USAID
FROM THE AMERICAN PEOPLE

LANDUSE/LANDCOVER MAPS OF SIX PROTECTED AREAS OF NISHORGO SUPPORT PROJECT (NSP)

August 2006

This report is made possible by the support of the American People through the United States Agency for International Development (USAID.) The contents of this report are the sole responsibility of International Resources Group (IRG) and do not necessarily reflect the views of USAID or the United States Government.

LANDUSE/LANDCOVER MAPS OF SIX PROTECTED AREAS OF NISHORGO SUPPORT PROJECT (NSP)

August 2006

CEGIS Center for Environmental and Geographic Information Services
House 6, Road 23/C, Gulshan-1, Dhaka-1212, Bangladesh. Tel: 8817648-52, Fax: 880-2-8855935

IRG

International Resources Group
1211 Connecticut Avenue, NW, Suite 700
Washington, DC 20036
202-289-0100 Fax 202-289-7601
www.irgltd.com

TABLE OF CONTENTS

TABLE OF FIGURES

TABLE OF TABLES

INTRODUCTION

INTRODUCTION

The Nishorgo Support Project (NSP) of the Forest Department (FD) launched in 2004 is engaged in establishing co-management in six Protected Areas (PA) in Bangladesh. The project will develop a formal co-management mechanism between FD and the stakeholders in the PAs. In addition, the project will also improve the management of the PAs. For improved management, a prerequisite is to build an accurate database on different management issues, as well as natural and socio-economic dimensions.

Under these circumstances it is necessary to develop landuse/landcover maps from satellite images to improve the accuracy of the existing landuse/landcover data, which are derived from different sources and from different organizations. The landuse/landcover maps will be used by the Forest Department for various activities suiting their purpose.

Nishorgo has requested CEGIS to prepare the landuse/landcover maps of six PAs. The maps will be prepared from IRS LISS III satellite images and landuse/landcover map of the Whykheong range of the Teknaf Game Reserve from a high-resolution QuickBird image that will be used for different activities.

This study included landuse/landcover mapping of the six protected areas of Bangladesh. The protected areas are Lawachara, Rema-Kalenga and Satchari in the northeastern part and Sitakund, Chunati and Teknaf in the south eastern part of Bangladesh. Two different types of satellite images were used for this study. A high resolution QuickBird satellite image was used only for the Whykheong range of the Teknaf Game Reserve area and IRS P6 LISS III images were used for all six protected areas. Digital image classification was used for the landuse/landcover mapping and a field survey was carried out to collect ground truth data. Ground truth data was used for digital classification of the QuickBird and IRS P6 LISS III images.

OBJECTIVES OF THE STUDY

The main objectives of the study were to:

- Develop landuse/landcover maps of the six protected areas from satellite images.
- Develop landuse/landcover maps of the Whykheong range from a high-resolution satellite image.
- Prepare a report.

STUDY AREA

The study area consisted of six protected areas of the Forest Department, Bangladesh. The protected areas are Lawachara, Rema-Kalenga and Satchari in the northeastern part and Sitakund, Chunati and Teknaf in the south eastern part of Bangladesh. Figure 1 shows the distribution of the protected areas and figure 2(a) and 2(b) show the study area boundary in yellow line and the protected areas in green line. The boundary of the study area, as delineated by IRG, includes the protected area and a 5km buffer around each protected area boundary. Buffer areas that are outside Bangladesh were excluded using the international boundary. Landuse/landcover mapping of the Whykheong range using a high-resolution QuickBird image area was chosen by IRG.

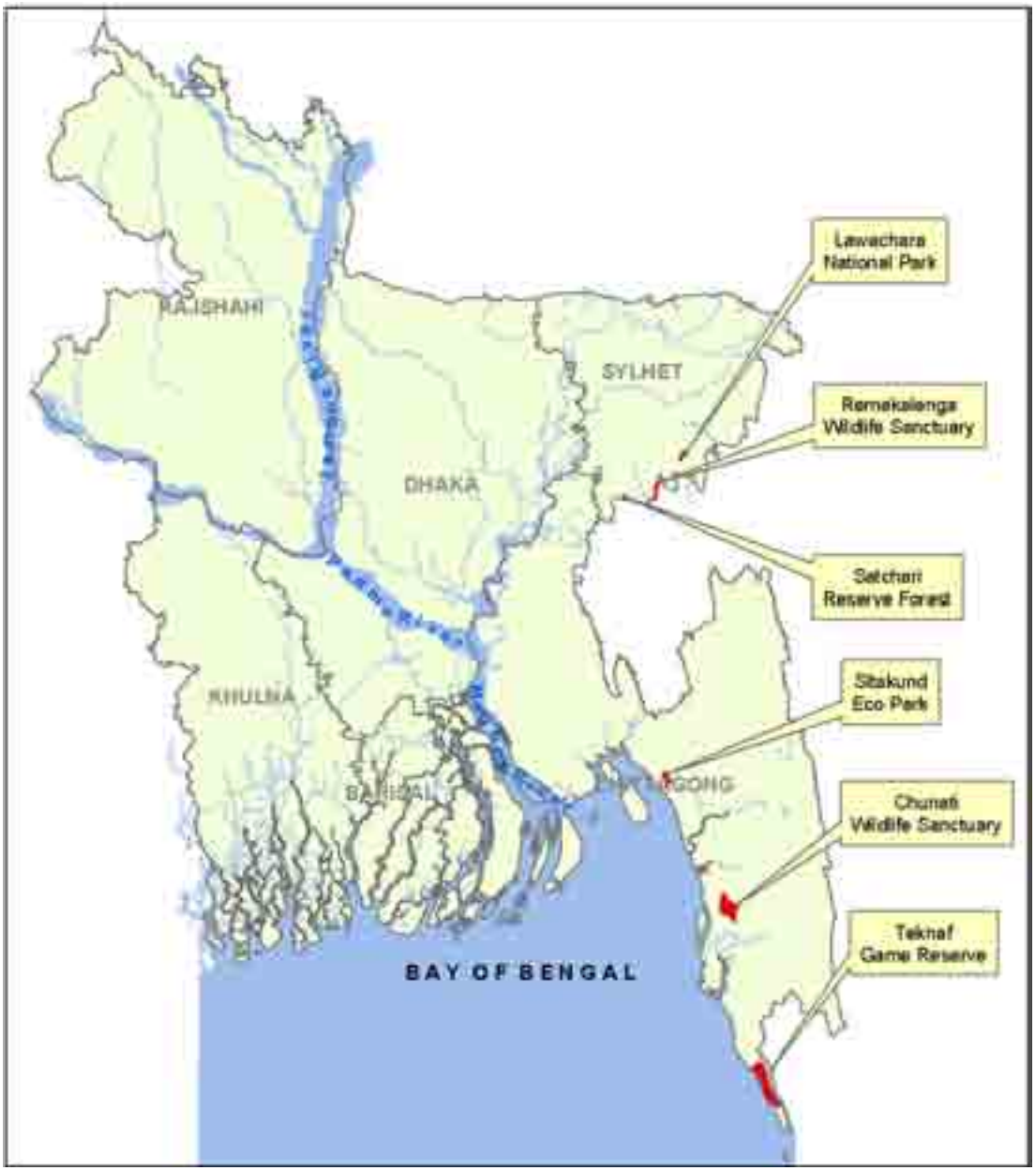
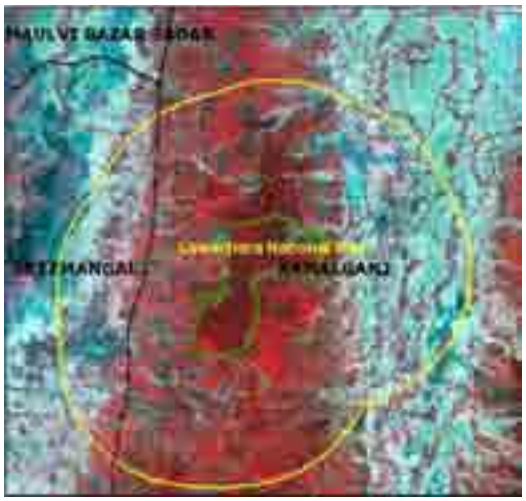
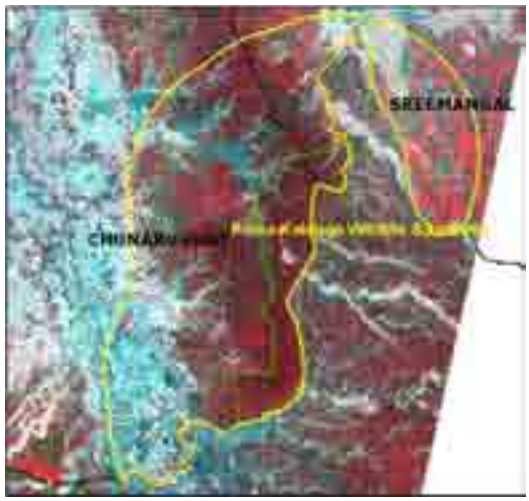

Lawachara
National Park
RAJSHAHI
SYLHET
Remakalenga
Wildlife Sanctuary
DHAKA
Satchari
Reserve Forest
KHULNA
Sitakund
Eco Park
BARISAL
CHITTAGONG
Chunati
Wildlife Sanctuary
Teknaf
Game Reserve
BAY OF BENGAL

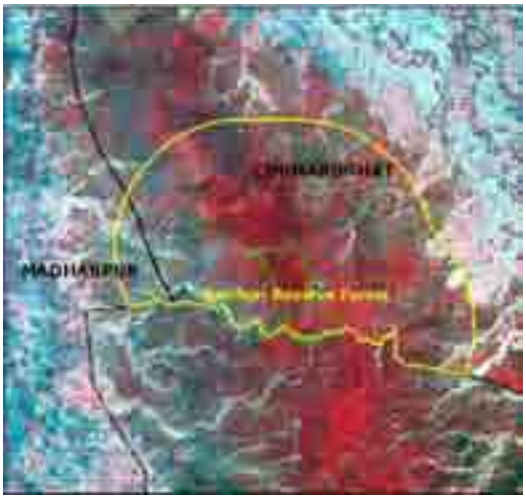
Figure 1: Location map of the protected areas



Lawachara National Park

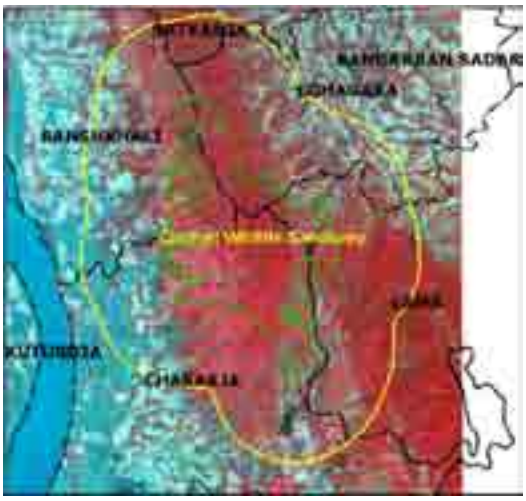


Rema-Kalenga Wildlife Sanctuary

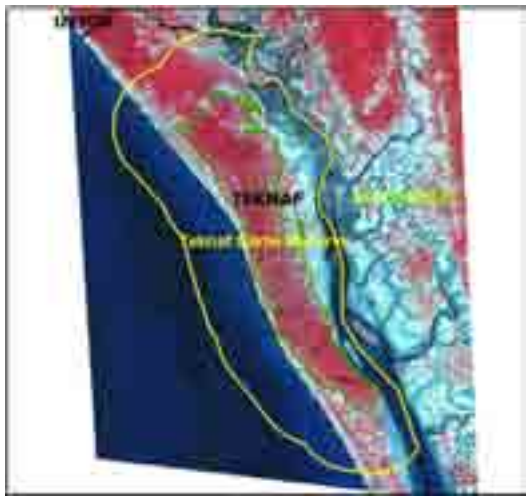


Satchari Reserve Forest

Sitakund Eco-park



Chunati Wildlife Sanctuary



Teknaf Game Reserve

Figure 2(a): Study Area boundary on IRS P6 LISSIII images

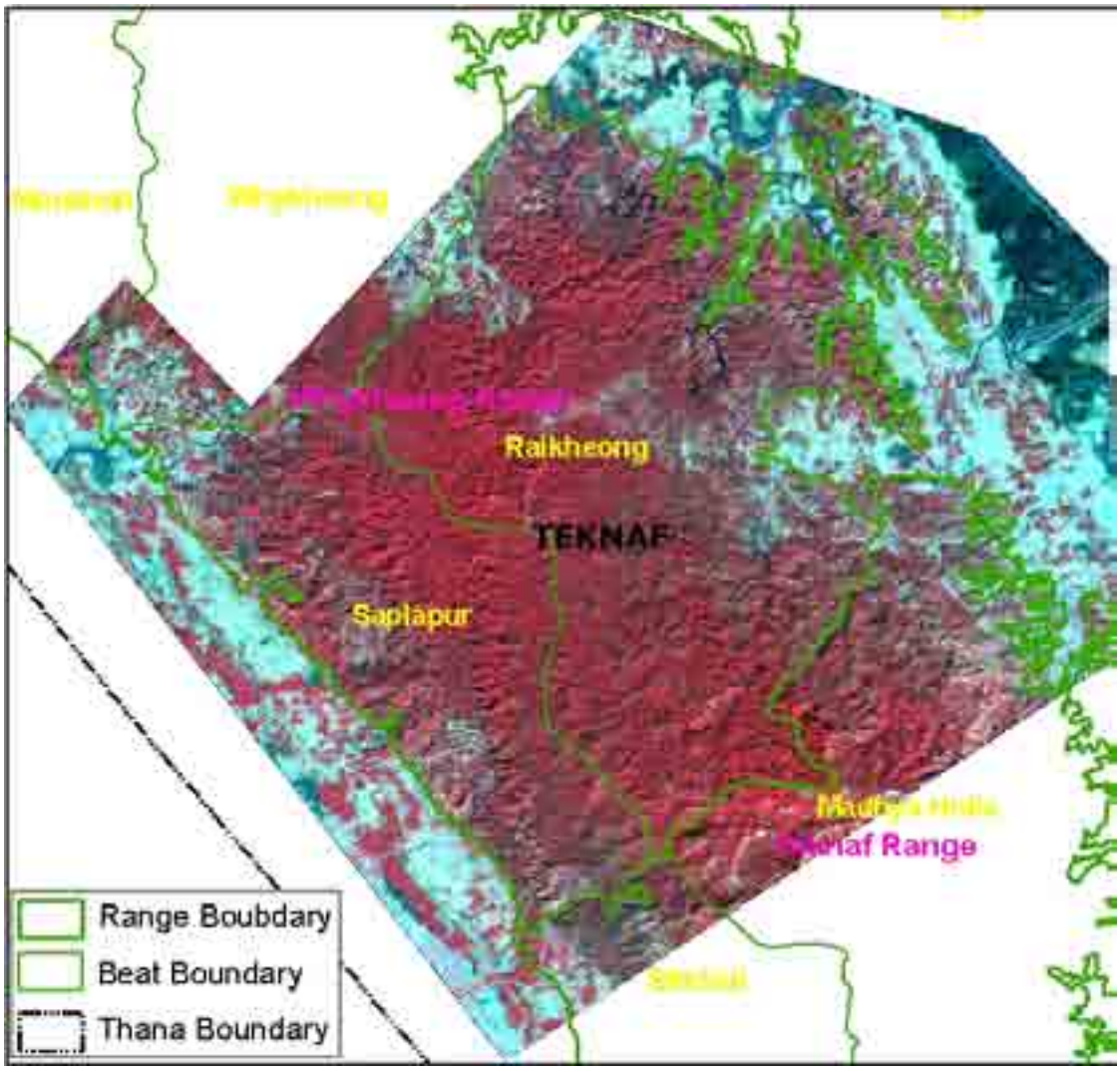


Figure 2(b): Study Area boundary on QuickBird image

METHODOLOGY

Two different types of optical satellite images were acquired to derive current landuse/landcover maps of the six protected areas. Figure 3 shows the methodology of landuse/landcover mapping from satellite images. After procuring the images, all of them were georeferenced into the Bangladesh Transverse Mercator projection by Ground Control Point (GCP) coordinates. The GCPs were collected from the study areas using the Differential Global Positioning System (DGPS). Both visual and digital interpretation techniques were used to derive the landuse/landcover information from these images. Field surveys were conducted to collect ground truth data for the information on current landuse/landcover, which are used for interpreting digital classification. Finally, landuse/landcover maps were produced by digital classification with the help of ground truth data.

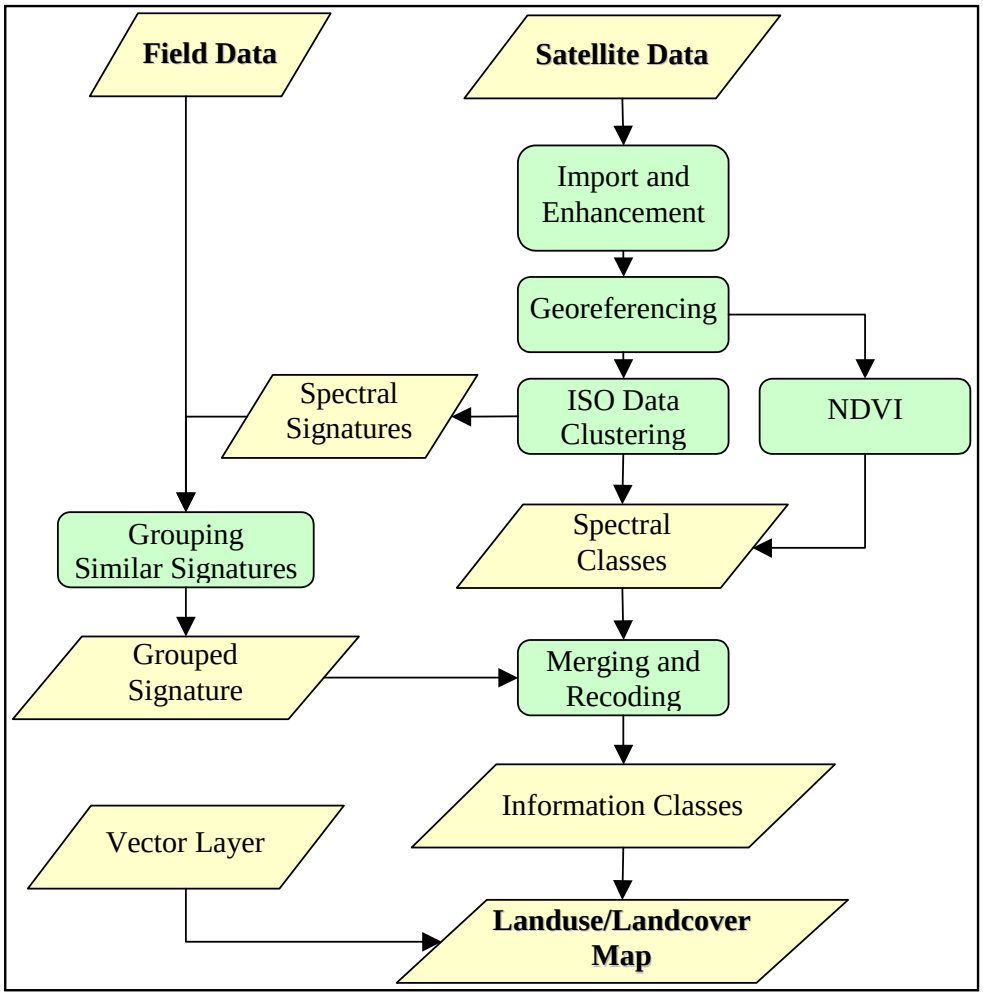


Figure 3: Methodology of landuse/landcover map preparation from satellite image

SATELLITE DATA

Moderate resolution IRS P6 LISS III satellite images of 2006 were procured for the preparation of Landuse/landcover maps of the study areas. A high resolution QuickBird image of 12 February 2003 was also procured for the Whykheong range of the Teknaf Game Reserve area. The sensor type and acquisition date of these images were selected considering climate/weather conditions and availability of the images in the vendor archive. Table 1 shows details of the satellite images along with image acquisition date. The LISS III sensor mounted on a IRS P6 platform acquires images using green (0.52 – 0.59 microns), red (0.62 - 0.68 microns), near infrared (0.77 - 0.86 microns) and short wave infrared (1.55 - 1.7 microns) bands. Whereas, the multispectral QuickBird acquires images using blue (0.45 – 0.52 microns), green (0.52 – 0.60 microns), red (0.63 – 0.69 microns) and near infrared (0.76 - 0.90 microns) bands and pan QuickBird acquires images using 0.45 – 0.90 microns wavelength.

Table 1: Details of Satellite Images used for Landuse/landcover map preparation

Protected Areas	Image Type	Spatial Resolution	Acquisition Dates
Satchari	IRS P6 LISS III	24m X 24m	10th February 2006
Rema-Kalenga	IRS P6 LISS III	24m X 24m	10th February 2006
Lawachara	IRS P6 LISS III	24m X 24m	22nd January 2006
Sitakund	IRS P6 LISS III	24m X 24m	22nd January 2006
Chunati	IRS P6 LISS III	24m X 24m	27th January 2006
Teknaf	IRS P6 LISS III	24m X 24m	27th January 2006
Whykheong	QuickBird PAN	0.60m X 0.60m	12th February 2003
	QuickBird MS	2.40m X 2.40m	12th February 2003

PRE-PROCESSING

SATELLITE DATA IMPORT AND ENHANCEMENT

All satellite images were received in digital format on CD. Images were imported from the CD to local machines in DN values. The commercial image processing software ERDAS IMAGINE was used to import data from the CD into an ERDAS IMAGINE supported raster format (.img) and was stored in a local machine. Visible bands (Band 2 and Band 3), infrared (Band 4) and short wave infrared (Band 5) were used to construct the multi spectral images of IRS P6 LISSIII images. Visible bands (Band 1, Band 2 and Band 3) and infrared (Band 4) were used to construct the multi spectral images of the QuickBird image. After loading the images, statistics were calculated for all images. Enchantment techniques were applied for better visualization of images.

GEOREFERENCING

Geo-referencing is undertaken to avoid geometric distortions. It is achieved by transforming image coordinates into projected geographic coordinates, which is also known as coordinate transformation. It is done using a transformation matrix, which is developed from a set of input ground control points (GCPs) and corresponding reference ground control points. Depending on the geometric distortions, the order of polynomials is determined. Usually a maximum of a third order polynomials will be sufficient for the existing remote sensing images. Using the transformation matrix, the IRS P6 images were georeferenced into the Bangladesh Transverse Mercator System.

IRS P6 LISSIII IMAGES

IRS-1D panchromatic images were used as reference image for geo-referencing the IRS P6 LISSIII images. The ground control points that were clearly visible in the IRS P6 LISSIII images were selected as input GCP and the corresponding points visible in the CEGIS archived DGPS corrected georeferenced IRS-1D panchromatic images were selected as reference GCP. The distribution of GCPs was almost equally spaced. A total of 20-40 GCPs were identified in the reference images. Both input and reference GCPs were used to develop the transformation matrix for the IRS P6 LISSIII images. Finally, the coordinates of all images were transformed into the BTM coordinate system using the Nearest Neighbor Resampling method. This resampling method transfers original data values without averaging them as the other methods do. Therefore, the extremes and subtleties of the data values are not lost. This is an important consideration when discriminating between vegetation types. The accuracy of geometric correction was measured as ±10 meters in the image plane.

QUICKBIRD IMAGE

The QuickBird image is of a ten times higher resolution than IRS-1D Panchromatic images. CEGIS archived DGPS corrected IRS-1D Panchromatic images could not be used to georeference the high-resolution QuickBird image with higher accuracy as needed for the image. So a field survey was done to collect GCPs by DGPS from the Whykheong range to georeference the QuickBird image. Thirty GCP coordinates were collected using DGPS from the study areas. These GCPs were used to georeference the QuickBird images. The distribution of the GCP coordinates which were collected from field are shown in figure 4. The horizontal accuracy of geometric correction was measured to be ±2 meters.

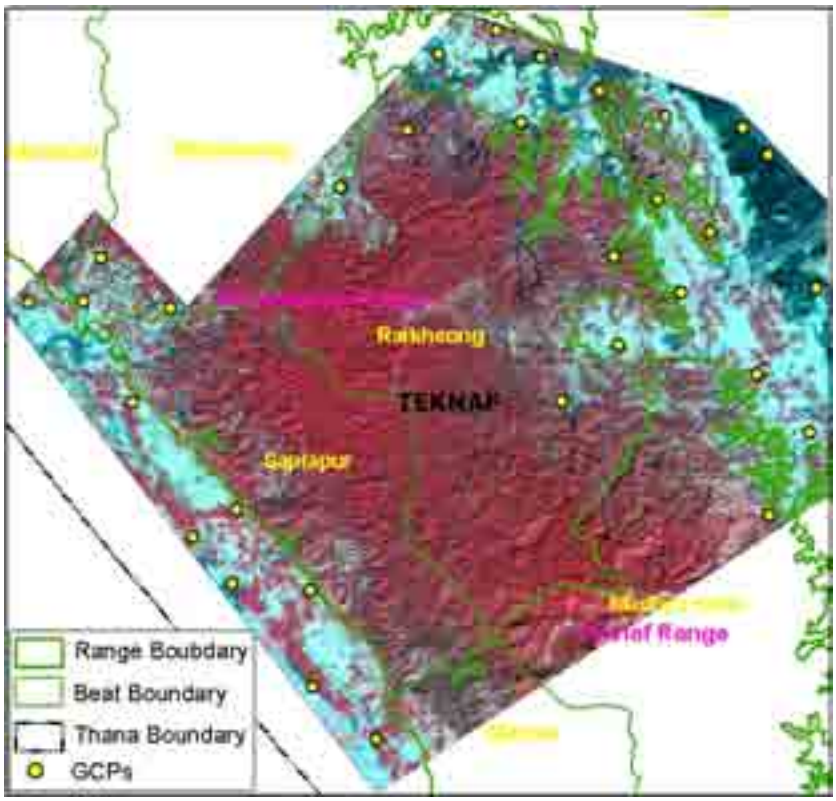


Figure 4: Distribution of the field collected GCPs on QuickBird image

GROUND TRUTH

Satellite images can be visualized in different colors or spectral patterns with different band combinations. Each of these spectral patterns represents a certain type of landuse/landcover on the ground. Field survey or ground truthing is required to identify these landuses/landcovers that are represented by these spectral patterns in the image.

For this study, field surveys were carried out in Satchari, Rema-Kalenga, Lawachara, Sitakund, Chunati and Teknaf. Before going to the field, different spectral patterns were identified on the multispectral images using a visual interpretation method. Field survey maps were prepared using the multispectral images with false color composition and different spectral patterns of interest were marked on the maps. Each of these patterns was visited during the field survey. Maps with high-resolution IRS 1D panchromatic images of 2003 were also used to identify the proper locations of the field sites. Assistance of local people was also taken to identify the selected field sites in the study areas. The main purpose of this field survey was to observe different landuse/landcover that exists on the ground by interviewing local people. During the field survey the following activities were carried out in each site:

- Recording the current landuse/landcover in the site and the landuse/landcover on image dates.
- Recording GPS coordinates.
- Photographs of each site.
- Writing down species composition of each field site in the forest area.
- Recording canopy closure and average height of each species using eye estimation.

In the Lawachara protected area, 42 sites were visited. The yellow dots on the IRS P6 LISS III image in figure 5 show the locations of the field sites that were visited. The main plants within the protected area are Segun, Chapalish, Bonak, Acacia, Mengium and Eucalyptus. The periphery of the Lawachara protected area is mainly composed of tea gardens and rubber forests.

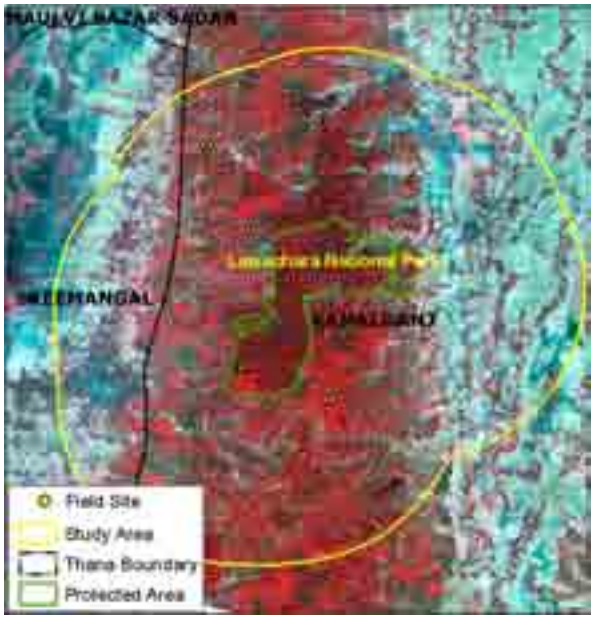


Figure 5: Yellow dots showing field sites in the Lawachara Protected Area

Within the Satchari protected area, ground truth data were collected from 56 sites (Figure 6). The dominant plants within the protected area are Acacia, Segun, Chapalish, Bamboo, Sungrass, Kadom and Malakana. Tea gardens are located in the periphery of the protected area.

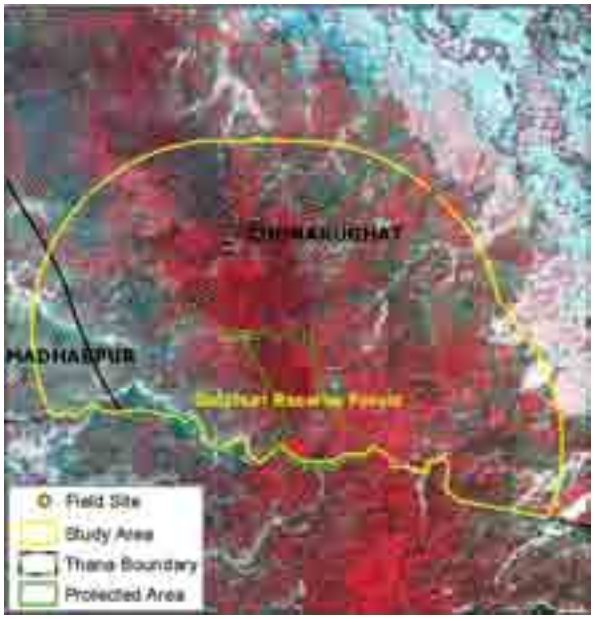


Figure 6: Yellow dots showing field sites in the Satchari Protected Area

Ground data were collected from 49 locations for Rema-Kalenga (Figure 7). The main plants of this protected area are Segun, Chapalish, Malakana, Mengium, Acacia, bamboo and herb-shrubs.

After collecting the field data it was converted into a digital format. A GIS layer was developed using the geographic position of each field site and ground information was linked with the GIS layer. The following is a detailed description of the field survey carried out for different landuses.

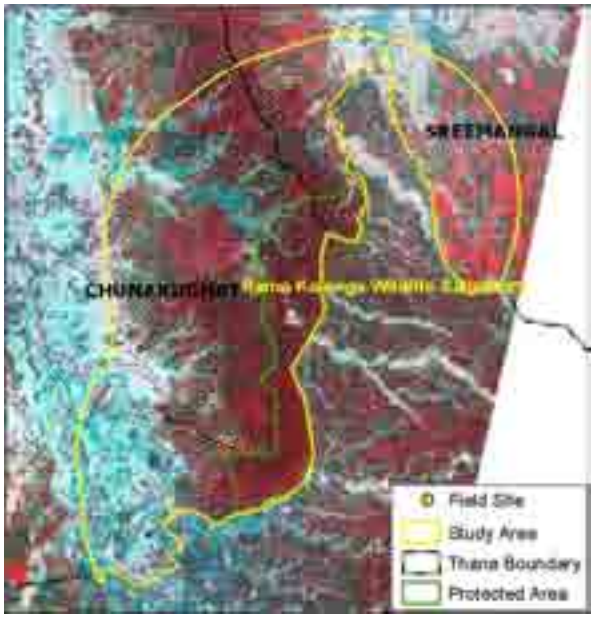


Figure 7: Yellow dots showing field sites in the Rema-Kalenga Protected Area

Ground data were collected from 29 locations for the Sitakund protected area (Figure 8). Most of the areas are barren with only grass and bush and some have a combination of tree plantations, bushy bamboos and herb-shrubs. Only a very few areas are covered with tree plantations without any bushes. The main vegetation covers of this protected area are Acacia plantation, eucalyptus plantation, Segun, and

different types of bamboo and herb-shrubs. The eco-park area has different types of plants and trees, but the area is not very big. There is a tea garden in the north eastern side of the study area.

Figure 8: Yellow dots showing field sites in the Sitakund Protected Area

Ground data were collected from 32 locations for the Chunati protected area (Figure 9). Most of the areas are barren with only grass and bush and some have a combination of tree plantations, bushy bamboos and herb-shrubs. Only a very few areas are covered with tree plantations without any bushes. The main plants of this protected area are Acacia plantation, eucalyptus plantation, Shal, Gorjon, and different types of bamboos and herb-shrubs. In the western part of the study area, some saltpans can be seen.

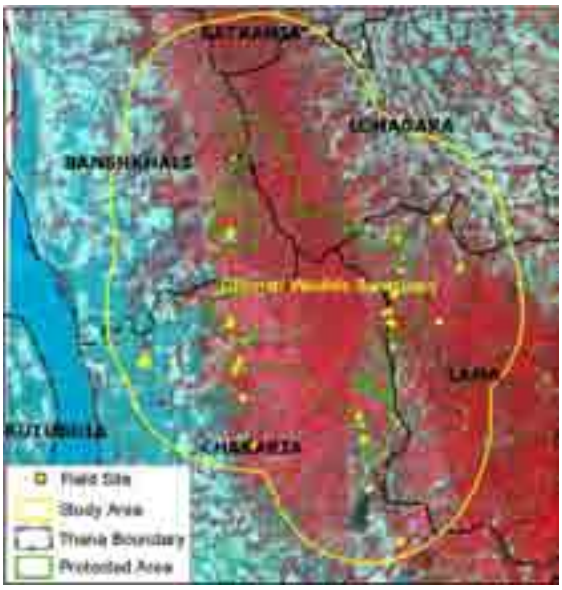


Figure 9: Yellow dots showing field sites in the Chunati Protected Area

Ground data were collection from 51 locations for the Teknaf Game Reserve (Figure 10). Most of the areas are barren with only grass and bush and some have a combination of tree plantations, bushy bamboos and herb-shrubs. Only a very few areas are covered with tree plantations without any bushes. Only in the northern part of the study area, there are some forests with tall trees and herb-shrubs. The main plants of this protected area are Segun, mahogany, Acacia, black berry, Gorjon, Jarul, Chapalish, Civit, some other different types of trees, and different types of bamboos and herb-shrubs. In the eastern part of the study area there are saltpans and shrimp ghers beside the Naf River. There is a large Gorjon forest in the western side of the area. Also, a large black berry forest can be seen in the south eastern part of the area.

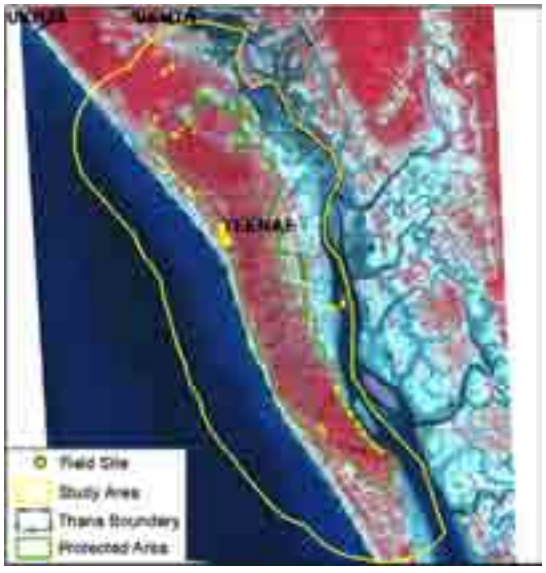


Figure 10: Yellow dots showing field sites in the Teknaf Protected Area

LANDUSE MAPPING

Landuse/landcover of the six protected areas were mapped from a digital image classification of IRS P6 LISSIII images of 2006. Settlement areas were captured from IRS Panchromatic images by on screen digitization and encroachment areas were mapped by using protected area boundaries with the help of GIS techniques.

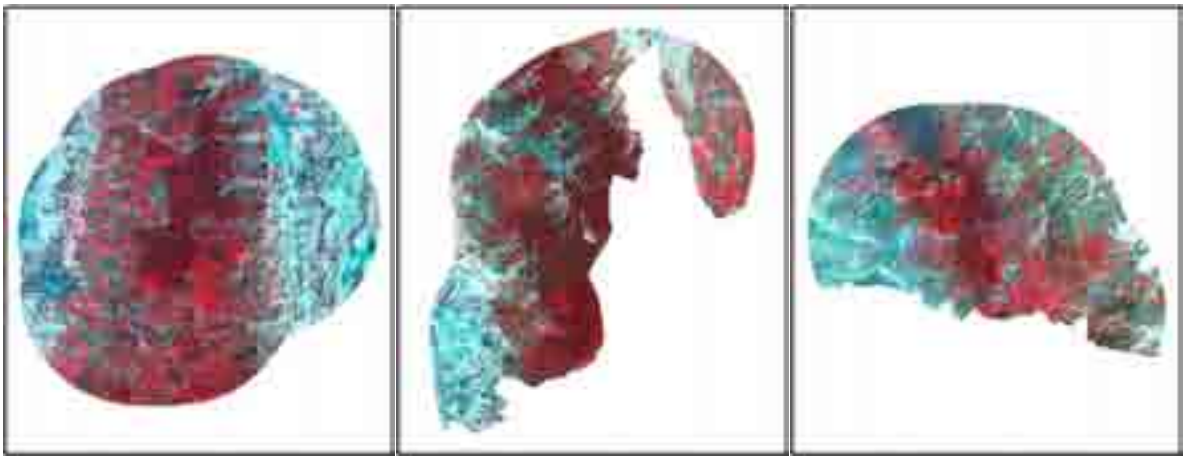
SIX PROTECTED AREAS

Figure 11 shows a false-color composition (Band 1, Band2, Band 3: Blue, Green, Red) of IRS P6 LISSIII images of (a) Lawachara, (b) Rema-Kalenga, (c) Satchari, (d) Sitakund, (e) Chunati and (f) Teknaf protected area. In this band combination, the vegetation appears reddish due to the high reflection of infrared compared to other bands. There are small and important differences in the reflectance of different plants that may eventually be used to obtain better information. The dominant factors controlling the leaf reflectance are leaf pigments, cell structure and water content. Leaf pigments and cellulose are transparent to near infrared (0.7-1.3 μm) wavelength and therefore leaf absorption is very small (10% maximum), but not the leaf reflectance and transmittance, which can reach 50%. Because of internal reflection within the cell structure of their leaves, they reflect a large proportion of the near infrared irradiance. As a result, the spectral reflectance of vegetation increases very steeply with the increasing wavelength between about 0.7 μm and 0.75μm. The level of this reflection is dependent on the internal leaf structure as well as on the space amount in the mesophyll that determines interfaces with different refraction indices (air or water cells). The abnormally low reflectance of plants in red, relative to their very high infrared response, causes vegetation to be rendered in these false-color composites as various shades of red.

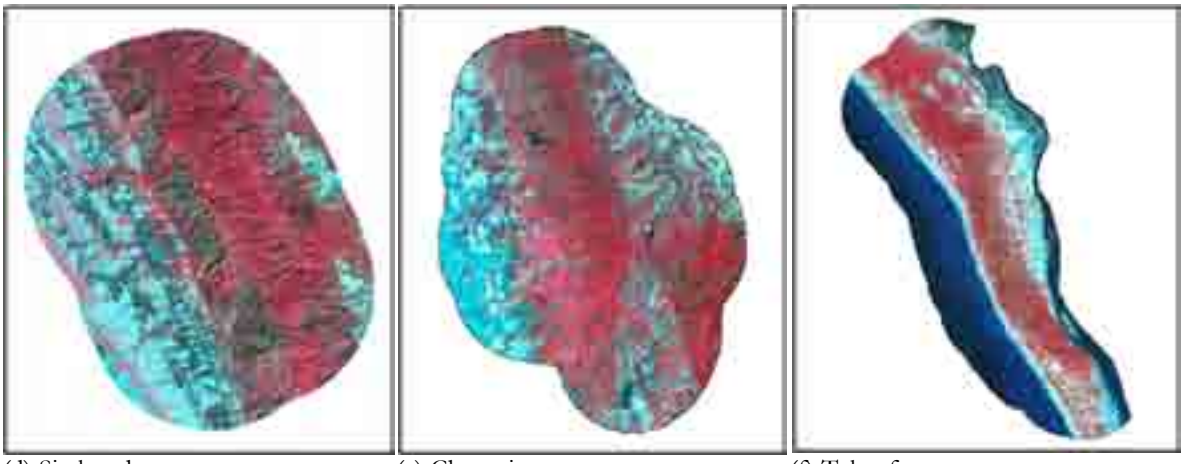
On the other hand, the water bodies absorb infrared and reflect visible bands highly making them appear turquoise to an even darker shade on the images. From fallow or agriculture land the reflection is high for all bands making them appear white.

After visual interpretation, a digital unsupervised classification was done to derive different landuses/landcovers from satellite images. At first, 100 spectral classes were generated using an unsupervised classification method. ERDAS IMAGINE uses the ISODATA algorithm to perform an unsupervised classification. ISODATA stands for "Iterative Self-Organizing Data Analysis Technique." It is iterative in that it repeatedly performs an entire classification (outputting a thematic raster layer) and recalculates statistics. "Self-Organizing" refers to the way in which it locates the clusters that are inherent in the data. The ISODATA clustering method uses the minimum spectral distance formula to form clusters. It begins with either arbitrary cluster means or means of an existing signature set, and each time the clustering repeats, the means of these clusters are shifted. The new cluster means are used for the next iteration. The ISODATA utility repeats the clustering of the image until either a maximum number of iterations has been performed, or a maximum percentage of unchanged pixels has been reached between two iterations.

The mean signature plot for each class was verified with ground truth data. The similar spectral classes were grouped together and labeled with a landuse/landcover based on ground truth data. Finally, information classes such as forests, tea gardens, agriculture land, fallow land and water were derived from 100 spectral classes. Figure 12 shows the mean spectral plot of the information classes of the Lawachara protected area. For the forest class the DN value of infrared band (band 3) is higher than the value of the red band (band 2). This spectral characteristic is also similar for the tea class. But the tea class was differentiated from the forest class using short wave infrared (band 4). At short wave infrared, the reflectance of tea is higher than the reflectance of forest. Due to high water content in the leaves of trees, the short wave infrared is highly absorbed. As a result, the reflectance of short wave infrared from trees is less. The reflectance of all four bands from fallow land is higher than that from agricultural land. The reflectance from water decreases gradually as the wavelength increases.



(a) Lawachara (b) Rema-kalenga (c) Satchari



(d) Sitakund (e) Chunati (f) Teknaf

Figure 11: False-color composition of IRS P6 LISS III Image (Band 1, Band 2, Band 3: Blue, Green, Red)

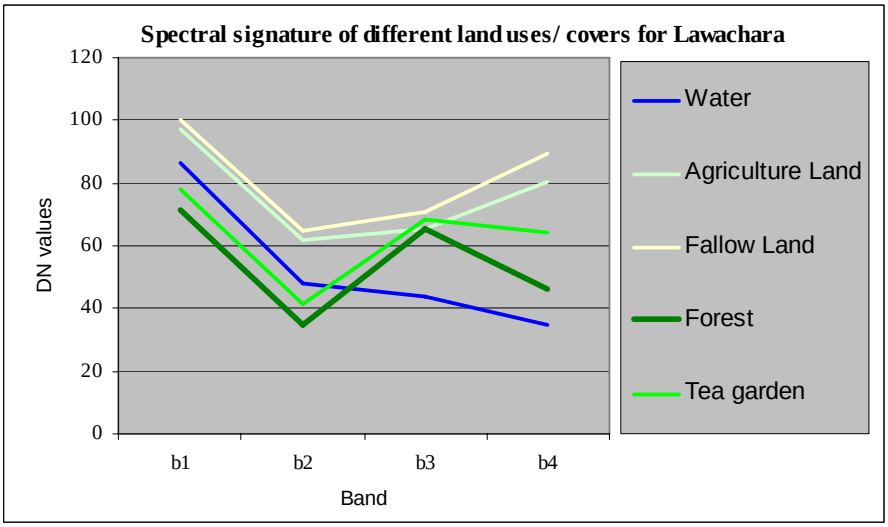


Figure 12: Spectral signature of different landuses/covers for the Lawachara protected area

Figure 13 shows the Landuses/covers map of the Lawachara protected area. The settlements and agriculture land that falls within the forest protected boundary are classified as "encroachment settlement" and "encroachment agricultural land" respectively.

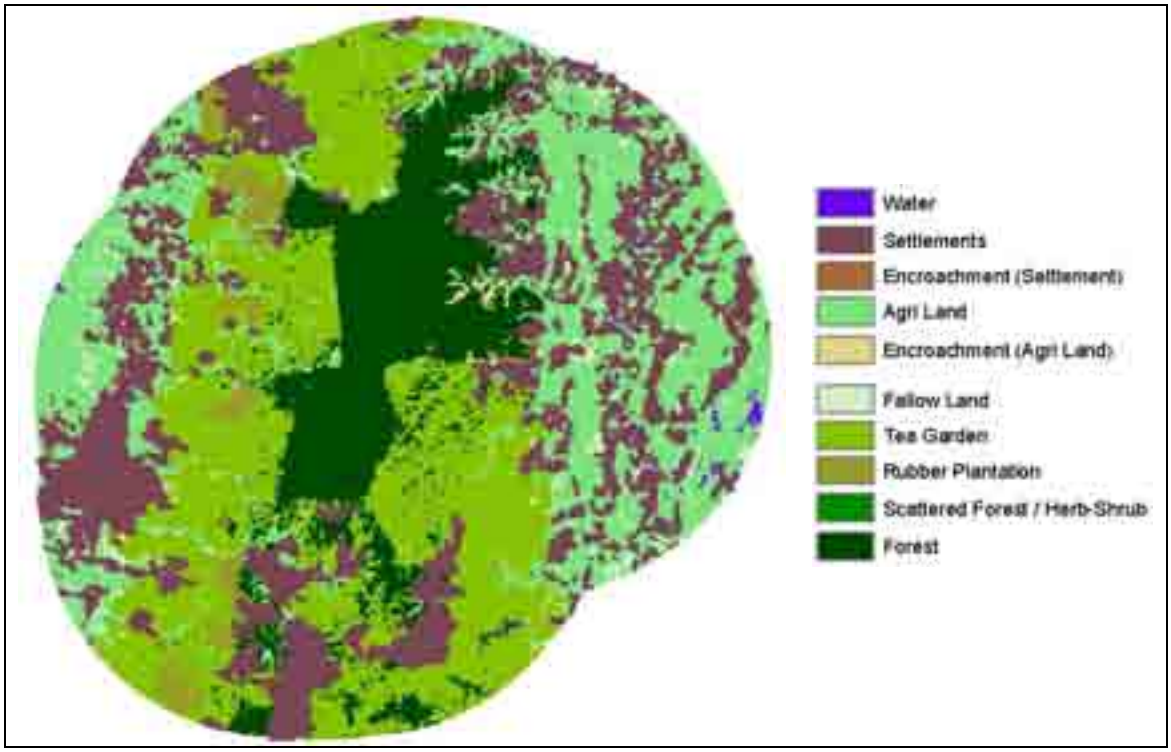


Figure 13: Landuses/covers map of the Lawachara protected area

Figure 14 shows the mean signature plot for each information class of the Rema-Kalenga protected area. The reflectance at infrared and short wave infrared from scattered forest/sun grass is higher than that of the reflectance at infrared and short wave infrared from forests. But it is lower than that of the reflectance at infrared and short wave infrared from the tea class. Figure 15 shows the Landuses/covers map of the Rema-Kalenga protected area.

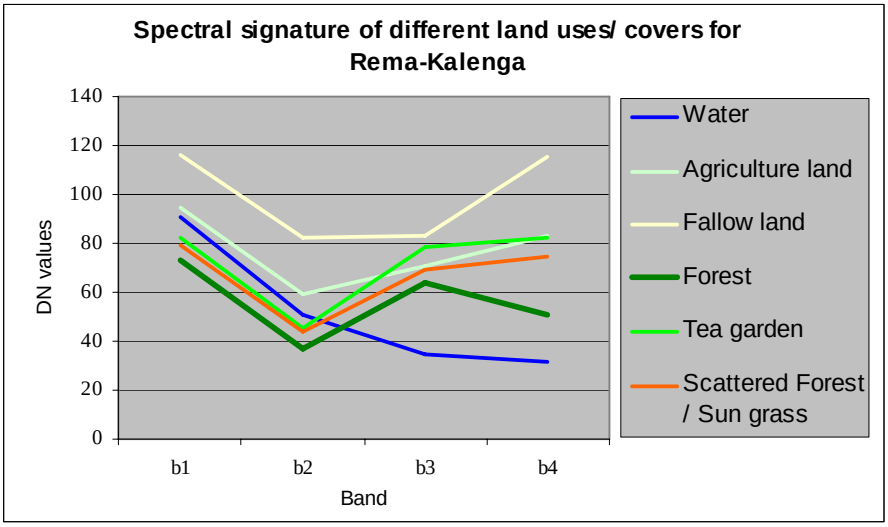


Figure 14: Spectral signature of different landuses/covers for the Rema-Kalenga protected area

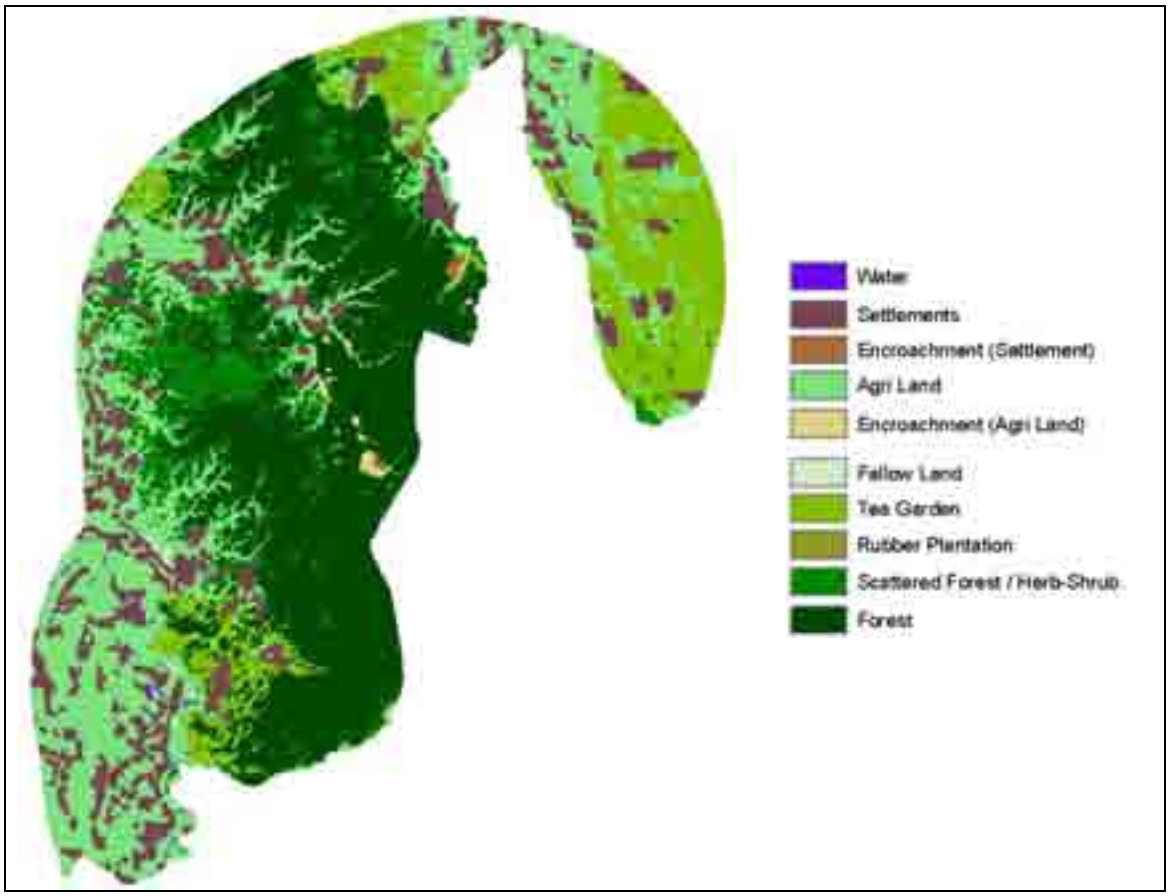


Figure 15: Landuses/covers map of the Rema-Kalenga protected area

Figure 16 shows the mean signature plot for each information class of the Satchari protected area. The difference in reflectance from "scattered forest/sungrass", "forest" and "tea" class is similar to what was found in the case of Rema-Kalenga. The reflectance of all bands from fallow land is higher than the reflectance from any other information class. Figure 17 shows the Landuses/covers map of the Satchari protected area.

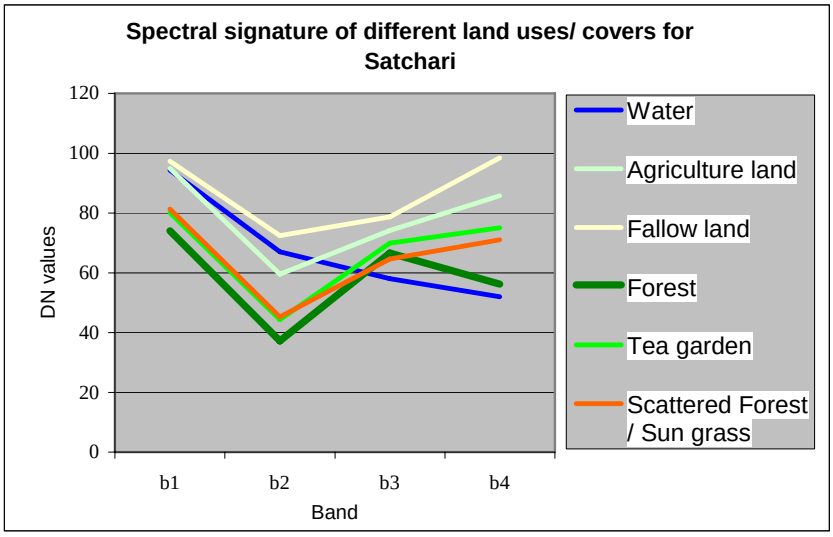


Figure 16: Spectral signature of different landuses/covers for the Satchari protected area

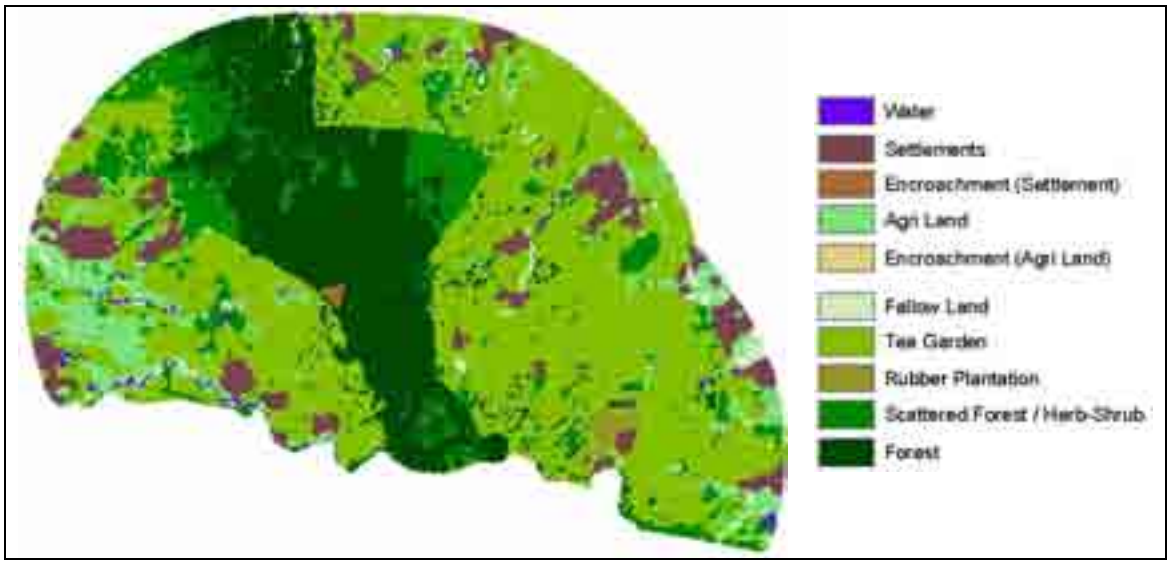


Figure 17: Landuses/covers map of the Satchari protected area

The south eastern part of Bangladesh which covers Sitakund, Chunati and Teknaf protected areas, have hilly patterns. So these areas have a shadow affect on one side of the hills in the images. The ISO data clustering digital image classification technique alone does not work well to separate different forest coverage. The Normalized Difference Vegetation Index (NDVI) technique was also used to do the separation. So, a combination of ISO data clustering and the NDVI technique was used to map the landuse/landcover of the three southeastern protected areas. The NDVI uses Near Infrared (NIR) and RED band ratios to calculate the greenness of vegetation. RED and NIR stand for the spectral reflectance measurements acquired in the red and near-infrared regions, respectively. These spectral reflectance are themselves ratios of the reflected over the incoming radiation in each spectral band individually, hence they take on values between 0.0 and 1.0. By design, the NDVI itself thus varies between -1.0 and +1.0. It can be seen from its mathematical definition that the NDVI of an area

containing a dense vegetation canopy will tend give to positive values (say 0.3 to 0.8) while clouds and shadow fields are characterized by negative values of this index.

Settlement class was extracted from high-resolution IRS-1D panchromatic images of 2003 using the on screen digitization method. Finally, settlements were added with the final information classes derived from the digital classification of satellite images.

The settlements and agriculture lands that fall within the forest-protected boundary are classified as encroachment settlement and encroachment agricultural land respectively.

The landuse/landcover map of the Sitakund protected area from a classified IRS P6 LISSIII image is shown in figure 18.

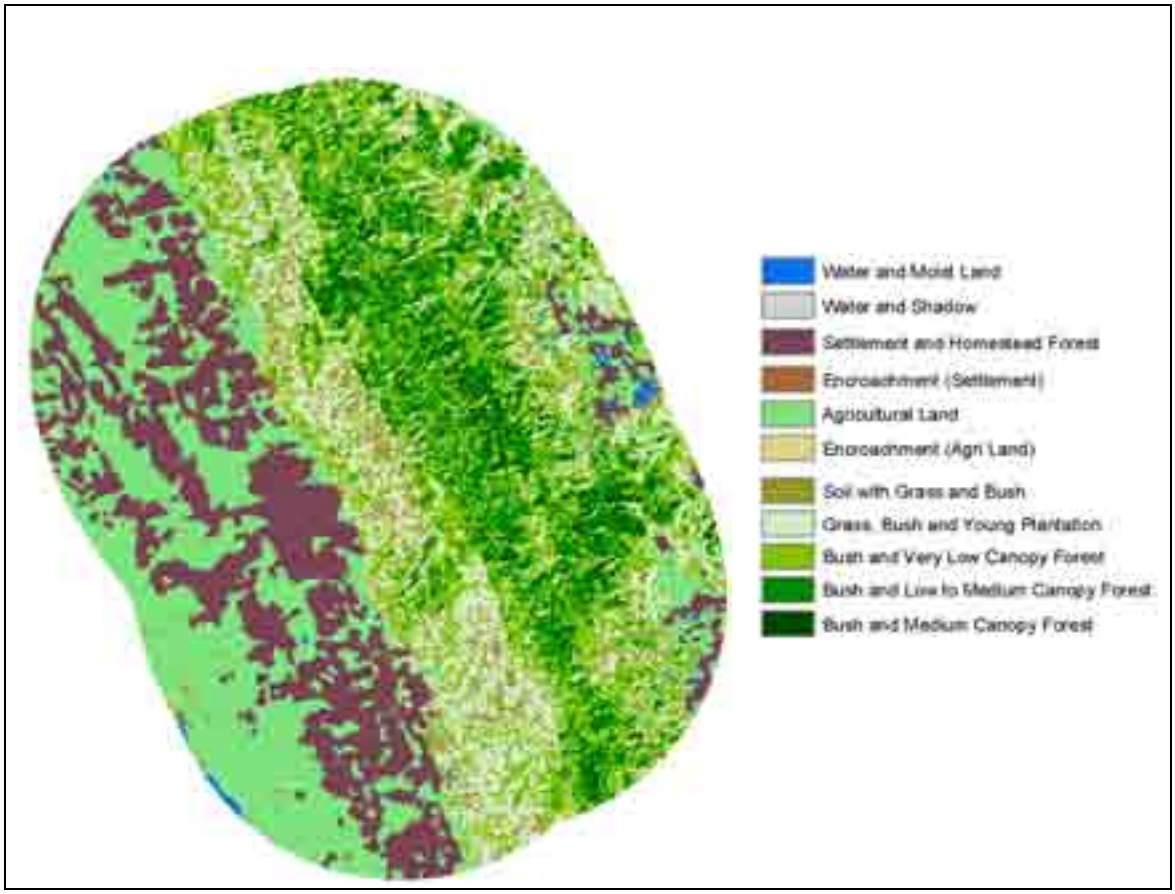


Figure 18: Landuses/covers map of the Sitakund protected area

The landuse/landcover map of the Chunati protected area from a classified IRS P6 LISSIII image is shown in figure 19.

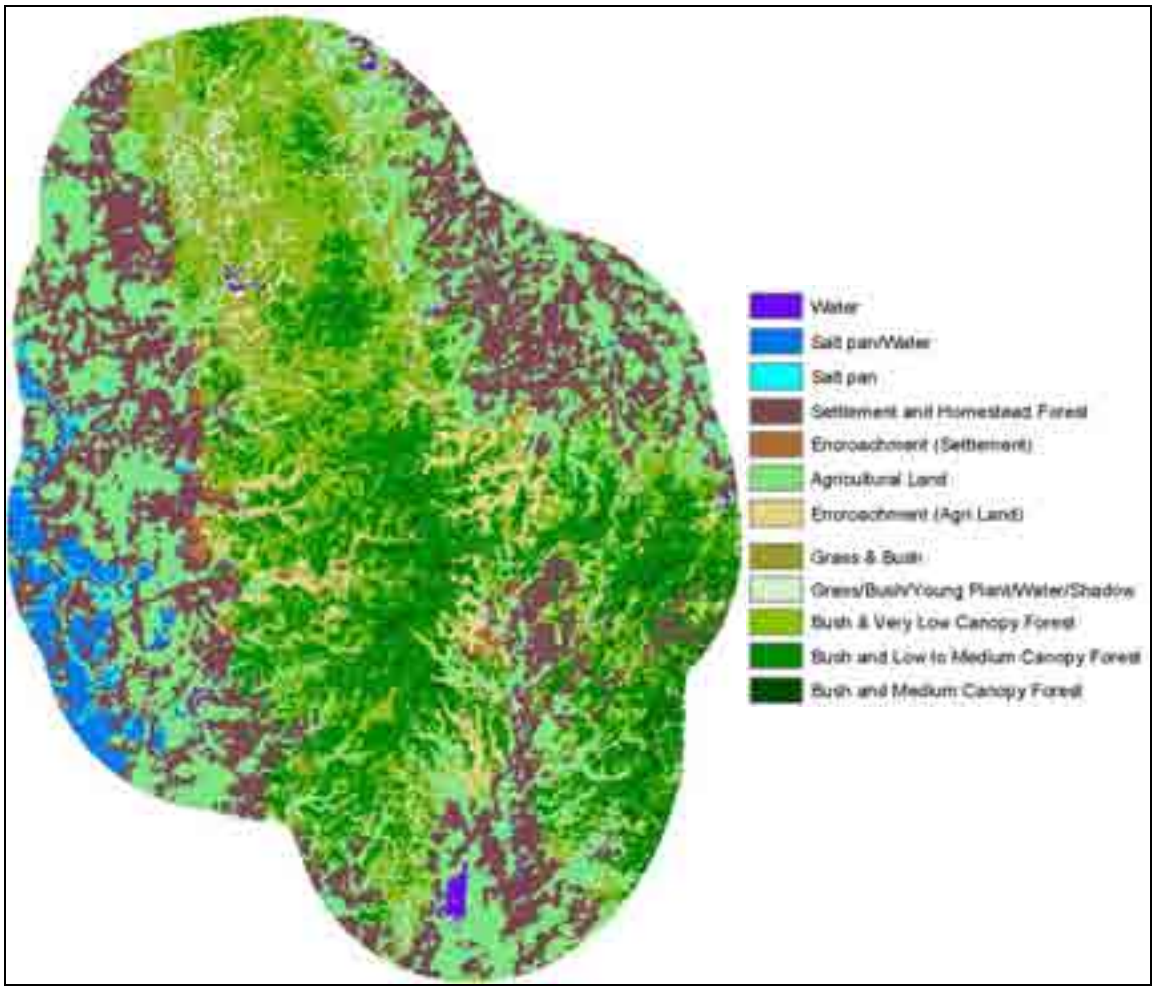


Figure 19: Landuses/covers map of the Chunati protected area

The landuse/landcover map of the Chunati protected area from a classified IRS P6 LISSIII image is shown in figure 20.

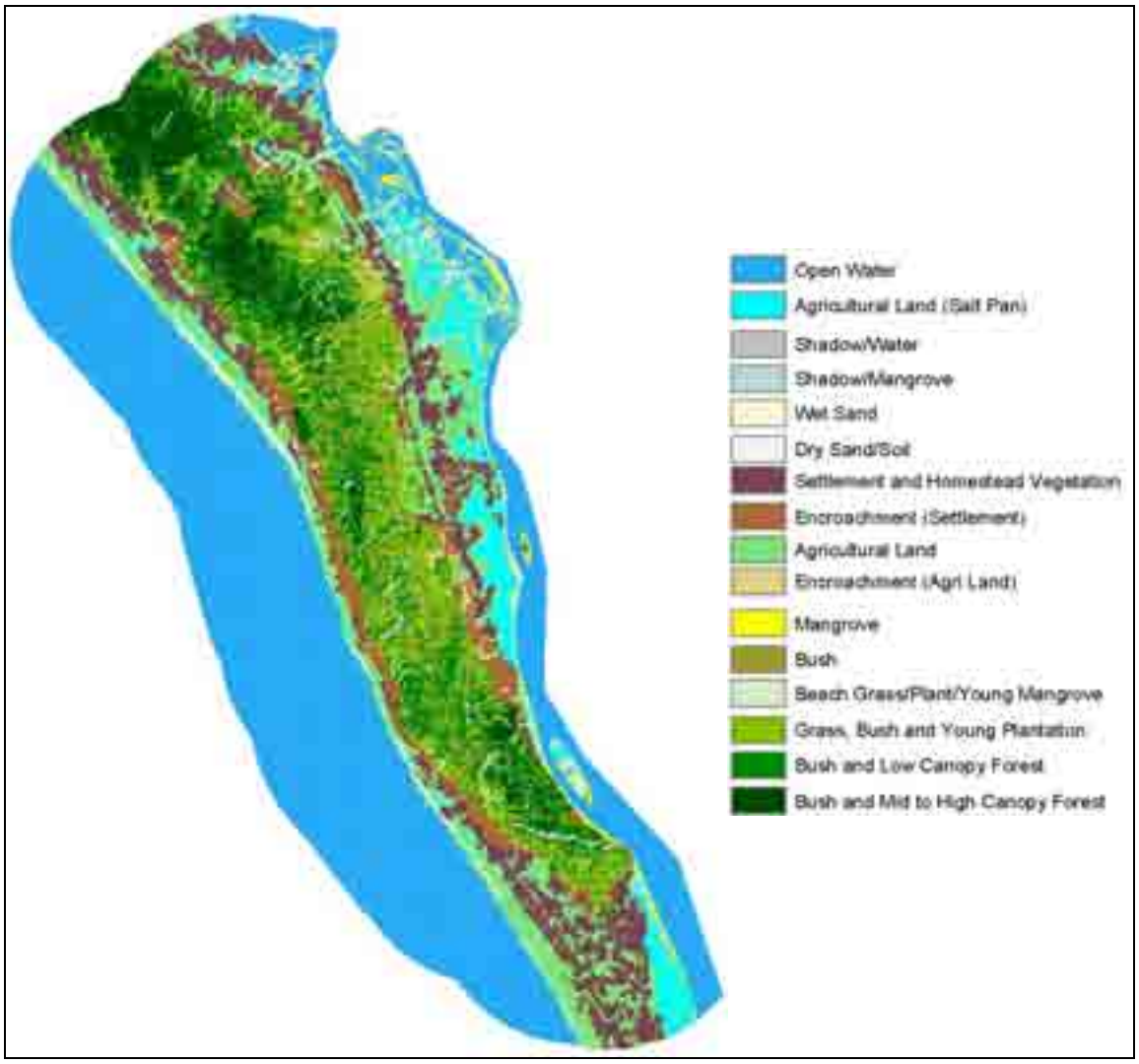


Figure 20: Landuses/covers map of the Teknaf protected area

WHYKHEONG RANGE OF TEKNAF

Digital ISO data clustering and NDVI techniques were used for landuse/landcover mapping from a high resolution QuickBird satellite image of the Whykheong range of Teknaf. Roads, Rivers/Canals/Chharas, Settlements and Homestead Vegetation were digitized from the image by visual interpretation, which was verified through a field survey. Health Centers, Educational Centers, Temples, FD Ranges/Beat Offices, Brick Fields, and Growth Center location coordinates were collected by GPS from the field survey, and were integrated by digitization.

The landuse/landcover map of the Whykheong range area from a classified QuickBird image is shown in figure 21.

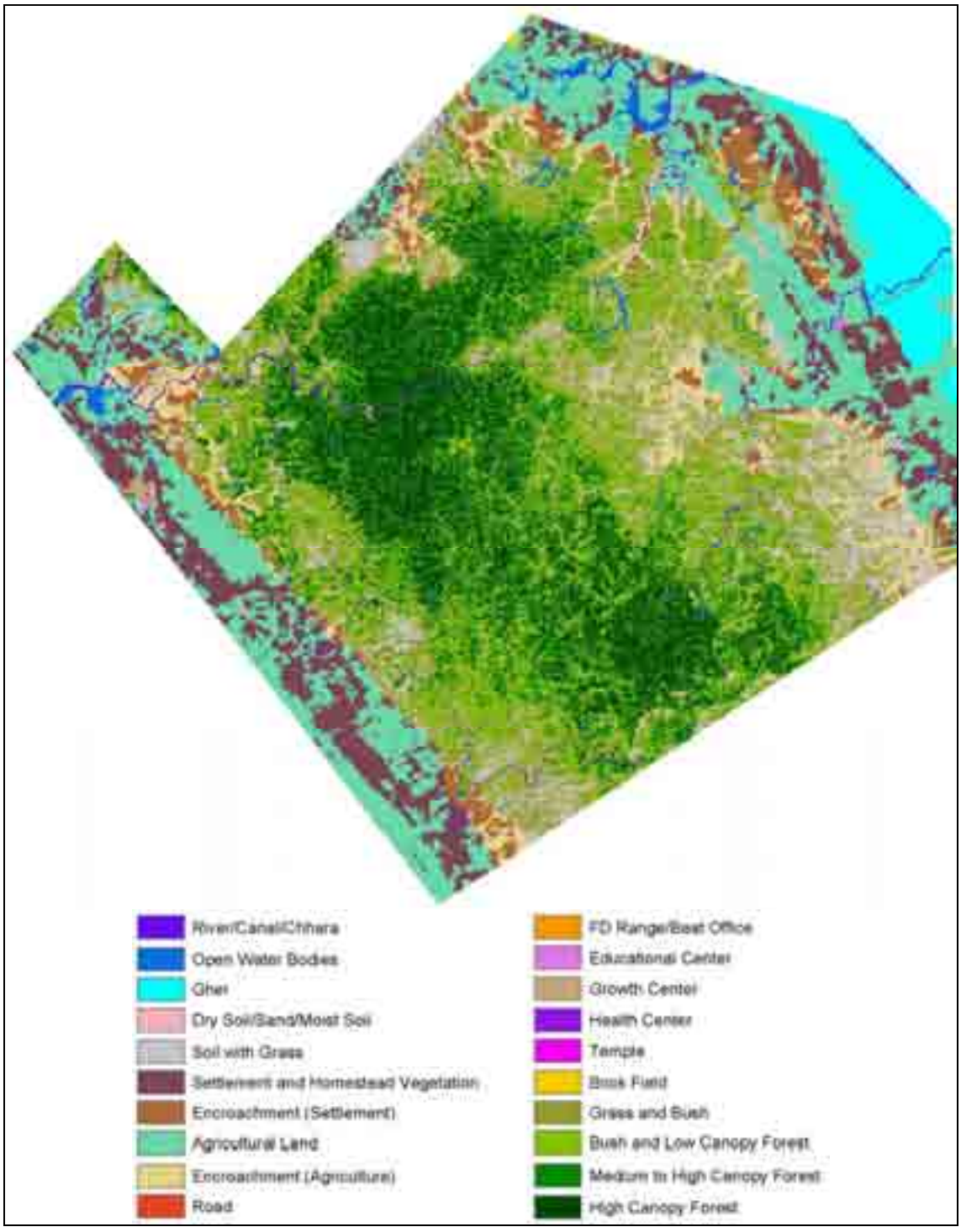


Figure 21: Landuse/cover map using a high resolution QuickBird image of the Whykheong range area

LANDUSE/LANDCOVER AREA COVERAGE

The area coverage by each landuse/cover was estimated for all six protected areas from the landuse/landcover maps. Table 2 shows the area coverage in hectare for each landuse/cover in the three north eastern protected areas.

Table 2: Area coverage of Lawachara, Rema-Kalenga and Satchari landuse/landcover

Information Classes	Area within PA and buffer (Hectare)		
	Lawachara	Rema-Kalenga	Satchari
Forest	3,041	4,643	1,998
Scattered Forest / Herb-Shrub	0	1,289	1,203
Tea Garden	5,411	1,927	4,597
Rubber Plantation	410	0	55
Agricultural Land	4,441	3,691	732
Fallow Land	383	28	155
Settlements	4,572	1,696	634
Water	68	28	66
Encroachment (Agri Land)	27	65	1
Encroachment (Settlement)	15	17	10

Table 3 shows the area coverage in hectare for each landuse/cover in the Sitakund and Chunati protected areas.

Table 3: Area coverage of Sitakund and Chunati landuse/landcover

Information Classes	Area within PA and buffer (Hectare)	
	Sitakund	Chunati
Agricultural Land	4,410	9,869
Soil with Grass and Bush	1,072	2,199
Grass, Bush and Young Plantation	3,014	1,677
Bush and Very Low Canopy Forest	3,751	6,690
Bush and Low to Medium Canopy Forest	2,521	8,744
Bush and Medium Canopy Forest	453	522
Water and Moist Land	74	220
Salt pan	0	295
Salt pan/Water	0	1,030
Water and Shadow	100	0
Settlement and Homestead Forest	3,687	9,017
Encroachment (Agri Land)	56	962
Encroachment (Settlement)	11	283

Table 4 shows the area coverage in hectare for each landuse/cover in the Teknaf protected area.

Table 4: Area coverage of Teknaf landuse/landcover

Information Classes	Area within buffer (Hectare)
	Teknaf
Agricultural Land	5,000
Agricultural Land (Salt Pan)	1,555
Beach Grass/Plant/Young Mangrove	1,080
Bush	1,368
Grass, Bush and Young Plantation	3,960
Bush and Low Canopy Forest	4,220
Bush and Mid to High Canopy Forest	2,651
Mangrove	186
Settlement and Homestead Vegetation	4,299
Open Water	17,451
Shadow/Mangrove	319
Shadow/Water	61
Wet Sand	25
Dry Sand/Soil	385
Encroachment (Agri Land)	501
Encroachment (Settlement)	1,389

Table 5 shows the area coverage in hectare for each landuse/cover in the Whykheong area of the Teknaf protected area.

Table 5: Area coverage of the Whykheong range landuse/landcover from a QuickBird image

Information Classes	Area within buffer (Hectare)
	Teknaf
Agricultural Land	746.02
Bush and Low Canopy Forest	838.05
Medium to High Canopy Forest	437.03
High Canopy Forest	647.32
Grass and Bush	632.07
Soil with Grass	424.12
Dry Soil/Sand/Moist Soil	11.23
Open Water Bodies	62.44
River/Canal/Chhara	48.28
Gher	172.78
Road	19.55
Settlement and Homestead Vegetation	402.58
Brick Field	0.95
Educational Center	3.22
FD Range/Beat Office	0.41
Growth Center	8.02

Health Center	0.37
Temple	0.23
Encroachment (Settlement)	140.31
Encroachment (Agriculture)	229.60

CONCLUSION

The capability of the high resolution QuickBird satellite images to identify and represent small features makes it highly suitable for detailed landuse/landcover mapping. Hence, high resolution satellite images may be considered for detailed mapping of the six protected areas.

ANNEX-I:
PHOTOGRAPHS OF DIFFERENT LOCATIONS OF THE SIX PROTECTED AREAS

Satchari Reserve Forest

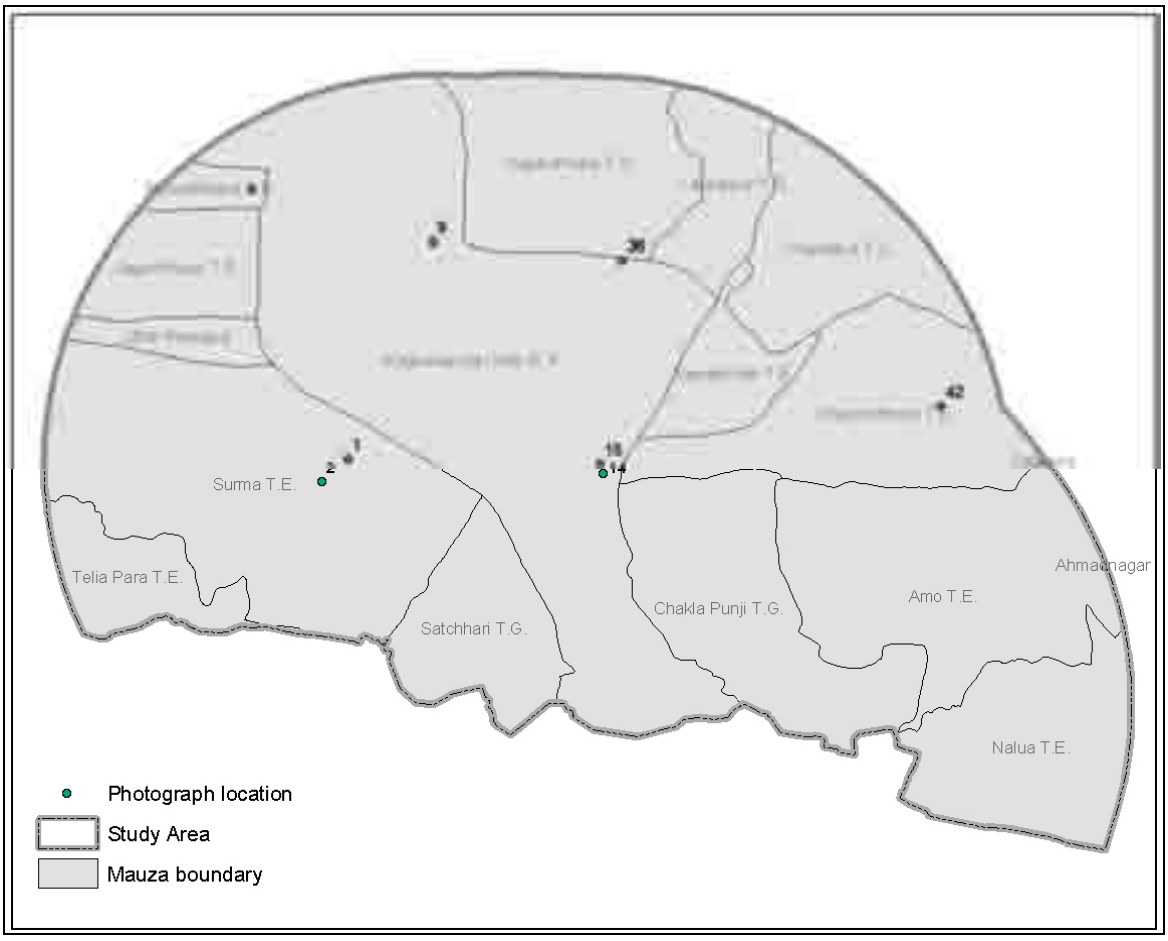


Photo 1

Photo 2

	
Photo 9	Photo 14
	
Photo 15	Photo 27
	
Photo 36	Photo 42

Rema-Kalenga Wildlife Sanctuary

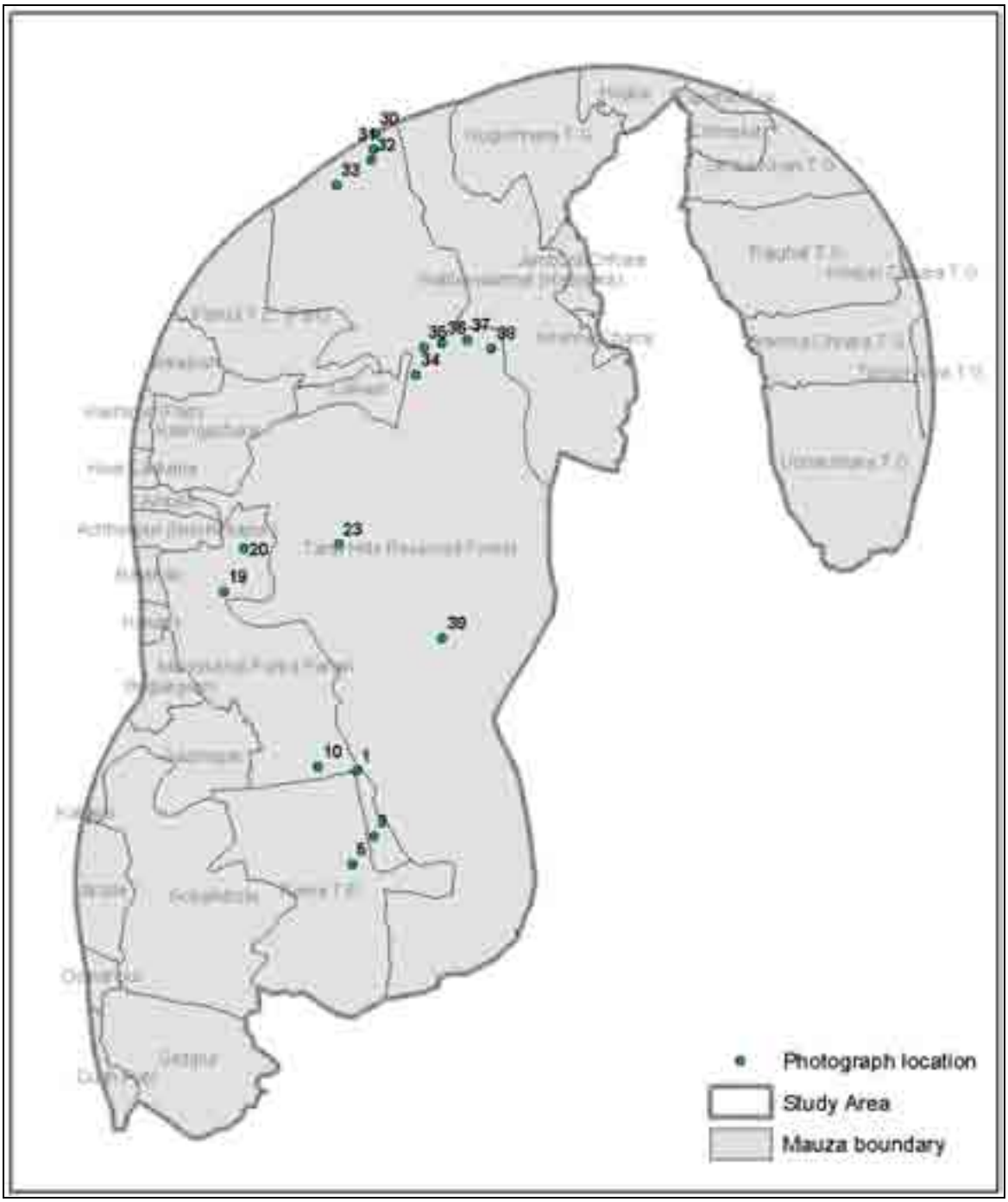


Photo 1

Photo 5

Photo 9

Photo 10

Photo 19

Photo 20

	
Photo 23	Photo 30
	
Photo 30	Photo 31
	
Photo 32	Photo 33

Photo 34

Photo 35

Photo 36

Photo 38

Photo 39

Lawachara National Park

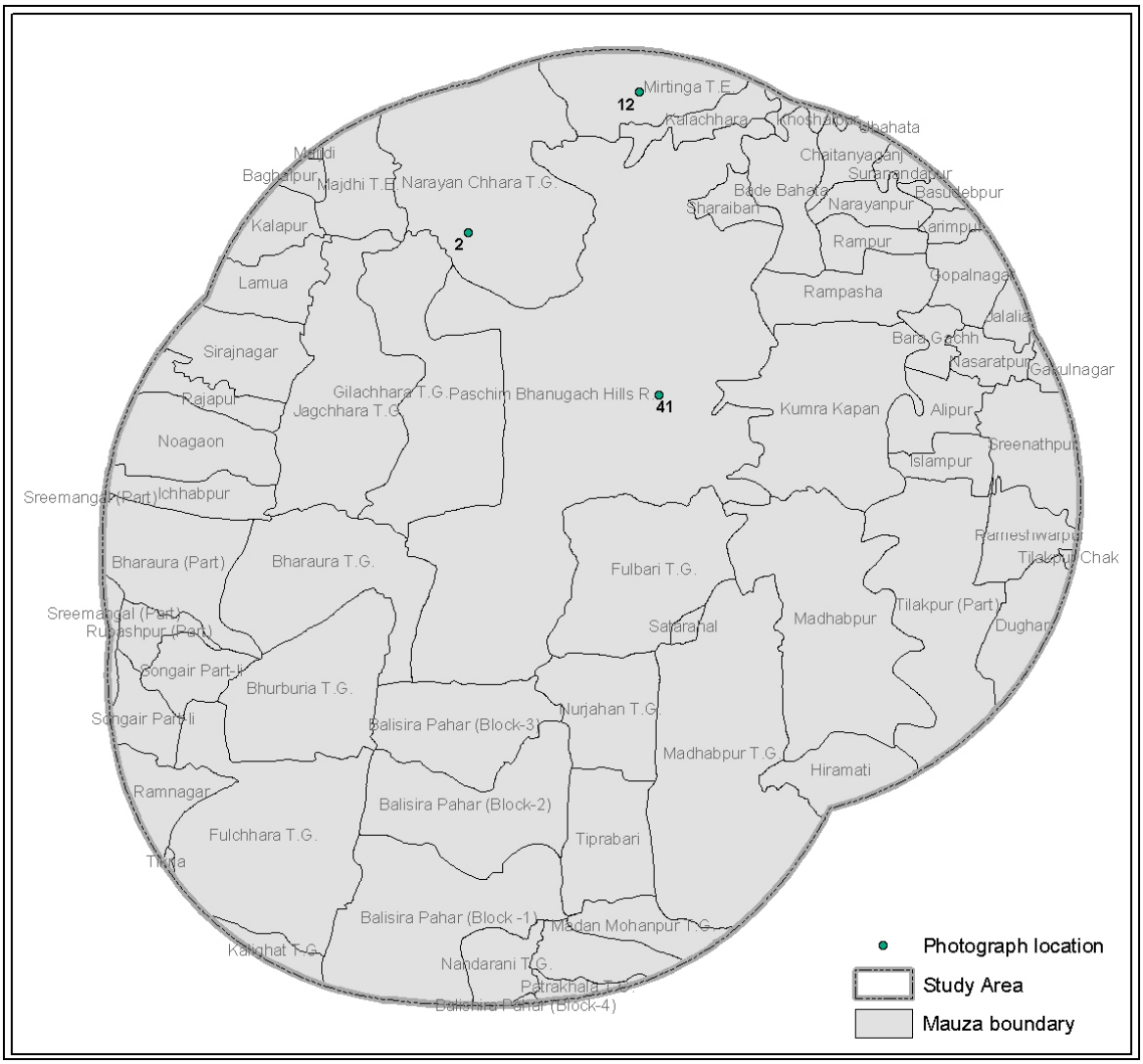


Photo 2

Photo 12

Photo 41

Sitakund Eco-Park

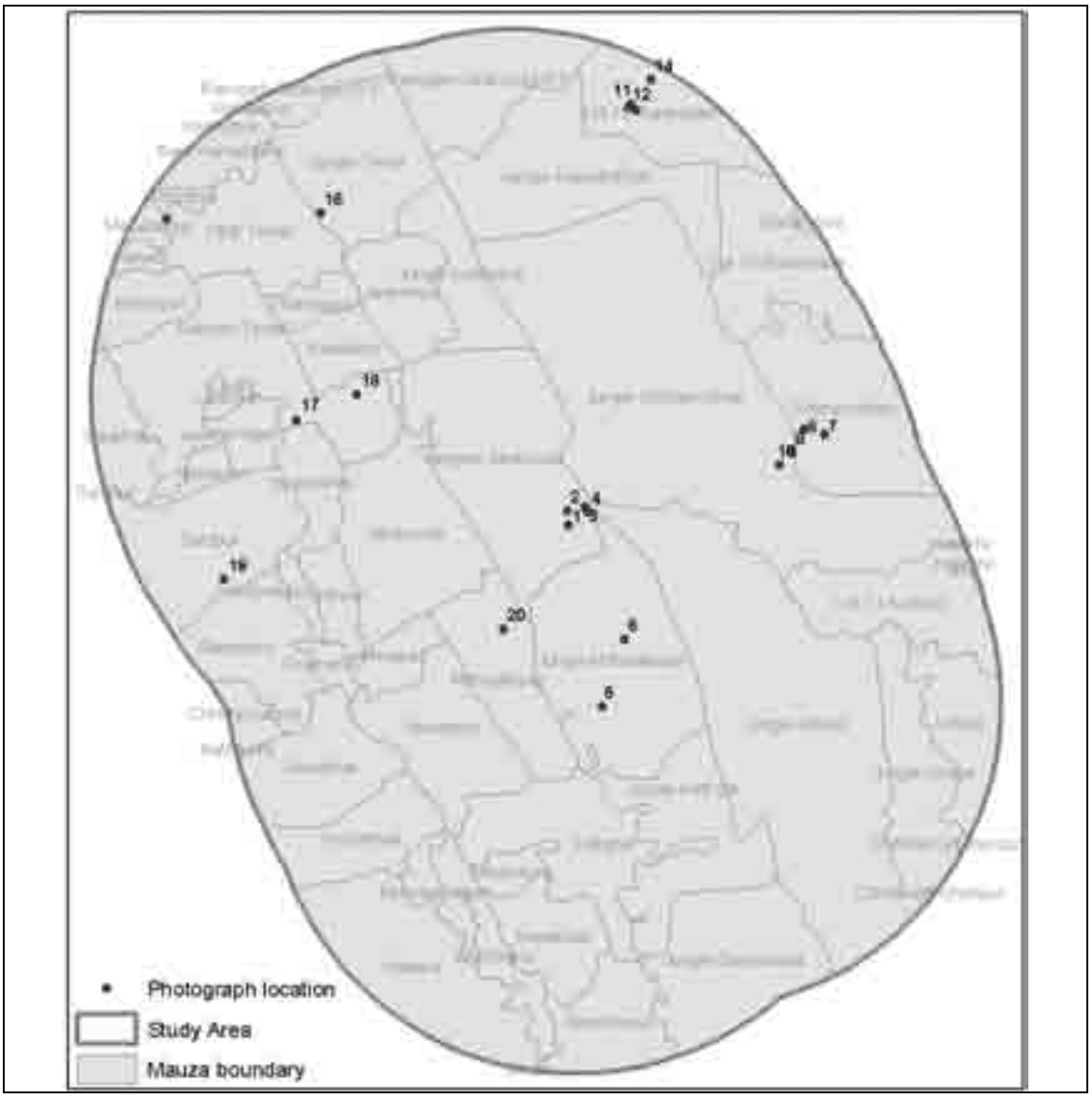


Photo 1	Photo 2
	
Photo 3	Photo 4
	
Photo 4	Photo 5
	

Photo 6	Photo 7
	
Photo 8	Photo 9
	
Photo 10	Photo 11
	
Photo 12	Photo 12

	
Photo 13	Photo 14
	
Photo 15	Photo 16
	
Photo 17	Photo 18

	
Photo 19	Photo 20

Chunati Wildlife Sanctuary

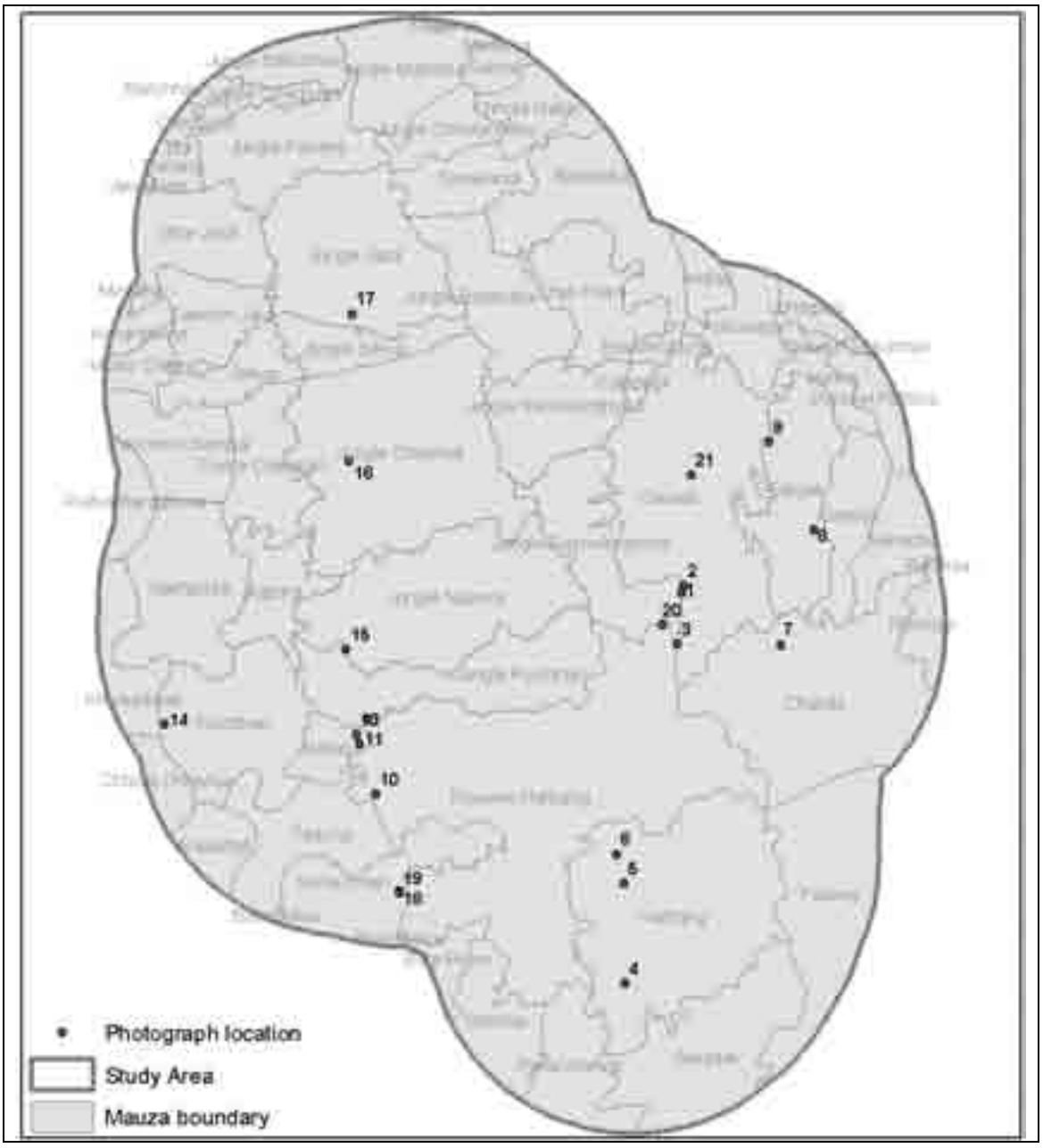


Photo 1

Photo 2

Photo 3

Photo 4

Photo 5

Photo 6

Photo 7

Photo 8

Photo 9

Photo 10

Photo 11	Photo 12
	
Photo 13	Photo 14
	
Photo 15	Photo 16
	
Photo 17	Photo 17

Photo 17

Photo 18

Photo 19

Photo 20

	
Photo 21	Photo 21

Teknaf Game Reserve

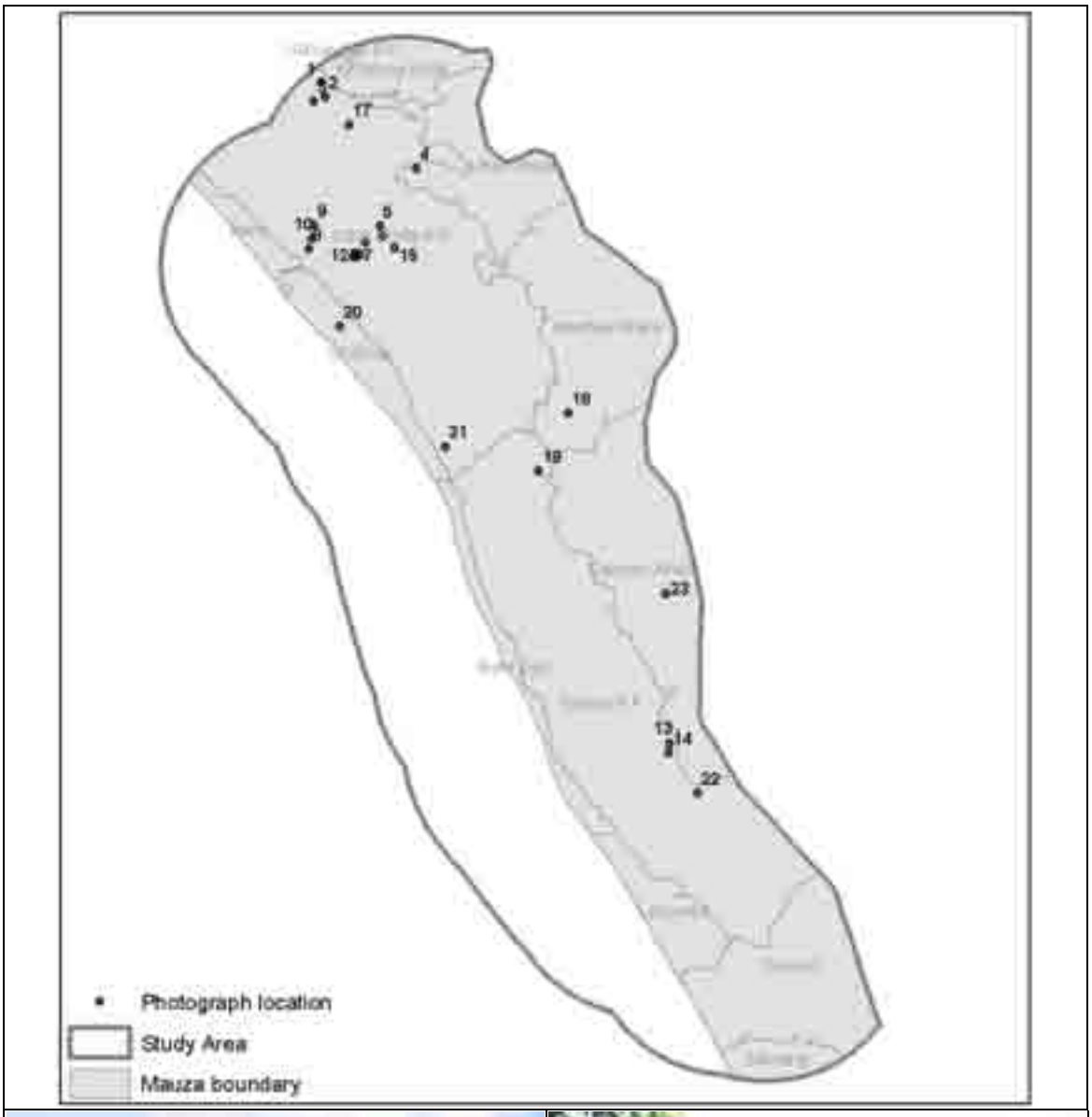


Photo 1	Photo 2
	
Photo 3	Photo 4
	
Photo 5	Photo 6
	

Photo 7	Photo 8
	
Photo 9	Photo 10
	
Photo 11	Photo 12
	

Photo 13	Photo 14
	
Photo 14	Photo 15
	
Photo 16	Photo 17
	

Photo 18	Photo 19
	
Photo 20	Photo 21
	
Photo 22	Photo 23