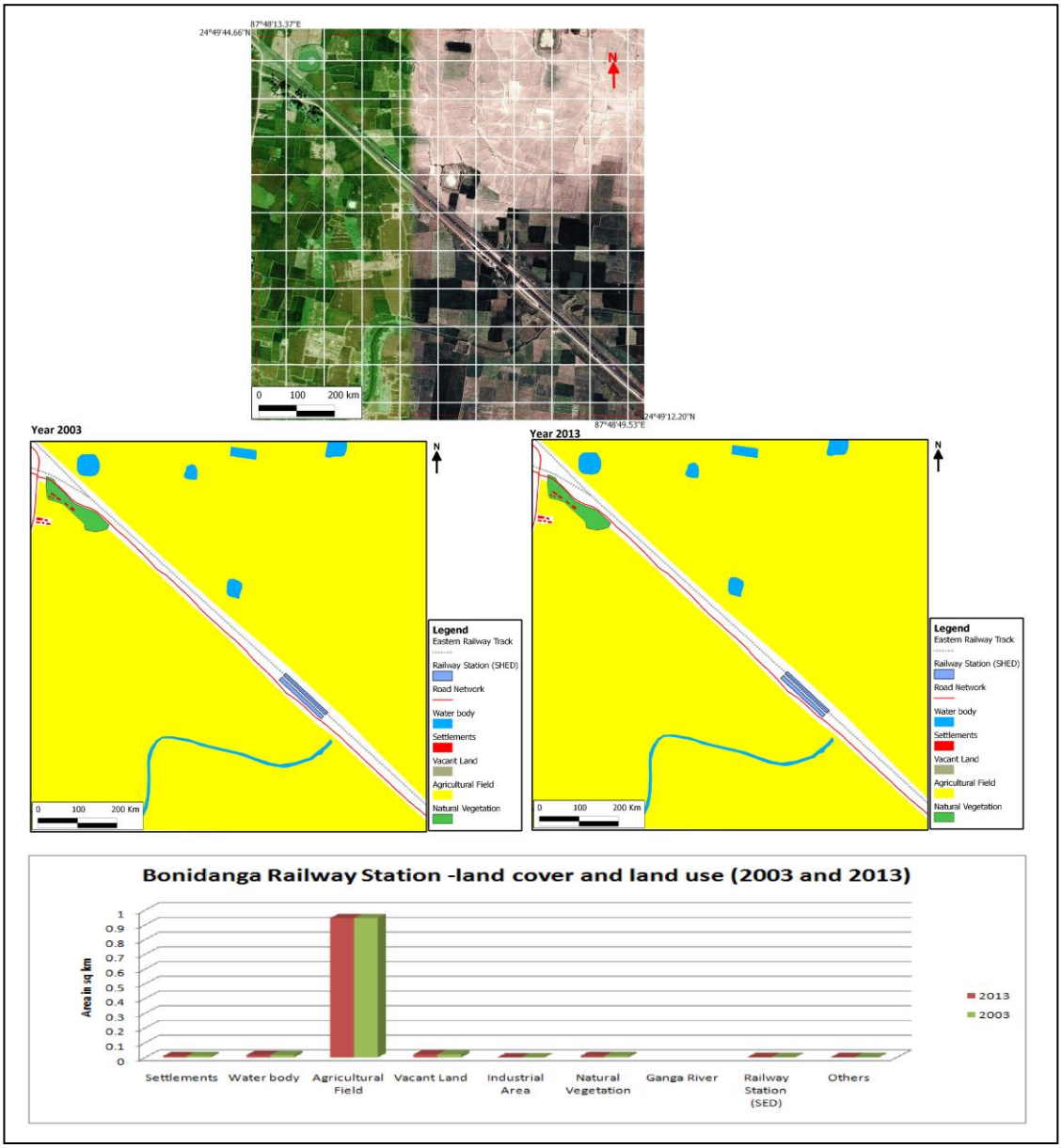


Fig.107

At Bonidanga Railway Station, there is increase in settlement, water body, vacant land, natural vegetation and others and decrease is noticed in agricultural field in the year 2013 compared to 2003.

Case Study: C

National Highway (NH-34) runs through Barasat, Pramanic, Bethuadahari, Sargachhi , Jangipur and PTS Bus Stop etc.

"R.S and G.I.S application in spatial dynamics of agriculture and industry along Sealdah-Maldah Transact, West Bengal"

Sampling Zone: Fatehpur and its Surrounding areas, North 24 Parganas District, WB

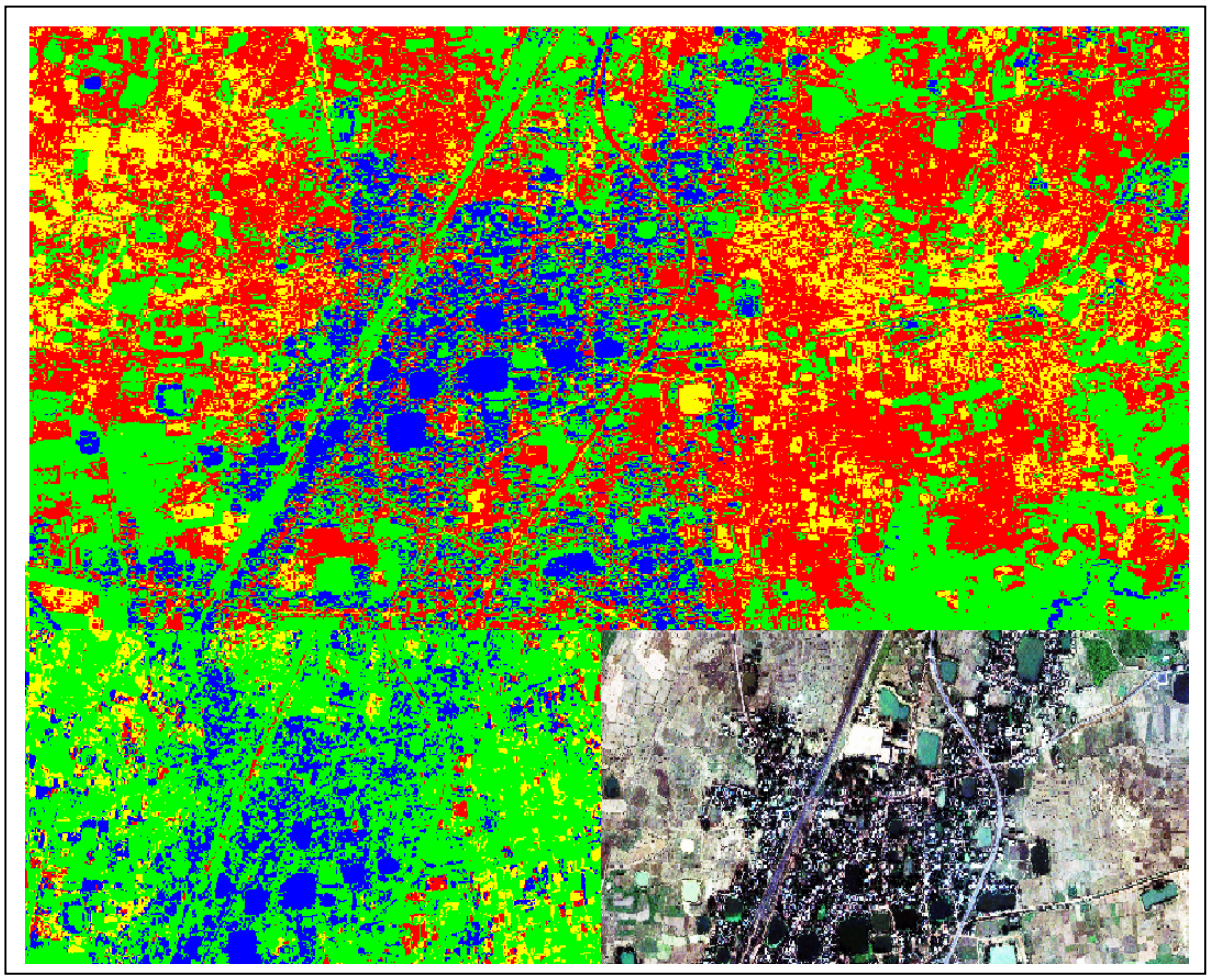


Fig.108

Objective: Economic development and population growth have triggered rapid changes to Earth's land cover over the last two centuries, and there is every indication that the pace of these changes will accelerate in the future. The present study shows the utility of remote sensing techniques integrated with GIS to study the spatial dynamics of Agriculture and Industry in the selected specified study area and its surroundings in Fatehpur, South 24 Parganas District. Various satellite image data were analyzed within a digital image processing system to provide up-to-date information of the whole area. The extracted information from remotely sensed data was then integrated with visually interpreted information and field inputs in a GIS to create a comprehensive spatial database. This permitted the integration of several layers of information with the remotely sensed data in both temporal and spatial dimensions.

Background: Remote sensing technology has been recognized as a useful means of supplying up to date information and have the potential to respond to the growing and urgent demand for timely and accurate land cover information over large areas. In the recent past, land cover mapping from satellites has come of age, Through research on various issues regarding data pre-processing, classification and accuracy assessment, new and unique data / land cover products are being generated which could not be produced by earlier techniques. Various data set of the area were used for interpreting and unifying them within GIS and Image Processing environment for analysis and interpretation.

Data Available: The following data were used for this project work:

- Landsat satellite image having 28.5 meter spatial resolution.
- IRS Cartosat multispectral satellite image having 5 meter spatial resolution.
- Digital Globe high resolution image (0.5m) from Open Source Google Earth repository for Visual interpretation and as a supplementary data for interpretation.

Software Used: TNTmips Pro 2014, the integrated GIS and Image Processing platform were used in the present study.

Duration: This study took almost 90 days for various analysis and interpretation.

Workflow:

- Satellite Images were imported in a project file within TNTmips Pro platform.
- The Images were geometrically rectified with the GCP by using Geographic co-ordinate system and World Geodetic System 1984 (WGS 84) as Datum. Affine transformation model has been deliberately selected for this sampling area to maintain the geometric area and shape accuracy.
- The sampling location extends from North 24°04′29.367″ to North 24° 04′ 58.950 ″ and East 87°43′ 17.867 ″ to East 87°43′50.273″ .
- As per the present scope of study to meet the temporal data requisite two different year data has been collected.
- Image preprocessing was implemented on both the images to improve the quality and interpretability
- Extraction model was implemented on the scenes to get the 1 sq km sampling area as decided to process with in the buffer zone of 5 kilometer both of the railway track from Sealdah to Maldah at the location of Fatehpur station to get the surroundings bird′s eye view.

Google Images 1 sq Km

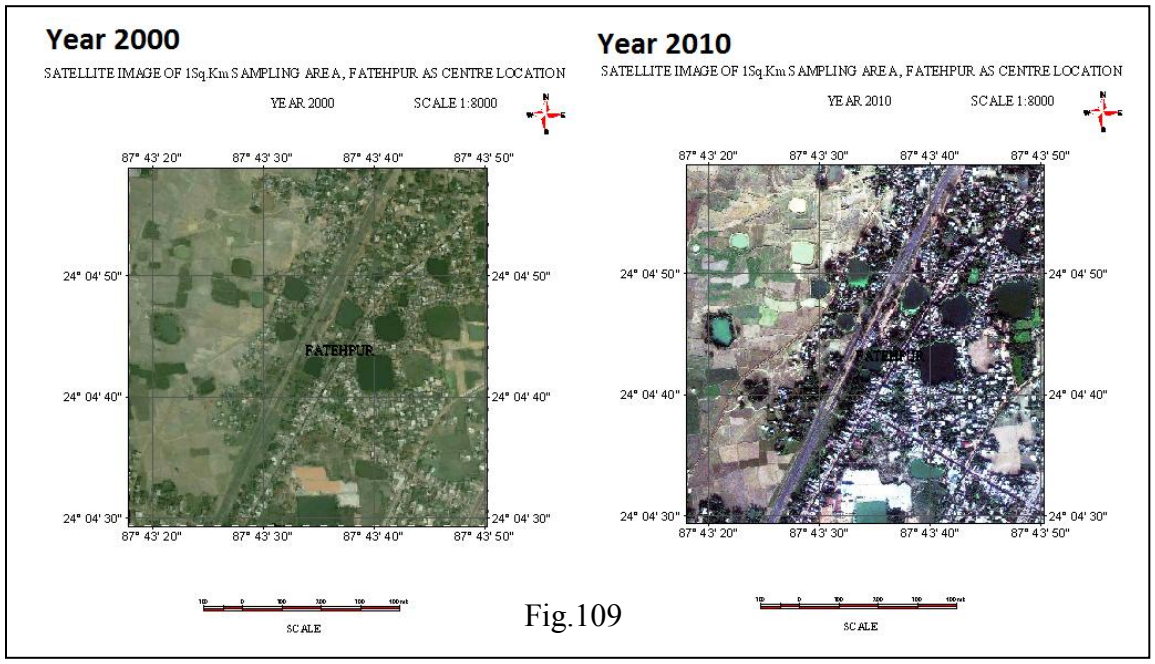


Fig.109

The given area extends from North 24° 02′ 16″ to North 24° 07′ 11″ and East 87° 46′ 15″ to East 87° 40′ 52″. The area of interest is shown below:

Google Images 78.51 sq Km

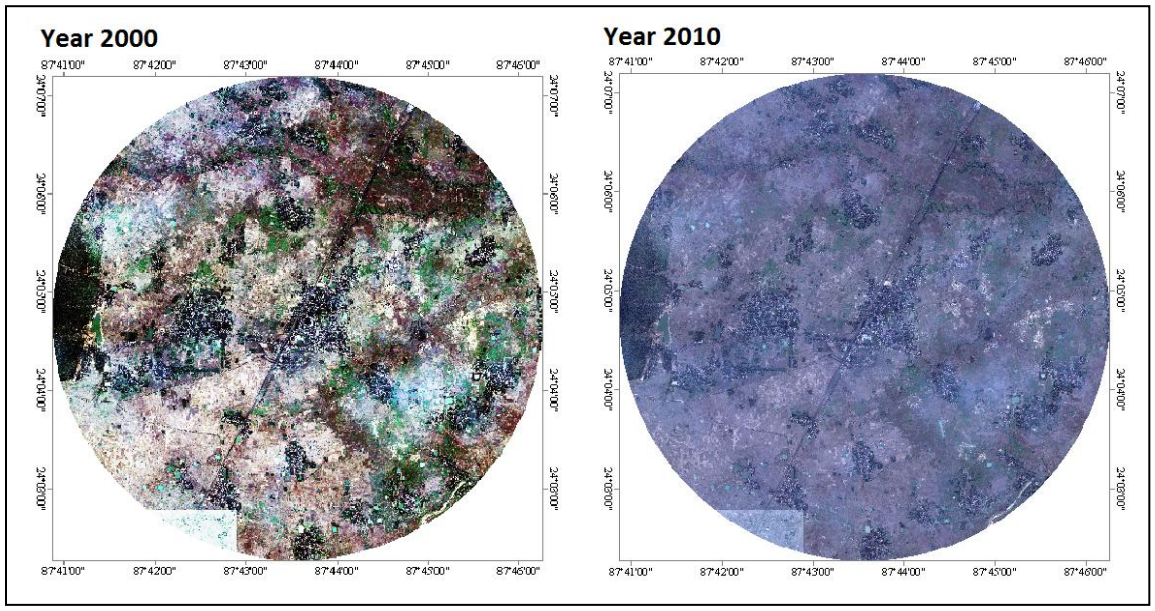


Fig.110

The study area is about 78.51sq.km.

RGB values

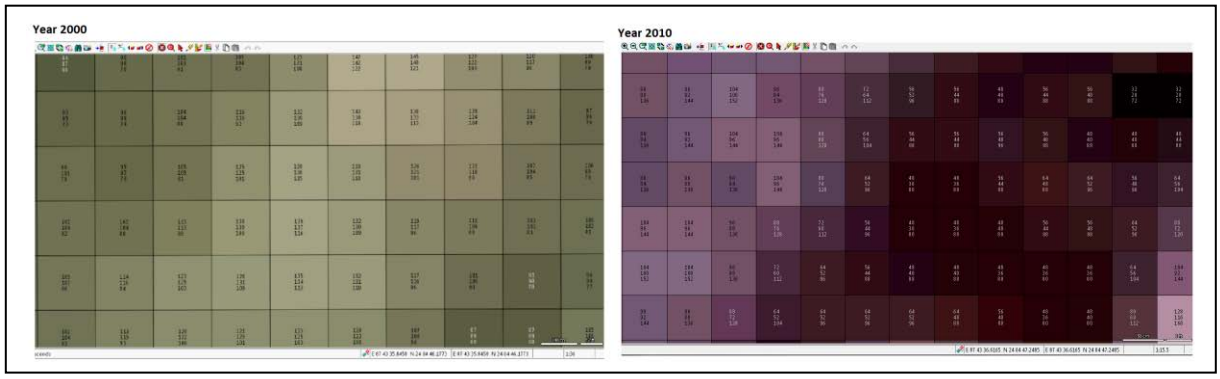


Fig.111

As a part of visual interpretation the important land-cover patterns have been delineated by using manual vectorization followed by building of topology between the spatial feature. The platform used through-out the process flow is a topology inbuilt system where we have achieved the optimum vector statistics for further comparison with digital interpreted result.

Vectorization layer

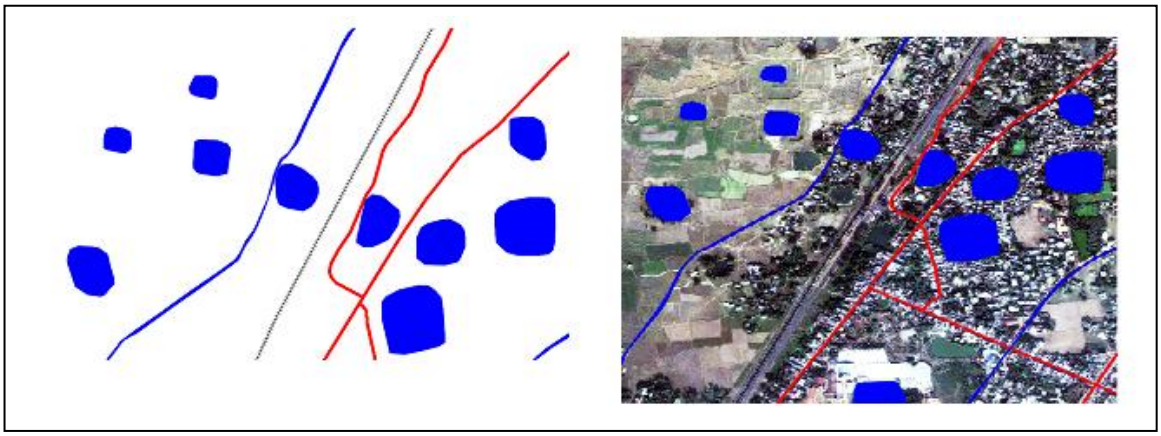


Fig.112

The implementation of the visual image interpretation technique, the areas having proper land use differentiation had been delineated. Areas are shown below:

Google Image 78.51 sq km Land Use and land cover Map

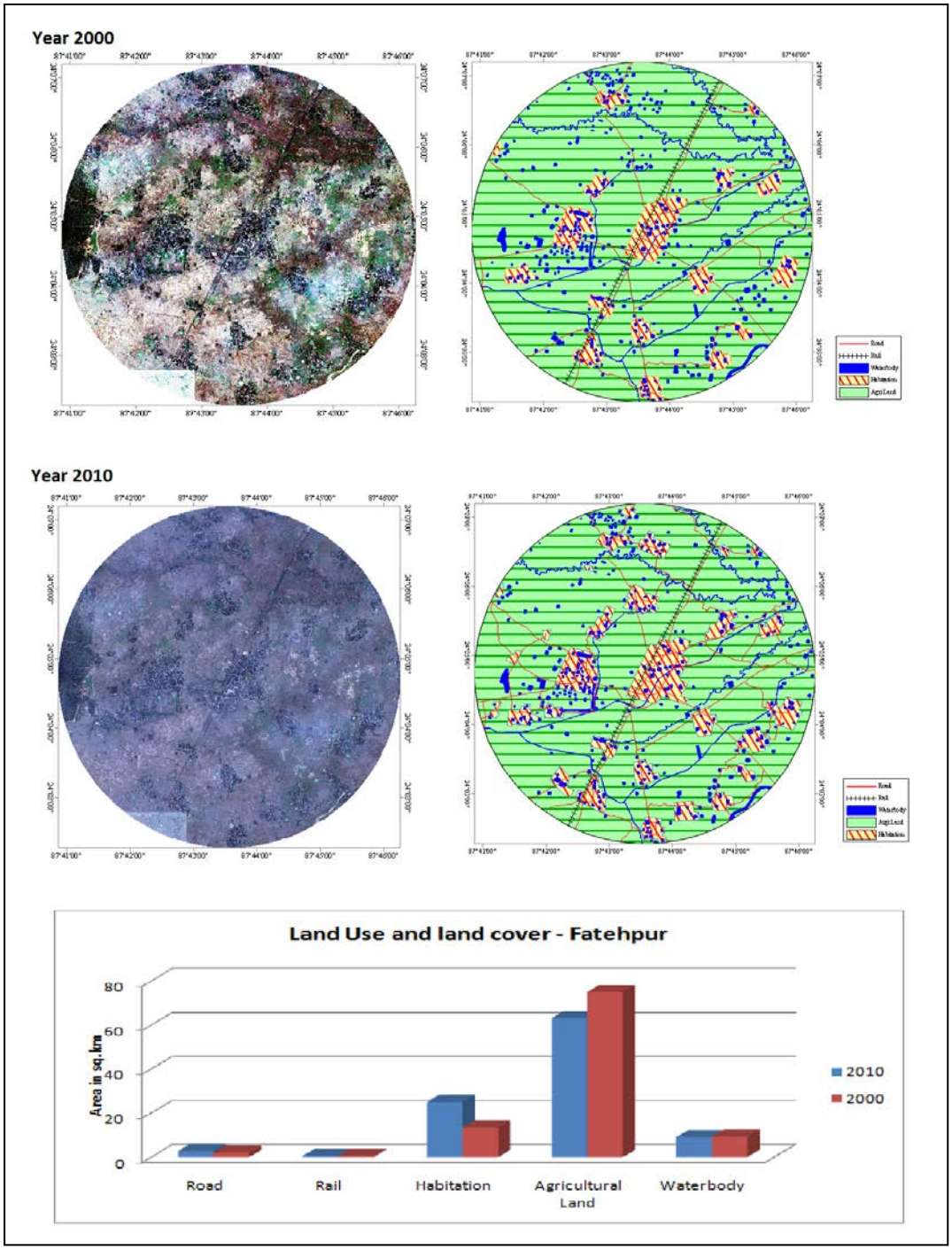


Fig.113

Factors Considered: Following factors were taken into consideration for delineating the zones of interest-

- In order to create a balanced and sustainable industrial growth in any zone and maximize use of uncultivable land in any area, it is felt that some parts of this zone can be identified as industrial growth poles, because of such factors such as availability of non-agricultural land, historical industrial presence and availability of good infrastructure. This will mean optimal use of the existing industrial infrastructure and up gradation of infrastructure where required and create new industrial infrastructure for project in backward areas.
- During land use classification habitation, vegetation and open land areas have been merged into a single category as in this scope of study we are trying to demarcate the land which can be acquired for industrial.
- From the observation of study area, most of the area covered by agricultural land. So there is high prospect in producing crop. Then it′s not healthy to create an industry in this particular area. There must have some social and political issues.
- Major criteria for industrial development is communication condition. In this area we can observed that Highway and Railway tracks are passing almost centre portion of this area

FCC Classification

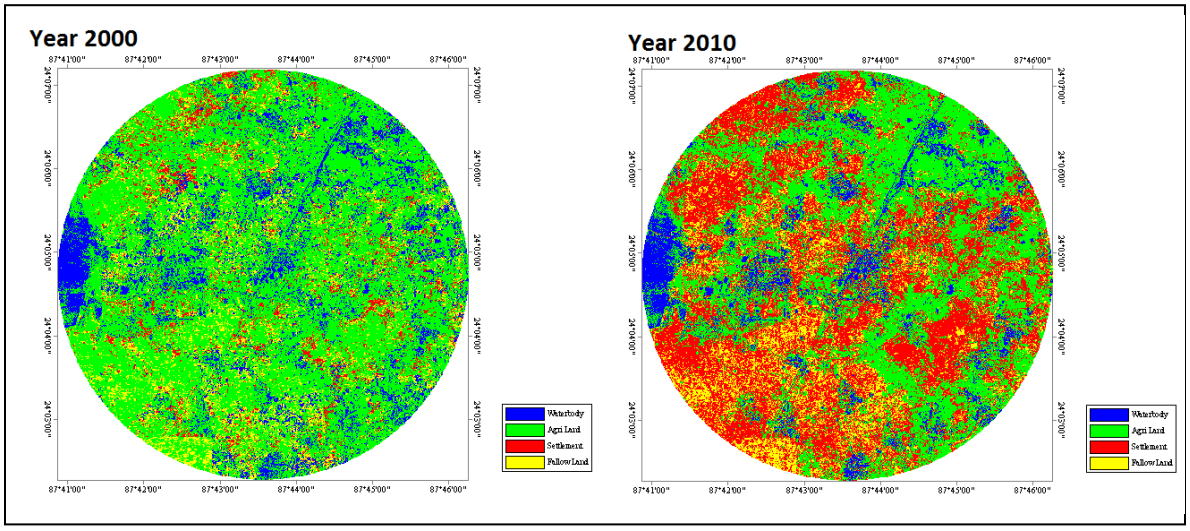


Fig.114

As we compare the FCC Classification image data of the desired area between the year 2000 and 2010 we can clearly see that the Agricultural land has decreased to some extent

due to the significant increase in settlement area and the decrease of water bodies. Also though there is potential industrial zones scattered throughout the aforementioned area, but scattered area are not healthy for built up a proper industrial zone. At least 1sq. km. continuous area is feasible for actual industrial zonation. So here setting up large or small scale factories may not be viable.

Another issue is rises up with settlement area. Here we can observe that, in the year 2010, the percentage of population is very much higher than the year 2000. So the scope of industrial is not possible in this heavy population zone, so pollution issues are arise.

In the next map the potential industrial zones are depicted for the area of interest.

Probable Industrial Zone

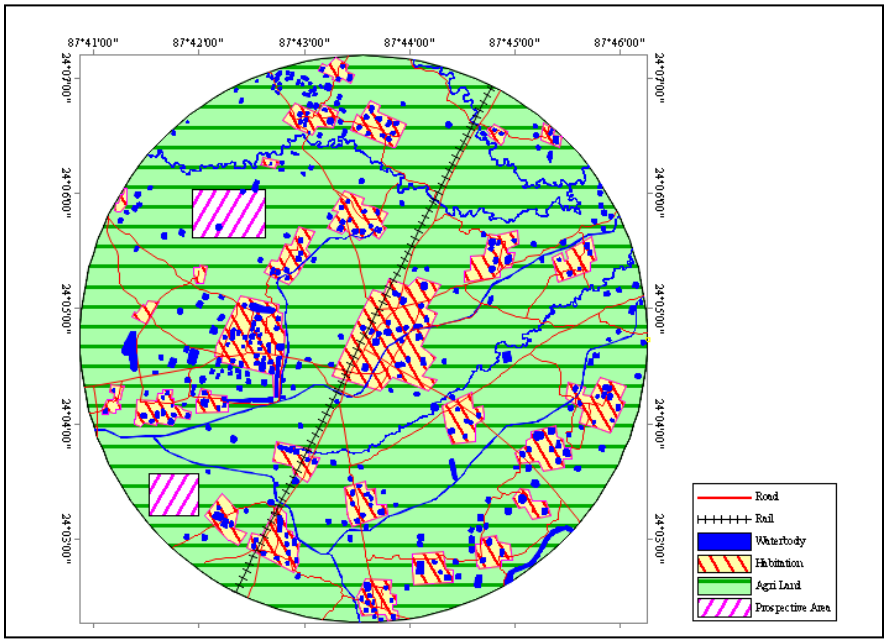


Fig.115

From this map we can clearly visualize that these two probable zones are ideal for industrial due to proper communication and availability of water. Areas of these prospective zones are 1.10 sq.km and 0.65 sq.km receptively. These two zones are under fallow land area, so it can't be hamper the agricultural growth of this particular area. Due to good communication network and availability of water resource most of the areas are densely populated and prosperity of agricultural growth are very high. So only these identified zones are feasible for industrial within our region of interest.

Communication Map

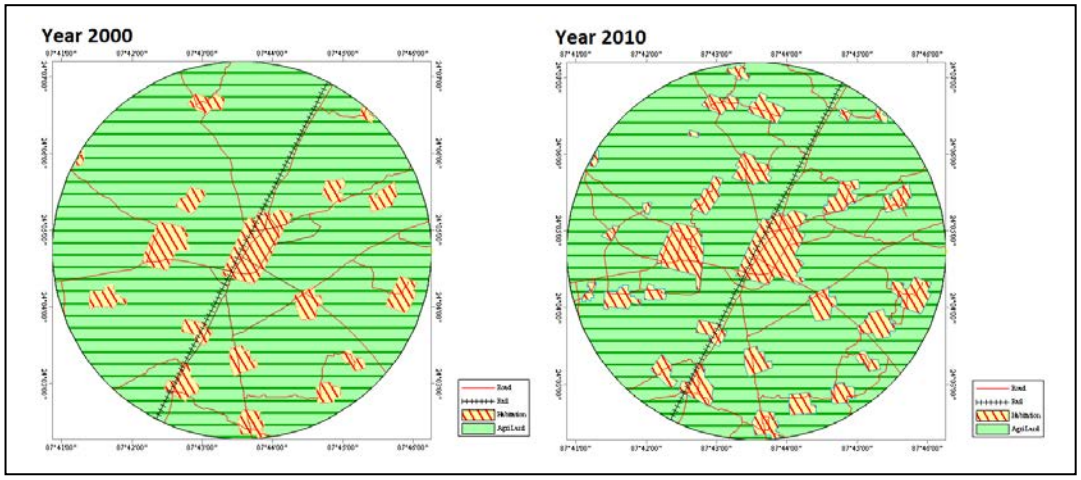


Fig.116

From this above two maps we can interpret that the communication system has been drastically change from year 2000 to year 2010 due to increase in population. So probability of industrial is maximum in this zone.

In spite of other social issues it can be concluded that this zone is superior for industrial.

Considering all these factors, the actual suggested area for industrial has shown below:

Actual prospective Area

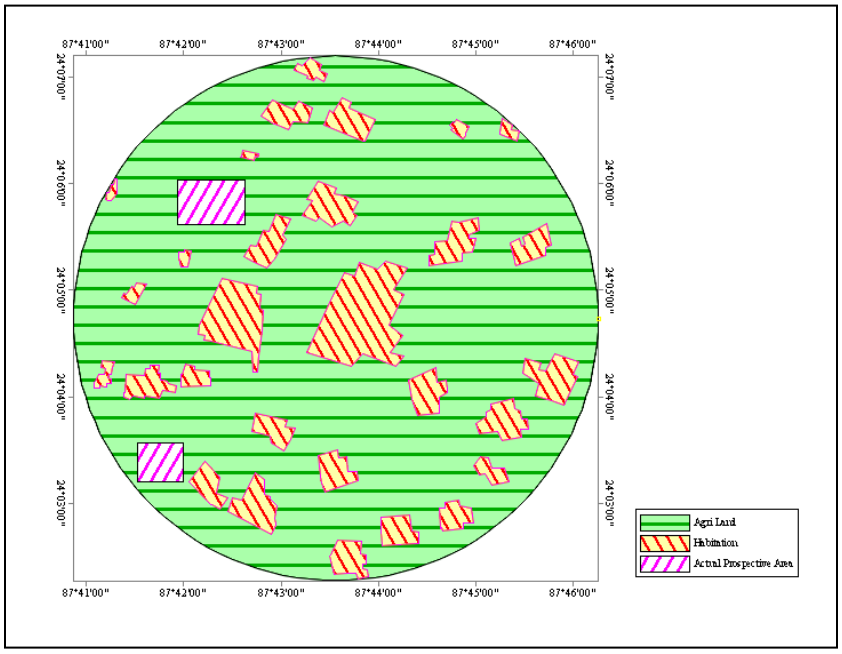


Fig.117

Conclusion: In the present status of study all the parameters related to industrial suitability had not been considered. The zones, which had been delineated as prospective area, should be verified using the field data. So, the delineated zones are the probable prospective area.

So using the same manual interpretation technique both the images were visually classified to get the spatial changes between the years-

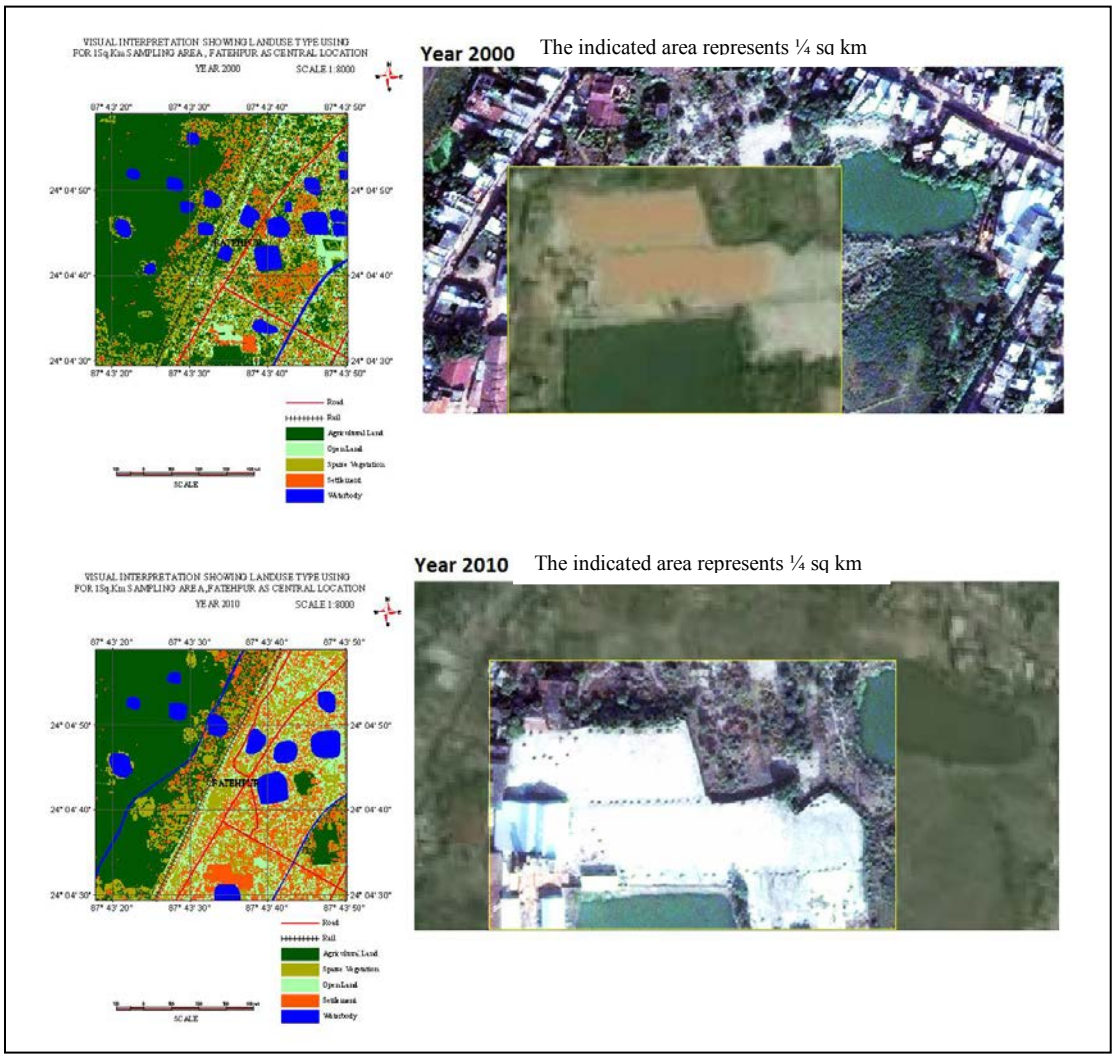


Fig.118

At the other hand same images have been used for digital image classification. The study area has been passed through hybrid classification technique, where the unsupervised classification has been followed by supervised classification method and finally the spurious classes were deliberately merged to get the intended result.

Google Image 1 sq km Land Use and land cover Map

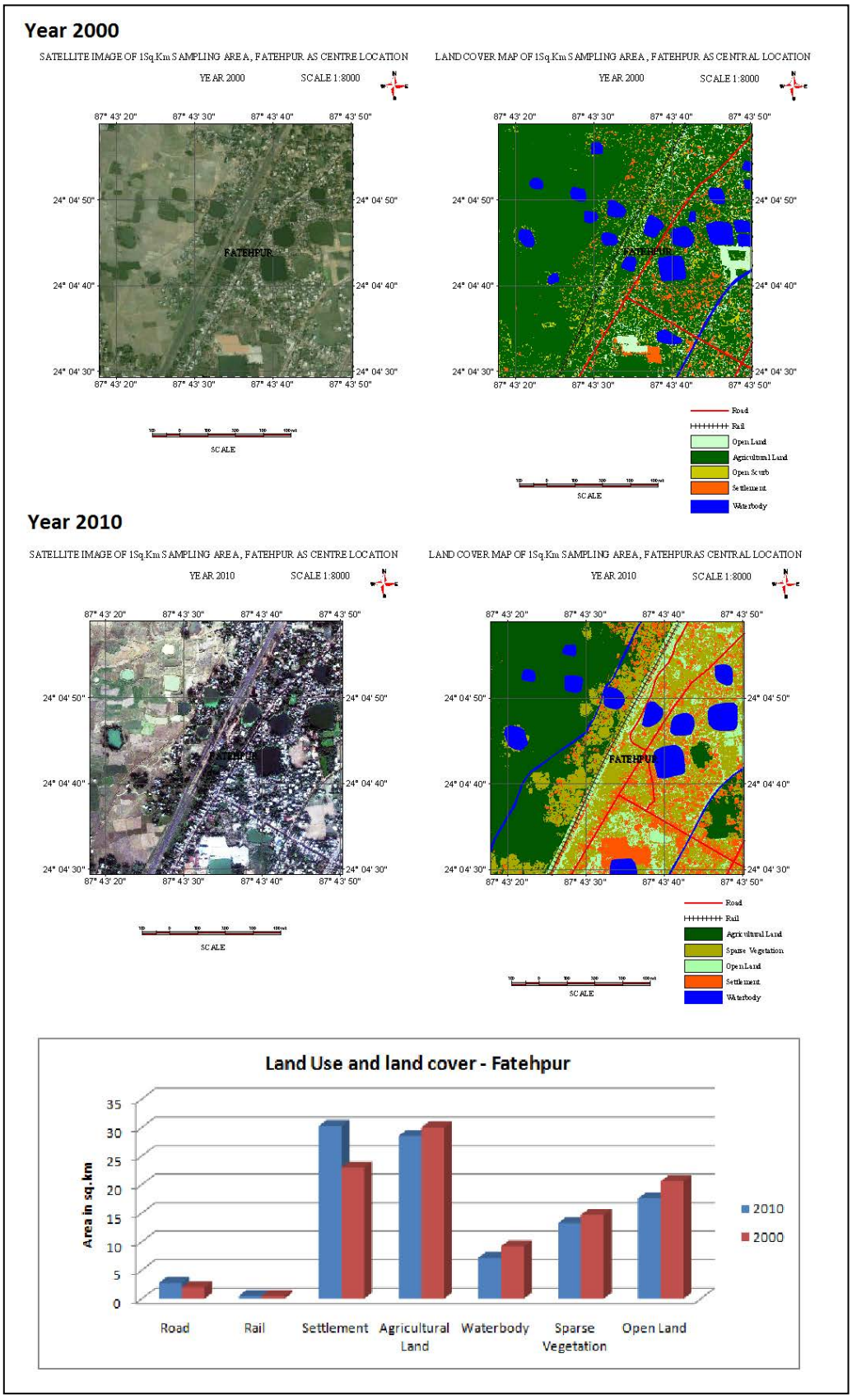


Fig.119

Cartographical map preparation with suitable scale. Throughout the mapping we have tried to use A4 page where maps were fitted with 1:8000 scale.

Interpretation and discussion

The sampling zone belongs to the surrounding of railway station of Fatehpur, South 24 Parganas is mostly occupied by settlement area, agriculture land and water body. For last ten years there is nothing to notice in terms of land use change except increase of population rather settlement area. As the area dominating with agricultural land observation is in terms of agricultural practice with increasing awareness program for increasing the productivity. No industry is traced within this sampling zone.

Land use and Land cover - Changing Pattern

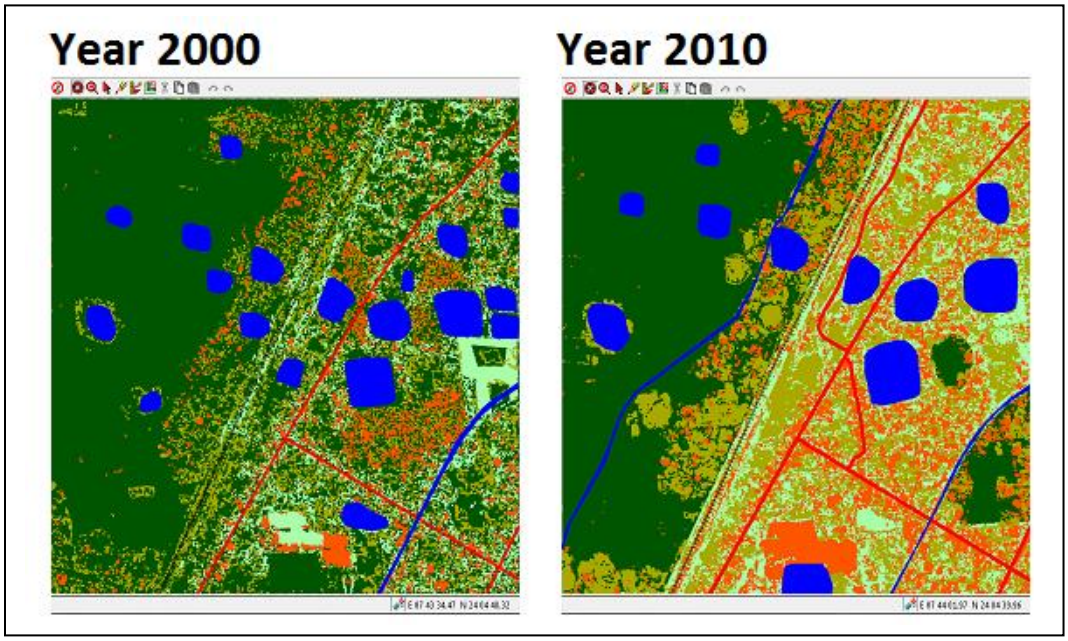


Fig.120

So, the spatial dynamics with this buffer zone can be depicted as increase in settlement, decrease in water body and change in agricultural practice. As a priority land use this is an agricultural zone where agro based industry can be developed.

Land Use and land cover Map
Pramanic Bus Stop (North 24 Parganas, West Bengal)

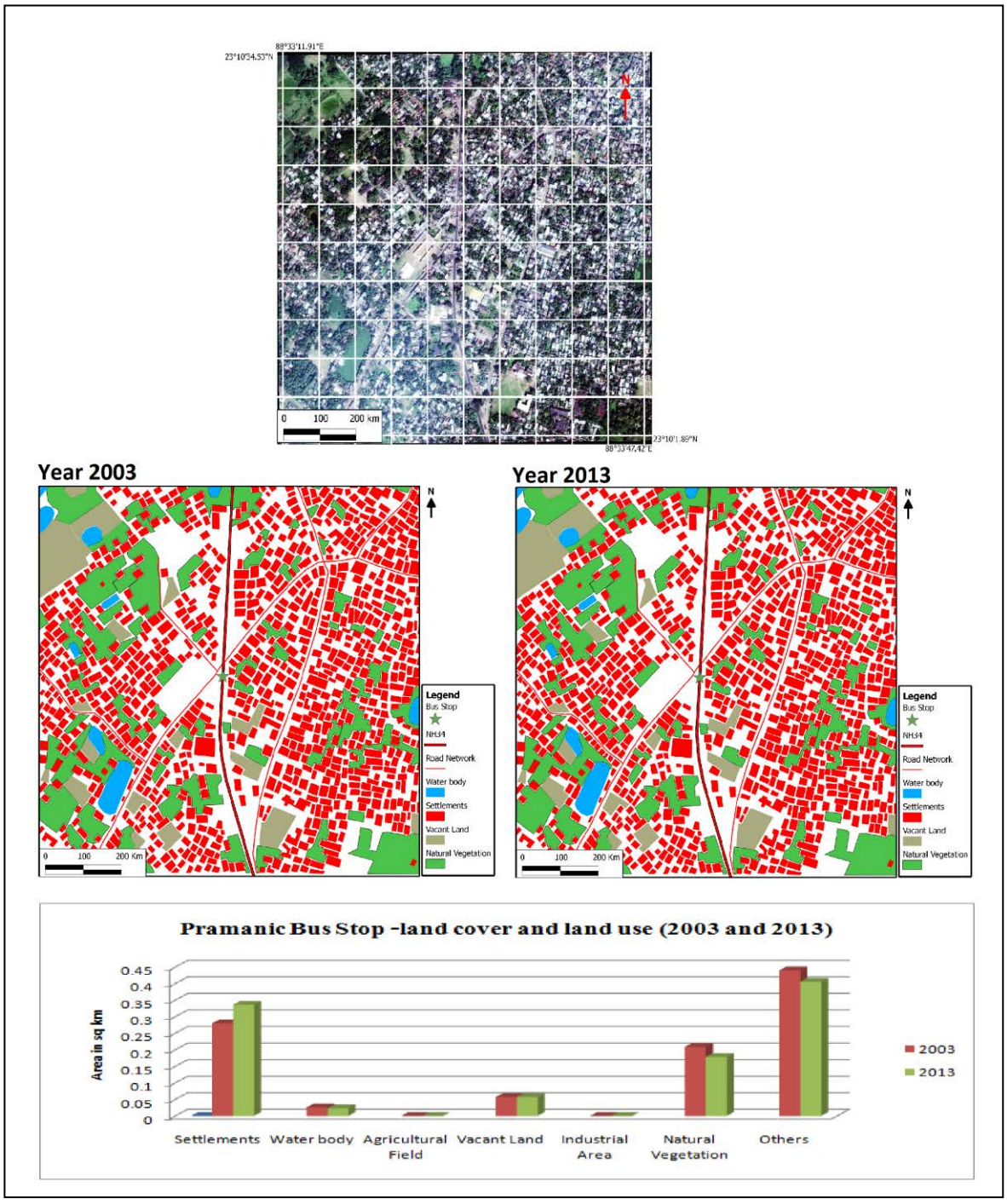


Fig.121

At Pramanic Bus Stop, there is increase in settlement, water body, vacant land, natural vegetation and others and decrease is noticed in agricultural field in the year 2013 compared to 2003.

Land Use and land cover Map
Bethuadahari Bus Stop (Nadia, West Bengal)

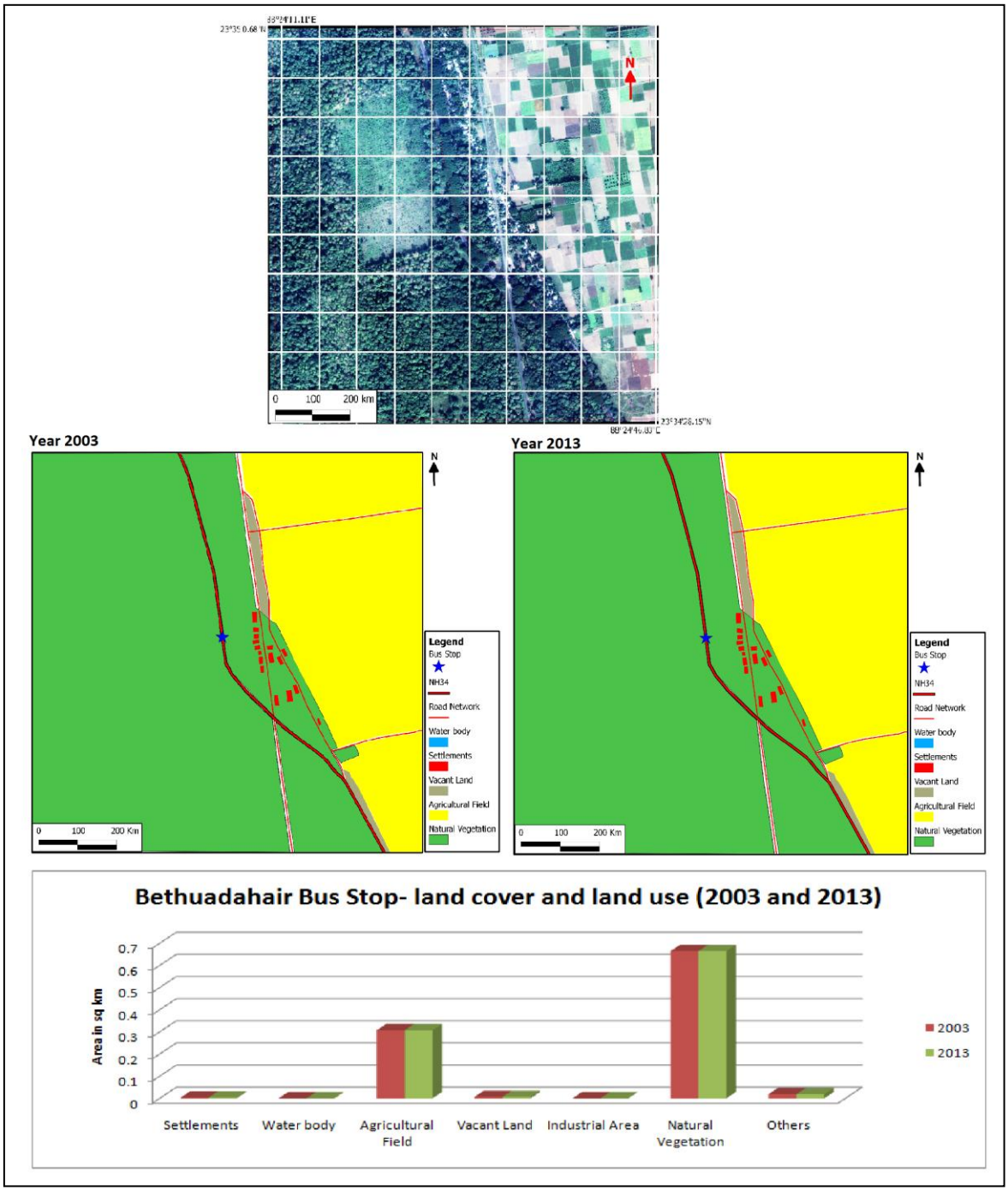


Fig.122

At Bethuadahari bus stop, there is increase in settlement, water body, vacant land, natural vegetation and others and decrease is noticed in agricultural field in the year 2013 compared to 2003.

"R.S and G.I.S application in spatial dynamics of agriculture and industry along Sealdah-Maldah Transact, West Bengal"

Sampling Zone: Tildanga and its Surrounding areas, Murshidabad District, WB

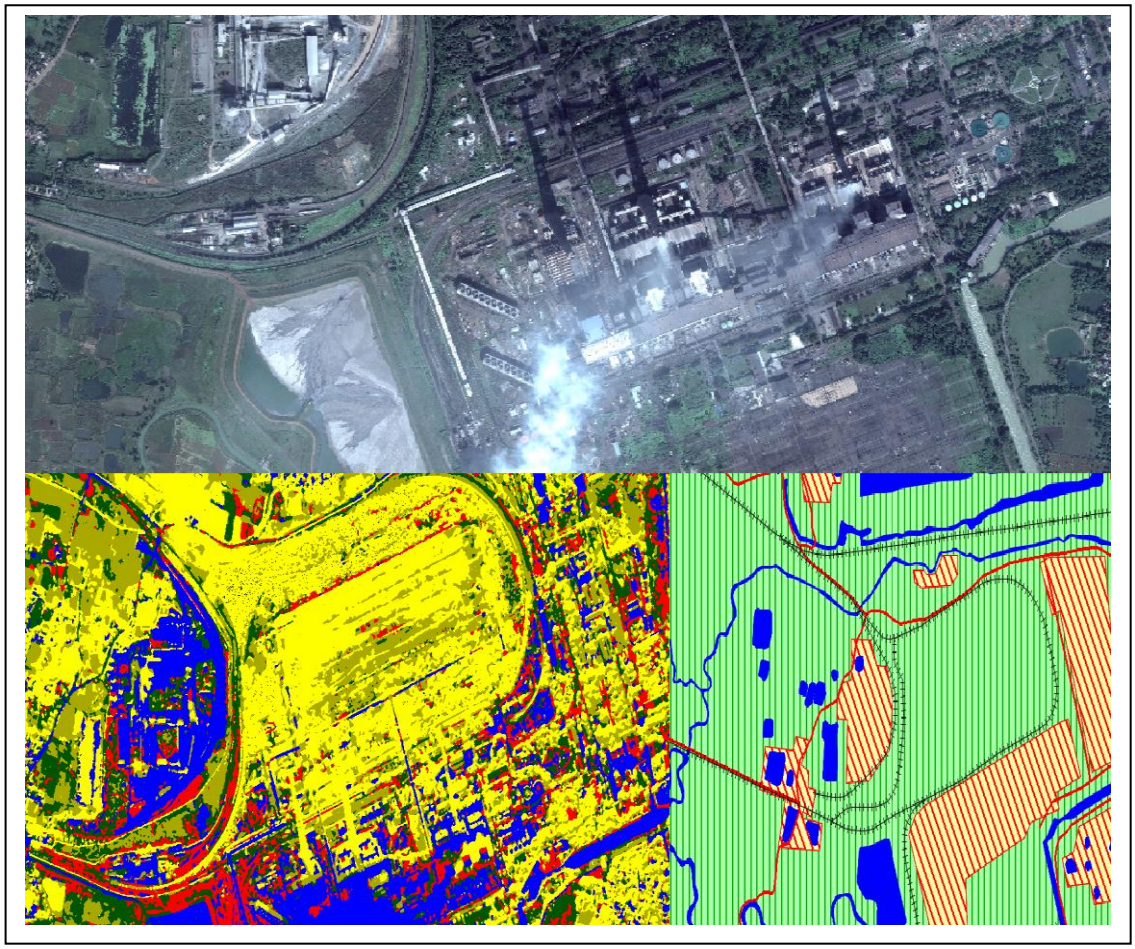


Fig.123

Objective: Economic development and population growth have triggered rapid changes to Earth's land cover over the last two centuries, and there is every indication that the pace of these changes will accelerate in the future. The present study shows the utility of remote sensing techniques integrated with GIS to study the spatial dynamics of Agriculture and Industry in the selected specified study area and its surroundings in Tildanga, Murshidabad District. Various satellite image data were analyzed within a digital image processing system to provide up-to-date information of the whole area. The extracted information from remotely sensed data was then integrated with visually interpreted information and field inputs in a GIS to create a comprehensive spatial database. This permitted the integration of several layers of information with the remotely sensed data in both temporal and spatial dimensions.

Background: Remote sensing technology has been recognized as a useful means of supplying up to date information and have the potential to respond to the growing and urgent demand for timely and accurate land cover information over large areas. In the recent past, land cover mapping from satellites has come of age, Through research on various issues regarding data pre-processing, classification and accuracy assessment, new and unique data / land cover products are being generated which could not be produced by earlier techniques. Various data set of the area were used for interpreting and unifying them within GIS and Image Processing environment for analysis and interpretation.

Data Available: The following data were used for this project work:

- Landsat satellite image having 28.5 meter spatial resolution.
- IRS Cartosat multispectral satellite image having 5 meter spatial resolution.
- Digital Globe high resolution image (0.5m) from Open Source Google Earth repository for Visual interpretation and as a supplementary data for interpretation.

Software Used: TNTmips Pro 2014, the integrated GIS and Image Processing platform were used in the present study.

Duration: This study took almost 90 days for various analysis and interpretation.

Workflow:

- Satellite Images were imported in a project file within TNTmips Pro platform.
- The Images were geometrically rectified with the GCP by using Geographic co-ordinate system and World Geodetic System 1984 (WGS 84) as Datum. Affine transformation model has been deliberately selected for this sampling area to maintain the geometric area and shape accuracy.
- The sampling location extends from North 24°46′55.651″ to North 24°47′ 28.192″ and East 87°52′ 06.627 ″ to East 87°52′ 42.257″ .
- As per the present scope of study to meet the temporal data requisite two different year data has been collected.
- Image preprocessing was implemented on both the images to improve the quality and interpretability
- Extraction model was implemented on the scenes to get the 1 sq km sampling area as decided to process with in the buffer zone of 5 kilometer both of the railway track from Sealdah to Maldah at the location of Tildanga station to get the surroundings bird′s eye view.

Google images 1sq km

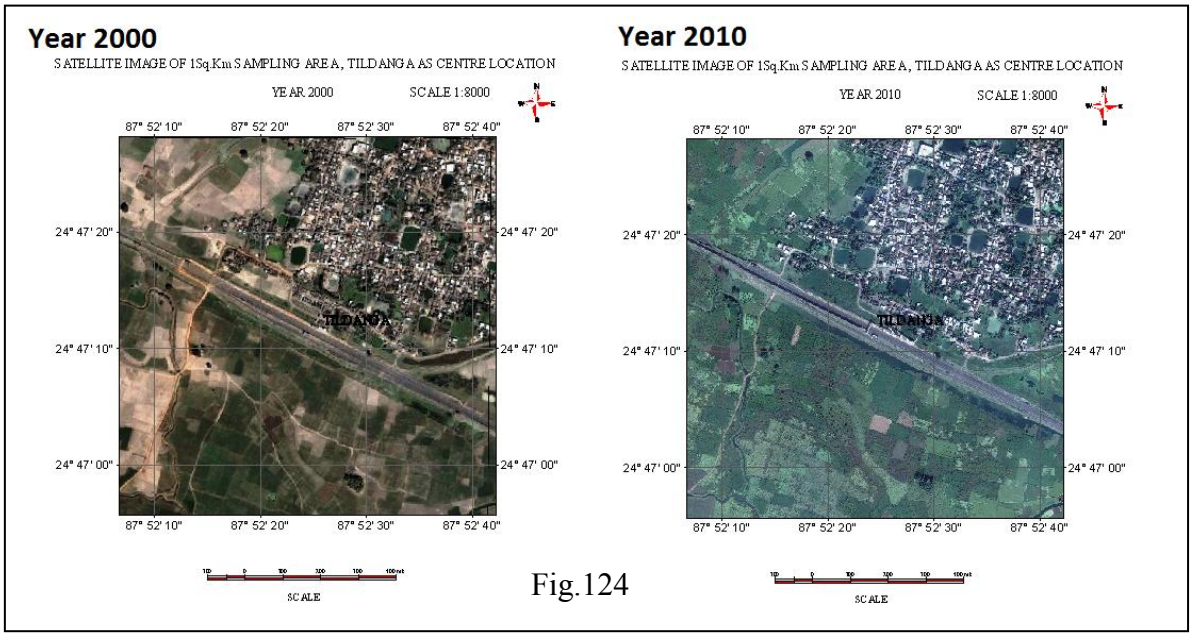
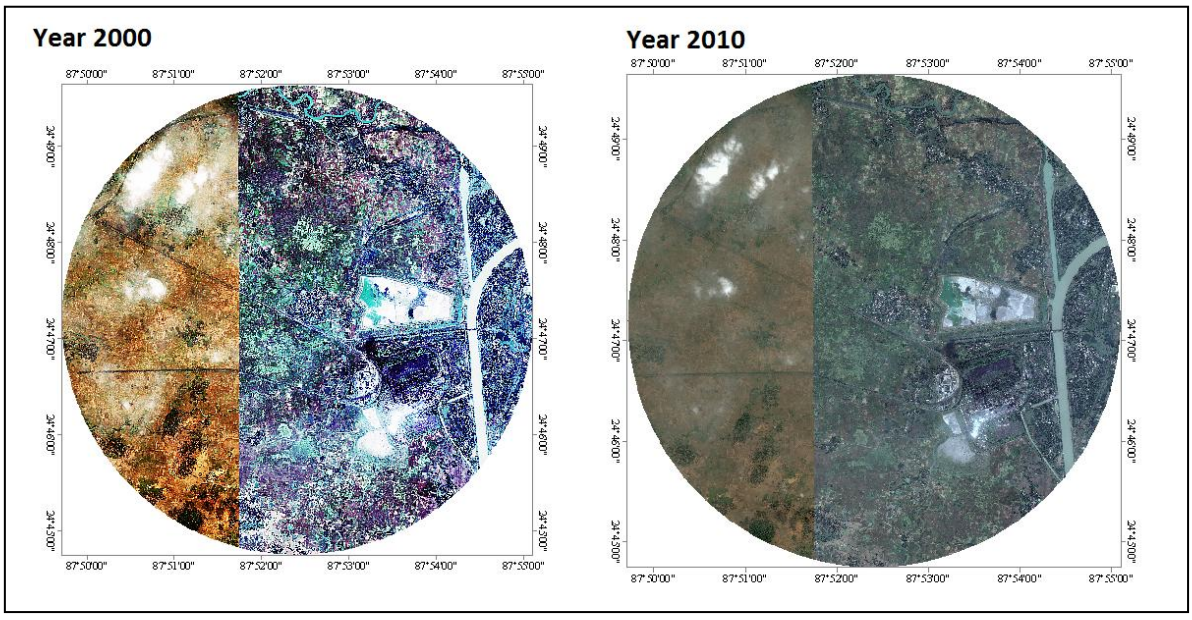


Fig.124

The given area extends from North 24°44′45″ to North 24°49′38″ and East 87°55′06″ to East 87°49′42″. The area of interest is shown below:

Google Images 78.51sq.km



The study area is about 78.51sq.km.

Fig.125

Once we have the processed image for both the years the remarkable change between reflectance values were quite obvious study though this factor is highly dependent on the solar illumination of that particular time and date. Here is a comparative diagram of those values of particular location-

RGB values

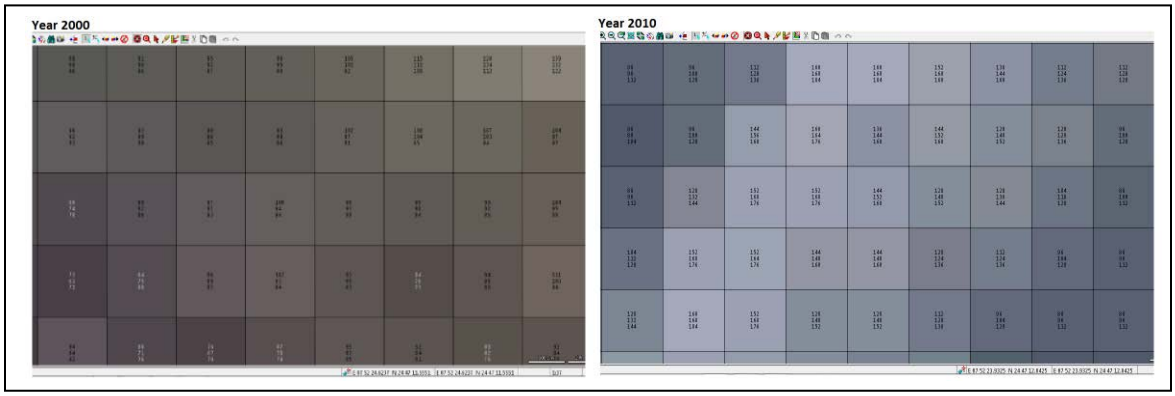


Fig.126

As a part of visual interpretation the important land-cover patterns have been delineated by using manual vectorization followed by building of topology between the spatial features. The platform used through-out the process flow is a topology inbuilt system where no we have achieved the optimum vector statistics for further comparison with digital interpreted result.

Vectorization Map

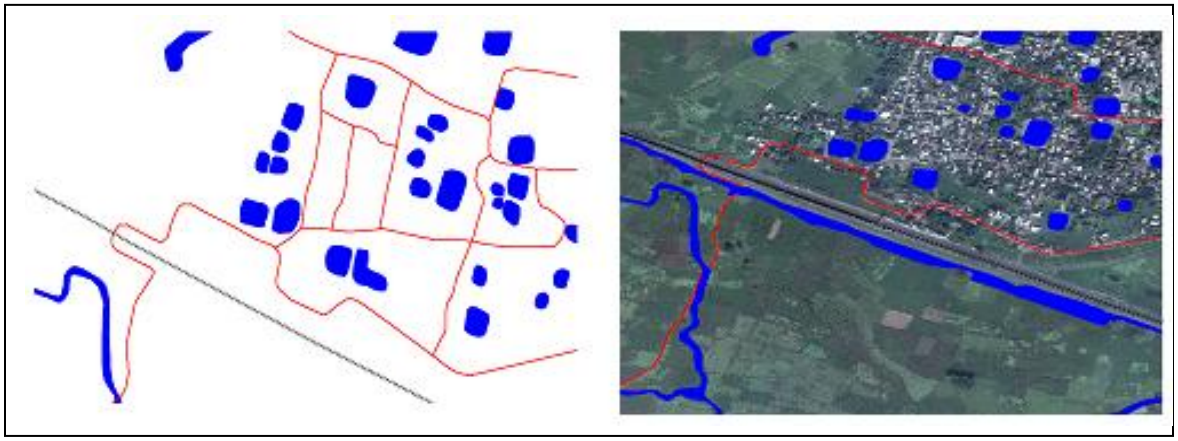


Fig.127

Google Image 78.51 sq km Land Use and land cover Map

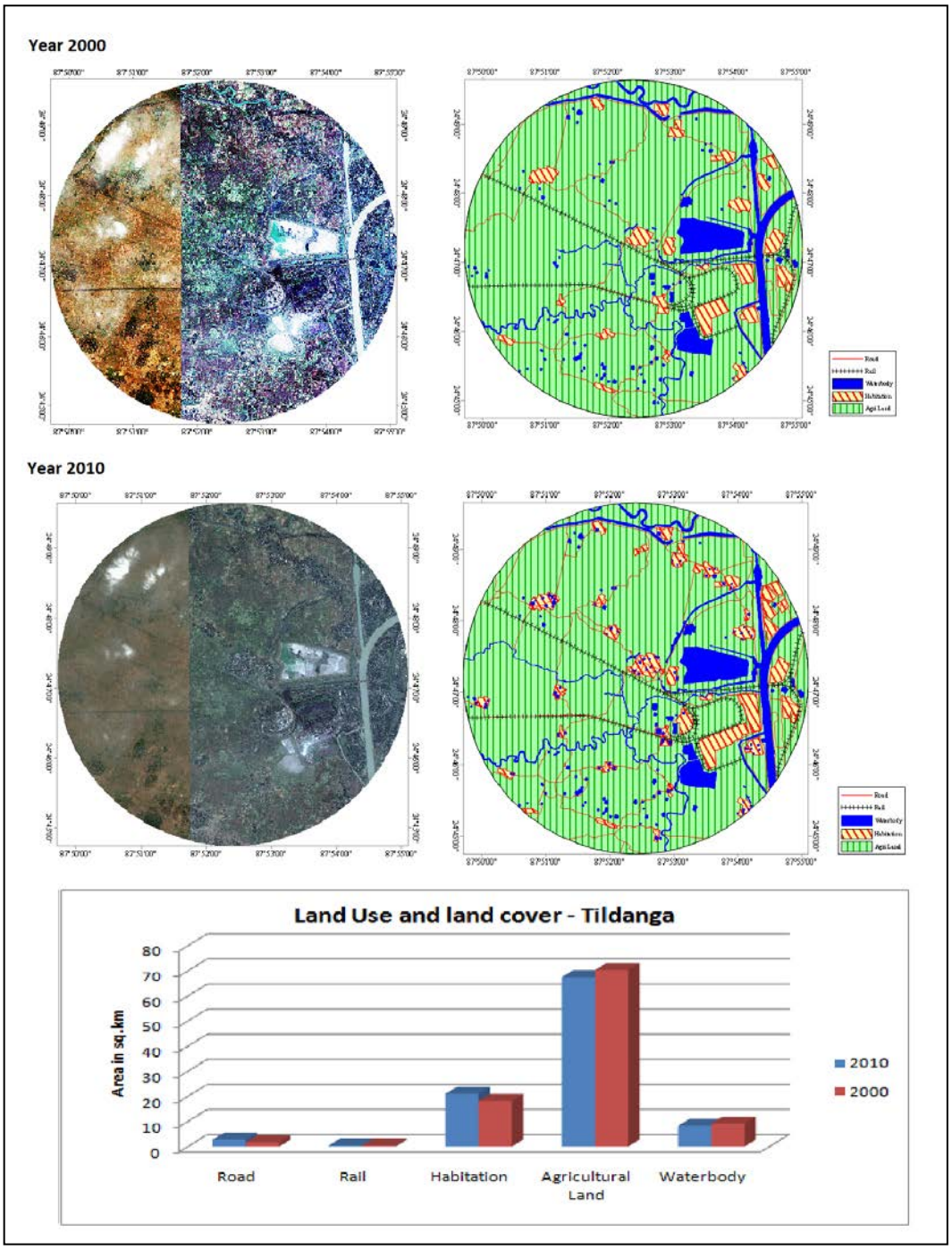


Fig.128

Factors Considered: Following factors were taken into consideration for delineating the zones of interest-

- In order to create a balanced and sustainable industrial growth in any zone and maximize use of uncultivable land in any area, it is felt that some parts of this zone can be identified as industrial growth poles, because of such factors such as availability of non-agricultural land, historical industrial presence and availability of good infrastructure. This will mean optimal use of the existing industrial infrastructure and up gradation of infrastructure where required and create new industrial infrastructure for project in backward areas.
- During land use classification habitation, vegetation and open land areas have been merged into a single category as in this scope of study we are trying to demarcate the land which can be acquired for industrial.
- From the observation of study area, most of the area covered by agricultural land. So there is high prospect in producing crop. Then it′s not healthy to create an industry in this particular area. There must have some social and political issues.
- Major criteria for industrial development is communication condition. In this area we can observed that Highway and Railway tracks are passing almost centre portion of this area

FCC Classification

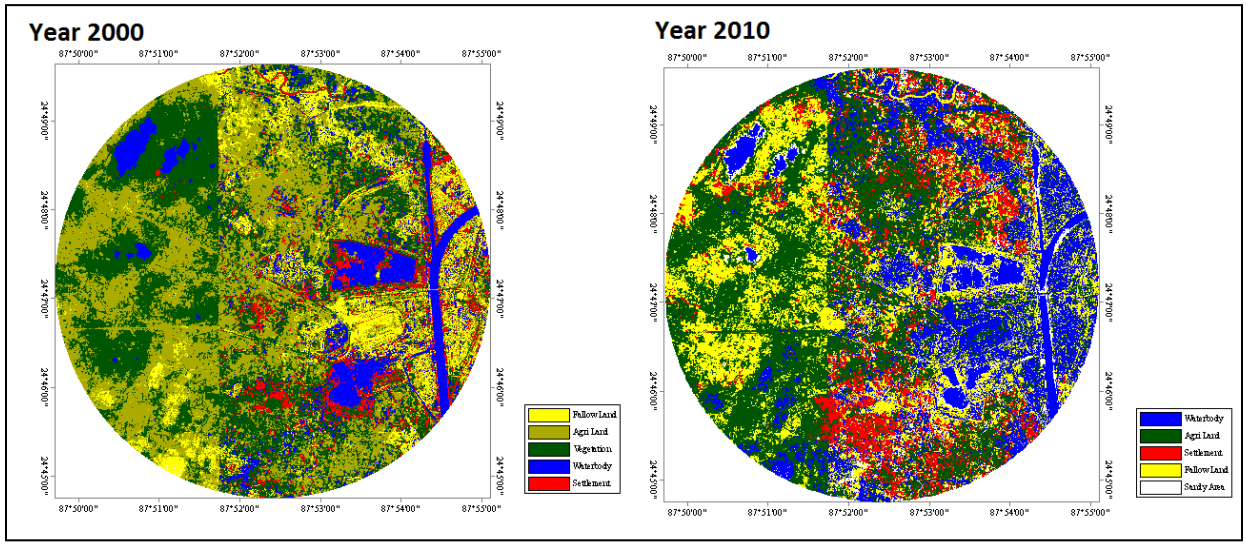


Fig.129

As we compare the FCC Classification image data of the desired area between the year 2000 and 2010 we can clearly see that the agricultural land has decreased to some extent due to the significant increase in settlement area and the decrease of water bodies. Also though there is potential industrial zones scattered throughout the aforementioned area, but scattered area are not healthy for built up a proper industrial zone. At least 1sq. km. continuous area is feasible for actual industrial zonation. So here setting up large or small scale factories may not be viable.

Another issue is rises up with settlement area. Here we can observe that, in the year 2010, the percentage of population is very much higher than the year 2000. So the scope of industrial is not possible in this heavy population zone, so pollution issues are arise.

In the next map the potential industrial zones are depicted for the area of interest.

Probable Industrial Zone

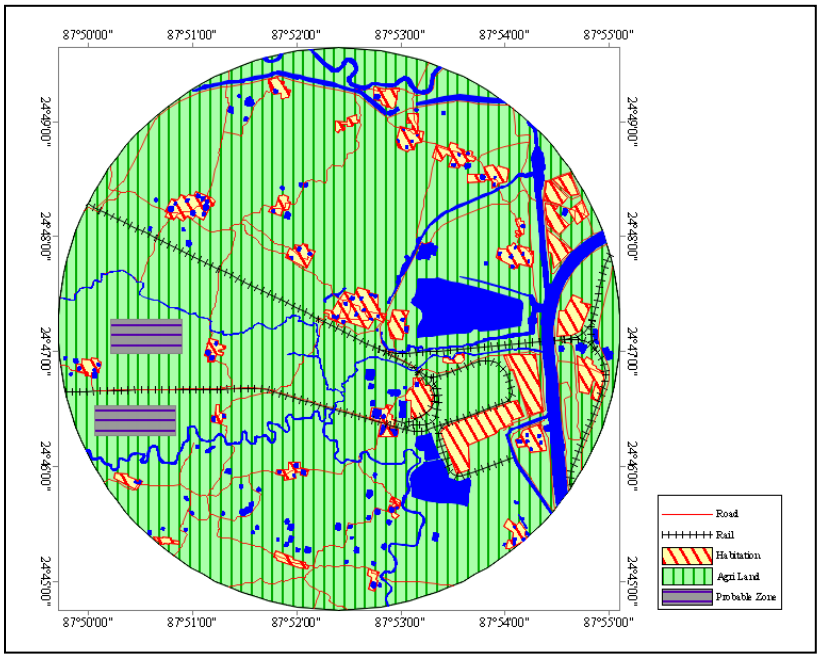


Fig.130

From this map we can clearly visualize that these two probable zones are ideal for industrial due to proper communication and availability of water. Areas of these prospective zones are 0.75 sq.km. and 0.76 sq.km. receptively. These two zones are under fallow land area, so it can't be hamper the agricultural growth of this particular area. Due to good communication network and availability of water resource most of the areas are

densely populated and prosperity of agricultural growth are very high. So only these identified zones are feasible for industrial within our region of interest.

Communication Map

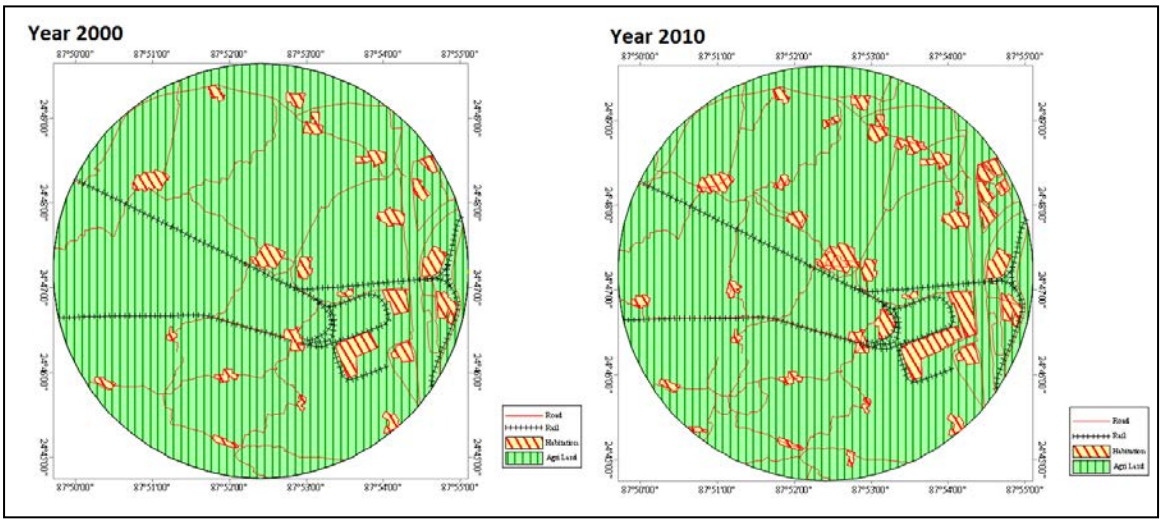


Fig.131

From this above two maps we can interpret that the communication system has been drastically change from year 2000 to year 2010 due to increase in population. So probability of industrial is maximum in this zone.

In spite of other social issues it can be concluded that this zone is superior for industrial.

Considering all these factors, the actual suggested area for industrial has shown below:

Actual prospective Industrial area

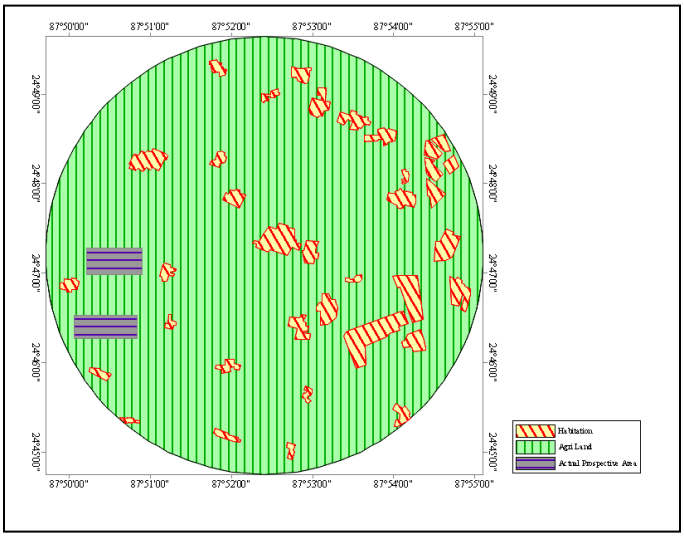


Fig.132

Conclusion: In the present status of study all the parameters related to industrial suitability had not been considered. The zones, which had been delineated as prospective area, should be verified using the field data. So, the delineated zones are the probable prospective area.

So using the same manual interpretation technique both the images were visually classified to get the spatial changes between the years-

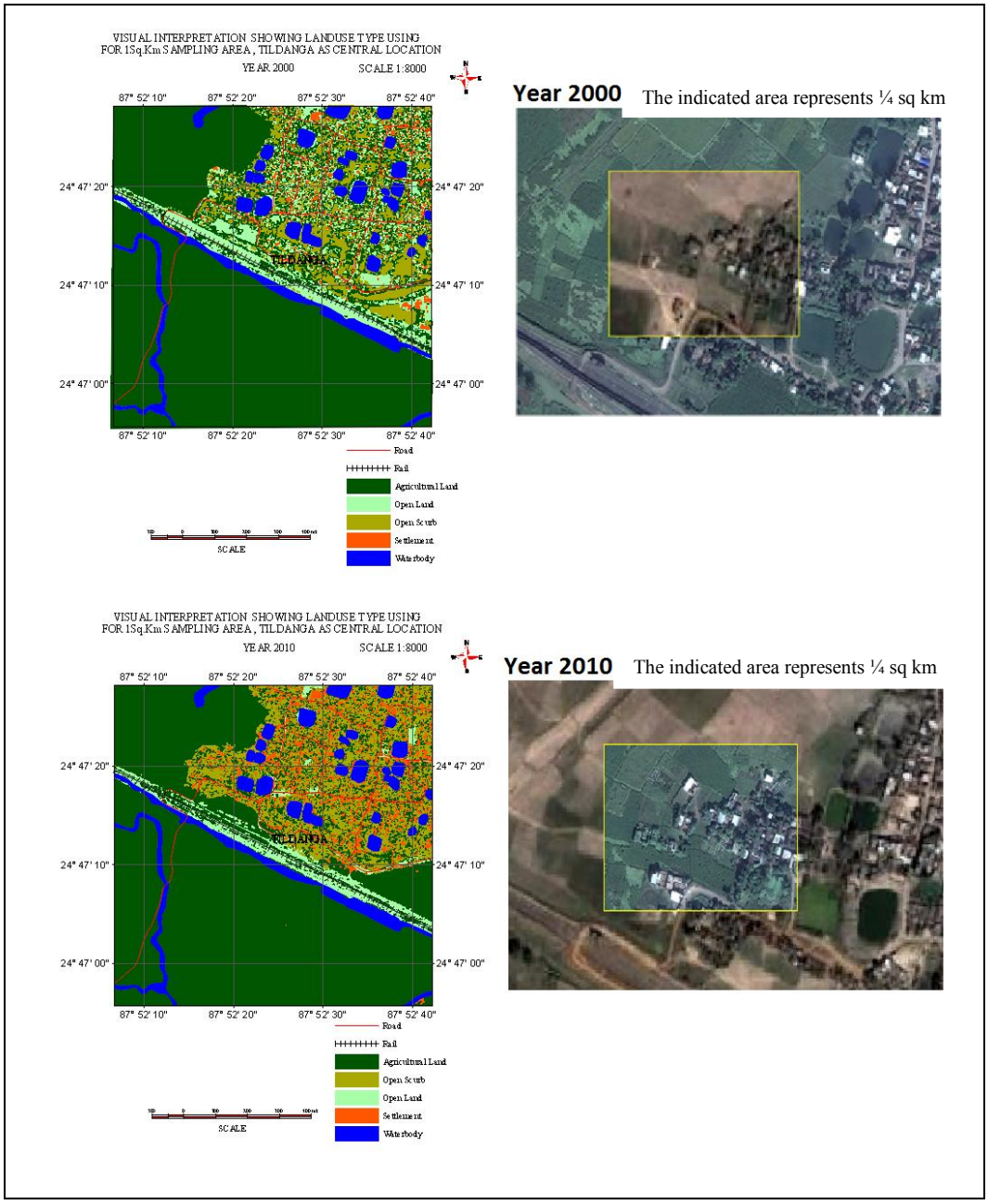


Fig.133

At the other hand same images have been used for digital image classification. The study area has been passed through hybrid classification technique, where the unsupervised classification has been followed by supervised classification method and finally the spurious classes were deliberately merged to get the intended result.

Google Image 1 sq km Land Use and land cover Map

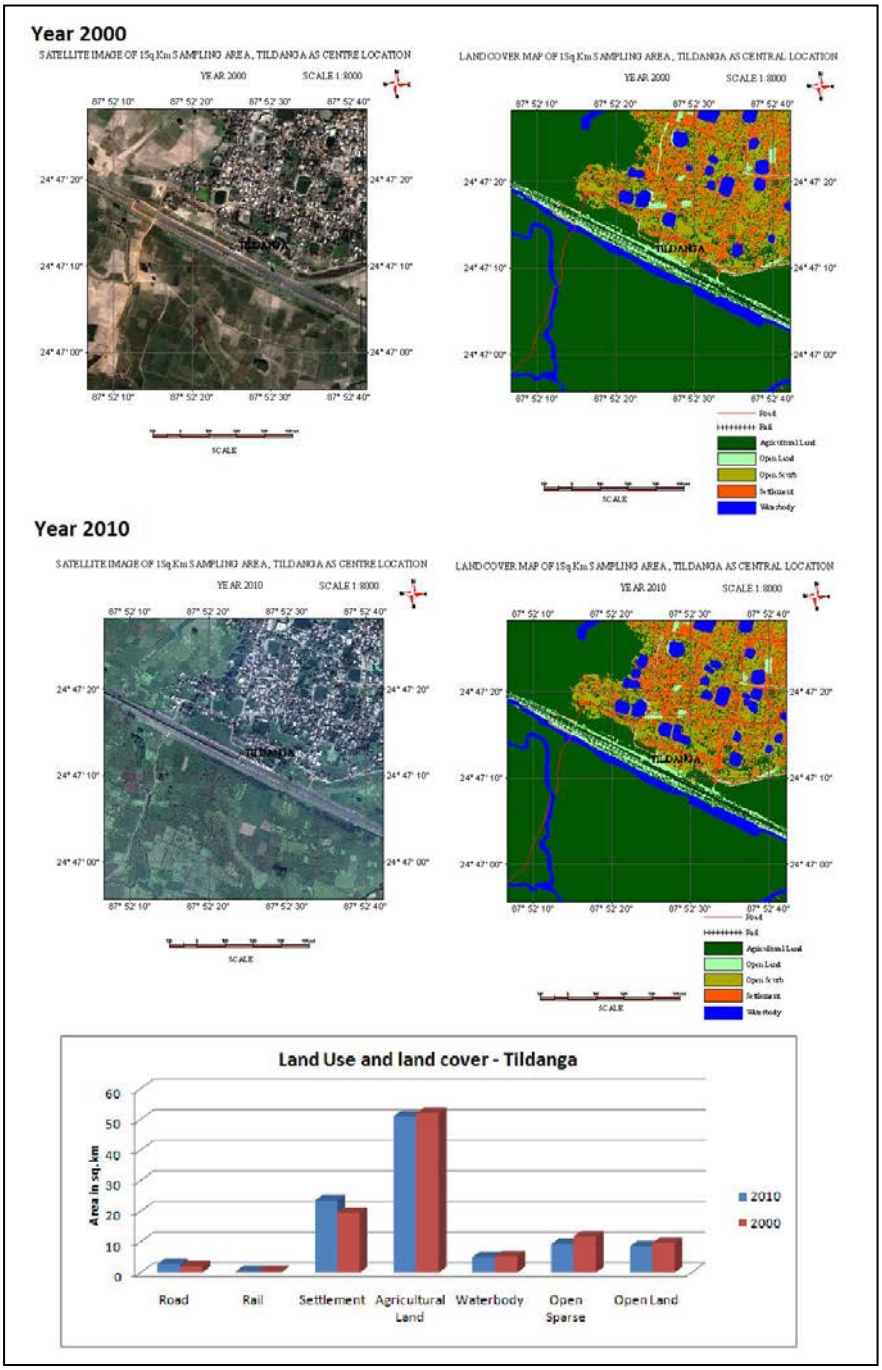


Fig.134

Cartographical map preparation with suitable scale. Throughout the mapping we have tried to use A4 page where maps were fitted with 1:8000 scale.

Interpretation and discussion

So, the procedural steps with the rigorous interpretation with both visual and digital technique for the study area between the years 2000 and 2010 this can be clearly interpreted that the '*Open Land'* and *'Open Scrub'* has decreased to huge extent due to the significant increase in 'settlement' area. As this zone is belongs to the one of the famous city of Murshidabad district, naturally the population is dramatically increased during last 10 years.

Land use and Land cover - Changing Pattern

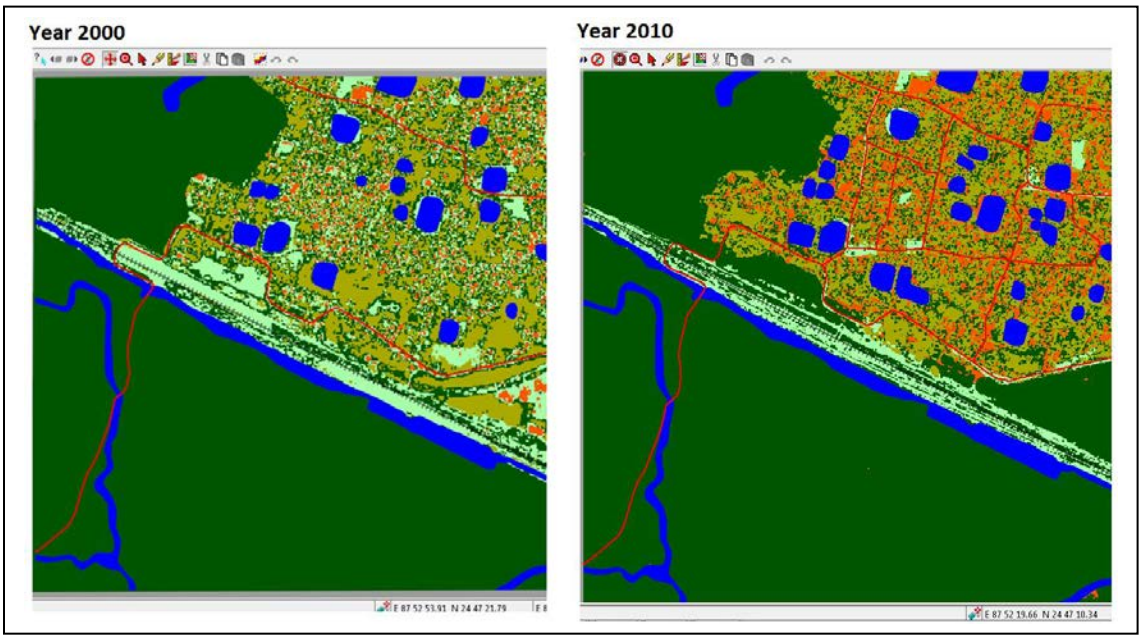


Fig.135

So, spatial dynamics has dramatically changed during last 10 years where the population change is quite significant in the quest of earning and lively hood. Naturally there is notable increase in small scale industries to the circumferences of this sampling study area. Time series study shows that, agricultural land is still prime landcover type in this zone. Major socio-economy component is based on cultivation. Immediate consequence of which is the boom in the agro-based industries. Also extension of road networks in the local habitat ensures the overall development in livelihood

Land Use and land cover Map

Sargachhi Bus Stop (Murshidabad, West Bengal)

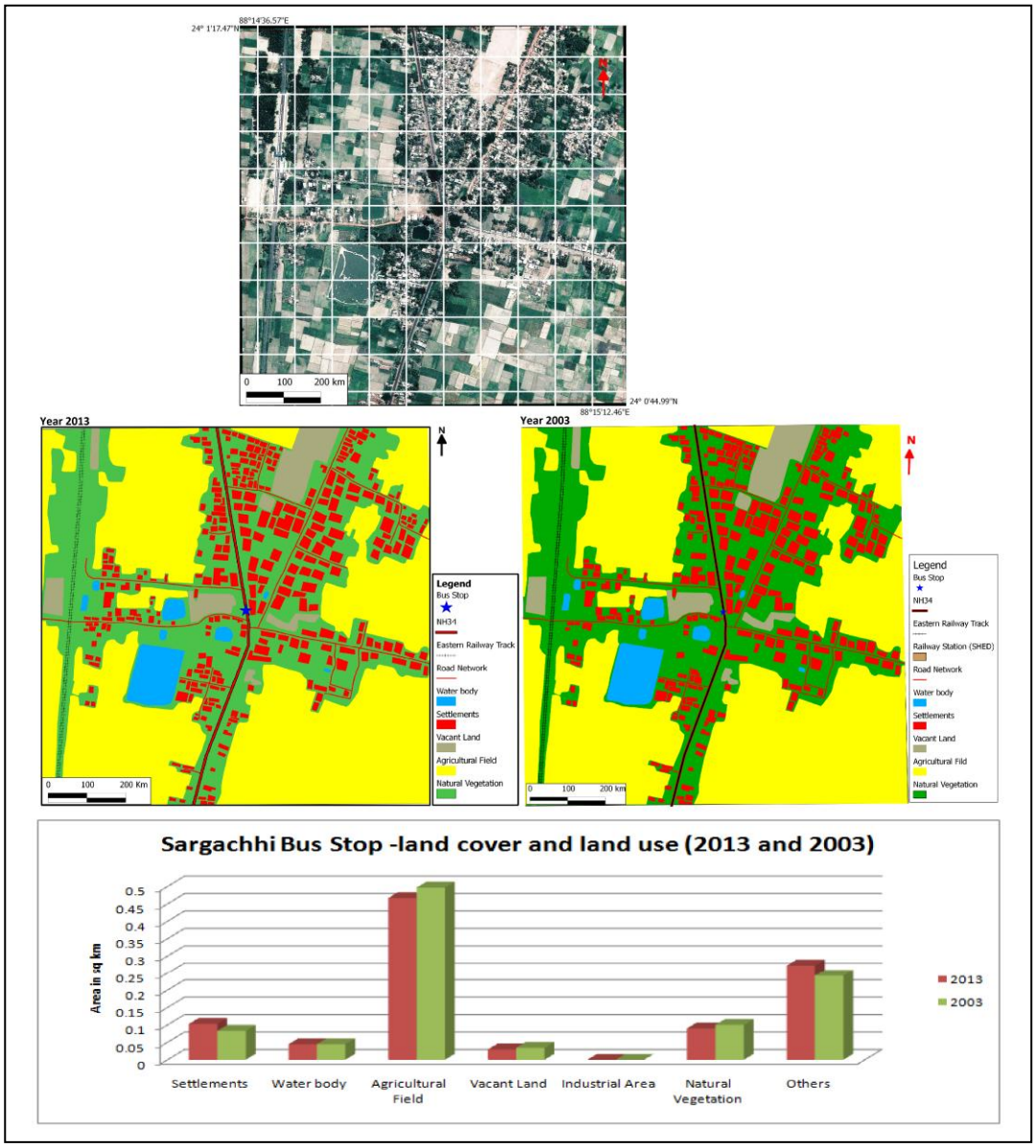


Fig.136

At Sargachhi bus stop, there is increase in settlement and others and decrease is noticed in agricultural field, vacant land, natural vegetation in the year 2013 compared to 2003.

Land Use and land cover Map

Jangipur Bus Stop (Murshidabad, West Bengal)

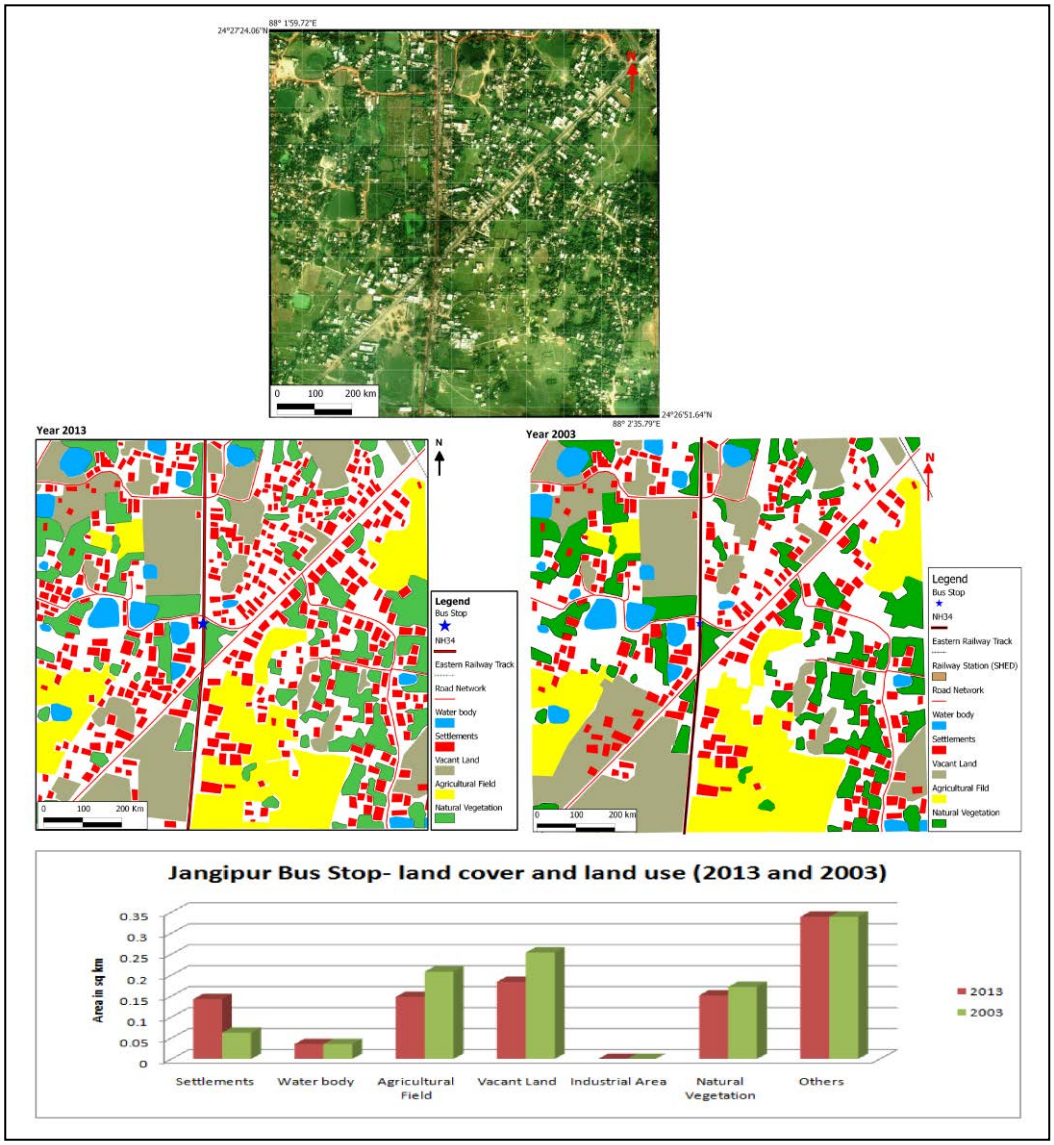


Fig.137

At Jangipur bus stop, there is increase in settlement and others and decrease is noticed in agricultural field vacant land, natural vegetation in the year 2013 compared to 2003.

Land Use and land cover Map

PTS Bus Stop (Maldah, West Bengal)

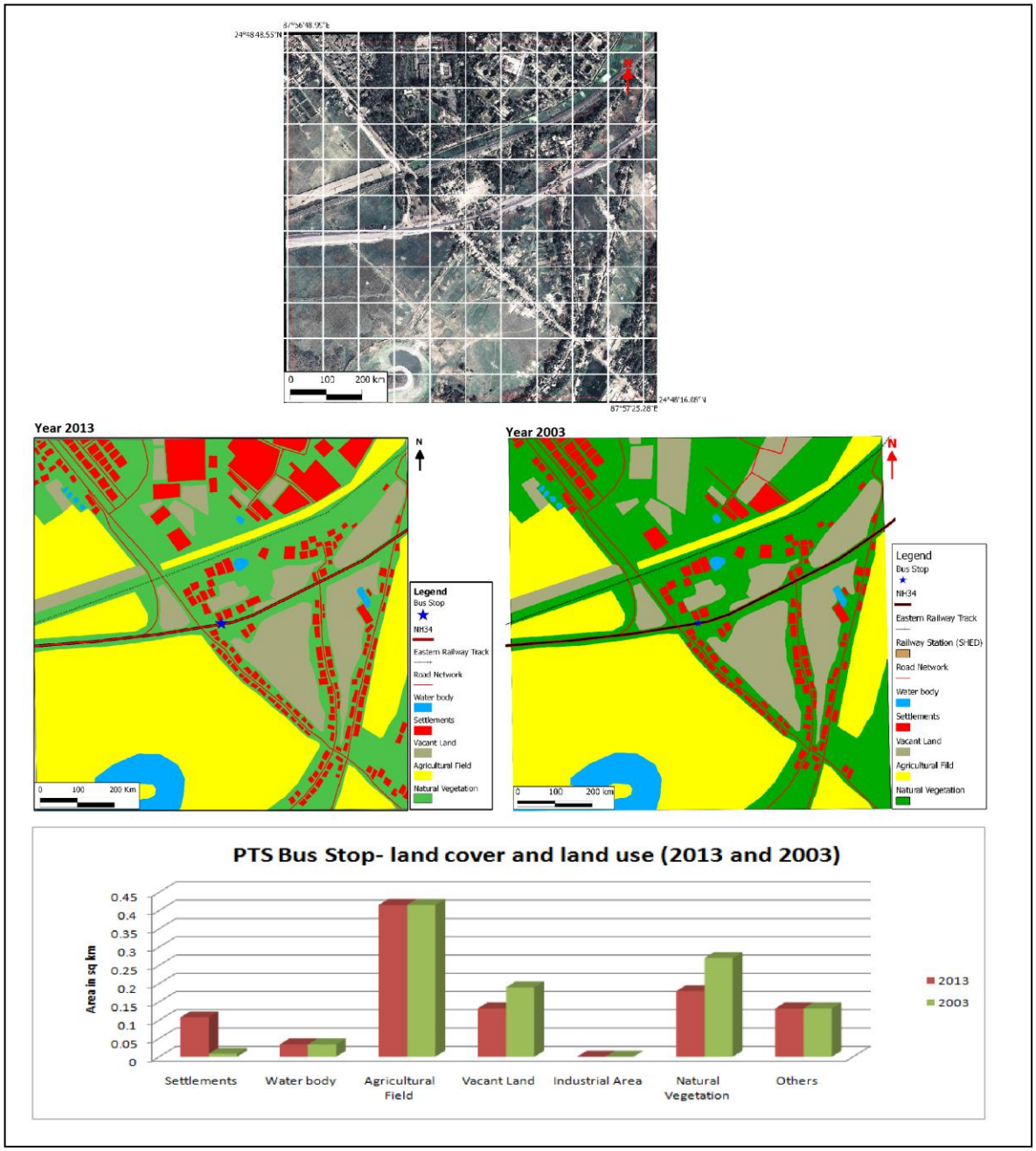


Fig.138

At PTS bus stop, there is increase in settlement and others and decrease is noticed in vacant land, natural vegetation in the year 2013 compared to 2003.

CHAPTER 3: Conclusion

The research work deals with the utilization of land particularly for agricultural and industrial activities in the southern districts of West Bengal with the help of Remote Sensing and Geographical Information System. The braided Sealdah-Maldah Transact within the study area exhibits differential rate of changes in agriculture and industry during eleven years (2003-2013). The study is confined to seven sample areas namely **Sealdah, Tribeni, Nabadwip, Salar, Azimgang, Nimta, Old Maldah,** along Sealdah-Maldah Railway Line via Nabadwip.

The study is confined to six sample areas namely **Begampur, Chanchai, Guskara, Sainthia, Chatra, Bonidanga,** along Sealdah-Maldah Railway Line via Bardhaman. The study is confined to five sample areas namely **PTS, Jangipur, Sargachhi, Bethuadahar, Pramanic,** along Sealdah-Maldah National Highway (NH-34). The present work using Remote Sensing and Geographical Information System with multi-date Google images data has revealed sharp changes in agriculture and industry land form in recent years resulting in considerable increased of inhabited land type. Research study has been made to analyze the 1 sq.km. and ¼ sq.km. share of land-use in the sample study areas. It is observed that in general the Sealdah-Maldah Transact has developed on both the sides throughout its except at few sites.

A comparative study has been made to analyze the different percentage share of land-use in the sample study areas from the following tables:

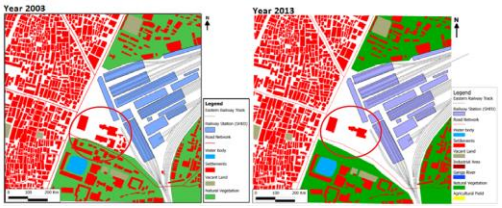
Table 6 - Land use in the sample study areas- along Sealdah – Maldah Eastern Railway via Nabadwip

(Unit in sq.km)

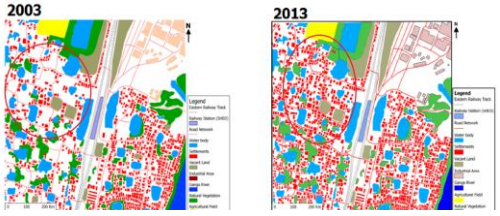
Sample Study Area	Year	Settlements	Water body	Agricultural Field	Vacant Land	Industrial Area	Natural Vegetation	Ganga River	Railway Station (SED)	Others	Total Area (Area in sq.km)
1. Sealdah	2003	0.22866806 (27%)	0.00783228 (1%)	xx (0%)	0.01900436 (2%)	xx (0%)	0.146043068 (17%)	xx (0%)	0.106043068 (13%)	0.340381629 (40%)	1 (100%)
	2013	0.29866806 (29%)	0.00783228 (1%)	xx (0%)	0.01400436 (1%)	xx (0%)	0.196070589 (19%)	xx (0%)	0.146043068 (14%)	0.377381629 (36%)	1 (100%)
2. Tribeni	2003	0.10095824 (8%)	0.09937592 (8%)	0.01451647 (1%)	0.03310242 (3%)	0.023571828 (2%)	0.170246918 (14%)	0.019010155 (2%)	0.146043068 (12%)	0.601115634 (50%)	1 (100%)
	2013	0.14595824 (15%)	0.11137592 (11%)	0.01451647 (2%)	0.04310242 (4%)	0.023571828 (2%)	0.097246918 (10%)	0.019010155 (2%)	0.004102395 (0%)	0.541115634 (54%)	1 (100%)
3.Nabadwip	2003	0.08007199 (8%)	0.04853503 (5%)	0.03598195 (3%)	0.10007477 5 (9%)	xx (0%)	0.501726224 (48%)	xx (0%)	0.007497902 (1%)	0.270012 1 (26%)	1 (100%)
	2013	0.09507199 (9%)	0.04853503 (5%)	0.03598195 (4%)	0.13337477 5 (13%)	xx (0%)	0.439726224 (44%)	xx (0%)	0.007497902 (1%)	0.239812 1 (24%)	1 (100%)
4. Salar	2003	0.04010123 9 (3%)	0.06004248 2 (5%)	0.71469440 6 (61%)	0.06588548 8 (6%)	xx (0%)	0.111363251 (10%)	xx (0%)	0.001658006 (0%)	0.170365128 (15%)	1 (100%)
	2013	0.05019123 9 (5%)	0.05784248 2 (6%)	0.40469440 6 (41%)	0.07188548 8 (7%)	xx (0%)	0.119363251 (12%)	xx (0%)	0.001658006 (0%)	0.294365128 (29%)	1 (100%)
5. Azimgang	2003	0.02174883 1 (2%)	0.0076605 (1%)	0.23524840 9 (23%)	0.01734740 9 (2%)	xx (0%)	0.398131 97 (39%)	0.020019851 (2%)	0.020019851 (2%)	0.301001 (29%)	1 (100%)
	2013	0.03674883 1 (4%)	0.0076605 (1%)	0.33524840 9 (33%)	0.02734740 9 (3%)	xx (0%)	0.248131 97 (25%)	0.020019851 (2%)	0.003721801 (0%)	0.321121 (32%)	1 (100%)
6. Nimta	2003	0.04012938 9 (4%)	0.02380567 4 (2%)	0.04504815 (5%)	0.07509488 (7%)	xx (0%)	0.750136546 (72%)	xx (0%)	0.002261674 (0%)	0.105524 (10%)	1 (100%)
	2013	0.05912938 9 (4%) (6%)	0.02380567 4 (2%)	0.04504815 (5%)	0.07209488 (7%)	xx (0%)	0.692136546 (69%)	xx (0%)	0.002261674 (0%)	0.105524 (11%)	1 (100%)
7.Old Maldah	2003	0.02008602 5 (2%)	0.14210007 4 (13%)	0.26010011 (24%)	0.07000115 (7%)	xx (0%)	0.420110028 (39%)	xx (0%)	0.005698151 (1%)	0.151104 7 (14%)	1 (100%)
	2013	0.02378602 5 (3%)	0.12226674 (12%)	0.24010022 (24%)	0.08269165 6 (8%)	xx (0%)	0.383152328 (38%)	xx (0%)	0.005698151 (1%)	0.142304 7 (14%)	1 (100%)

Land Use and land cover Sample Area (Sealdah-Maldah Transact)

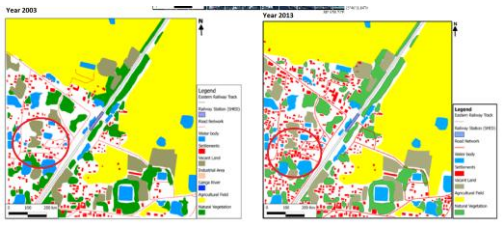
Sealdah Railway Station



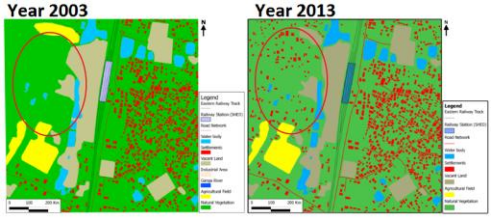
Tribeni Railway Station



Salar Railway Station

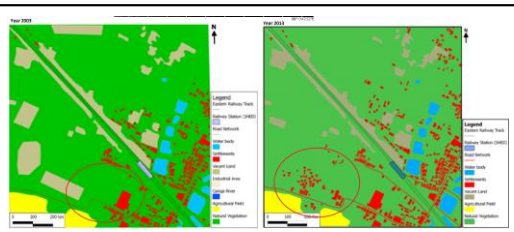


Nabadwip Railway Station



Azimgang Railway Station

Nimta Railway Station



Old Maldah Railway Station

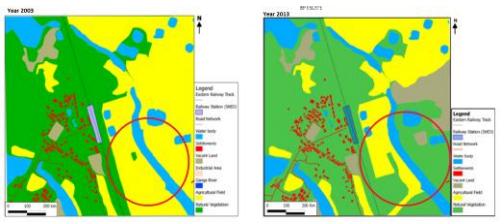


Fig. 139

Land Use and land cover Sample Area (Sealdah-Maldah Transact)

It is quite evident from Table-6 that Agricultural field occupies 41 percent (reducing from 6 percent -2003) of the total study area of Salar while it is 33 percent (increasing from 23 percent -2003) for Azimgang and 24 percent for Old Maldah. It is amazing that Tribeni alone contains only 2 percent of the total study area for industries. Nimta ranks alone first (69 percent) in natural vegetation coverage followed by Nabadwip (44percent),Old Maldah(38percent), Azimgang (25 percent) , Sealdah (19 percent), Salar (12 percent),Tribeni (10 percent). Old Maldah contains water bodies amounting to 12 percent of the total study area while Tribeni comes next (11 percent) followed by Salar (6 percent), Nabadwip (5 percent) and Nimta (2 percent). In the study area Ganga –Bhagirathi river flows through Tribeni and Azimgang. 29 percent of the total study area of Sealdah is devoted to settlements followed by Tribeni (15 percent), Nabadwip (9 percent), Salar (5 percent), Azimgang (4 percent), Nimta (4 percent) and old Maldah (3 percent). Railway cover 14 percent and 12 percent of the total study area of Sealdah and Tribeni respectively while it is 2 percent for Azimgang 1 percent for Nabadwip and 1 percent for Old Maldah Nabadwip tops the list (13 percent) in vacant land cover followed by Old Maldah (8 percent), Salar (7 percent), Nimta (7 percent), Tribeni (4 percent), Azimgang (3 percent) and Sealdah (1 percent). The analysis (2013) shows that no remarkable change in land use and land cover has taken place in the study area during 2003-2013.

Table 7- Land use in the sample study areas- along Sealdah – Maldah Eastern Railway via Bardhaman

(Unit in sq.km)

Sample Study Area	Year	Settlements	Water body	Agricultural Field	Vacant Land	Industrial Area	Natural Vegetation	Ganga River	Railway Station (SED)	Others	Total Area (Area in sq.km)
1.Begampur	2003	0.073011521 (7%)	0.12002503007 (12%)	0.067101000 19 (7%)	0.068103686 (7%)	xx (0%)	0.603682152 (60%)	xx (0%)	0.00539577 (1%)	0.06314015 (6%)	**1** (100%)
	2013	0.083027509 (8%)	0.094025339 (10%)	0.070901398 (7%)	0.079827687 (8%)	xx (0%)	0.603682152 (60%)	xx (0%)	0.00539577 (1%)	0.06314015 (6%)	**1** (100%)
2.Chanchai	2003	0.019927995 (2%)	0.068509804 (7%)	0.631880221 (63%)	0.048671824 (5%)	xx (0%)	0.1820007 (18%)	xx (0%)	0.004412631 (0%)	0.053140145 (5%)	**1** (100%)
	2013	0.023727395 (2%)	0.065509104 (7%)	0.631880221 (63%)	0.048671824 (5%)	xx (0%)	0.1726587 (17%)	xx (0%)	0.004412631 (1%)	0.053140145 (5%)	**1** (100%)
3.Guskara	2003	0.08927082 (9%)	0.094025339 (9%)	0.348024186 (35%)	0.0863131 (9%)	0.059819191 (6%)	0.289087382 (29%)	xx (0%)	0.012898216 (1%)	0.0225517 (2%)	**1** (100%)
	2013	0.101280827 (10%)	0.094025339 (9%)	0.348024186 (35%)	0.074313158 (8%)	0.059819191 (6%)	0.289087382 (29%)	xx (0%)	0.012898216 (1%)	0.0205517 (2%)	**1** (100%)
4.Sainthia	2003	0.1976621 (20%)	0.0510575 (5%)	0.007107764 (1%)	0.0732497 (7%)	0.074754603 (7%)	0.449789519 (45%)	xx (0%)	0.012898216 (1%)	0.14140015 (14%)	**1** (100%)
	2013	0.237662448 (24%)	0.054057543 (5%)	0.007187764 (1%)	0.070249761 (7%)	0.074754603 (8%)	0.411789519 (41%)	xx (0%)	0.012898216 (1%)	0.13140015 (13%)	**1** (100%)
5.Chatra	2003	0.014644397 (1%)	0.027060319 (3%)	0.887043344 (82%)	0.01725235 (2%)	0.001677916 (0%)	0.110771758 (10%)	xx (0%)	0.012898216 (1%)	0.0105517 (1%)	**1** (100%)
	2013	0.034644397 (3%)	0.025060319 (3%)	0.787043344 (79%)	0.01725235 (2%)	0.001777916 (0%)	0.110771758 (11%)	xx (0%)	0.012898216 (1%)	0.0105517 (1%)	**1** (100%)
6. Bonidanga	2003	0.010145 (1%)	0.01611606 (1.5%)	0.945380669 (94%)	0.0199 (1.5%)	xx (0%)	0.0099 (1%)	xx (0%)	0.002889218 (0.5%)	0.00242 (0.5%)	**1** (100%)
	2013	0.0091102 (1%)	0.01611606 (1.5%)	0.945380669 (94%)	0.0199 (1.5%)	xx (0%)	0.0099 (1%)	xx (0%)	0.002889218 (0.5%)	0.00242 (0.5%)	**1** (100%)

Land Use and land cover Sample Area (Sealdah-Maldah Transact)

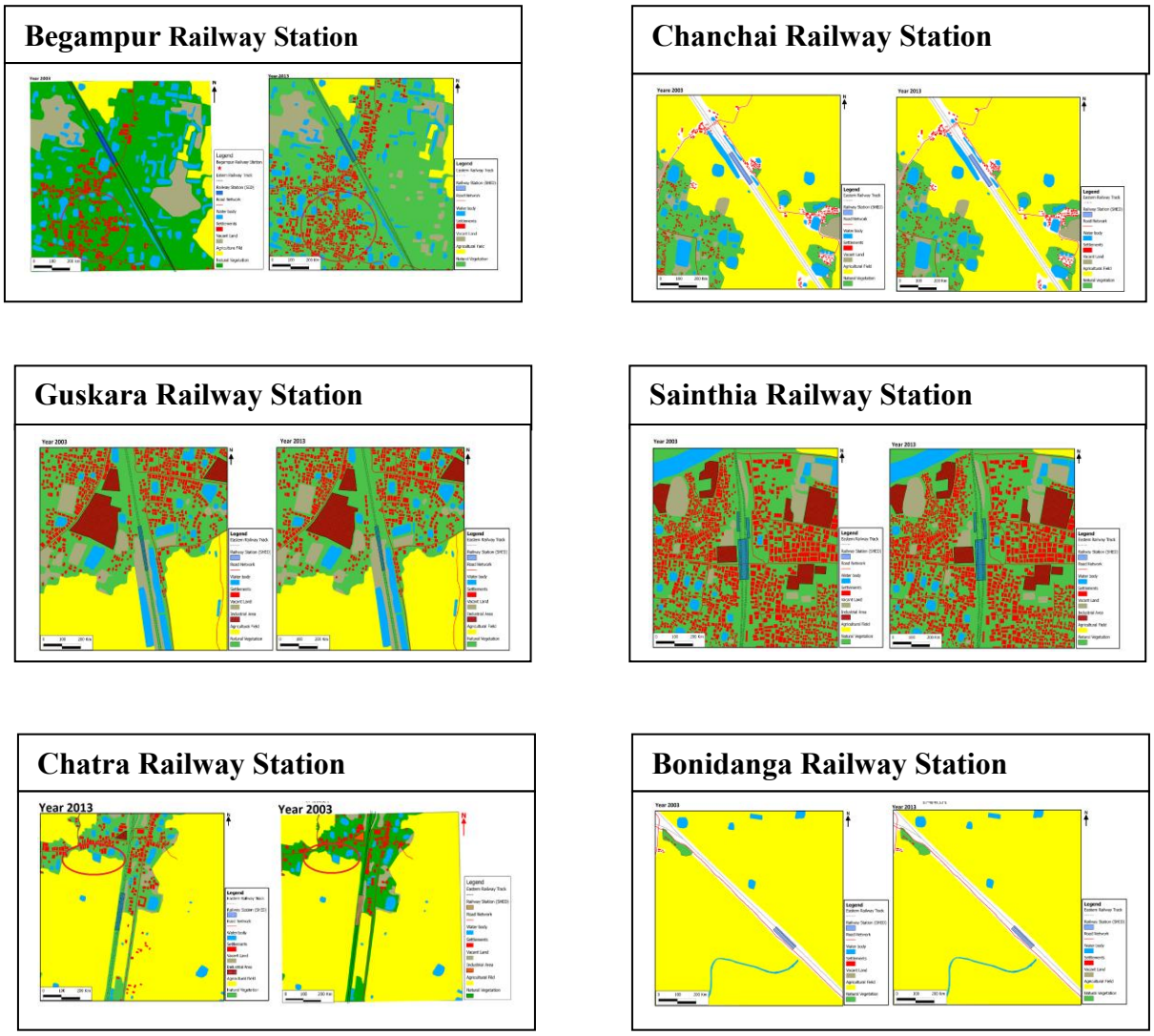


Fig. 140

It is clear form table -7 that agricultural field accounts for 94 percent of the total study area of Bonidanga while it is 79 percent for Chatra ,63 percent for Chanchai , 35 percent for Guskara, 7 percent for Begampur and 1 percent for Sainthia . Sainthia and Guskara have 8 percent and 6 percent of the total area under Industries respectively Begampur tops (60 percent) the list in natural vegetation coverage followed by Sainthia (41 percent) , Guskara (29 percent) , Chanchai (17 percent) ,Chatra (11 percent) and Bonidanga (1 percent) Begampur contains water bodies amounting to 10 percent of the total study area while Guskara comes next (9 percent) followed by Chanchai (7 percent)

,Sainthia (5 percent) ,Chatra (3 percent) and Bonidanga (1.5 percent) . 24 percent of the total study area of Sainthia is devoted to settlements followed by Guskara (10 percent), Begampur (8 percent), Chatra (3 percent) ,Chanchai (2 percent) and Bonidanga (1 percent) .Most of the sample stations have 1 percent of their area with railway cover . Begampur (8 percent) and Guskara (8 percent) rank first in vacant land cover followed by Sainthia (7 percent) Chanchai (5 percent),Chatra (2 percent) and Bonidanga (1.5 percent) From the analysis (2013) it may be noted that the change in land use and land cover during 2003-2013 is apparently very meagre.

Table 8- Land use in the sample study areas- along National Highway 34 (NH-34).

(Unit in sq.km)

Sample Study Area	Year	Settlements	Water body	Agricultural Field	Vacant Land	Industrial Area	Natural Vegetation	Ganga River	Others	Total Area (Area in sq.km)
1. PTS	2003	0.082114620 (8%)	0.033425216 (3%)	0.41518272 (41%)	0.151342501 (15%)	xx (0%)	0.20110121 (20%)	xx (0%)	0.132103558 (13%)	**1** (100%)
	2013	0.107814629 (11%)	0.033425216 (3%)	0.41518276 (42%)	0.132372584 (13%)	xx (0%)	0.179101254 (18%)	xx (0%)	0.132103558 (13%)	**1** (100%)
2. Jangipur	2003	0.072771206 (7%)	0.0353584 (3%)	0.187124181 (19%)	0.203012202 (20%)	xx (0%)	0.171612541 (17%)	xx (0%)	0.338840887 (34%)	**1** (100%)
	2013	0.142691296 (14%)	0.0353584 (4%)	00.147871810 (15%)	0.183595205 (18%)	xx (0%)	0.1516424 (15%)	xx (0%)	0.338840887 (34%)	**1** (100%)
3. Sargachhi	2003	0.085817007 (9%)	0.02424507 (2%)	0.540043001 (54%)	0.037021012 (3%)	xx (0%)	0.100990121 (10%)	xx (0%)	0.2122815 (21%)	**1** (100%)
	2013	0.102817667 (10%)	0.02424507 (3%)	0.496643702 (50%)	0.034121673 (3%)	xx (0%)	0.099890321 (10%)	xx (0%)	0.242281566 (24%)	**1** (100%)
4. Bethuadahari	2003	0.00339388 (0%)	xx (0%)	0.307055309 (31%)	0.00639326 (1%)	xx (0%)	0.664672576 (66%)	xx (0%)	0.01848497 (2%)	**1** (100%)
	2013	0.00339388 (0%)	xx (0%)	0.307055309 (31%)	0.00639326 (1%)	xx (0%)	0.664672576 (66%)	xx (0%)	0.01848497 (2%)	**1** (100%)
5. Pramanic	2003	0.28003103 (28%)	0.02600819 (2%)	Xx (0%)	0.05701023 (6%)	xx (0%)	0.208531001 (21%)	xx (0%)	0.440123231 (43%)	**1** (100%)
	2013	0.336132034 (34%)	0.02335859 (2%)	xx (0%)	0.05685043 (6%)	xx (0%)	0.178535719 (18%)	xx (0%)	0.405123232 (40%)	**1** (100%)

Land Use and land cover Sample Area (Sealdah-Maldah Transact)

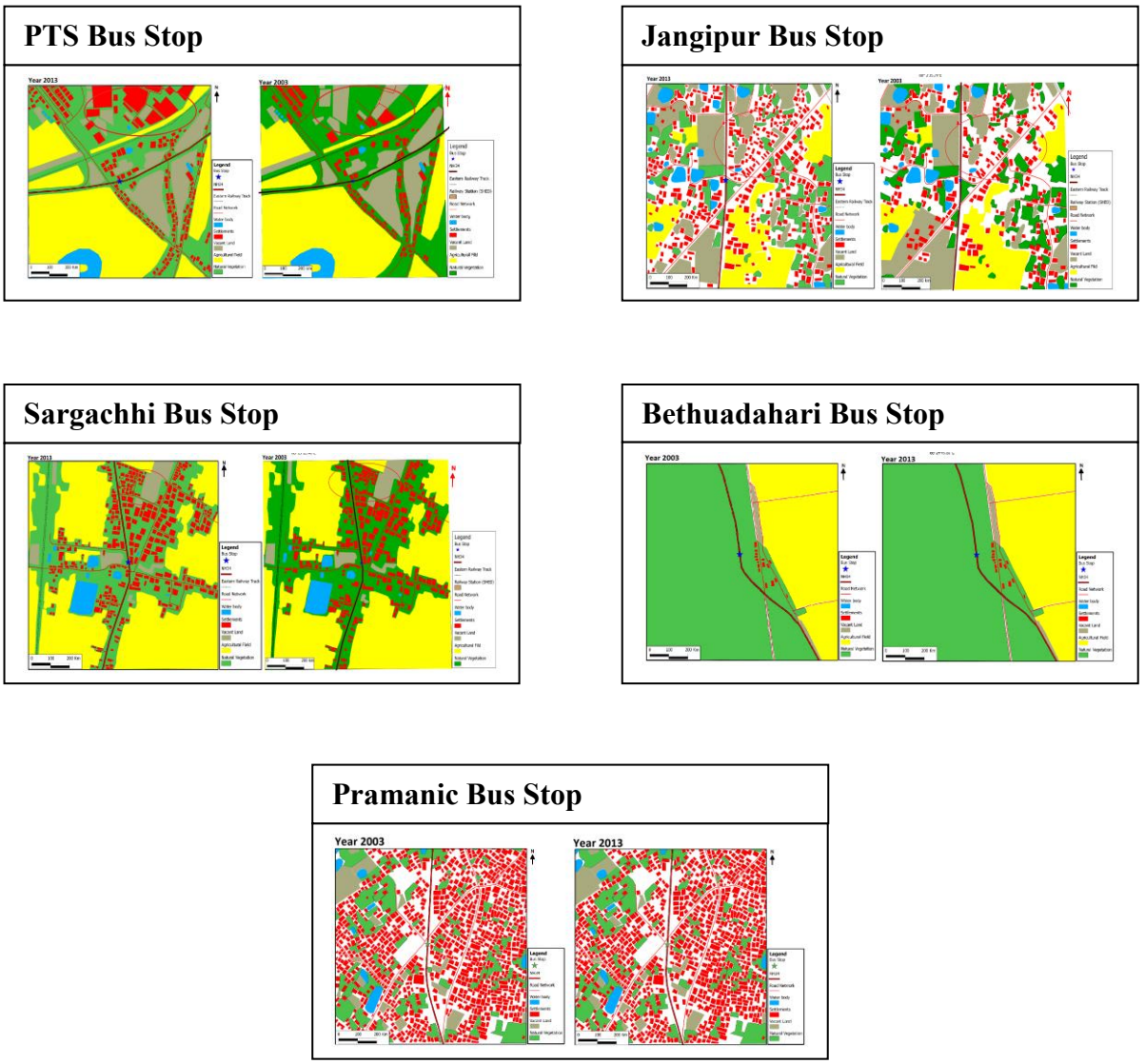


Fig. 141

Table -8 Shows that agricultural field amounts to 50 percent of the total study area of Sargachhi while it is 44 percent for PTS, 31 percent for Bethuadahari and 15 percent for Jangipur . Bethuadahari ranks first (66 percent) in natural vegetation coverage followed by PTS (18 percent),Pramanic (18 percent) , Jangipur (15 percent) and Sargachhi (10 percent) . Jangipur contains water bodies amounting to 4 percent of the total study area while PTS and Sargachhi come next (3 percent each) followed by Pramanic (2 percent). 34 percent of the total study area of Pramanic is allotted to settlements followed by

Jangipur (14 percent), PTS (11 percent) and Sargachhi (10 percent). Vacant land covers 18 percent of the total study area of Jangipur followed by PTS (13 percent), Pramanic (6 percent), Sargachhi (3 percent) and Bethuadahari (1 percent). Form the discussion (2013) it is highlighted that settlements increased in all the sample sites during 2003-2013 while change in land use and land cover took place at few sample stations during 2003-2013.

In the context of increasing population the Government of West Bengal has to seriously considered the mechanism to monitor the changes in the use of land. The technologies like Remote Sensing and GIS do provide a viable solution. The methodology should help not only in monitoring such changes but also to help in formulating policies in this regard. The spatial dynamics of agriculture and industry along Sealdah- Maldah transact have been found out with Remote Sensing. Now this information have been placed in GIS frame work which means administrative boundaries, road network, availability of water, power and manpower etc. This part was done along with the intensive field work in the selected study areas. The power of resolution plays an important role in identifying the land use (agriculture and industry) properly and distinctly. The experience derived from the case studies will help in developing a methodology for monitoring of agriculturalization and industrialization in West Bengal. Such an attempt aims to be an agricultural and industrial model for monitoring spatial dynamics not only in West Bengal, but for the country as well.

• • • • • •

Bibliography:

- *Adams, W.M. 1995, Green Development: Environmental Sustainability in the Third World, Rout1edge, London, pp 1-8, pp. 87-139.*
- *Allaby, M. 1996, Basics of Environmental Science, Routledge, London, p. 297.*
- *Alvi, Z. 1995, Statistical Geography: Methods and Applications, Rawat Pub. New Delhi, p. 194.*
- *Ahluwalia, I. J. (1985). Industrial Growth in India stagnation since mid – sixties, Oxford University Press, New Delhi.*
- *Arunachalam, P. (ed.) (2011) Micro-finance management, Serials Publication, New Delhi.*
- *Baarrsches, W.H. 1996, Eco-facts and Eco-fiction: Understanding the Environmental Debate, Routledge, London: p. 264.*
- *Beaumont, J .R. and Williams, S.W. 1983, Project Work in the Geography Curriculum, Croom Helm, London, p. 332.*
- *Campbell, J .B. 1996, Introduction to Remote Sensing, 2nd edition, Taylor & Francis, London, p. 622.*
- *Campbell, J .B. 1996, Introduction to Remote Sensing, 2nd edition, Taylor & Francis, London, p. 622.*
- *Canter, L. W. 1996, Environmental Impact Assessment, 2nd edition, McGraw Hill, New York, p. 660.*
- *Carter, H. 1981, Urban Geography, 3rd edition Arnold-Heinemann, New Delhi, p. 434.*
- *Chaisman, N. 1992, Exploring Geographical Information Systems, John Wiley and Sons Inc., New York, p. 198.*
- *Chaudhuri, M. R. (1971) The Industrial landscape of West Bengal – An Economic and Geographic Appraisal, Oxford and IBH Publishing Co., Kolkata.*
- *Chitambar, J.B. 1993, Introductory Rural Sociology, Wiley Eastern, New Delhi, pp. 129-285.*
- *Clough Donald J. (1977) Earth observation systems for resource management and environment control, Plenum Press , New York.*

- *Chaisman, N. 1992, Exploring Geographical Information Systems, John Wiley and Sons Inc., New York, p. 198.*
- *Chaudhuri, M. R. (1971) The Industrial landscape of West Bengal – An Economic and Geographic Appraisal, Oxford and IBH Publishing Co., Kolkata.*
- *Clough Donald J. (1977) Earth observation systems for resource management and environment control, Plenum Press , New York.*
- *Dasgupta, P. and Mller, K.G. 1997, The Environment and Emerging Development Issues, Volumes I and 2, Clarendon Press, Oxford, p. 593.*
- *Dickinson, R.E. 1968, City and Region: A Geographical Interpretation, Routledge and Kegam Paul Ltd. London.*
- *District Statistical Handbook – Hooghly District, (2006), Bureau of Applied Economy and Statistics, Government of West Bengal, p. 5, p. 52.*
- *District Statistical Handbook – Howrah District, (2006), Bureau of Applied Economy and Statistics, Government of West Bengal, p. 4, p. 50.*
- *District Statistical Handbook – North 24 Parganas District, (2006), Bureau of Applied Economy and Statistics, Government of West Bengal, p. 8, p. 55.*
- *Dadhwal, V.K. and Parihar, J.S. (1985). Estimation of 1983-84 wheat acreage of Karnal (Haryana) using Landsat MSS digital data. Scientific Note, IRS-UP/SAC/CPF/ SN/9/85, SAC, Ahmedabad.*
- *Dadhwal, V.K. and Sridhar,V.N. (1986). Sampling approach for remote sensing based crop inventory. Scientific Note, RSAM/SAC/CAPE/SN/01/86.*
- *Dakshinamurti, C., Krishnamurthy, B., Summanwar, A. S., Shanta, P. and Pisharoty, P.R. (1971). Remote Sensing for coconut wilt. Proc. Seventh Int. Symp on Remote Sensing of Envirn. May 17-21, 1971. 25-29.*
- *Dasgupta, P. and Mller, K.G. 1997, The Environment and Emerging Development Issues, Volumes I and 2, Clarendon Press, Oxford, p. 593.*
- *Dickinson, J., Gould, B., Clarke, C., Mather, S., Prothero, M., Siddle, D., Smith, C. and Thomas-Hope, E. 1996 : A Geography of the Third World, 2nd edition, Routledge, London, p. 334.*
- *Dickinson, R.E. 1968, City and Region: A Geographical Interpretation, Routledge and Kegam Paul Ltd. London.*

- *Economic Survey, (2011-2012), Government of India, Ministry of Finance, Department of Economics Affairs, Economic Division, Oxford University Press, New Delhi, pp.307-315.*
- *Elfic, M.H., Fryer, J.G. Brinkner, R.C. and Wolf, P.R. 1994, Elementary Surveying, 8th edition, Harper Collins Publishers, London, p. 510.*
- *Falconer, R.A. and Goodwin, P. (editor) 1994, Wet and Management, Thomas Telford, London, p. 289.*
- *Farmer, A. 1997, Managing Environmental Pollution, Routledge, London, p. 246.*
- *Gilpin, A. 1997, Environmental Impact Assessment: Culling Edge for the Twenty-first Century, Cambridge University Press, Cambridge, p.181.*
- *Government of West Bengal, Industrial Reconstruction Department, Position of BIFR, 2002, Calcutta.*
- *Hardoy, J .E Mittin, D. & Satterthwaite, D. 1992, Environment Problems in the World Cities, Earthscan Pub. Ltd. London.*
- *Hussain, S.K., and Nagaraj, M.S. 1992, Text Book of Surveying, S. Chand & Co. Ltd., New Delhi.*
- *Hudson, F.S. 1970: Geography of Settlements, Macdonald and Evans Ltd., Plymouth: pp. 3-12, pp. 61-70, pp. 79-101, pp. 141-145, pp. 217-230.*
- *Hussain, S.K., and Nagaraj, M.S. 1992, Text Book of Surveying, S. Chand & Co. Ltd., New Delhi.*
- *Indian Council of Social Science Research (1972) "A Survey of Research in Geography, Popular Production Pvt. Ltd., Mumbai.*
- *Institute of Social Sciences, 1994, Decentralised Planning and Panchayati Raj, Rawat Pub. Co., New Delhi, p. 64.*
- *Joseph George. (2005) Fundamental of remote sensing, University Press, Hyderabad.*
- *Javed A.,Pandey S. (2004), "Land-use/land-cover analysis for waste disposal",GIS@development,http://www.gisdevelopment.net/maganize/years/2004/jun/lanuse.as,accused 6-March-2007.*
- *Kanetkar, T.P., and Kulkatni, S. V. 1.988, Surveying and Levelling, Part I, Pune Vidyarthi Griha Prakashan, Pune, p. 608.*

- *Kellaway, G.P. 1979, Map Projections, 1st Indian edition, B.I. Publication, Delhi.*
- *Konecny Gottfield. (2003) Geoinformation : Remote sensing , Photogrammetry and Geographic Information systems. Taylor and Francis, London.*
- *Kaur Amarjeet, Dutta Venkatesh, Chaddha D. K. (2003), "Application of Remote Sensing and GIS tools in delineating Environmentally-Fragile-Areas (EFAs) for sustainable land use planning: A case study of Delhi Region", Proceedings of the Gap India Conferences.*
- *Kshama Gupta, Sadhana Jain, (2005), "Enhanced capabilities of IRS P6 LISS IV sensor for urban mapping", J. Curr. Sci, Vol. 89, No.11, pp. 1805-1812.*
- *Kellaway, G.P. 1979, Map Projections, 1st Indian edition, B.I. Publication, Delhi.*
- *Kochher, C.L. 1993, A Text Book of Surveying, S.K. Katariya & Sons, Delhi.*
- *Konecny Gottfield. (2003) Geoinformation : Remote sensing , Photogrammetry and Geographic Information systems. Taylor and Francis, London.*
- *Lillesand, T.M. and Kiefer, R. W. 1994, Remote Sensing and Image Interpretation, 3rd edition, John Wiley and Sons, New York, p. 750.*
- *Lepoutre, D. (1991). Satellite imagery for following crop production. Comptes-Rendus-de-l'Academie-d'Agriculture-de-France, 77(6), 75-84.*
- *Mac Donald R. B. (1984) A summary of the history of the development of automated remote sensing of automated remote sensing for agricultural applications. IEEE Trans. Geosci. Rem Sens. 22, 473-481.*
- *Meyer, R.J.(1991). Pilot project on remote sensing applied to agricultural statistics in Europe. In Options-Mediterranean's.- Serie -A,-Se' aires - Mediterranean. 4: 57-63.*
- *Mandal, R.B. 1988, Systems of Rural Settlements in Developing Counties, Concept Pub. Co., New Delhi.*
- *Marcolongo, B. And Mantorani, F. 1997, Photogeology: Remote Sensing Application in Earth Science, Oxford and IBH Pub. Pvt. Ltd., New Delhi, p. 195.*
- *McCay Roger M. (2006) Field method in remote sensing. Rawat Publications, Jaipur.*

- *Misra, H.M. (ed) 1987, Contributions to Indian Geography, Volume 9, Rural Geography, Heritage Pub, New Delhi.*
- *Monkhouse F.J., and Wilkinson, H.R. 1971, Maps and Diagrams, Their Compilation and Construction, B.I. Publications Private Limited, New Delhi, p. 527.*
- *Marcolongo, B. And Mantorani, F. 1997, Photogeology: Remote Sensing Application in Earth Science, Oxford and IBH Pub. Pvt. Ltd., New Delhi, p. 195.*
- *Mather Paul M. (2004) Computer processing of remotely - sensed images : an introduction. John Wiley , New York.*
- *McCay Roger M. (2006) Field method in remote sensing. Rawat Publications, Jaipur.*
- *Middleton. N, 1995, The Global Casino: An .Introduction to Environmental Issues, John Wiley and Sons Inc., New York, p. 332.*
- *Misra, H.M. (ed) 1987, Contributions to Indian Geography, Volume 9, Rural Geography, Heritage Pub, New Delhi.*
- *Monkhouse F.J., and Wilkinson, H.R. 1971, Maps and Diagrams, Their Compilation and Construction, B.I. Publications Private Limited, New Delhi, p. 527.*
- *Mukherjee,D.(2008), Contemporary Indian Economy New Central Book Agency (p) Ltd. Kolkata.*
- *Nag P. (1984) Census mapping survey. Concept Publishing , New Delhi.*
- *Nag P. and Kudrat M. (1998) Digital remote sensing. Concept Publishing , New Delhi.*
- *NASA, Johnson Space Centre, (1974). Corn blight watch experiment: Summary report, V.3 NASASP-353, NTIS, Springfield, VA.*
- *NASA, Johnson Space Centre, (1977). LACIE: wheat yield models for the United States: NASAJSC-0043, rev A NTIS, Springfield, VA.*
- *Navalgund, R. R., Jayaraman,V., Roy, P.S. (2007), "Remote sensing applications: An overview", J. Curr. Sci., Vol. 93, No.12, pp. 1747-1766.*
- *Pal, S.K. 1999, Statistics for Geoscientists, Concept publishing Company, New Delhi, p. 423.*

- *Parsons, T. and Knight, P.1995, How To Do .Your Dissertation in Geography and Allied Disciplines. Chapman and Hall, London. P. 151.*
- *Prabhakar, V.R. 1998, Social and Community Forestry, indian Pub. Distrb., New Delhi, p. 224.*
- *Panigraphy,S., Parihar, J.S. , Patel, N.K. , Dadhwal, V.K. , Medhavy, T.T. , Ghose, B.K. , Ravi, N. , Pant, K.C. , Panigrahy, B.K. , Sridhar, V.N., Mohanty, R.R. , Nanda, S.K. , Tripathy, D.P. , Mishra, P.K. , Bhatt, H.P., Oza, S.R. , Sudhakar, S. , Sudha,K.S. , Kumar, P. and Das, N.K. (1991). "Rice acreage estimation for Orissa using Remotely Sensed data". J. Soc. of Rem. Sens. I9(1), 17-26.*
- *Patkar, V.N. (2003), "Directions for GIS in Urban Planning", GIS@development, http://www.gisdevelopment.net/application/urban/overview/urban0042pf/htm,Map Asia Conferences, Urban Planning. Patkar, V.N. (1994), "GIS Applications and Innovative Practices for Solid Waste Management", Nagarlok, Vol. 26, No. 4, pp. 25-34.*
- *Pathan, S.K., Patel, J.G., Bhanderi, R.J., Arya, A.S., Navalgund, R.R., Shimpi, P.B., Dhawale, A.K. and Landge, S.D. (2000), "Remote Sensing and GIS Based Inputs for the Preparation of a Development Plan of Pimpari-Chinchwad Municipal Corporation (PCMC) Area for the Year 2018", Proceedings of Geomatics 2000: Conference on Geomatics in Electronic Governance, 21-22 January, 2000, C-DAC, Pune, pp. UP22-UP33.*
- *Pal, S.K. 1999, Statistics for Geoscientists, Concept publishing Company, New Delhi, p. 423.*

- *Parsons, T. and Knight, P.1995, How To Do .Your Dissertation in Geography and Allied Disciplines. Chapman and Hall, London. P. 151.*
- *Prabhakar, V.R. 1998, Social and Community Forestry, indian Pub. Distrb., New Delhi, p. 224.*

- *Rashid. S. M. (1996) Economics of remote sensing. Manak , New Delhi.*
- *Rai A., N.K. Gupta and Randhir Singh (2007) Small area estimation of crop production using spatial models. Mod. Asst. Stat. Apl. , 2(2), 89-98,*
- *Rai Anil, Srivastava A.K., Singh R, and Jain V.K. (2004) A study of land use*

statistics through integrated modelling using geographic information system. IASRI, New Delhi Publication.

- *Rajan, M.S. 1995, Space Today, 2nd edition, National Book Trust, New Delhi, p. 344.*
- *Rao, U .R. 1996, Space Technology for Sustainable Development, Tata McGraw-Hill, New Delhi, p. 564.*
- *Rashid. S. M. (1996) Economics of remote sensing. Manak , New Delhi.*
- *Robinson, A.H., Sale, R.D., Morrison, J. 1984, Elements of Cartography, Wiley, New York.*
- *Redondo F.V., Lacprogent C., Gargantini C., Anter M. and Fonda C. (1985). Estimating wheat cultivated area within large productivity region in Argentina using Landsat data. Proc. 19th Int. Symp. Rem. Sens. Environ. 361-367.*
- *Rahman Atiqure, (2006), "Application of Remote Sensing and GIS Technique for Urban Environment Management and Development of Delhi, India", Applied Remote Sensing for Urban Planning Governance and Sustainability,*
- *http://www.springerlink.com/index/x5w74277j3I13959pdf*
- *Sabins, F.F, 1997, Remote Sensing: Principles and Applications, 3rd edition, W.H. Freeman & Company, New York, p. 494.*
- *Shepherd, F.A. 1983, Engineering Surveying, Edward Arnold, London.*
- *Silk, J. 1979, Statistical techniques in Geography, George Allen and Unwin, London, p. 276.*
- *Singh, N. Surveying, Tata McGraw-Hill Publishing Company Ltd., New Delhi.*
- *Singh, R.L. (editor) 1971, India: A Regional Geography, National Geographical Society of India, UBS Pub. Distributors Ltd., New Delhi, p. 992.*
- *Singh, R.L. and Singh, R.P.B. 1.991, Elements of Practical Geography, Kalyani Pub. New Delhi. P. 421.*
- *Survey of Indian Industry- The Hindu(1998).*
- *Sahoo, P. M., Singh, R. and Rai, A. (2006): Spatial sampling procedures for agricultural surveys using geographical information system. J. Ind. Soc. Agril. Stat. 60 (2)134-143.*

- *Sahoo, P. M., Singh, R. and Rai, A., Handique B.K. and Rao C. S. (2005). Integrated approach based on remote sensing and GIS for estimation of area under paddy crop in north-eastern hilly region' J. Ind. Soc. Agril. Stat. 59(2), 151-160.*
- *Saha, S. K. (1999) Crop yield modeling using satellite remote sensing and GIS-current status and future prospects. Proc. Geoinformatics- Beyond 2000. Int. Conf on Geoinformatics for natural resource assessment, monitoring and management. Dehradun. 9 -11 March, 1999.*
- *Singh, R., Goyal, R.C. Saha, S.K. and Chhikara, R.S. (1992) Use of satellite spectral data in crop yield estimation surveys. Int. J. Rem. Sens. 13(14), 2583-2592.*
- *Singh, R. and Goyal, R.C. (1993) Use of remote sensing technology in crop yield estimation surveys. Project Report, IASRI, New Delhi.*
- *Singh, R. and Ibrahim, AEI (1996) Use of spectral data in markov chain model for crop yield forecasting. J. Ind. Soc. Rem Sens. 24(3), 145-152*
- *Singh, R. Semwal, D.P., Rai, A. and Chhikara, R.S. (2002) Small area estimation of crop yield using remote sensing satellite data. Int. J. Rem. Sens. 23(1): 49-56.*
- *Singh, R., Semwal, D.P., Rai, A. and Chhikara, R.S. (2000a) Small area estimation of crop yield using remote sensing satellite data. Accepted for publication in Int. J. Rem. Sens.*
- *Singh, R. and Goyal, R.C. (2000 b) Use of remote sensing technology in crop yield estimation surveys. Project Report, IASRI, New Delhi.*
- *Sukhatme. P.V. and Panse, V.G. (1951). Crop surveys in India-II. J. Ind. Soc. Agrl. Stat. 2, 95-168.*
- *Sudhir. H. S., Ramachandra, T.V., and Jagadish, K.S. (2003), "Urban Sprawl pattern recognition and modelling using GIS," GIS@development,*
- *http://www.gisdevelopment.net/application/urban/sprawl/mi03142.htm-11k, Map Asia*
- *Tiwary, D. P. (2003), "Remote Sensing and GIS for efficient Urban planning in India",*

GIS@development.net,http://www.gisdevelopment.net/application/urban/oveview/ma03

- *Vogler, J. 1995, The Global Commons : A Regime Analysis, John Wiley and Sons Ltd., Chichester, p.55, p. 233.*
- *Venkatramaiah, C. 1996, A Textbook of Surveying, Universities Press / Orient Longman Ltd., Hyderabad: p. 76.*
- *Walford, P,1995, Geographical Data Analysis, John Wiley and Sons Inc., New York, p. 446.*
- *Walford, P,1995, Geographical Data Analysis, John Wiley and Sons Inc., New York, p. 446.*
- *Wathern, P. (editor) 1988, Environmental Impact Assessment: Theory and Practice, Routledge, London, p. 332.*
- *World Development Report (1991) - Oxford University Press, Washington DC (USA).*
- *World Development Report (2003) - Oxford University Press, New York.*
- *World Resources (1995), Oxford University Press, New Delhi.*
- *Wathern, P. (editor) 1988, Environmental Impact Assessment: Theory and Practice, Routledge, London, p. 332.*

●●●●●●