APPENDIX 16

Satellite Data Analysis and Interpretation –Areas in the neighbourhood of the proposed Mega power Plant, Kutchch District, Gujarat State

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CONTENTS

Tables

EXHIBITS

Chapter 1.0

INTRODUCTION

TCE Consulting Engineers Ltd. has retained CARE Sustainability CARE), Navi Mumbai, to carry out "**Satellite Data Analysis, Interpretation and Ground Observations- for the areas of interest located at Kutchch district**, in the State of Gujarat. The scope of work was to derive land use/land cover from satellite data.

In accordance with the terms of reference CARE professionals have undertaken:

- Procurement of satellite data
- Study of relevant documents
- Field Survey- Ground Truthing
- Generation of landuse- landcover maps using IRS-P6 satellite data

The methodology adopted for the study is detailed in Chapter 2.0. Chapter 3.0 describes the field observations and Global Positioning System (GPS) made from ground survey. Chapter 4.0 explains the dominant and representative ground features showing the digital photographs. Chapter 5.0 gives the satellite images, which include classified land use/land cover thematic maps.

Chapter 2.0

APPROACH and METHODOLOGY

Satellite image analysis was carried out for the generation of land use/ land cover map of the study region. The study region, is located the district of Kutchch, Gujarat. The approach for satellite data analysis adopted the well-proven Image processing procedures. The analysis was preceded with a ground survey, which comprised of data collection of ground features along with the respective geographical position in terms of latitudes and longitudes. The interpretation of the satellite data was supplemented by these ground truth studies. The satellite data used has the below specifications:

- Satellite and Sensor: IRS P-6, LIS III (L-3)
- Date on which the image was taken: 26-November-05

The said time period of acquisition of the satellite data has been judiciously chosen to depict the vegetation and other ground features at its best, as also avoid the cloud cover over the satellite data.

The image processing software used is the professional version of ERDAS IMAGINE 8.4 under Windows NT. A Pentium 1V based computing machine with high processing speed and graphic facilities under the operating system of Windows NT is used for the image processing and interpretation.

The detailed description of methodology followed for the generation of landuse-landcover map is given in the paragraphs below.

IRS P6 data were extracted using the ERDAS Imagine's extract utility. The raw satellite data was subjected to the enhancing steps such as edge enhancement and histogram equalization, the built in functions of the image processing software, so as to obtain the best classification results. The satellite data were georeferenced by adopting the raster to raster geocoding. For georeferencing, the ground control points (GCP) recorded by Global Positioning System (GPS) during ground truthing of the study area were used. The GCPs were taken at locations well spread across the study region, and hence enabled to obtain very high georeferencing accuracy. UTM projection system was applied to the image.

The georeferenced image was viewed under different band combinations in the viewer of ERDAS IMAGINE and different features were demarcated based upon the tone, texture shape, size, association etc. The locational maps of study region and ground truthing data were also used for reference. Field studies proved to be very helpful in correctly demarcating the features. For classification, 'supervised classification' was adopted. The classified features were verified with ground truth data. Land use/ land cover maps depicting the classified ground features for different areas of interest were subsetted from the master classified image. Circular regions with project site as center and radial distances of 50kms, as shown in the subsequent sections, were few of the derived areas of interest. The proportional presence of different land uses in terms of statistical percentages was also derived for the said areas of interest. Appropriate legends were used to represent the various categories of landuse-landcover, and are written on the prepared landuse-landcover maps.

Chapter 3.0

GROUND SURVEY AND GPS READINGS

The region for field survey was chosen around the project site, spreading radially on the land side about thirty kilometers from the project site. The field survey was carried out, during May 15-18, 2006 in order to observe and understand the ground features. The GPS readings and observations of land features were taken at several ground locations spread evenly in the study region. The project site, being close to the gulf of Kutchch waters, the field observations have been made mainly on the land.

The following table enumerates the land features and its corresponding GPS readings of all the ground truthing locations selected for the study.

Table 1. Land use features, GPS readings at locations on the land within the radial distance of 35kms from the proposed project site. The Table 1 also provides the taluka and village of each location

Sr No	GPS reading		Category	Description	Taluka	Village
	Latitude	Longitude				
1	22° 48.179’ N	069°32.078’ E	Sandy Shore	Barren sandy area with no vegetation.	Mundra	Tunda wandh
2	22° 50.602’ N	069°31.682’ E	Built up area	Concrete buildings with roofed top.	Mundra	Kandagara
3	22° 50.124’ N	069°31.271’ E	Scrub forest	The area is with small bushes or in many places exposed sandy soil is seen	Mundra	Kandagara
4	22° 49.849’ N	069°29.323’ E	Agricultural land	Plantation of Kharik. Admeasuring an	Mandvi	Nana Bhadia

				area of > 5acres		
5	22° 49.845' N	069°29.068' E	Built up area	Human settlement	Mandvi	Nana Bhadia
6	22° 49.569' N	069°28.502' E	Artificial Lake	Pond constructed by human effort > 4 acres	Mandvi	Tragadia
7	22° 49.555' N	069°28.179' E	Built up area	Building construction Panchayat office	Mandvi	Tragadia
8	22° 49.818' N	069°26.516' E	Agricultural land	Tilled land ready for sowing.	Mandvi	Gundiyali
9	22° 50.273' N	069°25.405' E	Artificial Lake	Naran Sarovar Artificial Lake of > 25acres With no traces of water.	Mandvi	Gundiyali
10	22° 50.176' N	069°25.198' E	Built up area	Houses built for human settlement	Mandvi	Gundiyali
11	22° 49.945' N	069°24.578' E	Agricultural Land	Cultivation of Hinjwa, used for feeding livestock.	Mandvi	Gundiyali
12	22° 50.180' N	069°23.359' E	Agricultural Land	Coconut Farm	Mandvi	Maska
13	22° 50.211' N	069°23.330' E	Agricultural Land	Bajra Plantation Standing crop Plot admeasuring 1 to 2acres	Mandvi	Maska
14	22° 50.190' N	069°22.920' E	Built up area	A small temple	Mandvi	Maska
15	22° 50.298' N	069°21.982' E	Highway	Mandvi-Bhuj Highway octroy point near Reliance petrol pump	Mandvi	Mandvi
16	22° 49.979' N	069°21.566' E	River	Rukmavathi river near Mandvi bridge	Mandvi	Mandvi
17	22° 50.164' N	069°22.740' E	Built up area	Ek ka Das Mahadev Temple	Mandvi	Maska
18	22° 51.076' N	069°23.788' E	Agricultural land	Ready for sowing >10acres	Mandvi	Bag
19	22° 51.047' N	069°24.141' E	Built up area	Township with good green cover Houses small red tiled roof.	Mandvi	Bag

20	22° 51.675’ N	069°24.225’ E	Water tank	Shallow water tank artificially created having stagnant water > 500 SqM	Mandvi	Bag
21	22° 51.648’ N	069°24.224’ E	Agricultural land	Harvested land, used for crop rotation. Crops like wheat ,cotton, jowar, are cultivated in these land	Mandvi	Bag
22	22° 52.202’ N	069°24.685’ E	Agricultural land	Jowar crop ready for harvesting	Mandvi	Bag
23	22° 52.383’ N	069°26.137’ E	Built up area	Village settlement small houses with roofed top	Mandvi	Pipari
24	22° 53.874’ N	069°26.949’ E	Agricultural land	Chickoo plantation > 2-4 acres	Mandvi	Bidada
25	22° 53.215’ N	069°53.215’ E	Built up area	Temple Manav Mandir	Mandvi	Bidada
26	22° 53.750’ N	069°28.447’ E	Built up area	Human settlement	Mandvi	Bidada
27	22° 51.410’ N	069°28.646’ E	Built up area	Human settlement	Mandvi	Mota Bhadia
28	22° 50.210’ N	069°29.017’ E	Artificial lake	>50 acres No trace of water seen	Mandvi	Nana Bhadia
29	22° 48.179’ N	069°32.078’ E	Sandy Shore	Barren sandy area with no vegetation.	Mundra	Tunda wandh
30	22° 48.447’ N	069°42.518’ E	Built up area	Human settlement Houses are very peculiar dome shaped with mud wall and thatched roof.	Mundra	Tunda wandh
31	22° 48.881’ N	069°32.060’ E	Road	Junction road meeting project site with local road.	Mundra	Tunda wandh
32	22° 50.618’ N	069°44.428’ E	Built up	Houses with	Mundra	Baroi

			area	concrete walls with tiled roof		
33	22° 50.373’ N	069°50.447’ E	Road	Main Bus depo of Mundra city.	Mundra	
34	22° 50.665’ N	069°41.799’ E	Dried water coarses or nallah	Dried river trespassing the village	Mundra	Nana Kapaya
35	22° 50.589’ N	069°41.663’ E	Built up area	Main village	Mundra	Nana Kapaya
36	22° 51.010’ N	069°40.465’ E	Dried water coarses or nallah	Dried river trespassing the village.	Mundra	Borana
37	22° 51.186’ N	069°40.020’ E	Built up area	Main village	Mundra	Borana
38	22° 51.365’ N	069°39.333’ E	Artificial lake	Lake constructed	Mundra	Pratpara
39	22° 51.398’ N	069°38.974’ E	Built up area	Main village	Mundra	Pratpara
40	22° 51.639’ N	069°38.464’ E	Agricultu ral land	Castor plantation >5 acres.	Mundra	Bhujpur
41	22° 51.751’ N	069°38.300’ E	Agricultu ral land	Chickoo plantation inter spaced with kharik	Mundra	Bhujpur
42	22° 52.432’ N	069°37.893’ E	Built up area	Main village	Mundra	Bhujpur
43	22° 53.048’ N	069°37.320’ E	River	Nagvanthi river Completely dried.	Mundra	Bhujpur
44	22° 52.941’ N	069°37.203’ E	Agricultu ral land	Mango plantation Ready for harvesting	Mundra	Bhujpur
45	22° 50.400’ N	069°35.823’ E	Dried water coarses or nallah	Water coarce trespassimg through Village	Mundra	Navianal
46	22° 50.010’ N	069°35.907’ E	Built up area	Human settlement	Mundra	Navianal
47	22° 49.863’ N	069°35.892’ E	Artificial lake	>25acres dried	Mundra	Navianal
48	22° 50.169’ N	069°37.738’ E	River	River crossing the road Dried	Mundra	Navianal

49	22° 50.202’ N	069°39.027’ E	Built up area	Human settlement	Mundra	Jarpara
50	22° 50.060’ N	069°40.811’ E	Built up area	Human settlement, Mosque	Mundra	Dhrab
51	22° 50.239’ N	069°41.741’ E	Highway	Zero point highway Junction leading to adani port	Mundra	Dhrab
52	22° 52.726’ N	069°42.192’ E	Highway	Bhuj- mundra Highway	Mundra	Mota Kapaya
53	22° 53.817’ N	069°41.806’ E	Highway	Highway junction near pangrapol Bhuj –mundra	Mundra	Pragpar
54	22° 55.045’ N	069°41.089’ E	Highway		Mundra	Baraya
55	22° 55.082’ N	069°40.936’ E	Dried river		Mundra	Baraya
56	22° 56.708’ N	069°39.576’ E	Built up area	Village settlement	Mundra	Karagoga
57	22° 57.861’ N	069°38.899’ E	Built up area	Human settlement	Mundra	Bocha
58	22° 58.107’ N	069°38.907’ E	Barren hilly area		Mundra	Bocha
59	22° 58.321’ N	069°38.735’ E	Barren hilly area	Rock cliffs	Mundra	Bocha
60	22° 58.637’ N	069°38.556’ E	Highway	Junction from Bocha village to Bhuj highway	Mundra	Bocha
61	23° 00.084’ N	069°34.197’ E	Built up area	Human settlement	Mundra	Tumbadi Moti
62	22° 59.945’ N	069°33.600’ E	Agricultural land	Fertile land for cultivation	Mundra	Moti Tumbadi
63	22° 59.680’ N	069°32.446’ E	Built up area	Temple	Mundra	Tumbadi Nani
64	22° 59.948’ N	069°32.084’ E	Barren hill		Mundra	Tumbadi Nani
65	22° 59.981’ N	069°32.022’ E	Built up area	Temple	Mundra	Tumbadi Nani
66	23° 00.185’ N	069°31.672’ E	Agricultural land	Fertile land admeasuring >10 acres	Mundra	Tumbadi Nani
67	23° 00.970’ N	069°30.128’ E	Built up area	Village settlement	Mandvi	Punadi
68	23° 01.080’ N	069°28.346’ E	Road	Road from Punadi to Mandvi	Mandvi	Punadi

				bhuj highway		
69	22° 59.743’ N	069°27.273’ E	Road	Junction point at Mota Asambia and Nana Asambia	Mandvi	Asambia Mota & Asambia Nana
70	22° 57.934’ N	069°26.344’ E	Highway	Junction of Mandvi –Bhuj highway leading to Mota Asambia	Mandvi	Asambia Mota
71	22° 58.526’ N	069°26.621’ E	Agricultural land	Cultivation of Jowar, ready for harvesting	Mandvi	Goniyasar Mota
72	22° 59.790’ N	069°27.255’ E	Agricultural field	>5-10 acres fertile land The area is fully infested with thorny undergrowth. These are considered as nuisance weeds, which makes the agricultural activities difficult	Mandvi	Goniyasar Mota

Chapter 4

SIGNIFICANT LAND USE FEATURES

The proposed power plant site is situated in the **Kuchch** district of Gujarat state. A study of the significant ground features were carried out in and around the site within the periphery of 30kms.radial distance from the project site. The study area falls under two Talukas viz, Mundra and Mandvi. There are more than 57 villages covered during the field visit.

1. General Phytogeography of the State of Gujarat

The state of Gujarat is situated on the west coast of India between 20° and 25° north latitude and 68° and 75° east longitudes. Its boundaries are defined by Arabian sea on the west, the state of Rajasthan on the north-east, Madhya Pradesh on the east and Maharashtra on the south east and south. On the north-western fringe it has a common boarder with Pakistan

The state of Gujarat has a landmass of 1,9602400 hectares that accounts for about 6 per cent area of the country which 23,34,400 hectares are under irrigation. The state has 8,48, 300 hectares under permanent pasture and grazing land. In addition to this 8,62,800 hectares are under fodder crops. The state has 1600Km of coastal area. Rainfall varies from about 340mm in the western arid district of Kachch to about 1800mm in the southern hills of Dangs and Bulsar. The climate varies from arid to dry sub-humid in Kachch and Bulsar districts. Nearly 25% of the geographical area in the western part is arid.

From the point of view of the forest distribution and description of vegetation the whole of the state can be divided into three distinct zones viz, area of the south of the Narmada consisting of deciduous forests with teak as the main economic species, the areas between

the river Narmada and the extreme north excluding Saurashtra and Kutch covering dry deciduous forests with or without teak, and the area of Saurashtra and Kutch with poor teak forests in Junagadh, scrublands, mangrove forests and desert areas.

2. The Topography of the area covered under study

The present study area falls in Kutchch peninsula. The topography of the area is such that the central portion forms the table land sloping on all sides. It is practically an undulating rocky area with small hills and with rann of Kutch lying on the northern end, consisting of vast expense of tidal mud flats with salt-encrusted mud. The soil vary a great deal from place to place, along the coastline, there are alluvial soil and in some parts they are saline. There are also areas with sandy soil.

Photo No-1: General Topography of the area

2.1 General pattern of vegetation

The forest type of the area falls under scrub forest as per the classification of Champion and Seth (1968). These forests are typical of arid and semi-arid zones of the earth where

the total rainfall ranges from 25-100Cm. The vegetation presents a very open appearance so that the trees and shrubs are widely spaced. The bulk of the vegetation consist of co-dominant, spinous shrubs and trees capable of drought resistance.

The typical species found in these areas are given in the following photographs.

Photo No -2: Dichrostachys cinerea

Photo No:-3 Capparis decidua

Photo No-4: Prosopis *juliflora* (swartz) DC.

2.2 Agricultural crops

The major agricultural crops cultivated in the area are Jowar, wheat, cotton, castor etc. Fruit trees like sapota, mango, are also cultivated in some part of the district. The most

dominant species which is found growing in almost all parts of the district is ***Phoenix robusta*** (Bell.) Bell. & Hook. f. locally known as Kharik. It is a commercial crop cultivated for its edible fruits.

Photo No 5: Phoenix robusta (Bell.) Bell. & Hook.f.

3. Land use pattern of the study area

The following are the significant land use features encountered during the ground truthing survey:

3.1. Open scrub forest

Most of the land area of the district is covered by scrub forest, which is either exposed or sparsely covered by vegetation cover.

Photo No-6: Open scrub forest

3. 2. Barren hilly areas

These areas are mostly seen on both side of the Bhuj- Mundra highway. These are open dry land without any vegetation cover. There are no water bodies present in and around these sites.

Photo No-7 : Barren hilly areas

3.3. Agricultural land

These are agricultural lands spread like the huge tract of land admeasuring 10-50 Acres of area, divided into small, medium and large plots. These lands are found under the possession of landlord or individual farmers. Different agricultural crops such are cotton, jowar, bajra, wheat etc. are cultivated in these plots. Such agricultural lands are found in the villages like Nana Bhadia, Gundiyali, Maska, etc. Presently these agricultural fields are tilled and exposed to sun. The sowing is done immediately after the fall of the first shower.

Agricultural land with different crop type, different stage of cultivation such as harvested field, ready for harvesting, standing crop etc. are also covered in the ground truthing survey.

Each of these plot is bordered on four sides with tall perennial species like coconut, Kharik etc.

Photo No-8 : Typical view of agricultural field

3.4. Sandy shore

Are mostly seen in the coastal belt and are subjected to all extremes such as temperature, salinity, turbidity, wave action etc. There are no vegetation seen on these sites, however there are some faunal intertidal molluscan species visits these sites occasionally. The remnants of their shells are most frequently seen.

Photo No-9: Sandy Shore

3.5. Built up area

Are mostly restricted near the village headquarters where the village sarpanch and other infrastructural facilities like schools, hospitals, temple, mosque, market etc are located. Every village has a central point where the human settlement is maximum.

Photo No-10 : Built up areas

3.6. Roads and Highways

There are two major highways passing through the project site viz, Mundra – Bhuj Highway (SH-48) and Mandvi – Bhuj Highway (SH-47). Apart from this another major road (SH-6) connecting the two highways trespasses through the project boundary.

Photo No-11: Highway at zero point

3.7. Rivers

There are two major perennial rivers viz Nagvati and Rukmavathi rivers passes through the project boundary. These rivers are the only water sources for the entire area.

Photo No-12: Rukmavathi River

3.8. Dried water courses or Nallah

There are many small river coarses or nallah passing through each village. They are highly seasonal and the water is available only in the limited period of the year. In summer these rivers are literally dry.

3.9. Artificial lake

With the Governments active participation and the sramadhan from the local people there are many artificial lakes constructed. The main purpose is to store water to make it available throughout the year. These lakes are seen in villages like Gundiyali, Tragadia , etc. Many of them are very huge covering more than an area of 25-30 acres.

Photo No-13: Artificial lake at Gundiyali village

3.10.Water tank

These are structures used for storing water to meet the day to day agricultural and livestock requirement. The water is pumped from the ground water which is 200 - 300meters below and stored on the surface in small artificially made water tanks. Such water bodies are recorded from the village Bag, Gundiyali, etc.

Photo No-14: Water Tank at Bag village

Chapter 5.0

SATELLITE DATA INTERPRETATION - CLASSIFICATION

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The landuse-landcover in the region comprises of various types, referred as classes. The features derived from the satellite image after validation by the ground observations, have been presented as nine classes and are given below. These classifications types are as per the 'level classification' categories followed by National Remote Sensing Agencies (NRSA), -

1. Cultivated Land
2. Fallow Land
3. Built-up Area
4. Water Bodies
5. Barren Area
6. Marshy Land / Low Land
7. waste land
8. Forest Cover
9. Sparse Forest

Satellite data from IRS-P6 (November 26, 2005) has been used . The approach used for analysis is given at the Chapter 2.0.

Inorder to understand the land use and land features covering the entire study region, both False Composite and classified images have been derived. FCC images depicts the land features such as the coastal boundaries, while the classified images show different land use classes listed above. The coverage statistics, the area covered by each land use class, are also derived through satellite data analysis and given below in different Tables.

FCC and Classified images have been derived for 30kms 20 kms , 10kms and 5kms

The images classified into the above-mentioned nine classes for different regions of interest are given at Exhibits, . Brief description of each type of the class forming landuse-landcover, derived from the satellite data analysis and the ground observations, is depicted in the classified image. Here, it is advised that the photographs given at the Chapter 4.0 are also referred.

The coverage areas of these nine classes of land use existing in the study region have also been derived from the satellite image analysis. The statistical percentage of these various classes, forming the land use/land cover, is also derived for the different regions of interest, 30kms, 20kms., 10kms, and 5kms .

Table 2:

Land Use Types and Its Coverage within 5, 10 and 30 Km. radius (Statistical Percentages)

LAND USE CLASSESS WITHIN 5 KM RADIUS

Classes	Area (Km^2)
Scrub forest	1.326274637
Salt Pan	8.319278704
Mangrove	0.054819352
Built up area	14.78530965
Fallow land	18.88261409
Nallah	7.241459516
Agricultural land	5.15743997
Water Bodies	5.406779602
Barren hill	5.210490956
Marshy Land	12.89581038
Total	**79.28027686**

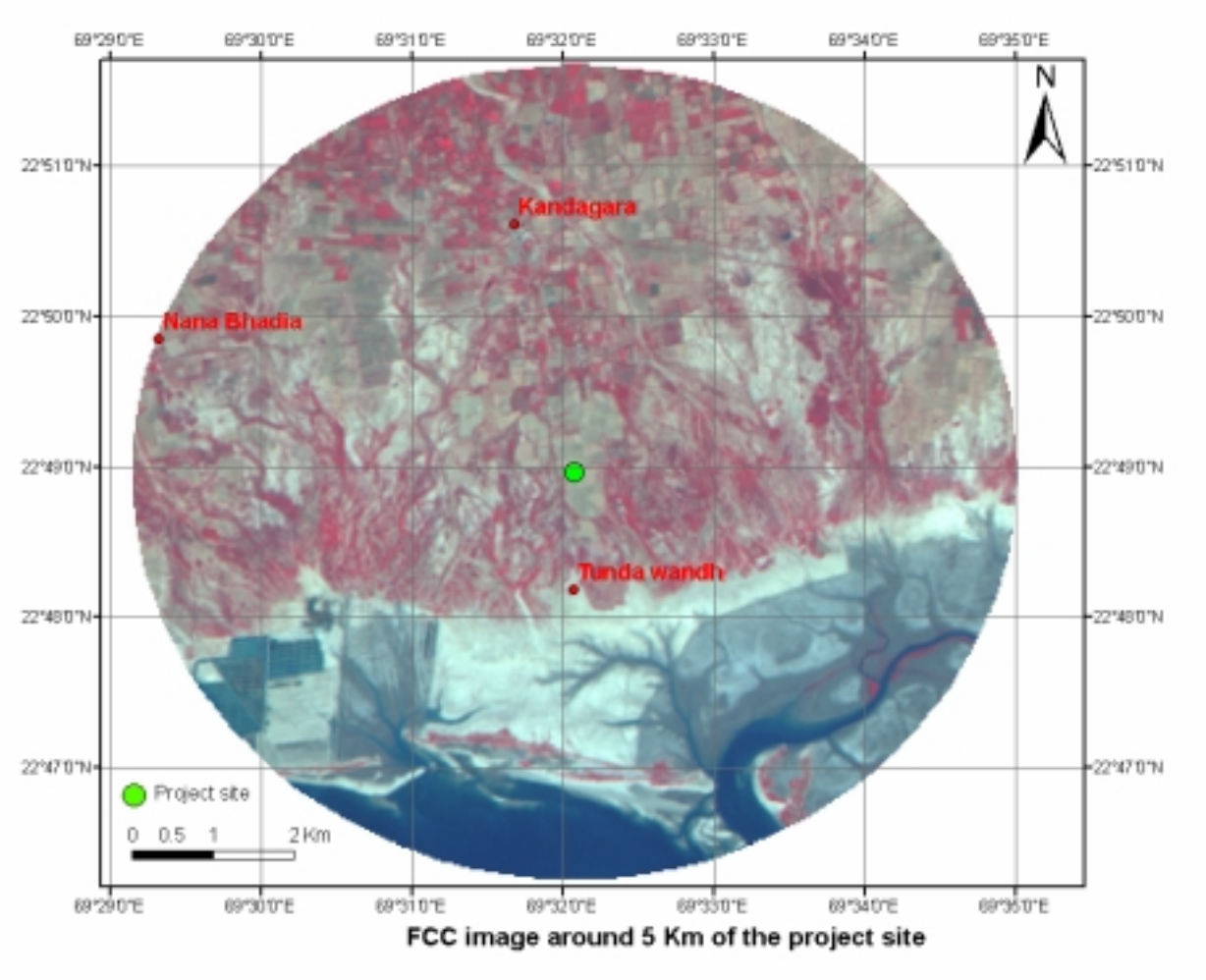
LAND USE CLASSESS WITHIN 10 KM RADIUS

Scrub forest	2.829385891
Salt Pan	13.23445251
Mangrove	0.719725036
Built up area	44.29934123
Fallow land	70.77974062
Nallah	15.3839016
Agricultural land	33.14890827
Water Bodies	63.53651274
Barren hill	25.53697604
Marshy Land	46.71581362
Total	**316.1847575**

LAND USE CLASSESS WITHIN 30 KM RADIUS

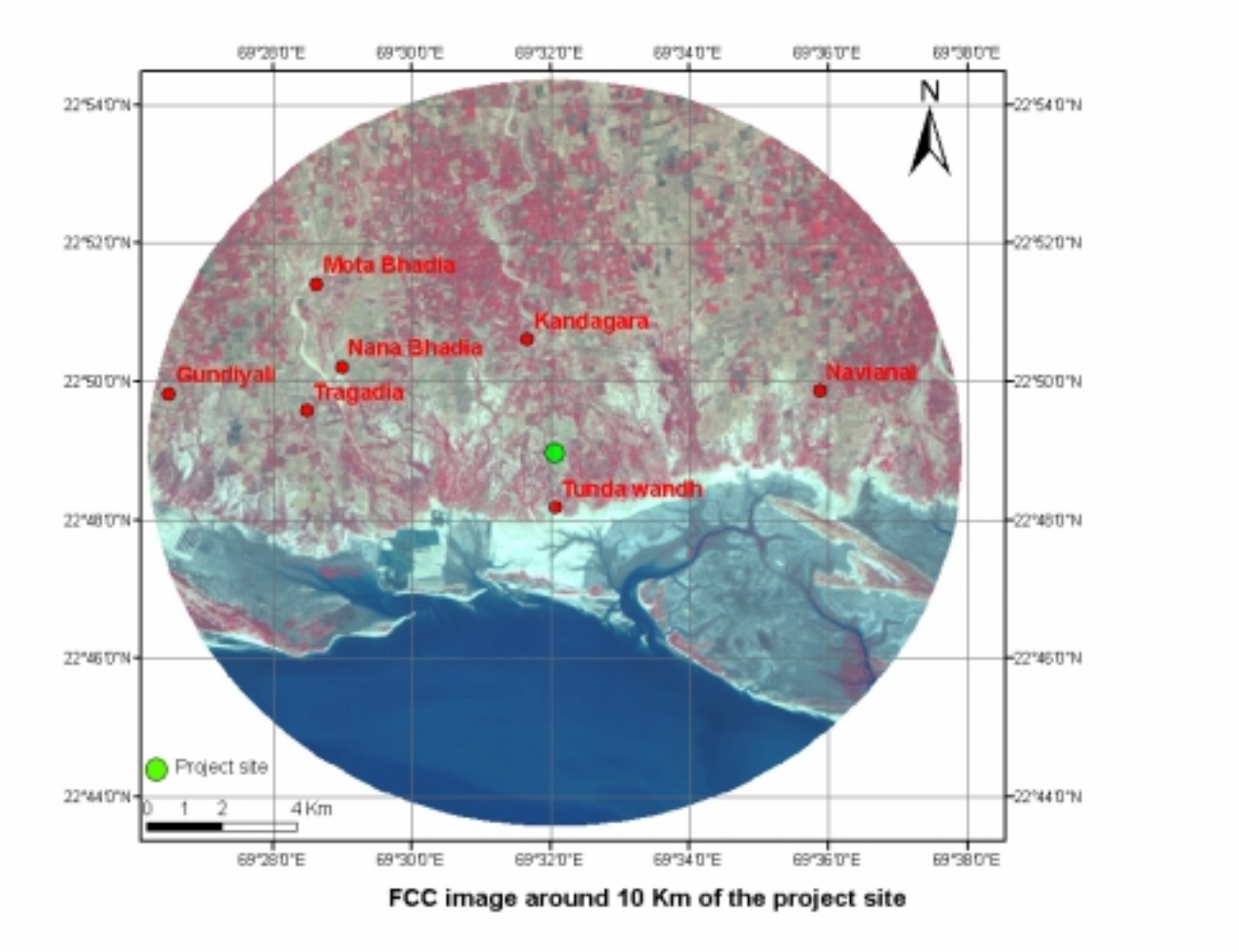
Scrub forest	53.16239253
Salt Pan	32.66260757
Mangrove	6.764000647
Built up area	280.4018678
Fallow land	443.8271969
Nallah	84.7790115
Agricultural land	158.2316376
Water Bodies	515.5998752
Barren hill	414.0859303
Marshy Land	120.9942667
Total	**2110.508787**

Figure 1



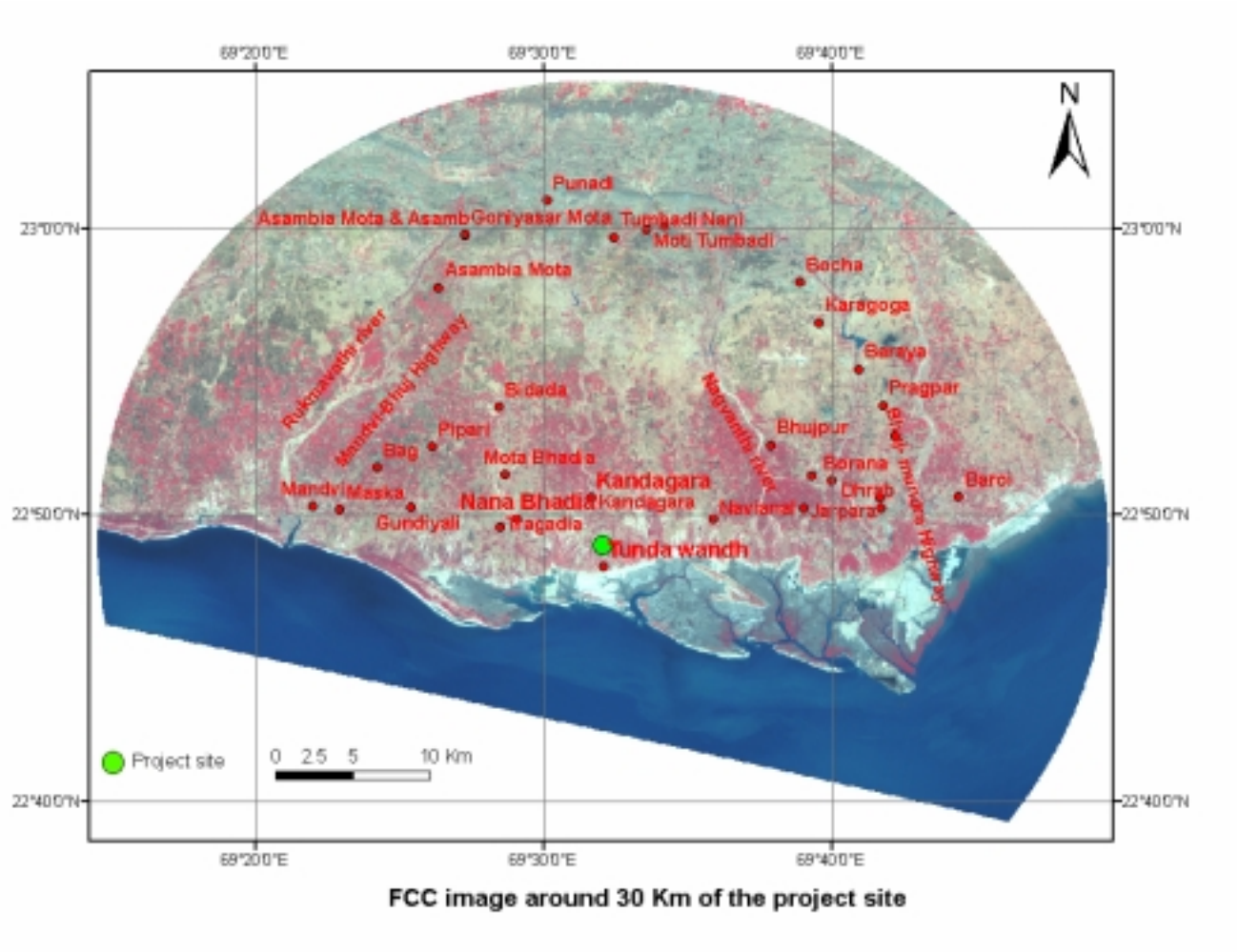
FCC image around 5 Km of the project site

Figure 2



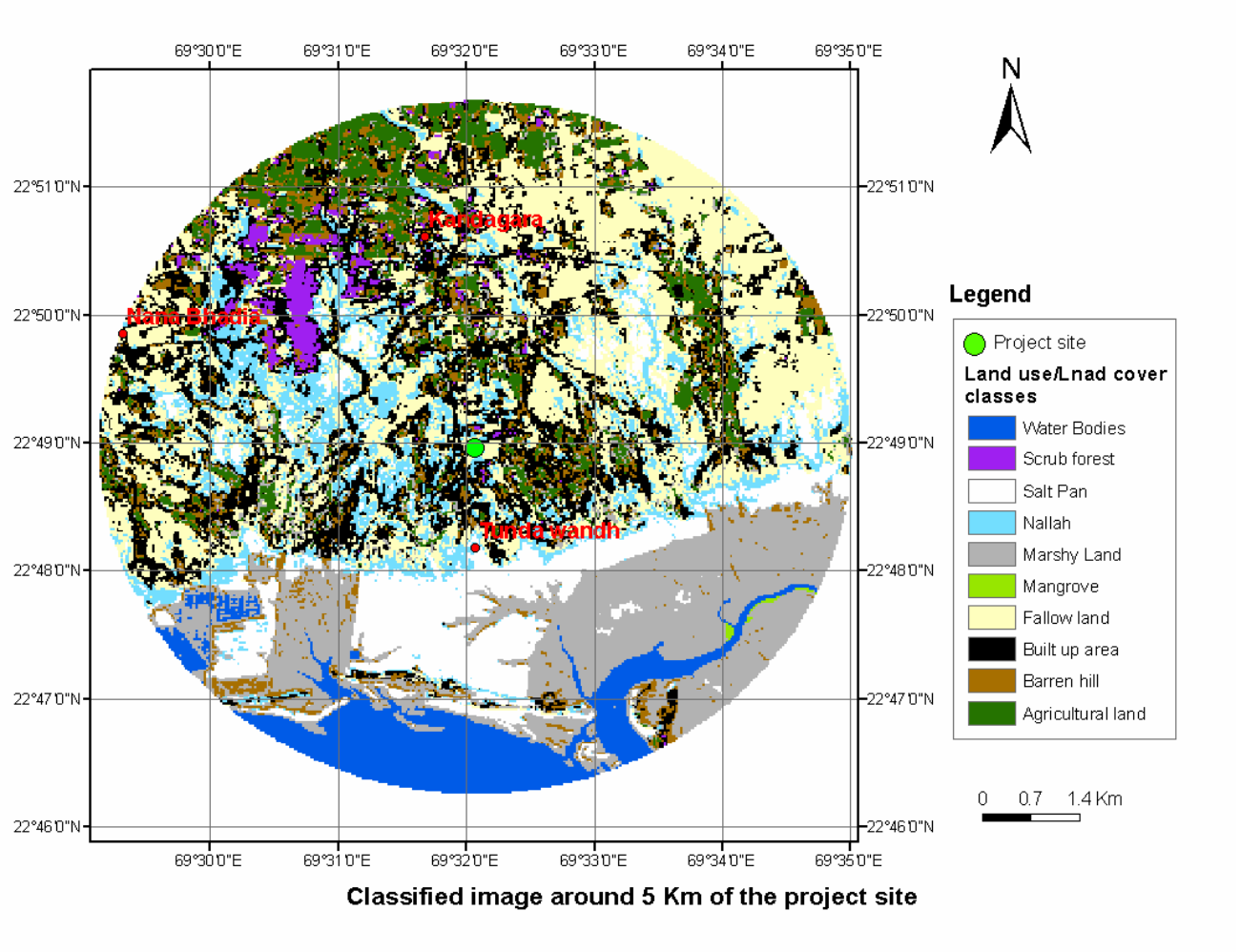
FCC image around 10 Km of the project site

Figure 3



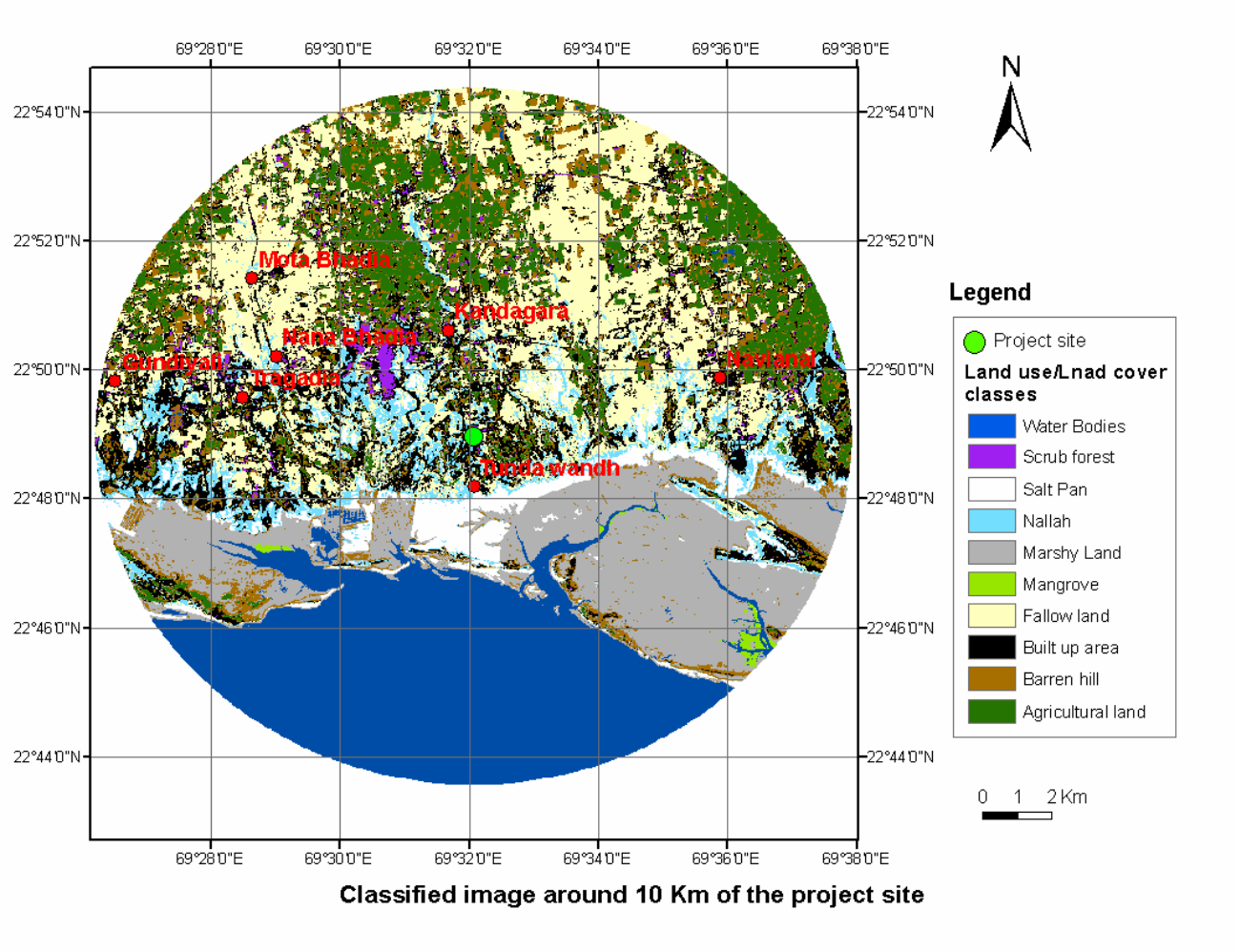
FCC image around 30 Km of the project site

Figure 4



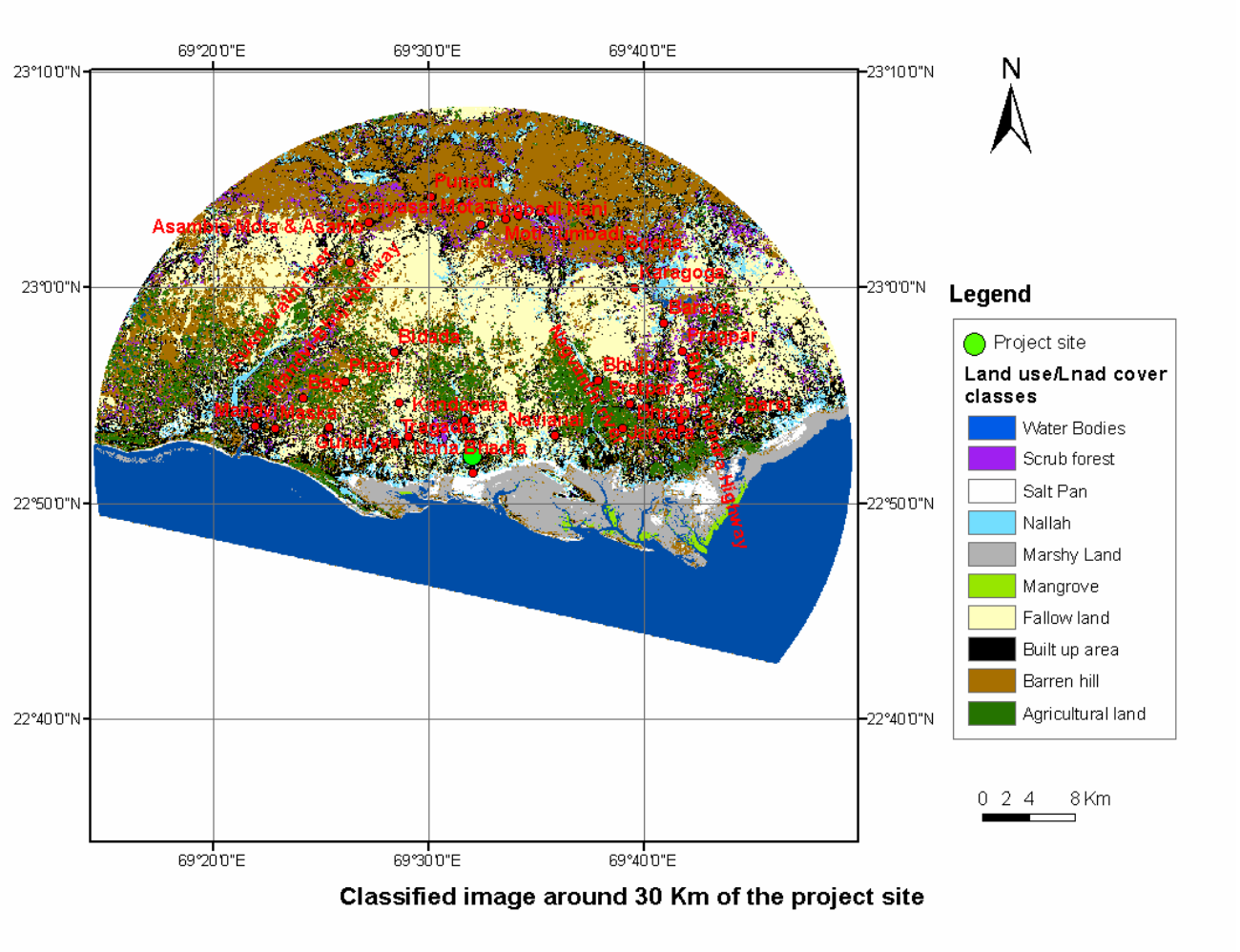
Classified image around 5 Km of the project site

Figure 5



Classified image around 10 Km of the project site

Figure 6



Classified image around 30 Km of the project site