ATLAS OF MANGROVE WETLANDS OF INDIA

Part 3 - Orissa

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FOREWORD

This Atlas, third in the series, deals with the mangrove wetlands of Orissa. Orissa is often referred to as a biological paradise since it is very rich in biodiversity. The Koraput area of Orissa is a center of diversity for rice. The Bhitarkanika mangrove wetlands contain very rich genetic diversity in mangroves. The breeding ground for the Olive Ridley Turtle occurring in coastal Orissa is one of the few of its kind in the world.

Unfortunately, the mangrove forests of Orissa are under severe anthropogenic threats. Many good mangrove forests have become degraded. In recent years, coastal communities have started realising the multiple significance of mangroves in the area of sustainable human security. This was particularly evident after the super-cyclone, which hit the Orissa coast a few years ago. Coastal families are now trying to rehabilitate degraded mangrove wetlands and also create more mangrove forests. This Atlas gives information on the mangrove wealth of Orissa and indicates its current status. A periodic updating of such an Atlas will help us to monitor the impact of the ongoing restoration and rehabilitation measures.

My sincere thanks go to the Officers of the Forest Department of Orissa State for their guidance, assistance and cooperation. The guidance and help of the following were of invaluable assistance in the preparation of this Atlas.

Mr P R Mohanty, IFS, Principal Chief Conservator of Forests, Mr S K Patnaik, IFS, Mr D S Patnaik, IFS, Former Principal Chief Conservators of Forests, Mr A P Tripathy, IFS and Mr S C Mohanty IFS, Additional Principal Chief Conservator of Forests. Mr P N Padhi, IFS, Mr S Raghavan, IFS, Mr M Satyanarayana, IFS, Mr C S Kar, Mr Ajit Barduar, IFS, Ms Rebecca Nair, IFS, Mr S K Mishra and Mr Siubhagya Sahoo of Raj Nagar Mangrove Division and Mr Abhaya Acharya of Badrak Wildlife Division extended considerable help.

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Devi mouth Mangrove Wetland

Bhitarkanika Wildlife Sanctuary

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ABBREVIATIONS

TM	:	Thematic Mapper
IRS	:	Indian Remote Sensing Satellite
LISS	:	Linear Imaging Self scanning System
LJSS	:	Luna Jungla Samrakshana Samiti
BWLS	:	Bhitarkanika Wildlife Sanctuary
MMU	:	Mangrove Management Unit
RF	:	Reserved Forest
PF	:	Protected Forest
MPT	:	Multi Purpose Tree

ATLAS OF MANGROVE WETLANDS OF INDIA

Part 3 - Orissa

Chapter 1

Introduction

Mangroves are tropical and subtropical coastal vegetation, found in the inter-tidal zones of river deltas. They survive in substrate salinities ranging from fresh water alongside rivers to hyper saline ponds and mudflats. The composition, richness and diversity of mangrove species depend upon the degree of inundation of water and are influenced mainly by seasonal rainfall, salinity gradient, soil character and silt-clay-sand proportion. They create habitats for a diverse and characteristic community, including numerous mangrove-dependent organisms. They are critical, not only for sustaining biodiversity in these inter-tidal swamps, but also for their direct and indirect benefits to human activities. Energy and nutrients are assimilated and stored in leaves of mangrove trees. As a detritus-based ecosystem, leaf litter from these trees provides the basis for adjacent aquatic and terrestrial food webs. Mangrove wetlands function as nurseries for most of the sport and commercial fishes found in the deep coastal waters. They also provide feeding and spawning ground for many inshore fishes and crustaceans.

Besides supporting and renewing coastal fishing stock, mangrove wetlands also benefit human economic development by stabilizing shorelines. This is a critical function in tropical countries like India, which has a long coastline that is periodically battered by tropical storms and hurricanes. Mangroves play a major role in the global cycle of nitrogen and sulphur and act as reservoirs in the tertiary assimilation of wastes (De La Curz, 1979).

Despite their ecological and economic significance, mangrove wetlands are endangered ecosystems. Historical records indicate that the original extent of mangrove forests has declined considerably under pressure from human activity. A recent estimate by World Resources Institute (2000) reveals that national proportions of mangrove loss vary from 4 to 84 percent, with the most rapid losses occurring in recent decades. Overall, as much as half of the world's mangrove forests may have been lost. Conversion of mangrove wetlands for agriculture, industrial development, human settlement and recently, shrimp farming are major threats to mangrove wetlands. Apart from these, severe degradation of mangrove wetlands also results from excessive extraction of wood for fuel and other purposes as well as unscientific management practices and reduction in fresh water flow.

1.1 Distribution of Mangroves

Mangroves are generally found along the coastlines of tropical and subtropical regions, usually between 25° N and 25° S latitudes. As an exception to these, mangroves are found as far south as New Zealand and as far north as Japan. Local environmental factors such as warm sea current, frost, salinity stress, wave action, etc., determine the occurrence of mangroves beyond the above-mentioned latitudinal limits. Most tropical countries had mangroves in the past. According to Fisher and Spalding (1993) the total area of the world mangroves is about 198,818 sq.km and some 60 species of trees and shrubs are exclusive to the mangrove habitat (WCMC,

1992). Walsh (1974) considered the world mangroves to be broadly divided into two main areas, (1) the Indo-Pacific region and (2) Western Africa and American regions.

1.2 Mangroves of India

The coastal zone of the mainland of India and Andaman and Nicobar islands is endowed with the presence of extensive and diverse mangrove wetlands. On a macro scale, geomorphic settings of the mangrove wetlands of the east coast of India are different from those of the west coast. The coastal zone of the west coast is narrow and steep in slope, due to the presence of the Western Ghats. Secondly, there is no major west-flowing river. As a result, mangrove wetlands of the west coast of India are small in size, less in diversity and less complicated in terms of tidal creek network. On the other hand, the presence of larger brackish water-bodies and a complex network of tidal creeks and canals characterize the mangrove wetlands of the east coast. This is mainly due to the larger deltas created by east-flowing rivers and the gentle slope of the coast. According to the Forest Survey of India (1999), out of 487,100 ha of Indian mangroves, nearly 56.7% (275,800 ha) is present along the east coast, 23.5% (114,700 ha) along the west coast, and the remaining 19.8% (96,600 ha) is found in the Andaman and Nicobar islands (Table 1).

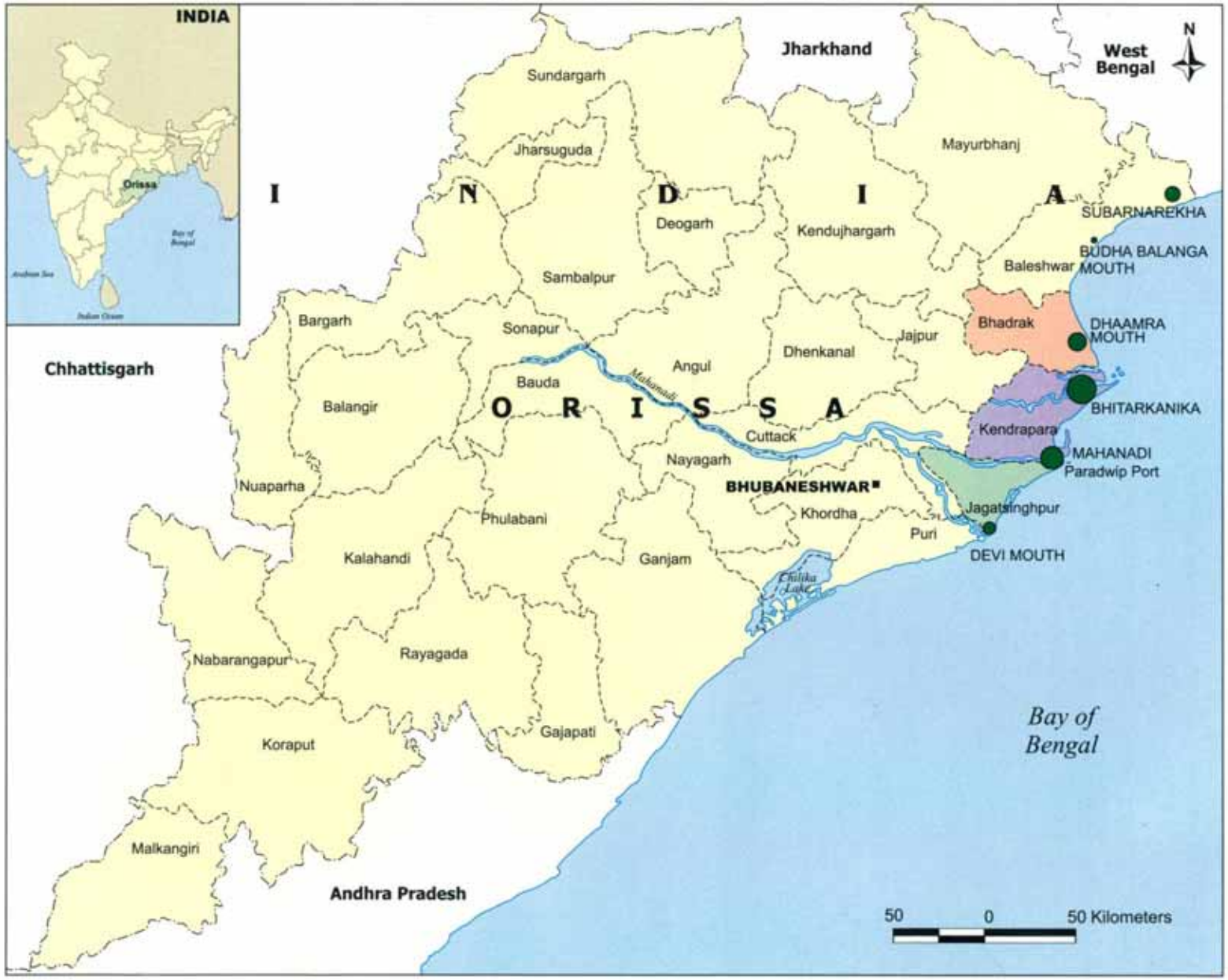
Table 1. Area of the mangrove wetlands of India (FSI, 1999)

State	Site	Mangrove Forest Area (ha)
East Coast		
West Bengal	Sundarbans	212,500
Orissa	Mahanadi	21,500
Andhra Pradesh	Godavari	24,100
	Krishna	15,600
Tamil Nadu	Pichavaram	900
	Muthupet	1,200
West Coast		
Gujarat	Gulf of Kutchch	85,400
	Gulf of Khambat	17,700
Other mangroves	–	11,600
Andaman and Nicobar islands		
Andaman islands	–	92,900
Nicobar islands	–	3,700
Total		**487,100**

According to Government of India (1987), India has lost 40 percent of its mangrove area in the last century. The National Remote Sensing Agency (NRSA) recorded a decline of 7000 ha of mangroves in India within a period of six years from 1975 to 1981. In Andaman and Nicobar Islands about 22,400 ha of mangroves were lost between 1987 and 1997. However, as indicated by the estimates of the Forest Survey of India, mangrove forest cover in many of the Indian mangroves is gradually increasing due to restoration and other management efforts. Increasing human population in coastal areas is resulting in increased pressure on mangrove ecosystems, with the growing demand for land for various purposes including agriculture, aquaculture, development of industrial complexes and human settlements as well as for timber, fuel, fodder and other non-wood forest products. To ensure the conservation of mangroves for environmental benefits, together with a sustainable supply of various forest and other products to meet the day-to-day requirements of the local people, appropriate management systems need to be developed and put in place.

Recognizing the importance of mangroves, the Government of India set up the National Mangrove Committee in the Ministry of Environment and Forests in 1976 to advise the government about mangrove conservation and development and the present atlas is a small step towards helping the National Committee to formulate suitable management practices for the mangrove wetlands of Orissa.

Map 2.1 Distribution of mangroves in Orissa



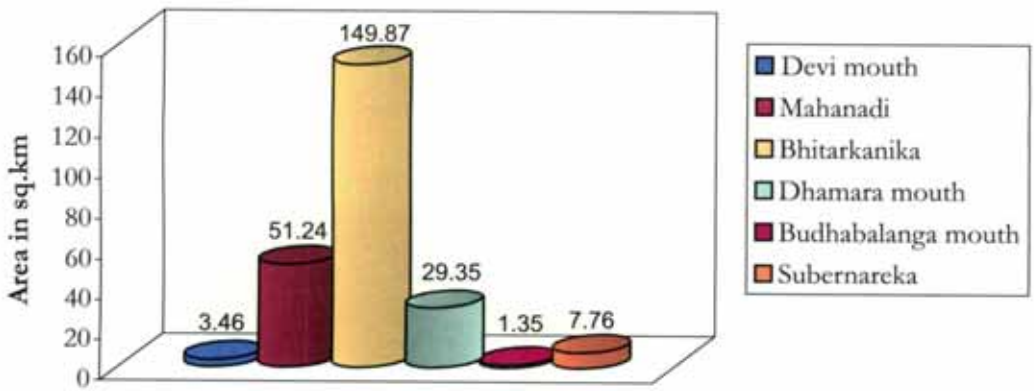
Chapter 2

Mangrove wetlands of Orissa

Orissa is located between 17°49' N and 22° 34' N latitudes and between 81° 27' E and 87° 29' E longitudes. It has a geographical area of 155,707 sq.km out of which an area of 52,472 sq.km is forested area, which amounts to 33.7% of the geographical area. Out of 52,472 sq.km of forested area mangrove forests constitute 243 sq.km, which is only about 0.46 % of the total forest area of the state. The extent and location of mangrove forests in the estuaries of Orissa are shown in Map 3 and Figure 1. The estuarine areas of the Mahanadi, Brahmani and Baitarani rivers harbour spectacular mangrove forests, which are rich in species diversity and biomass.

In Orissa, rice cultivators grow varieties of salt tolerant paddy and also practise aquaculture in the mangrove areas. Large mangrove forest areas have been converted for these purposes. In Paradwip area, large tracts of pristine mangroves were cleared for the development of Paradwip port.

The present atlas covers the mangrove wetlands of Mahanadi, Devi mouth and Bhitarkanika of the Orissa coast.



Source: BIGYAN DIGANTA, Nov-Dec. 1999

Figure 1. Area of different mangrove wetlands of Orissa

2.1 Floristic diversity of mangroves of Orissa

Floristically, mangrove forests of Orissa harbour the following exclusive and associated species.

Table 2. True and associate mangrove species recorded from Orissa coast

Sl.No.	Plant species and Family	Local Name	Habit	Distribution
	True or exclusive mangrove species			
1	*Acanthus ilicifolius* L. ACANTHACEAE	Harkancha	Shrub	Common
2	*Acanthus volubilis* Wall. ACANTHACEAE	Harkancha	Shrub	Rare
3	*Acrostichum aureum* L. ADIANTACEAE	Kharakhari	Fern	Common
4	*Aegialitis rotundifolia* Roxb. PLUMBAGINACEAE.	Banarua	Tree	Common
5	*Aegiceras corniculatum* (L.) Blanco MYRSINACEAE	Khrasi	Tree	Common
6	*Aglaia cucullata* Ker-Gawl. AMARYLLIDACEAE	Uanr	Tree	Rare
7	*Avicennia alba* Bl. AVICENNIACEAE	DhalaBani	Tree	Common
8	*Avicennia marina* (Forsk.) Vierh. AVICENNIACEAE	SingalBani	Tree	Common
9	*Avicennia officinalis* L. AVICENNIACEAE	Bani	Tree	Common
10	*Bruguiera cylindrica* (L.) Bl. RHIZOPHORACEAE	Rifil	Tree	Common
11	*Bruguiera gymnorrhiza* (L.) Savigny RHIZOPHORACEAE	Bandari	Tree	Common
12	*Bruguiera parviflora* (Roxb.) Wight & Arn. Ex Griff. RHIZOPHORACEAE	Kaliachua	Tree	Common
13	*Bruguiera sexangula* (Lour.) Poir. RHIZOPHORACEAE	Bandari	Tree	Rare
14	*Ceriops decandra* (Griff.) Ding Hou RHIZOPHORACEAE	Garani	Tree	Common
15	*Ceriops tagal* (Perr.) Robins. RHIZOPHORACEAE	Badgarani	Tree	Rare
16	*Cynometra ramiflora* L. CAESALPINACEAE	Singda	Tree	Rare
17	*Dolichandrone spathacea* (L.f.) K. Schum. BIGNONIACEAE	Gosinga	Tree	Common
18	*Excoecaria agallocha* L. EUPHORBIACEAE	Guan	Tree	Common
19	*Heritiera fomes* Buch.-Ham. STERCULIACEAE	Sundari	Tree	Common
20	*Heritiera kanikensis* Majumdar & Banerjee STERCULIACEAE	Kanika Sundari	Tree	Endangered and endemic
21	*Heritiera littoralis* Dryand ex Ait. STERCULIACEAE	Dhala Sundari	Tree	Rare
22	*Kandelia candel* (L.) Druce RHIZOPHORACEAE	Sindhuka	Tree	Common

(Contd.)

Table 2. True and associate mangrove species recorded from Orissa coast

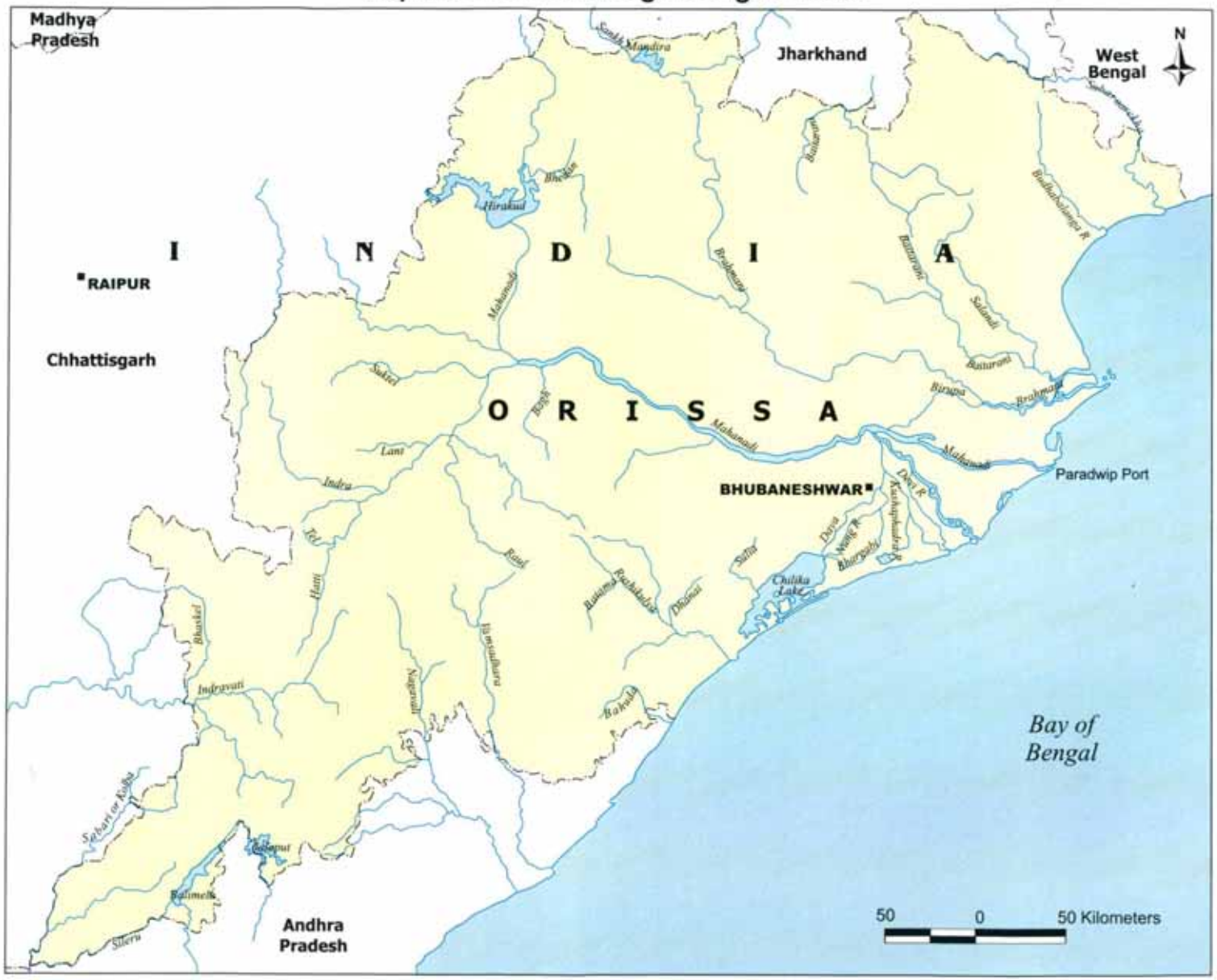
Sl.No.	Plant species and Family	Local Name	Habit	Distribution
23	*Lumnitzera racemosa* Willd. COMBRETACEAE	Churanda	Tree	Rare
24	*Rhizophora apiculata* Bl. RHIZOPHORACEAE	Raai	Tree	Common
25	*Rhizophora mucronata* Lam. RHIZOPHORACEAE	Raai	Tree	Common
26	*Rhizophora stylosa* Griff. RHIZOPHORACEAE	Raai	Tree	Rare
27	*Sonneratia apetala* Buch.-Ham. SONNERATIACEAE	Keruan	Tree	Common
28	*Sonneratia caseolaris* L. SONNERATIACEAE	Orua	Tree	Common
29	*Sonneratia griffithii* Kurz. SONNERATIACEAE	Orua/Chakada	Tree	Rare
30	*Xylocarpus granatum* Koen. MELIACEAE	Shishumar	Tree	Common
31	*Xylocarpus mekongensis* Pierre. MELIACEAE	Pitakurua	Tree	Rare
32	*Xylocarpus molluccensis* (Lam.) M. Roem. MELIACEAE	Pitamari	Tree	Rare
	Associate species			
1	*Brownlowia tersa* L. TILIACEAE	-	-	Common
2	*Caesalpinia crista* L. CAESALPINIACEAE	Nentei	Climbers	Common
3	*Caesalpinia nuga* Ait. CAESALPINIACEAE	Nentei	Climbers	Rare
4	*Capparis horrida* L. CAPPARACEAE	Mendhi	Shrub	Common
5	*Cerbera manghas* L. APOCYNACEAE	Paniamba	Tree	Rare and endangered
6	*Clerodendrum inerme* Gaertn. VERBANACEAE	Chiyani	Shrub/Climbers	Common
7	*Crinum defixum* Ker-Gawl. AMARYLLIDACEAE	Panikenduli	Shrub	Common
8	*Cyperus compactus* Retz. CYPERACEAE	Tiansi	Grass	Common
9	*Cyperus corymbosis* Rottb. CYPERACEAE	Keutia	Grass	Common
10	*Dalbergia spinosa* Roxb. FABACEAE	Gohira	Shrub	Common
11	*Derris heterophylla* (Willd.) Back. & Bakh. FABACEAE	Katiranai	Climbers	Common

(Contd.)

Table 2. True and associate mangrove species recorded from Orissa coast

Sl.No.	Plant species and Family	Local Name	Habit	Distribution
12	*Finlaysonia maritime* Back. Ex Heyne PERIPLOCACEAE	Latiraai	Climbers	Common
13	*Flagellaria indica* L. JUNACEAE	Bahu -mriga	Shrub	Common
14	*Hibiscus tiliaceus* L. MALVACEAE	Bania	Tree	Common
15	*Intsia bijuga* (Colebr.) Kuntze CAESALPINIACEAE	Ma Sitha	Tree	Rare
16	*Merope angulata* (Kurz) Swingle RUTACEAE	Banlembu	Shrub	Common
17	*Myriostachya wightiana* (Nees ex Steud.) Hook.f. POACEAE	Nalia	Grass	Common
18	*Pandanus fascicularis* Lam. PANDANACEAE	Lunikia	Shrub	Common
19	*Phoenix paludosa* Roxb. ARECACEAE	Hental	Tree	Common
20	*Phragmites karka* (Retz.) Trin. Ex. Steud. POACEAE	Nala	Grass	Common
21	*Porteresia coarctata* (Roxb.) Tateoka. POACEAE	Dhanidhan	Grass	Common
22	*Salacia chinensis* L. HIPPOCRATACEAE	Batara lata	Shrub/Climbers	Common
23	*Salvadora persica* L. SALVADORACEAE	Miriga	Shrub	Common
24	*Salicornia brachiata* Roxb. CHENOPODIACEAE	Salicornia	Shrub	Common
25	*Suaeda maritima* (L.) Dumort CHENOPODIACEAE	Giria	Herb	Common
26	*Suaeda nudiflora* (Willd.) Moq. CHENOPODIACEAE	Giria	Herb	Common
27	*Tamarix indica* Willd. TAMARICACEAE	Jagula	Shrub	Common
28	*Thespesia populnea* Roxb. MALVACEAE	Habali	Tree	Common
29	*Tylophora tenuis* Bl. Bijdr. ASCLEPIADACEAE	Anantmula	Climbers	Common

Map 2.2 Rivers flowing through Orissa



2.2 Rivers of Orissa

There are four groups of rivers, which flow through Orissa into the Bay of Bengal. They are:

- Rivers that originate outside the State (the Subarnarekha, the Brahmani and the Mahanadi).
- Rivers that originate inside the State (the Budhabalanga, the Baitarani, the Salandi and the Rushikulya).
- Rivers that originate inside Orissa, but flow through other states (the Bahudu, the Vamsadhara and the Nagavali).
- Rivers that originate inside Orissa, but tributary to rivers that flow through other states (the Machkund, the Sileru, the Kolab and the Indravati).

Of these, the estuaries of the following rivers have mangrove vegetation.

River Mahanadi

It is the major river of Orissa and the sixth largest river in India. It originates from the Amarkantak hills of the Bastar Plateau in Raipur district of Chhattisgarh. It is about 857 km long (494 km, inside Orissa) and its catchment area spreads over 141,600 sq.km (65,580 sq.km inside Orissa). The river carries on an average about 92,600 million cu. m of water. The main tributaries of the Mahanadi river are Seonath, Hasdeo, Mand, Ib, Jonk, Ong and Tel and its distributaries are Birupa, Nung, Devi, Kushaphadra, Bhargavi and Daya.

River Devi

The river Kathijori, a distributary of the Mahanadi river forms an interflow region with the Kandala Nadi and runs as river Devi in Jagatsinghpur district (90 km). The Devi river meets the Bay of Bengal forming a tidal estuary with meandering creeks and channels.

River Brahmani

River Brahmani is the second largest river in Orissa. It originates as two major rivers called Sankh and the Koel from the Chhotanagpur plateau of Bihar and both join at Veda Vyasa near Rourkela in Sundargarh District of Orissa, forming the major Brahmani river. It flows through the Eastern Ghats in Sundargarh, Kendujhar, Dhenkanal, Cuttack and Jajpur Districts into the coastal plains and enters the Bay of Bengal along with a combined mouth with the Mahanadi known as the Dhamra. The Brahmani river is about 799 km in length and its catchment area spreads over 39,033 sq.km in Orissa.

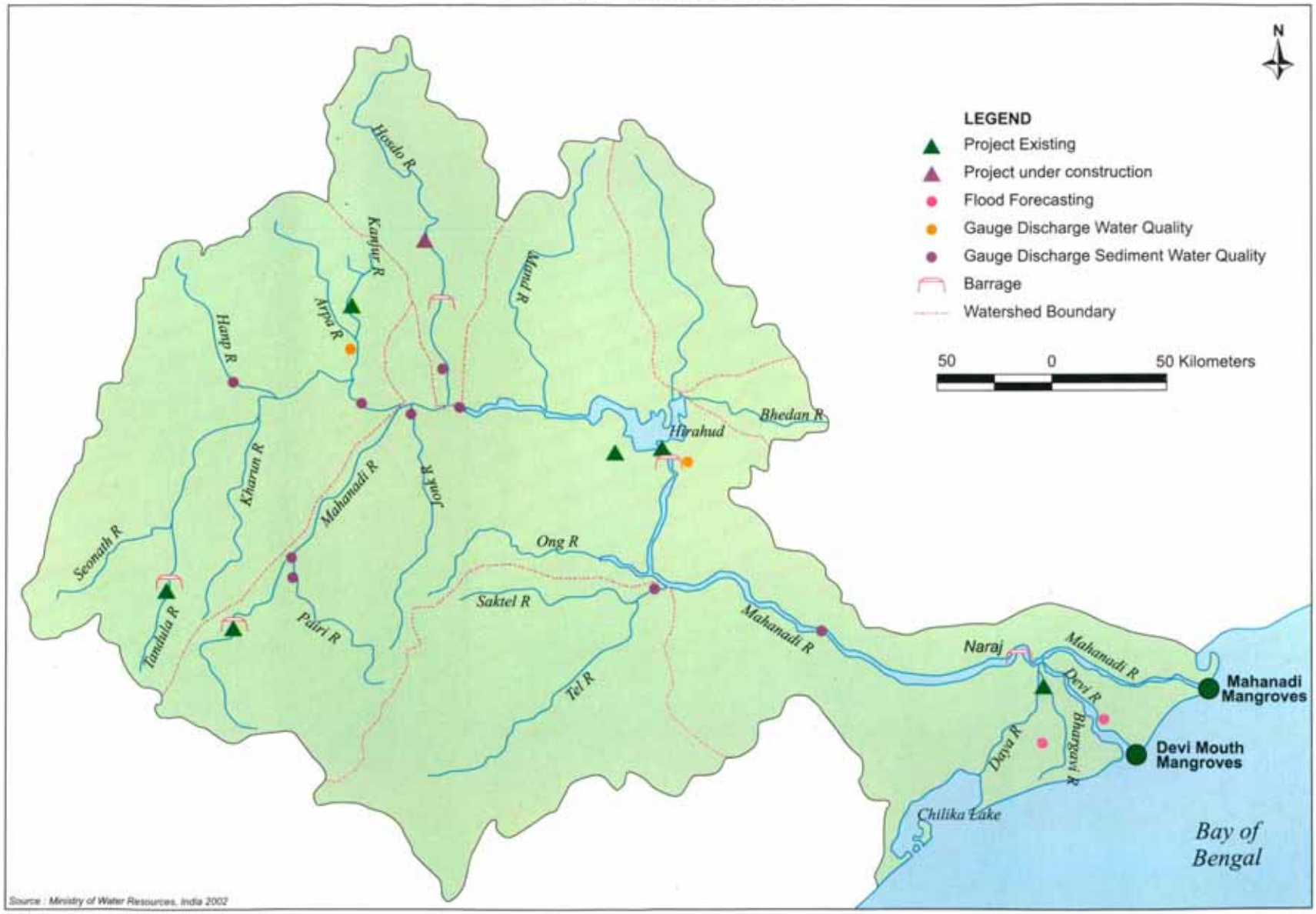
River Baitarani

It originates from the Gonasika Hills of the Keonjhar district. It is about 365 km long and its catchment area spreads over about 12,790 sq.km. It enters the Bay of Bengal after joining the Brahmani at Dhamra mouth near Chandabali.

River Subarnarekha

It originates from the Chhotanagpur plateau of Bihar. It is 433 km long (70 km inside Orissa) and has a catchment area of 19,500 sq.km (3,200 sq.km inside Orissa) with a mean annual flow of 7,900 million cu.m.

Map 2.3 Mahanadi Basin



Map 2.4 Brahmani - Baitarani Basin

2.3 Mahanadi Basin

The Mahanadi basin extends over an area of 141,589 sq.km, which is nearly 4.3% of the total geographical area of the country. The basin lies in the states of Madhya Pradesh including Chhatisgarh (75,136 sq.km), Orissa (65,580 sq.km), Bihar (635 sq.km) and Maharashtra (238 sq.km). The Mahanadi river rises from Raipur district of Madhya Pradesh and flows for about 851 km before its outfall into the Bay of Bengal.

Physiographically, the basin can be divided into four regions, namely, the Northern Plateau, the Eastern Ghats, the Coastal Plain and the Erosional Plains of the Central Table Land. The first two are hilly regions. The coastal plain is the central interior region of the basin, traversed by the river and its tributaries. The main soil types found in the basin are red and yellow soils, mixed red and black soils, laterite soils and deltaic soils. An average annual surface water potential of 66.9 cu.km has been assessed in this basin. Out of this, 50.0 cu.km is utilisable water. Cultivable area in the basin is about 8.0 million ha, which is 4.0% of the total cultivable area of the country.

Present use of surface water in the basin is 17.0 cu.km. Live storage capacity in the basin has increased significantly since independence. From just about 0.8 cu.km in the pre-plan period, the total live storage capacity of the completed projects has increased to 8.5 cu.km. In addition, a substantial storage quantity of over 5.4 cu.km would be created on completion of projects under construction. Additional storage to the tune of over 11.0 cu.km would become available on execution of projects under consideration. The hydropower potential of the basin has been assessed as 627 MW at 60% load factor. Figure 2 shows the average annual discharge of water at Naraj which clearly indicates that there is no reduction in fresh water flow since the 1960s whereas reduction in fresh water flow is a serious threat to the mangroves of Tamil Nadu as well as Krishna in Andhra Pradesh.

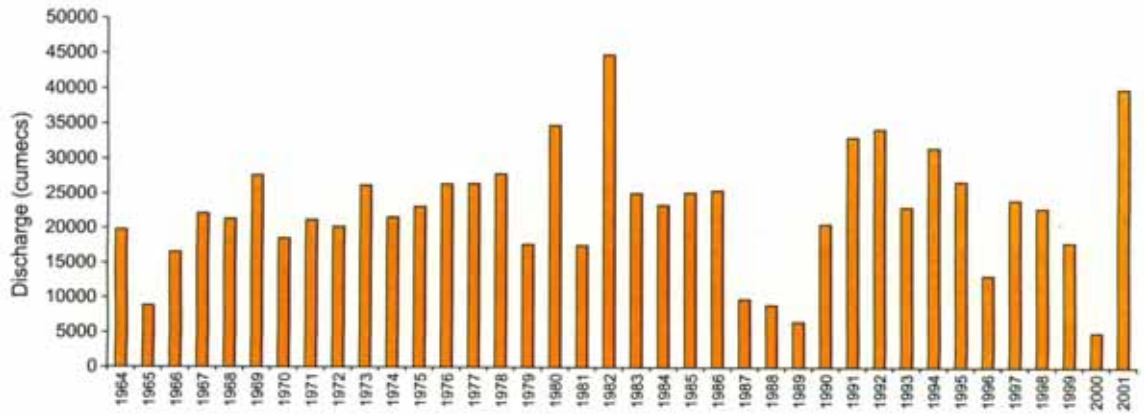
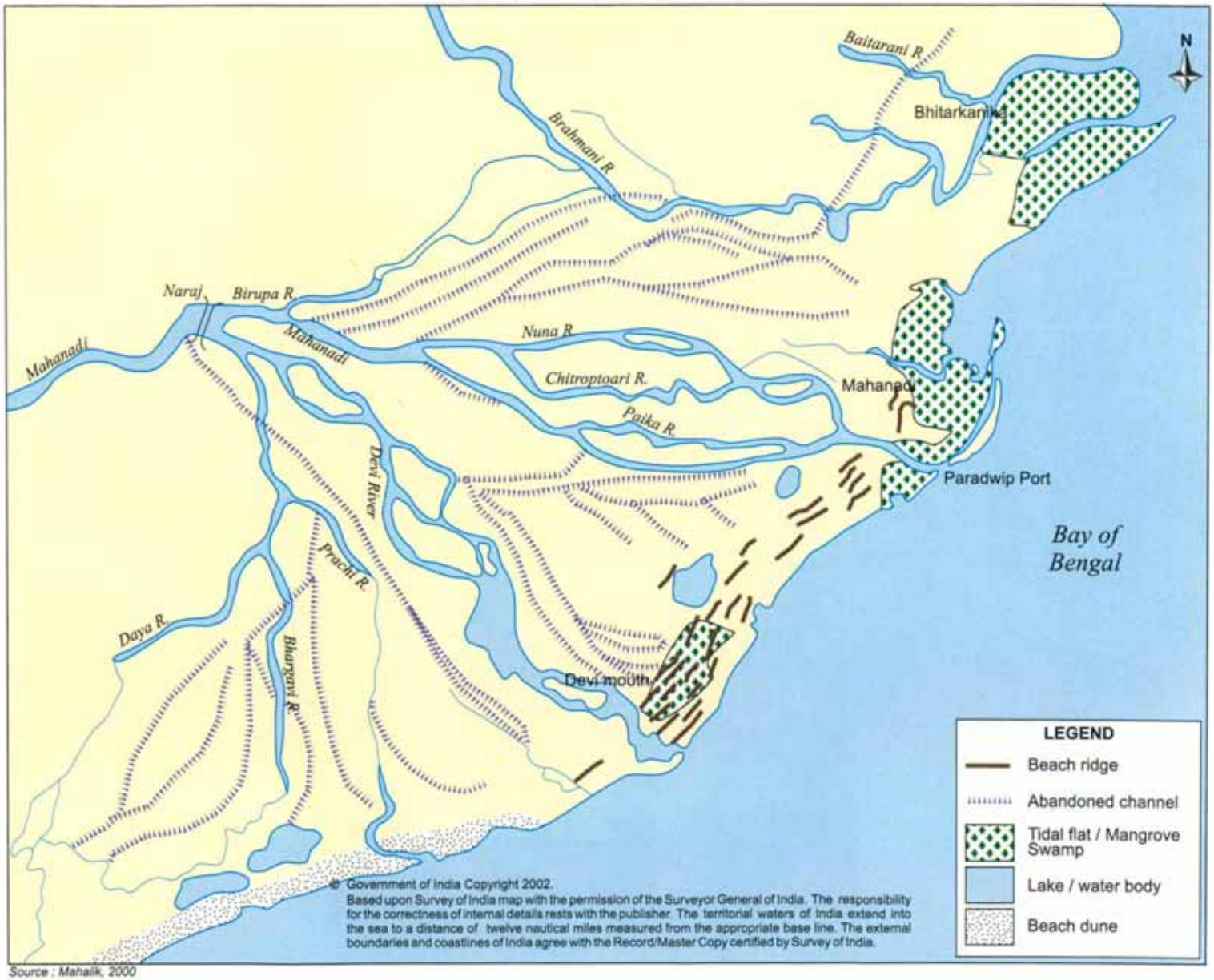


Figure 2. Average annual discharge at Naraj in Mahanadi

2.4 Brahmani-Baitarani Basin

The Brahmani and Baitarani basin jointly extends over an area of 51,822 sq.km, which is nearly 1.7% of the total geographical area of the country. The independent drainage areas of the Brahmani and Baitarani are 39,033 sq.km and 12,789 sq.km respectively. The basin lies in the states of Orissa (34,749 sq.km), Bihar (15,757 sq.km) and Madhya Pradesh (1,316 sq.km).

Map 2.5 Geomorphology



Source : Mahalik, 2000

The Brahmani river rises near Nagri village in Ranchi district of Bihar at an altitude of about 600 m and has a total length of 799 km. The Baitarani river rises in the hill ranges of Keonjhar district of Orissa at an altitude of about 900 m and has a length of about 355 km. Both the river systems outfall into the Bay of Bengal, forming a common delta area. The important tributaries of the Brahmani are the Karo, the Sankh, and the Tirka and those of Baitarani are the Salandi and the Matai (Map 2.4).

The basin consists of four well-defined regions, namely, the Northern Plateau, the Eastern Ghats, the Coastal Plains and the Central Table Land. An average annual surface water potential of 28.5 cu.km has been assessed in this basin. Out of this, 18.3 cu.km is utilisable water. Cultivable area in the basin is about 320 sq. km. which is 1.6% of the total cultivable area of the country.

Live storage capacity in the basin has increased significantly. From just about 0.06 cu.km in the fifth-plan period, the total live storage capacity of the completed projects has increased to 4.8 cu.km. In addition, a storage quantity of 0.2 cu.km would be created on completion of projects under construction. An additional storage to the tune of over 8.7 cu.km would become available on execution of projects under consideration. The hydropower potential of the basin has been assessed as 548 MW at 60% load factor.

2.5 Geomorphology

The Mahanadi delta is a classical arcuate type delta occupying an area of 9,000 sq.km. It is about 100 km wide in the east-west direction and about 200 km in the north east-south west direction. The Mahanadi river splits into two channels at Naraj, considered as the head of the delta namely, Mahanadi on the north and Kathjodi on the south. These two further divide down stream into many branches, which make up four active distributary systems (Mahalik 2000). The Mahanadi delta has developed in seven different stages. These stages of development have occurred at 26,18,15,12,9, 6 and 1.5 m contour lines. These individual contour lines touch the points of bifurcation of the distributaries. After the seventh stage of development there is an upliftment, as a result of which three sets of parallel sand dunes developed along the coast. These raised sand ridges brought changes in the drainage pattern as well as minor changes in the deltaic geomorphology. These parallel sand dunes have the maximum development between the Chilika and the Devi mouth and from there up to the north of Dhamra. As a consequence, the entire coastline has become a prograded coast, except at Paradwip, which in turn causes choking at the river mouth, hindering free discharge of fresh water.

The Orissa coast is extended in the middle, from Brahmagiri on Chilika in the southwest to Chandbali in the north-northeast where the Mahanadi, the Brahmani and the Baitarani have formed a combined delta. In this portion, the coast is convex to the Bay of Bengal while from Chandbali to the Subarnarekha mouth it is concave as no major river has pushed the shoreline to the Bay of Bengal. In the coastline, all the signs of a prograded coast become quite obvious. The bay bars in the mouth of the Chilika Lake, in the Devi mouth and the left bank of the Mahanadi mouth are the best examples. In the Mahanadi mouth, the complex spit with a number of hooks is formed due to the offshore long current and the strong southwest monsoon current during the rainy season, when the load discharge in the Mahanadi is maximum. The daily high and low tides have kept the mouths of the Devi, the Mahanadi, the Brahmani and the Baitarani open to form estuaries.

2.6 Climate

Orissa enjoys a tropical monsoon type of climate like many other parts of coastal India. Its annual rainfall is about 200 cm. The variability of rainfall is about 15 percent in the north and northeastern part of the state. In the southern, southwestern and western parts the variability ranges between 15-20 percent (Sinha, 1999). As per Koppen's climatic classifications, most parts of Orissa come under the AW having a tropical Savannah type of climate (at least one month under 6.0 cm of rainfall). The southwest monsoon normally sets in between 5 June and 10 June in the coastal plains. By 15 October, the southwest monsoon withdraws completely. An analysis of the rainfall during the southwest monsoon reveals that the monsoon rainfall in percentage of the total annual receipts is the highest in western Orissa, where it exceeds 80 percent, and the Eastern Ghats act like a divide between the coastal plains and the inland rolling uplands. As a result, the percentage of rainfall gradually declines and it is only 60% in the Ganjam plains while the coastal plains, as a whole, receive 70% of the total annual rainfall during the southwest monsoon season. On the basis of the annual rainfall, Orissa has been divided into regions of high (155 cm or more), medium (135-155 cm) and low rainfall (135 cm or less) regions. The deltaic region of the Mahanadi, Brahmani and Baitarani, where extensive mangroves are present, falls under the high rainfall region.

The Orissa coast is a cyclone prone zone. The cyclonic storms during the monsoon, which originate in the Bay of Bengal often cross the east coast between Paradwip and Chandbali, where mangroves are present luxuriantly. There are two cyclonic peaks in their occurrence, one during May-July and the other during October-November, when maximum cyclones hit Orissa. An analysis indicates that more than half (55%) of the total cyclones that originate in the Bay of Bengal hit the Orissa coast. As far as the frequency of storms is concerned, the maximum number of cyclones occur during the southwest monsoon period, followed by the post-monsoon period of the northeast monsoon and pre-monsoon period. Very frequently, these tropical storms attain "severe" intensity when the wind speed varies between 48 and 63 knots. On October 29 and 30, 1999 Super-cyclone, with wind speed ranging from 260 to 300 km/hour (hurricane category 5) hit the 90 mile coast of Orissa with a storm surge that increased the Bay of Bengal water level 30 feet higher than normal. The water rushed violently to submerge the coastal areas, including the port city of Paradwip and areas within 30 km from the shore. The Super-cyclone caused the loss of nearly 10,000 human lives and 450,000 livestock. Crops and plantations in about 1.8 million ha were also damaged. It has been reported that in some of the areas, which are under protection from mangroves, loss of human lives and livestock and damage to crops and plantations and other property was less.

2.7 Components of Atlas

The present atlas of Orissa mangroves consists of three major components namely, Mahanadi mangrove wetlands, Devi mouth mangrove wetlands and Bhitarkanika Wildlife Sanctuary.

The Orissa coast, which is 510 km in length, has mangroves in patches from Devi mouth in the south to Bhitarkanika in the north and the distance between these mangroves is about 184 km. Representation of such a large area in a single map would not provide a perceptible picture of the mangrove and its ecosystem. Apart from this, the Mahanadi and Devi mouth mangrove wetlands fall under the Mahanadi basin and are declared as reserved forests. On the other hand, Bhitarkanika falls under the Brahmani - Baitarani basin and is declared as a wildlife sanctuary and is also one of the Ramsar sites in India. Hence, it was decided to represent the mangroves of Orissa in 3 different components, to provide information with clarity.

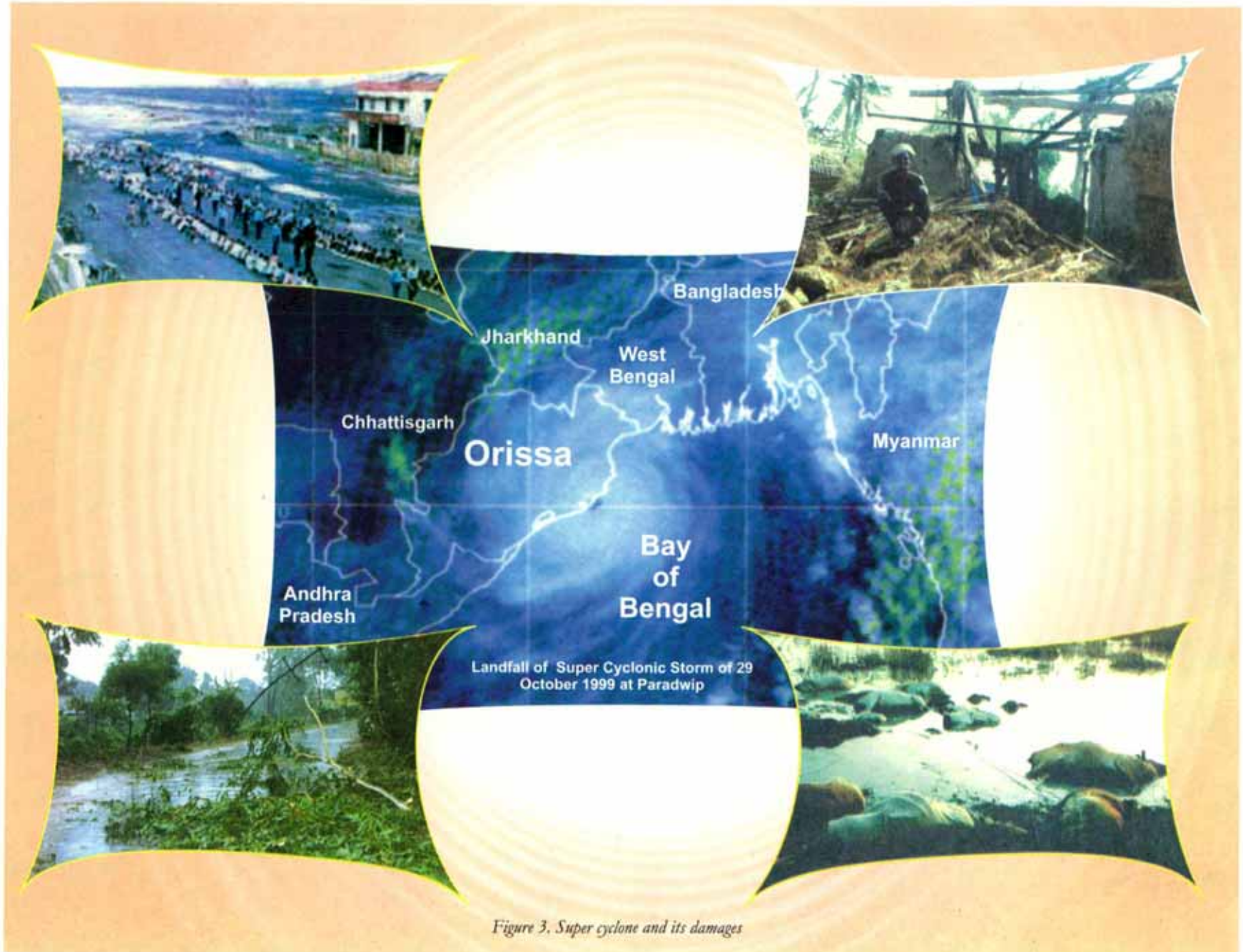


Figure 3. Super cyclone and its damages

Map 3.1 Landsat 5 TM Remote Sensing imagery of Mahanadi delta - 1985

Chapter 3

Mahanadi Mangrove Wetland

The river Mahanadi is the largest river in Orissa. The Mahanadi mangrove wetland is located in the district of Kendrapara, between 20° 18' and 20° 32' N latitude and between 86° 41' and 86° 48' E longitude. It is present in the mid-region of the Orissa coast, 250 km south of Sundarban mangroves.

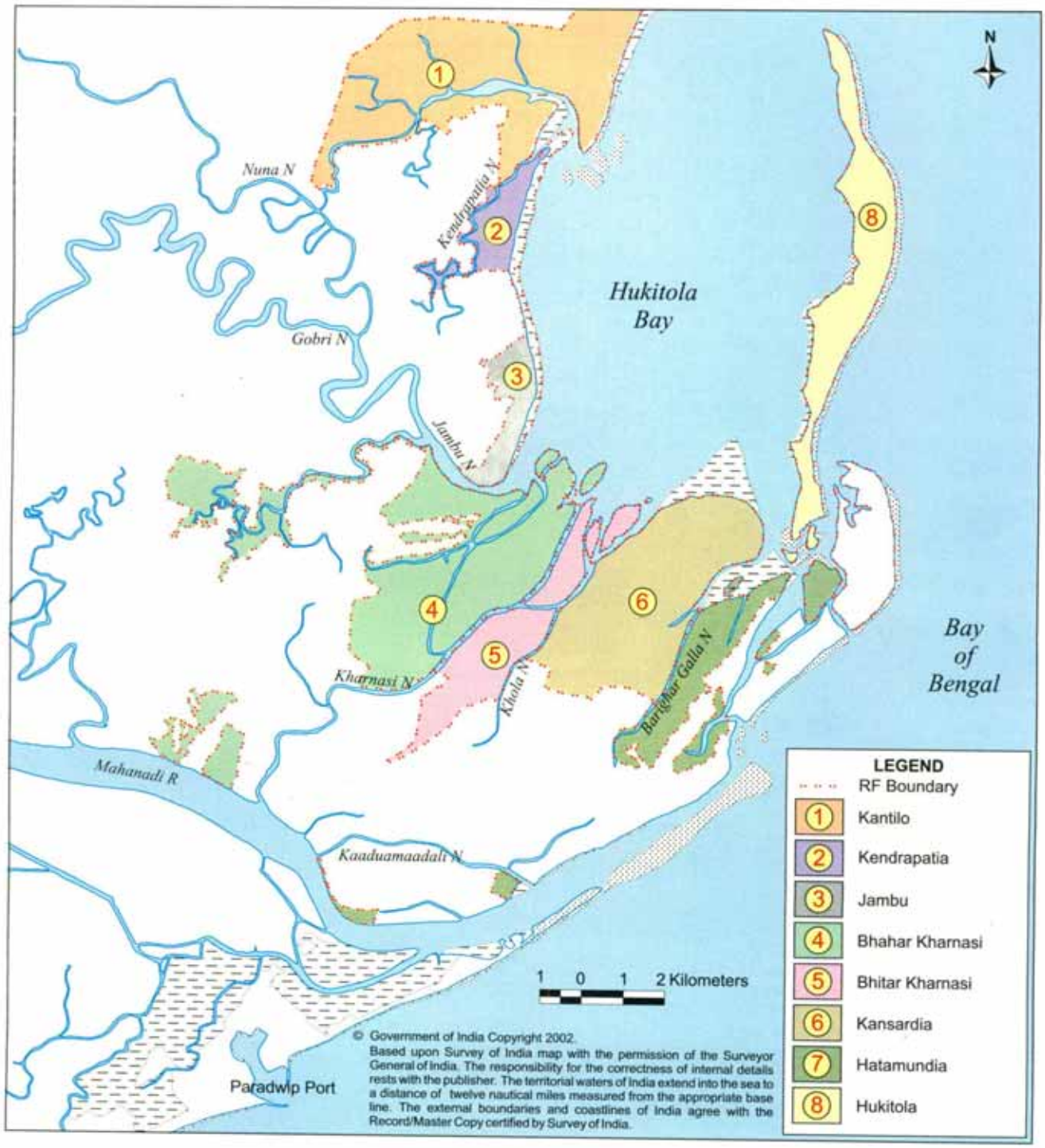
Figure 4. Mahanadi Mangroves

3.1 Remote Sensing Imagery

The remote sensing imagery of Mahanadi mangrove wetland (Map 3.2 IRS P6 LISS III of March, 2004) shows the presence of dense mangroves in the Hukitola Bay formed between the stream Jagari Jhor in the north and the Mahanadi river mouth near Paradwip port in the south. The smooth bright colour in the middle of the image shows the presence of dense mangrove vegetation which receives fresh water flow through the Mahanadi river and its tributaries like Jambu, Kharnasi etc and tidal inundation through Mahanadi mouth and small streams which confluence the Hukitola Bay. The linear white stretch in the right of the image shows the beach running southwest to north along the coastline, which ends in the spit. The small island with beach and casuarina plantation can be seen with bright white adjoining dark red and brown colours respectively in the north-east part of the imagery. The tidal flats in the bay can also be seen along the shoreline, adjacent to core mangroves by the grayish blue colour which gradually progrades to sea in dark blue colour showing the different depths in the bay area. The eastern part of the bay, seen in deep red and brown colour shows the presence of casuarina plantations

Map 3.2 IRS P6 LISS III Remote Sensing Imagery of Mahanadi Delta - 2004

Map 3.3 Forest Blocks



along the beach. Casuarina plantations are also seen west of the main mangroves near Kharnasi river and adjacent to the linear stretch of mangroves north of Jambu river. Regular rectangular or square shapes of features in bright gray and bluish gray found in the periphery of mangroves are aquaculture farms, which were not found in the remote sensing imagery of 1985 (Map 3.1), as they did not exist then. The black and white square features found at the Mahanadi river course and southwest to Paradwip Port are fertilizer plants (lower left corner of the Map 3.2).

The 1985 imagery is of November when there was intensive cultivation in the Mahanadi deltaic region whereas the 2004 imagery is of March when harvest is almost over. As a result, in the 1985 imagery most of the terrestrial area, which was under cultivation, is seen as coarse textured red colour and in the 2004 imagery these areas, which are fallow, are seen as light green colour. Regular linear features in red colour in the middle of the imagery of 2004 indicate vegetation on the sides of the road and irregular linear features in blue and black are the rivers, streams and canal networks. The meandering Jambu river can be clearly seen in the imagery.

3.2 Forest Blocks

The presence of innumerable meandering creeks, channels, islets with regular flushing by tidal waters and discharge of large quantities of fresh water for longer periods of time create suitable niches for the development of luxuriant mangroves in the Mahanadi mouth region. The Mahanadi mangrove wetland consists of 8 forest blocks namely Kantilo, Kendrapatia, Jambu, Bhitar Kharnasi, Bhahar Kharnasi, Kansaridia, Hatamundia and Hukitola.

The boundaries of these forest blocks were traced from Survey of India Toposheets (75L11 and 75L15) in the scale of 1:50,000 and transferred on to remote sensing imagery. The area of the mangroves within the forest boundary was measured using ARC GIS Software. The above calculation indicates that the total area of the mangroves in these forests is about 3062.75 ha (Table 3).

Table 3. Forest details in Mahanadi wetland

S.No.	Forest Block Name	Forest area in ha.	Mangrove area in ha.
1	Kantilo	1678.30	159.43
2	Kendrapatia	359.75	163.80
3	Jambu	326.24	210.83
4	Bhitar Kharnasi	688.00	414.76
5	Bhahar Kharnasi	2131.24	787.06
6	Kansaridia	1358.77	674.11
7	Hatamundia	1100.53	574.82
8	Hukitola	792.78	77.94
	Total	**8435.61**	**3062.75**

3.3 Flora of the mangrove forest

Vegetation structure and composition of the forests were studied by setting quadrates in 10 randomly selected sites in all the 8 forest blocks and the size of the quadrates was 10 m x 10 m. All the trees and shrubs were enumerated from the quadrates. The density of each species recorded in these forest blocks is shown in Table 4.

Table 4. Density analysis of different mangrove species in Mahanadi wetlands

Species / Forest	Density m / ha.							
	Kansardia	Hatamun-dia	Hukitola	Bhitar-Kharnasi	Jambu	Petchhola	Kendra-i patia	Kantilo
Avicennia alba	4260	4800	100	10	2090	200	2210	520
A. marina	240	500		180	950	100	150	140
A. officinalis	120	100	100	200	30	280	270	
Bruguiera cylindrica	1000	1380					30	20
B. parviflora	280	80		10				
B. gymnorrhiza	60	30						
Ceriops decandra	600	560	1720	120	40	220	410	610
Dalbergia spinosa		10	20	40	90	420	340	170
Aegiceras corniculatum	120	240	140	110	470	340	50	350
Aegialitis rotundifolia	120	630	100					
Heritiera fomes		90		530		20		
Sonneratia apetala		10	40	80	160	20	10	
S. caseolaris	20							
S. griffithii		60	800					
S. alba					10			
Excoecaria agallocha	1680	580	1720	720	80	4760	100	2400
Kandelia candel				90	10	100	10	
Merope angulata		30			60			
Rhizophora apiculata	440	120	160				40	
Rhizophora mucronata	60							
Derris scandens				220	20		210	
Xylocarpus granatum	40			30				
X. mekongensis			20					
Dalbergia candenatenss				20				
Acanthus ilicifolius		50		1230	830			8650
Cynomitra iripa								
Brownlowia tersa	40			1310				
Phoenix paludosa						1120		70
Clerodendrum inerme								10
Pandanus tectorius						80		
Caesalpinia crista	80			20		380		
Finalysonia obovata				10				
Tamarix troupii	40				100			10
Lumnitzera racemosa			120					

Kendrapatia Forest Block

In the north block of Kendrapatia forest, *Avicennia alba* is dominant. *Sonneratia apetala, Avicennia alba* and *Excoecaria agallocha* are also present in large numbers along with *Ceriops decandra, Aegialitis rotundifolia, Aegiceras corniculatum and Heritiera fomes,* etc. *Rhizophora apiculata is* rare.

Figure 5. Ceriops decandra

Near the saline embankment of this forest block, non-littoral species are found in large numbers. Among these *Streblus asper, Pithecellobium dulce, Lannea coromandelica, Eugenia bracteata, Erioglossum rubiginosum, Pongamia pinnata, Azadirachta indica, Manilkara hexandra* and *Ixora undulata* occur along the embankment. In the sandy areas *Azima tetracantha, Salvadora persica, Capparis sepiaria* and *Optuntia stricta* are present, while *Ipomoea pescaprae* covers the sand dunes.

Jambu Forest Block

This forest block is highly degraded. *Avicennia officinalis, A. marina, Sonneratia apetala, Excoecaria agallocha,* and *Ceriops decandra* are present but the dominant species is *A. alba. Tamarix troupii* occurs commonly in this area.

Bhitar Kharnasi Forest Block

In this forest block *Avicennia officinalis* is the dominant species. *Avicennia marina, Heritiera fomes, Ceriops decandra, Brownlowia tersa, Sonneratia apetala, Avicennia alba, Dalbergia spinosa, Bruguiera cylindrica, Excoecaria agallocha,* etc. are also abundant.

Bhahar Kharnasi Forest Block

In this forest block *Avicennia marina* is the most dominant species occurring in association with *A. alba, A. officinalis, Sonneratia apetala, Heritiera fomes, Excoecaria agallocha* etc. Other species, namely *Kandelia candel, Bruguiera gymnorrhiza* and *B. cylindrica* are sporadically distributed.

Kansardia Forest Block

In this forest block, *Rhizophora mucronata, R. apiculata, Avicennia alba, A. officinalis, Excoecaria agallocha, Aegialitis rotundifolia, Ceriops decandra, Aegiceras corniculatum,* and *Lumnitzera racemosa* are present in large numbers. Species such as *Bruguiera cylindrica, Tamarix troupii* and *Lumnitzera racemosa* are moderately distributed. *Bruguiera parviflora, B. gymnorrhiza, Xylocarpus granatum, X. mekongensis* and *Kandelia candel* are rare. Among the climbers, *Derris trifoliata, Finlaysonia obovata* and *Tylophora tenuis* are noteworthy.

Some marshy areas within this block are covered with *Sesuvium portulacastrum, Suaeda nudiflora, Salicornia brachiata* etc. The occurrence of *Phoenix paludosa* and *Acanthus ilicifolius* is also common. Though this forest block exhibits rich species diversity, it is in a degraded state due to prawn culture and over exploitation. The Orissa Forest Department and MSSRF jointly propose to establish a Mangrove Genetic Resources Conservation Center in this forest block.

Figure 6. Lumnitzera racemosa

Hatamundia Forest Block

The dominant species is *Excoecaria agallocha.* The abundantly present elements are *Avicennia marina, Rhizophora apiculata, Rhizophora mucronata, Ceriops decandra, Avicennia marina, A. officinalis, A. alba, Heritiera fomes, Aegialitis rotundifolia,* and *Brownlowia tersa.* Species like *Bruguiera cylindrica, Xylocarpus granatum and Aegiceras corniculatum* are common. In the western part of Hatamundia forest block, *Avicennia marina* forms the dominant vegetation in association with *Avicennia alba* particularly over recently deposited material. *Sonneratia alba* and *S. apetala* are commonly observed whereas *Rhizophora* spp. is less abundant. The ground flora is represented by *Suaeda monoica, S. nudiflora,* and *Sesuvium portulacastrum. Tamarix troupii* occurs occasionally. *Myriostachya wightiana* is found in the muddy banks in association with *Porteresia coarctata.* On the eastern side of the Hatamundia forest block, *Casuarina equisetifolia* are planted. Most of the forest areas have been cleared for prawn culture. The mangroves are also heavily degraded due to over-exploitation.

In the sandy areas (above tidal influence) of Hatamundia Forest Block, non-littoral forests are observed. *Syzygium cumini* and *Casuarina equisetifolia* (introduced) forms the top canopy. The shrubby elements, namely *Ziziphus oenoplia, Caesalpinia bonduc, Lantana camara, Pavetta indica, Carissa spinarum, Opuntia stricta, Salvadora persica, Capparis sepiaria, Eugenia bracteata,* etc. are frequent. Among the herbaceous elements *Mimosa pudica, Trianthema portulacastrum, Croton bonplandianus, Portulaca quadirtfda, Portulaca tuberosa* and *Zoysia matrella* are noteworthy. The commonly observed twiners and climbers are *Ipomoea pes-caprae, Passiflora foetida, Tylophora indica,* etc. Species like *Aristolochia indica* are rarely observed.

Interestingly, a different type of vegetation is found on the bunds of aquaculture ponds. In the elevated areas of bunds, *Sesuvium porulacastrum* in pure formation exhibits luxuriant growth. At places, *Trianthema portulacastrum* occurs in patches, in association with *Mimosa pudica, Croton bonlandianus* and *Zoysia matrella.*

Figure 7. Bruguiera cylindrica

Hukitola Forest Block

Hukitola forest block exhibits both mangroves and non-littoral vegetation. In the areas under tidal inundation, mangroves and their associates dominate. The areas devoid of tidal influence harbor non-littoral species. *Salvadora persica* is found in both the conditions. Species like *Eugenia bracteata, Carissa spinarum, Ziziphus oenoplia Syzygium cumini, Ziziphus mauritiana, Tamarindus indicus, Lannea cormoandelica, Streblus asper, Mitragyna parviflora, Ixora undulata, Pongamia pinnata, Azadirachta indica, Ficus bengalensis, F. religiosa, Opuntia stricta, Tephrosia purpurea, T. villosa, Caesalpinia bonduc, Ipomoea pes-caprae, Trianthema portulacastrum, Achyrathes aspera, Portulaca tuberosa* and *Ochna obtusata* are worth mentioning among fresh water species. *Heliotropium curassavicum* occurs in sandy soil under partial tidal inundation. The dominant species in mangrove vegetation are *Excoecaria agallocha. Aegialitis rotundifolia, Sonneratia apetala, Avicennia officinalis, Ceriops decandra, Dalbergia spinosa, Aegiceras corniculatum, Lumnitzera racemosa* and *Sonneratia alba* are distributed moderately. Species like *Cynometra ramiflora* and *Rhizophora apiculata* are rare. *Aegialitis rotundifolia* and *Ceriops decandra* are found in patches in swampy areas. Species like *Acanthus ilicifolius*

and *Clerodendrum inerme* are also commonly found. In the point bar, situated southwest of Hukitola, *Sonneratia alba, Avicennia marina* and *A. officinalis* exist mostly in stunted form.

Petchhola Forest

This forest block is highly degraded. Patches of mangrove elements are observed sporadically. A patch of dense vegetation exists in the north block. There is gradual decrease of vegetation cover towards the southwest of Petchhola Forest Block, where the forest is completely denuded or represented by a few sporadically scattered mangrove elements.

Avicennia officinalis is the dominant species. *Avicennia alba, Sonneratia apetala, Excoecaria agallocha, Aegiceras corniculatum* and *Dalbergia spinosa* are moderately distributed whereas *Rhizophora apiculata, Heritiera fomes, Kandelia candel* and *Xylocarpus granatum* are rare. The plants are mostly in shrubby state. Highly degraded areas are colonized by *Phoenix paludosa, Acanthus ilicifolius, Clerodendrum inerme*, etc.

Saanatobi Forest

Highly degraded mangroves are present along the banks of the river Kharnasi. Stunted growth of *Excoecaria agallocha* is commonly observed in this area. Mangroves, namely *Avicennia officinalis, Dalbergia spinosa, Ceriops decandra, Excoecaria agallocha, Phoenix paludosa, Acanthus ilicifolius* and *Sonneratia apetala* are sporadically extant. *Finlaysonia obovata, Derris trifoliata* are found occasionally. Large parts of the area are almost devoid of mangrove vegetation, except grasses with the occasional occurrence of *Excoecaria agallocha* and *Acanthus ilicifolius*. The mangroves in the forest block have been cleared for rice fields and prawn farms.

Figure 8. Brownlowia tersa along the creek

Barkulkhola Forest

On the Khola river bank, near Nipania village sparse vegetation is met with at places. The highly degraded mangrove vegetation is represented by *Excoecaria agallocha, Ceriops decandra, Phoenix paludosa, Derris trifoliata, D. scandens, Sonneratia apetala, Kandelia candel, Rhizophora apiculata, Heritiera fomes, Brownlowia tersa, Hibiscus tiliaceus, Myriostachya wightiana* and *Porteresia coarctata.* Among these elements *Rhizophora apiculata* and *Heritiera fomes* are of rare occurrence.

Along the banks of the Khola river, from Nipania to the south of Barkulkhola, luxuriant mangroves are observed. Near Barkulkhola the mangrove vegetation is highly degraded. At Batighar munda, *Avicennia officinalis, Ceriops decandra, Heritiera fomes, Excoecaria agallocha, Dalbergia candenatensis, Phoenix paludosa, Brownlowia tersa, Sonneratia apetala, Flagellaria indica, Merope angulata, Wedelia biflora* and *Clerodendrum inerme* are extant. *Derris scandens* and *Derris trifoliata* are common. *Rhizophora mucronata* and *Xylocarpus granatum* are rare. Occurrence of *Bruguiera sexangula* is noteworthy.

Figure 9. Kandelia candel

Figure 10. Clerodendrum inerme

3.4 Mangrove species zonation

The dominant species in the Mahanadi delta are *Avicennia officinalis, A. marina, Sonneratia apetala, Excoecaria agallocha* and *Rhizophora mucronata.* The distribution of species is directly related to salinity of water, soil and tidal inundation. Species like *Excoecaria agallocha* and *Acanthus ilicifolius* are found both in high salinity and fresh water conditions. Similarly, *Avicennia alba* is well adapted in different salinity conditions whereas *Avicennia marina* is restricted to high salinity areas. *Sonneratia caseolaris* is found in low salinity condition whereas *Sonneratia griffithii* and *S. alba* are found only in high salinity areas. The species zonation of the Mahanadi was prepared from remote sensing digital data for the year 2002 and shown in Map 3.4.

Figure 11. Sonneratia caseolaris

3.5 Soil properties

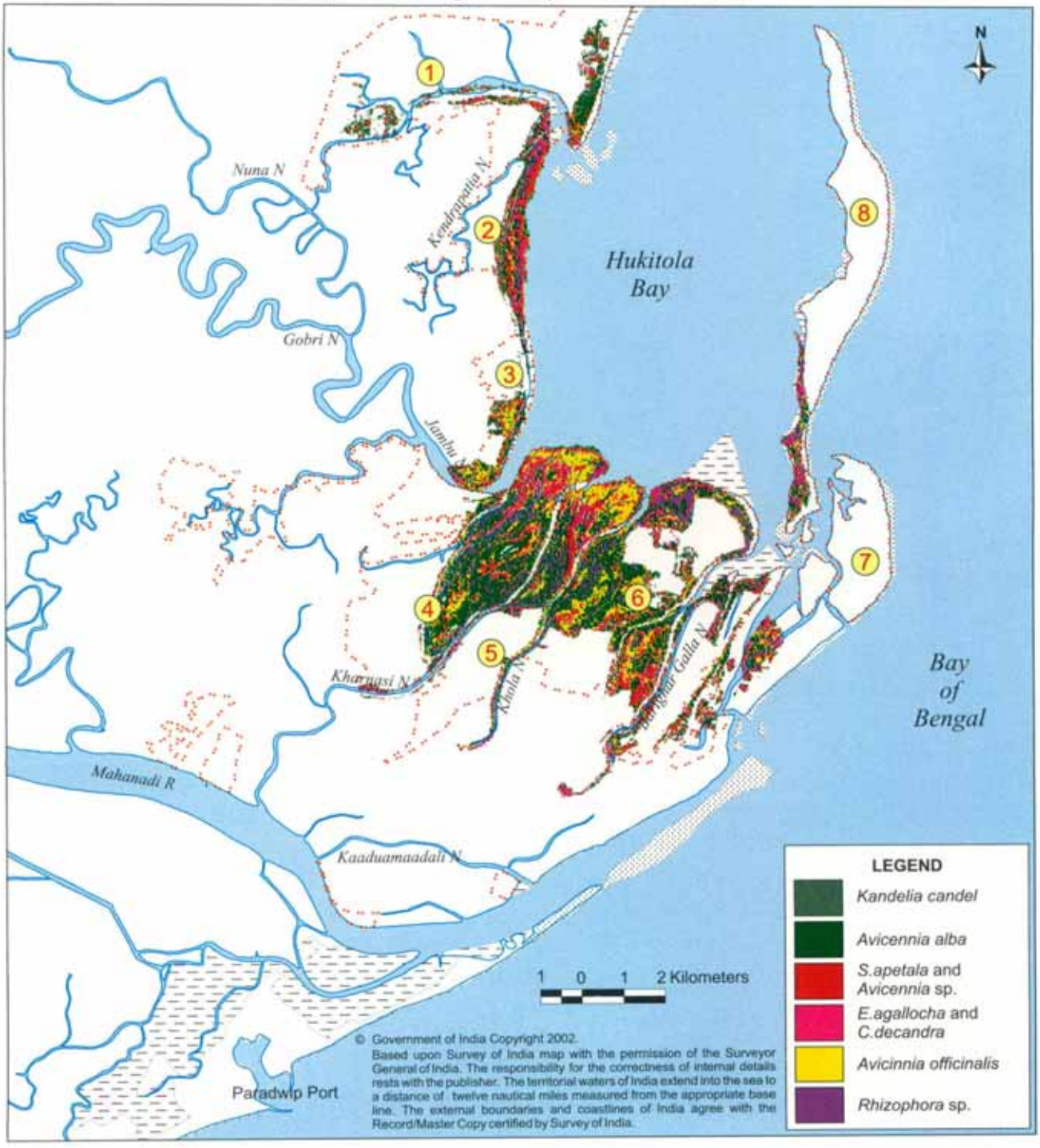
The colour of the soil ranges from pale gray and pale yellow to deep gray and the texture ranges from coarse sand to silty clay to clay. Silty clay derived chiefly from land is nutrient-rich. The organic matter content in soils varies from 2.5 to 4.8 % (Banerjee and Rao, 1990). These soils are generally fertile, with low status of nitrogen and available phosphoric acid at certain places. Within 10 km proximity of the sea, the soils are saline and narrow strips of sandy soils are also met with. The Kendrapara district has mainly two varieties of soils viz. alluvial soil in the southeast and northern parts and normal strip of saline soil in the northeast. Soil salinity in most of the mangrove blocks of the Mahanadi delta is very low, ranging from 7.1 to 9.7 parts per thousand (ppt or gm/l) even during the summer season (Map 3.5) and soil pH is slightly acidic (Map 3.6).

3.6 Hydrological Conditions

Tidal amplitude

Tidal amplitude in the Mahanadi river shows wide variation during different seasons. In general during July-August a maximum height of 6.0 m can be observed near the river mouth and 3.5 m in the inner part. During February-March, the maximum values reduce to 3.5 m in the mouth region and to 2.0 m in the interior. Tidal amplitude measured in the creeks of the Kantilo forest block shows a reduction of spring tidal amplitude from 2.4 m to 1.2 m from monsoon to dry season, which is 50%. Similarly the reduction in neap tidal

Map 3.4 Mangrove species zonation



amplitude is also (50 %) from 0.46 m during the monsoon to 0.22 m during the dry season. Hence it is clear that canals have to be excavated in the Kantilo forest block for the mangrove plantation to get sufficient tidal inundation.

Water Salinity and Temperature

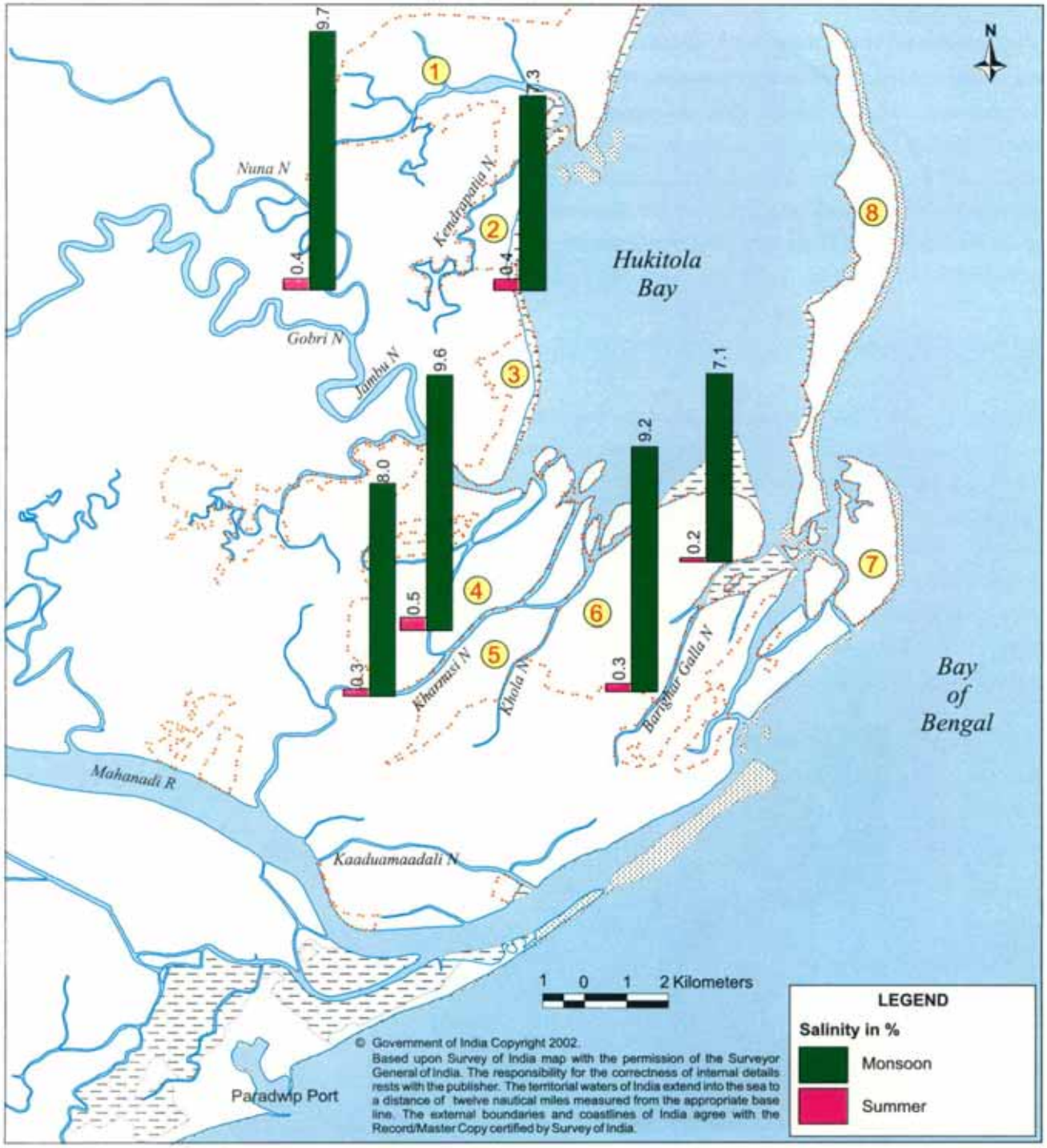
Water salinity in the Mahanadi delta varies greatly, depending upon tidal amplitude, amount of fresh water discharged and the impact of rain. Salinity shows considerable variation between the monsoon and summer season and also from mouth region to the interior part of the mangroves. Map 3.7 shows salinity recorded in different parts of the Mahanadi mangroves, which shows higher values (11.5 to 19.90 ppt) in the areas near the sea, whereas it decreases to 0.3 to 0.7 ppt in the interior mangrove region.

3.7 Wood and fishery resources

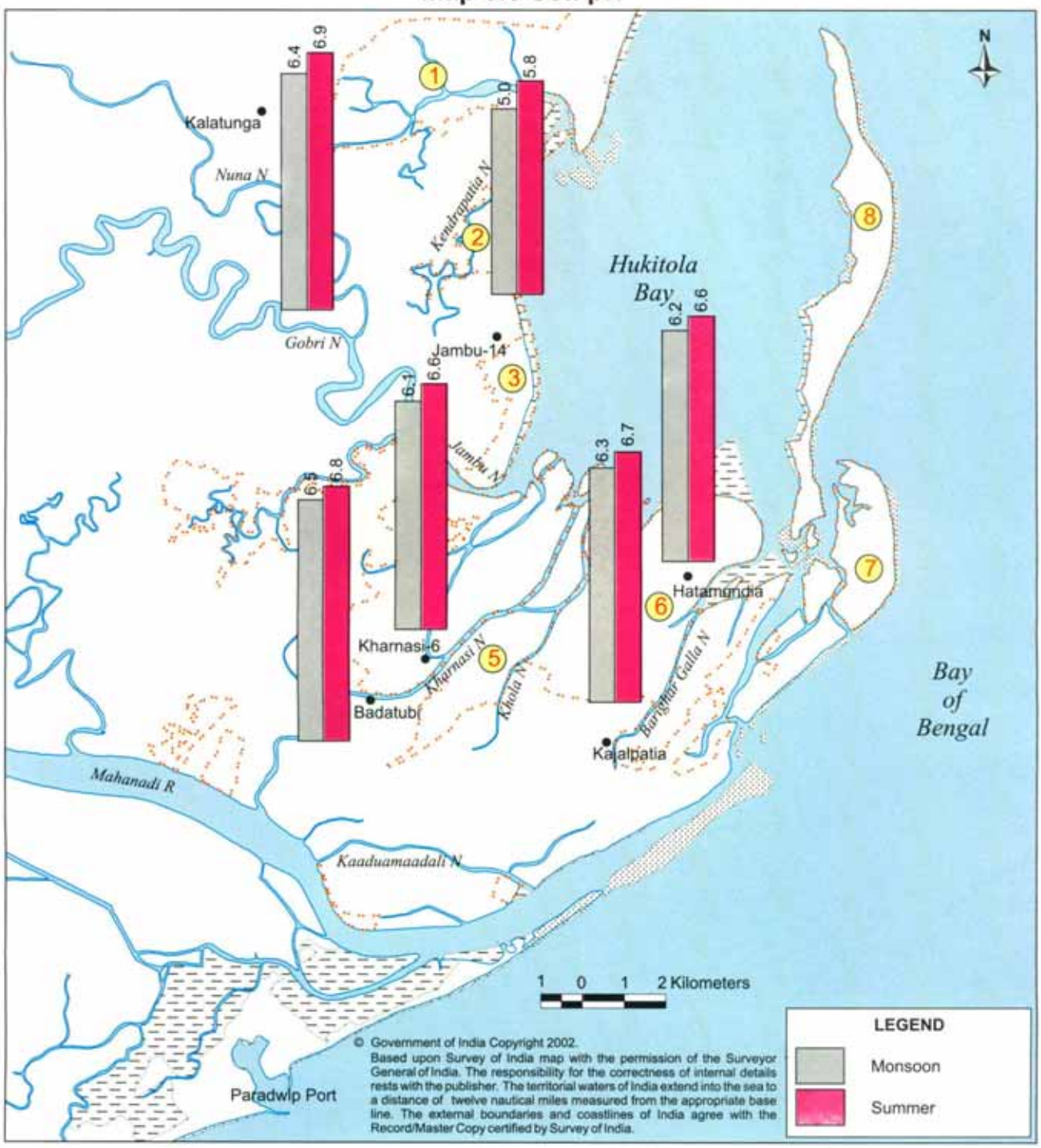
Fishing is one of the main sources of income in the coastal villages adjoining the mangroves of Mahanadi and Devi, falling under the districts of Kendrapara and Jagatsingpur respectively. Data from the Fisheries Department show that in Kendrapara district 40,373 fishermen are dependant on fishing, out of which Mahakalpara block has 31,093 and Rajnagar block has 9,280 fishermen. Jagatsingpur district has 37,925 fishermen of which Kujang, Erasama and Balikuda have 27990, 4817 and 5118 fishermen respectively. (ADF Annual report, 2000-01). The above data includes fisherfolk depending both on mangroves and the sea; no separate data is available. Fish catch data from the eight landing centres in Kendrapara district show landing of about 13,205 metric tons in a year which approximately fetches Rs. 1,980.8 lakhs in the market. The fish catch in Jagatsingpur district was 33,893.7 metric tons from six landing centres with an approximate value of Rs. 5,504.5 lakhs. The above data includes fish caught from the mangroves and the sea and no separate data is available. About 34 species constitute most of the fish catch, which also includes 10 penaeid prawns/ squid, and cuttle fish (mollusc), which are available in this region. Table 5 shows the different uses of mangrove wood resources. As indicated in the table, mangrove species are mainly used for fuel and house building material.

Figure 12. Fishery resource

Map 3.5 Soil salinity



Map 3.6 Soil pH



Map 3.7 Water salinity in percentage

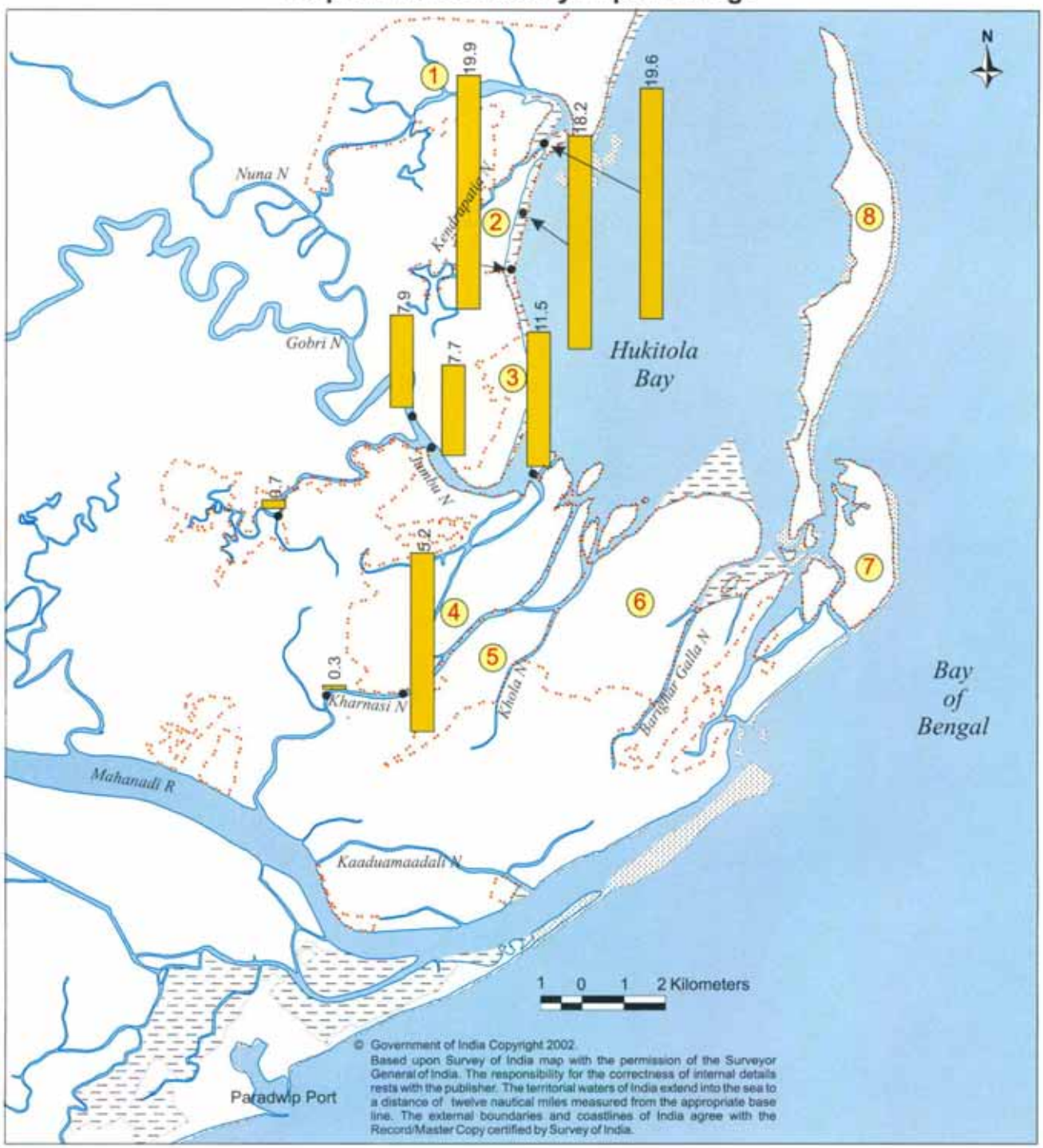


Figure 13. Fishing in canal

Table 5. Comparative scoring of Mangrove species against use

Sl. No.	Species	Easily Available	Fire Wood	House Building	Fencing	Fodder	Boat Repair	Miscellaneous (Weaving Rope, Furniture, Granary)
1	*Rhizophora apiculata*		High	High				
2	*Avicennia* Spp.		High	High				
3	*Ceriops decandra*			High	Medium			High (Granary)
4	*Brownlowia tersa*	✓	Low		Low			
5	*Heritiera fomes*		Low	Low	Low			
6	*Bruguiera cylindrica*			Medium				
7	*Aegialitis rotundifolia*			Low				
8	*Excoecaria agallocha*	✓	Low	Low	Low	Low		
9	*Sonneratia apetala*						Low	
10	*Phoenix paludosa*	✓						Low (Furniture)
11	*Myriostachya wightiana*	✓	Low	Low		Low		Low (Weaving)

Map 3.8 Mangrove user villages

3.8 Socio-economic condition

The socio-economic profile of the user villages of Mahanadi mangrove wetland was prepared on the basis of the results obtained through Rapid Rural Appraisal.

Mangrove user villages

The following villages, which are solely dependent on the mangrove wetlands for their day-to-day requirements, have been selected as demonstration villages in the Mahanadi mouth region for Joint Mangrove Management:

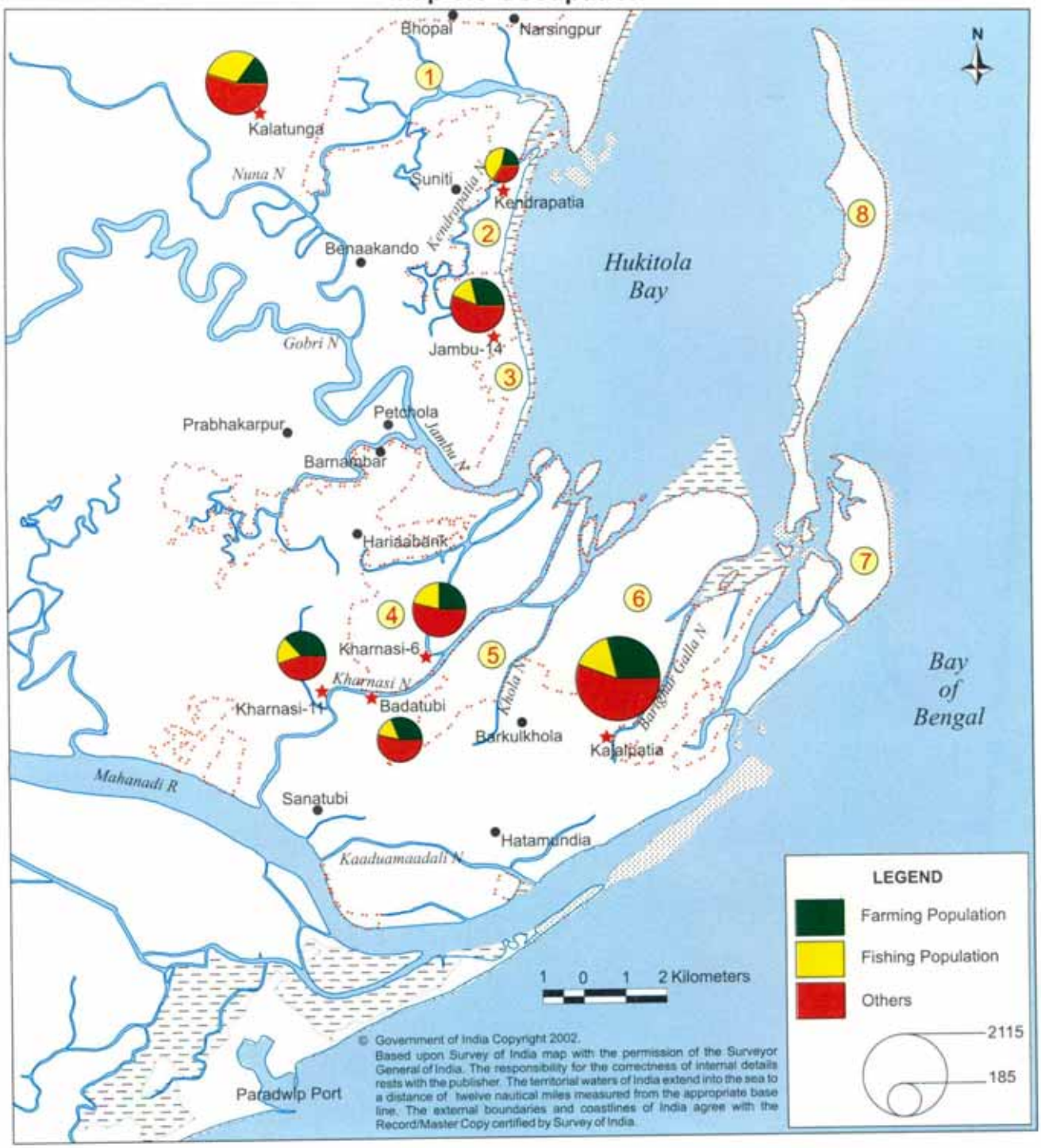
1. Kharnasi - Ward No. 6
2. Kharnasi - Ward No. 11
3. Jambu - Ward No. 14
4. Kendrapatia
5. Kalatunga
6. Badatubi
7. Kajalpatia

Population, Occupation and Literacy

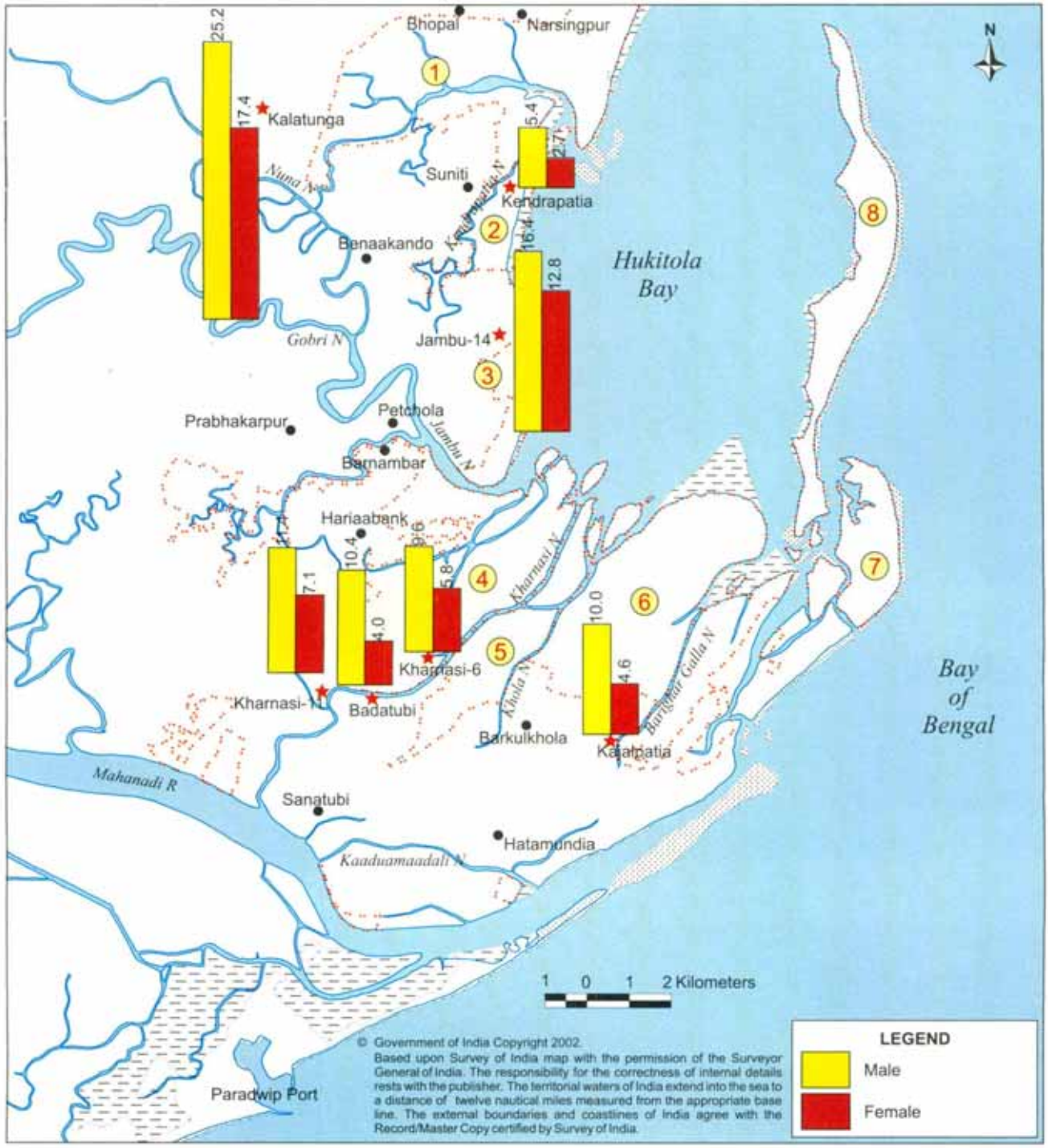
The total households of these demonstration villages are 5876. According to the benchmark survey conducted by MSSRF in all these villages, the fishing population constitute nearly 25%, farmers 21% and the remaining 54 % of the population are wage labourers either in fishing or agriculture-related works depending upon the season. The literacy rate is very low in the demonstration villages being 14 % for men and 8% for women. The survey also indicates that about 35% of those in the employable age (18-55 years) have no stable occupation.

Figure 14. Mangrove user village

Map 3.9 Occupation



Map 3.10 Literacy



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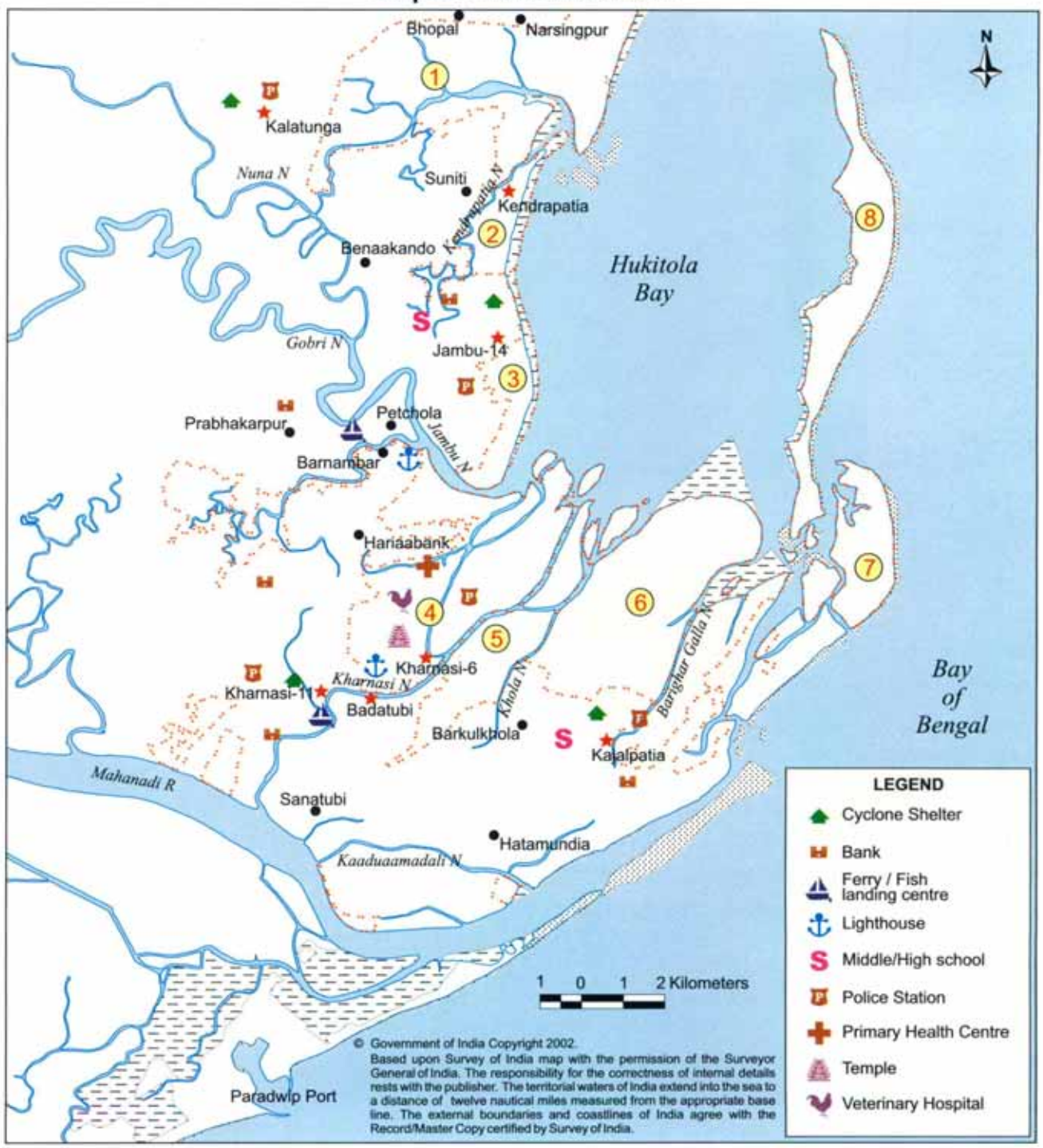
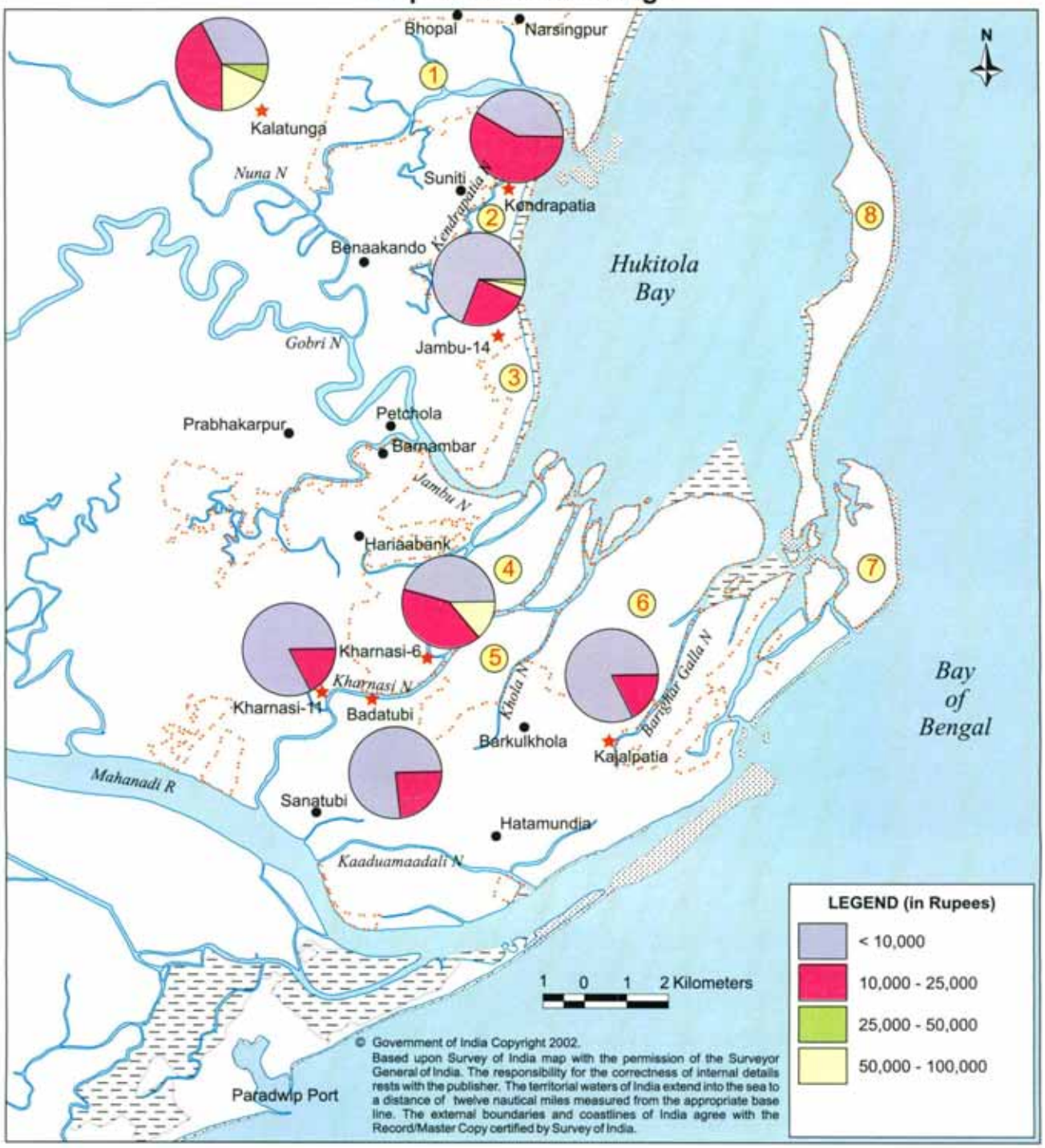
Map 3.11 Infrastructure



Map 3.12 Income range



Infrastructure

Most of the villages are connected only by saline embankments and not by proper roads. Cyclone shelter and community shelter are available in a few villages. There is one light house (Batighar) in the entire fishing villages of the Mahanadi coast and schools are also very limited. Two major fish landing centers, one at Jambu and another at Kharnasi - 11, are found in the mangrove user villages.

Income range and income sufficiency

The annual income for 65% of the households falls within Rs. 10,000/- and 28 % falls under Rs.10,000 to 25,000 and 6% under Rs. 25,000-50,000. Regarding income sufficiency level nearly 65% of the households feel that the annual income is insufficient for most of the time and 12.8% of the households feel that their income is sufficient. In all the 7 villages, sufficient annual income is seen in only 9.4% of the total households. The levels of income in the user villages, which utilize the mangrove resources, are shown in Figure 15.

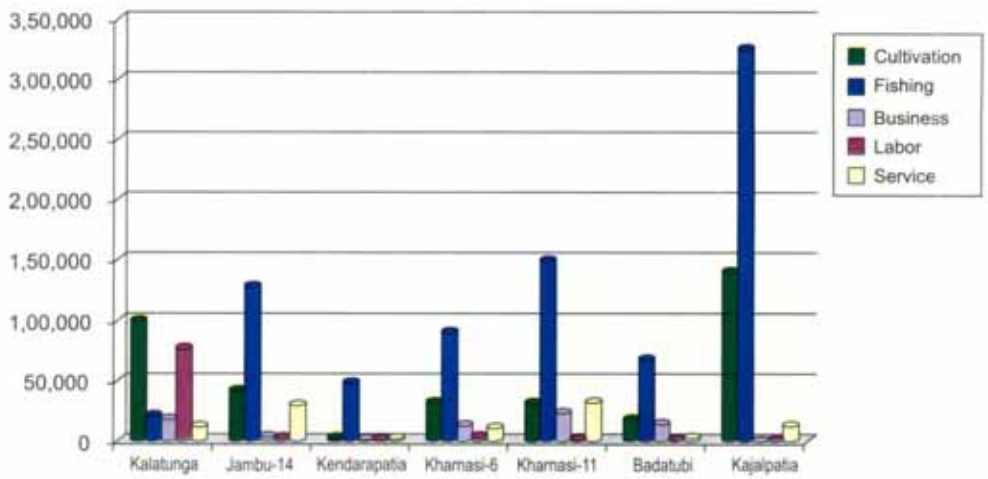


Figure 15. Distribution of income on different categories

3.9 Livestock

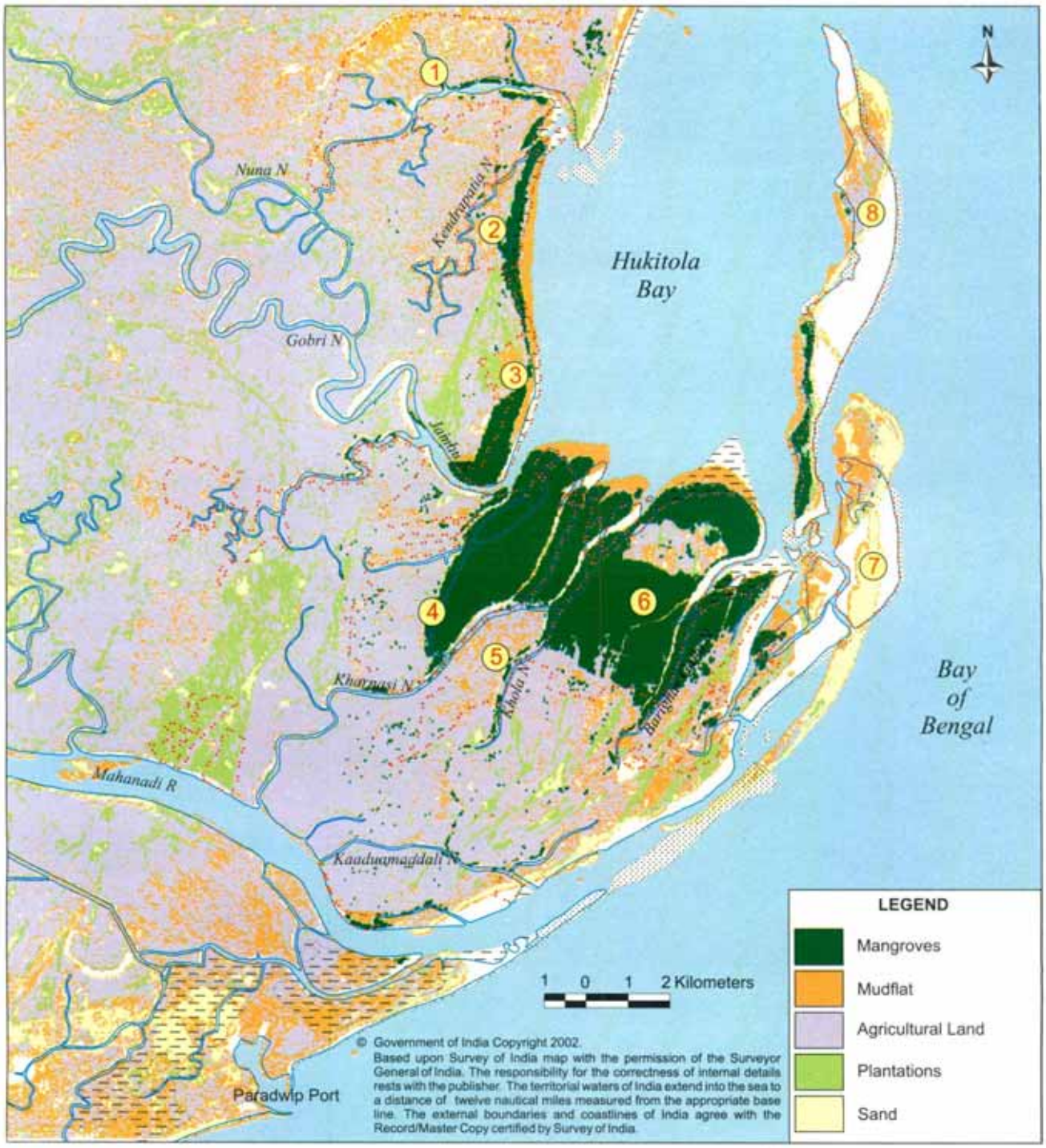
Most of the villagers own livestock mainly for the purpose of obtaining milk, manure and ploughing. In addition, the local community considers cattle as one of the important and more reliable sources of hard cash at critical times. The total heads of livestock in the user villages is about 1,560, of which 702 are cattle, 390 are buffalo and 468 are goats. Some villages use the mangrove wetland as grazing ground for their cattle.

3.10 Landuse around mangroves

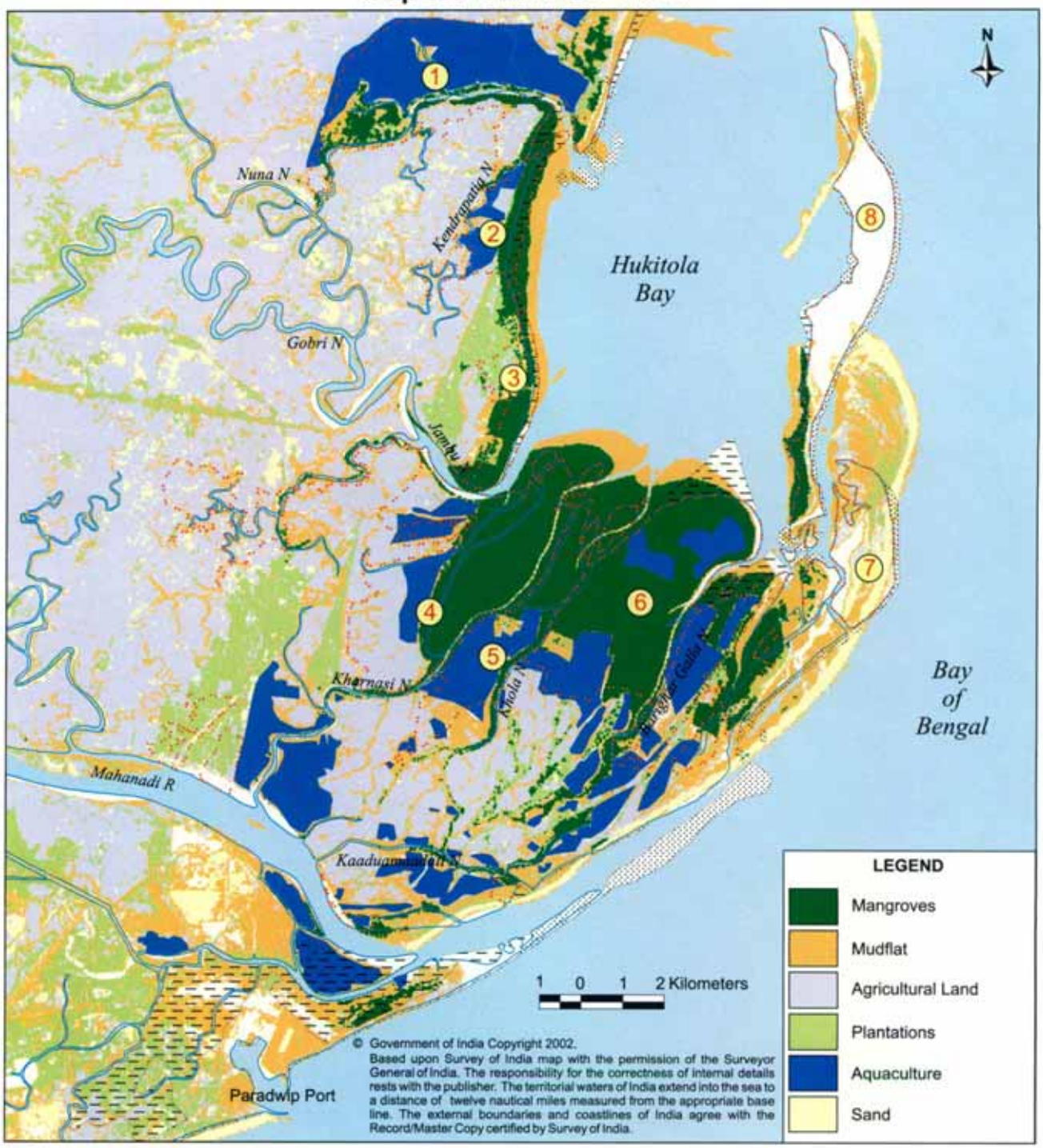
Cropping Pattern

A saline tolerant variety of paddy is the only crop being cultivated in almost all the villages. Paddy is cultivated once a year from June to December. Groundnut and pulses are cultivated particularly in Jambu and seasonal vegetables in Kajalpatia, Kendrapatia, and Kharnasi-6 and Kharnasi-11 in the elevated sandy areas from the middle of November to the middle of March. A few households in Kalatunga village also cultivate potatoes in winter.

Map 3.13 Landuse - 1985



Map 3.14 Landuse - 2004



Aquaculture

Brackish water aquaculture is a new pattern of land use in this region. It was introduced in the Mahanadi deltaic zone around 1985. Aquaculture farms were not found in the early 80s and were limited even in 1987. The approximate area under aquaculture in 1996 was 1,843 ha which increased to 2,890 ha in 2004. Prawn is the major species cultivated in the aquaculture farms in a semi-intensive way. The rampant prawn farming has hastened the degradation of the mangroves of the region.

Figure 16. Aquaculture

Figure 17. Landuse near mangroves

3.11 Dependency

Grazing

Grazing is one of the important factors that affect the mangrove vegetation. Field observation indicates that cattle feed heavily on leaves, propagules and seedlings of *Avicennia* spp, *Sonneratia* spp, and *Bruguiera* spp. during the monsoon period. In addition, seedlings of most of the mangrove species reach maximum growth during the rainy season and hence, grazing during this period affects the survival and growth rate of the other mangrove seedlings. Stunted mangrove bushes can be seen in almost all the areas of the Mahanadi mangrove wetland where cattle grazing is high. The villagers said that reduced availability of fodder, low supply of cattle feed and no cultivation of fodder grass for fodder in the wetland areas are the main reasons for increased dependency on mangroves for grazing. About 1,560 livestock, including about 700 cattle and 400 buffalo graze in the Mahanadi mangrove wetlands for most of the time in the year. A steep decline in grazing has been noticed after the village level institutions were formed and awareness enhanced. The villagers manage their livestock in the following two ways:

- Milch and plough animals (especially cattle) are kept with the farming families throughout the year. They are grazed in the harvested field for about 7 to 8 months in a year. However, the buffaloes usually graze in the mangrove forests throughout the year. The buffalo owners keep their animals near the fringes of mangrove forest and do not allow them to go inside the forests. During the paddy season, from July to November, they keep their buffaloes in their homes to be stall-fed.
- Dry and aged cattle are given to the traditional cattle grazers for grazing and maintenance. They graze these animals in the agriculture fields during the off-season. Once agriculture activities start in July, they

Figure 18. Grazing near Mangrove Forest

send the cattle to the mangrove wetlands where the cattle stay permanently for about 5-6 months. The villagers take no care when these dry and aged cattle are sent to the mangroves. In January, cattle grazers take back the cattle and graze them in the harvested paddy fields.

Firewood collection

The following table (Table 6.), which shows the mangrove dependency for firewood, indicates the dependency of the villagers on the mangroves and the alternatives provided. It is observed that the level of awareness has increased in the villagers not to use the mangrove forests alone for firewood and fodder purposes. The plantation of Multi Purpose Tree (MPT) species and supply of smokeless stoves, which reduced the fuel wood requirements, helped the communities a great deal. In addition to that, in some of the villages, Liquified Petroleum Gas (LPG) stoves were also supplied and it is observed that if at least 60% of the total houses in these villages are provided with alternatives like smokeless stoves, kerosene stoves and gas stoves, then the requirement of firewood from mangroves will reduce by 75 %.

Figure 19. Fire wood collection

Table 6. Mangrove dependency for firewood, house construction and fencing

Village	Houses	Wood requirement (tonnes per year)	No. of poles for house construction	No. of poles for fencing	Reduction due to smokeless stove (tonnes per year)
Kajalpatia	308	675.10	113,288	2,700	125.58
Kendrapatia	40	88.33	14,706	760	28.29
Kharnasi-11	110	211.15	74,849	1,780	63.34
Badatubi	80	167.35	69,768	1,456	45.60
Kharnasi-6	105	188.55	56,765	1,345	56.95
Kalatunga	180	380.85	89,458	2,446	89.34
Jambu-14	120	256.75	79,674	1,897	45.97

Fishing in mangrove waters

The State Fishery Department report states that Kendrapara district has the maximum number of fisher men (40,373) followed by Jagatsinghpur (37,925) while Bhadrak district is third. As the Kendrapara district has the maximum area of mangroves of 180 sq km out of the total 243 sq.km., the mangrove area itself is considered a boon by the local fishermen in terms of their livelihood. There are about 34 species of fishes and 10 species of prawn found in the Mahanadi mangroves. Although the people residing in the Mahanadi mangroves do not belong to the fishermen community, they have adopted fishing as their livelihood option, given the major source of income from fisheries.

Heavy pressure on the riverine systems, creeks and mangrove areas for fish, crabs, prawn seed collection, conversion of mangrove areas for prawn farming and paddy cultivation has resulted not only in the loss of mangrove areas, but also the loss of breeding and spawning grounds for fishes, crabs and prawns. There is a need for a clear policy on fishing. The present system has a regulation on deep-sea fishing during the turtle nesting season, when fishing is prohibited in the Gahirmatha Marine Sanctuary area, which needs to be better monitored. Awareness generation and tangible measures need to be taken up by the government and non-government agencies for judicious utilization of the fishery resources, for the sustainable livelihood of the fisherman in the region.

3.12 Causes of degradation

Mangrove forests are protected by the Forest Departments under the State Forest Act and the Wildlife Protection Act, 1972. The Coastal Zone Regulations, proclaimed by the Government of India, are applicable to mangroves and associated coastal wetlands as well. In recent years, increasing human population and subsequent pressure on resources has resulted in a significant increase in the destruction of mangroves. Human induced activities, ranging from over-exploitation by felling trees, uncontrolled cattle grazing, conversion of mangroves into aqua farms or agricultural lands and development of new settlements have resulted in a steep reduction in mangrove forests and loss of precious biodiversity. Further more, adverse hydrological and geomorphological processes have also resulted in sub-optimal environmental conditions, leading to the reduction in mangrove vegetation.

Figure 20. Degradation near shoreline

3.13 Management practices

Past Management Practices

The mangroves of Mahanadi delta and Brahmani-Baitarani confluence were part of the Zamindari forests of Kujang and Kanika respectively. During the Zamindari regime, mangrove forests were considered to be in excess as compared to the needs of the local people under the two Zamindaries. Revenue from land was the only financial source of the states. Hence, reclamation of fringe mangroves was encouraged for agriculture. As the local inhabitants were not keen to reclaim the mangroves, the Zamindars invited and encouraged people from West Bengal to reclaim as much area from the mangrove forests as possible. Thus, indiscriminate encroachments of mangroves were a regular practice for a long period during the Zamindari system. The aim of the Zamindars was to meet the timber and fuel demands of the people in lieu of wages. Under the Zamindari regime the total forest area was about 130 sq.km.

With the abolition of the Zamindari system, the mangrove forests came under the administrative control of Government of Orissa since 26th November 1951. The administration of the area was vested with the "Anchal Sasan" under the Revenue Department, Government of Orissa.

During the period of administrative control of these forests under "Anchal Sasan" people also started encroaching forest lands for agriculture and felling trees for timber and firewood. The depletion of mangroves was hastened with the establishment of Paradwip port, ancillary industries, settlements of refugees and migrants and fish landing stations.

In 1956, the forest blocks of Hukitola, Batighar, Hatamundia, Jogidhan Kund and Kharinasi were declared as protected forests.

From 15th November 1957 the mangrove forest of Bhitarkanika and Mahanadi Delta came under the administrative control of "Athgarh Forest Division", Department of Forest and Environment, Government of Orissa. In 1979, Hukitola, Bhahar Kharnasi, Bhitar Kharnasi and Kantilo forest blocks were declared as Reserved Forests.

Present Management Practices

To improve the management of the mangroves of Orissa a separate division called the Mangrove Forest Division was created in November 1990. The mangrove forests of the Mahanadi delta come under this division. There are 4 Reserve Forests, 14 Proposed Reserved Forests and 2 Protected Forests in the Mahanadi delta. Two Reserve Forest blocks of Mahanadi delta, namely Hukitola and Bhitar Kharnasi, have been included in Ghairmatha (Marine) Wildlife Sanctuary vide notification no. 18805 F & E dt. 27th September, 1997.

Restoration programmes of mangrove forests have gained momentum since the creation of the Mangrove Forest Division (WL) with its headquarters at Rajnagar, Kendrapara.

3.14 Restoration and Redevelopment

Mangrove restoration activity similar to the Pichavaram model (canal method) was carried out in the Mahanadi mangrove wetlands. Restoration work was carried out through the gap filling method. Afforestation or rehabilitation of degraded mangroves was effected in nearly 155 ha in 7 demonstration villages in the Mahanadi site during 1999 to 2003 (Table 7). Four mangrove nurseries of nearly 300,000 saplings capacity were raised in the demonstration villages as per availability of seeds and propagules, area, inundation of tidal water etc. The raising of the nurseries, afforestation and protection work were carried out by the local people themselves, exhibiting their enthusiasm, cooperation and involvement in the project.

Figure 21. Mangrove nursery for restoration

Figure 22. Digging of canal for restoration

Figure 23. Restored mangroves

Table 7. Details of restoration (area in ha) and Mangrove Management Units (MMU) site

Demonstration Villages	Land permitted (ha)	Area restored (ha)	Survival rate (%)	Area under MMU (ha)
Kajalpatia	39	39	75	95
Kendarapatia	25	25	90	80
Kharnasi-11	12	12	35	65*
Kalatunga	35	35	80	50
Kharnasi-6	10	10	50	65*
Badatubi	14	7	35	65*
Jambu-14	35	27	75	80
Total	**170**	**155**	**65.7**	**370**

N.B: * The MMU area of Kharnasi-11, Kharnasi-6 and Badatubi are common, which come under the jurisdiction of Bhitar Kharnasi Forest block (Hence, one Panchayat level Regional mangrove Forest Protection Committee (RMPC) has been formed)

Mangrove protection through "thengapalli"

A unique method of protection in the mangrove management units (MMU) has been introduced through "thengapalli" (turn wise protection by the communities by holding a lathi or stick) in some of the demonstration villages in Orissa. MSSRF and the Forest Department made efforts to popularize this system in all the mangroves areas. Under the system, two or three families join together and patrol the mangrove areas. The stick is carried while patrolling and handed over to the other batch the next day. Through this system, the entire village protects the area in a true spirit of community participation.

Formation of mangrove Eco-clubs in schools

The objective of forming eco-clubs is to involve the school children into the movement of mangrove conservation and management programme, being carried out in their villages/regions. The school Head Master, school committee president/secretary or community leader would be the signatories of the bank account and an amount of Rs. 5,000/- is deposited by MSSRF in the fixed term deposit in the name of the Eco-Club. The interest accrued from the fixed deposit will be utilized for conducting World Environment Day, World Wetland Day, etc. Four such eco-clubs have been formed (Kalatunga, Jambu - 14, Kharnasi - 6 and Shashikadeipur) in both Mahanadi and Dhaamra mouth sites.

Figure 24. Exposure cum mangrove plantation by School students

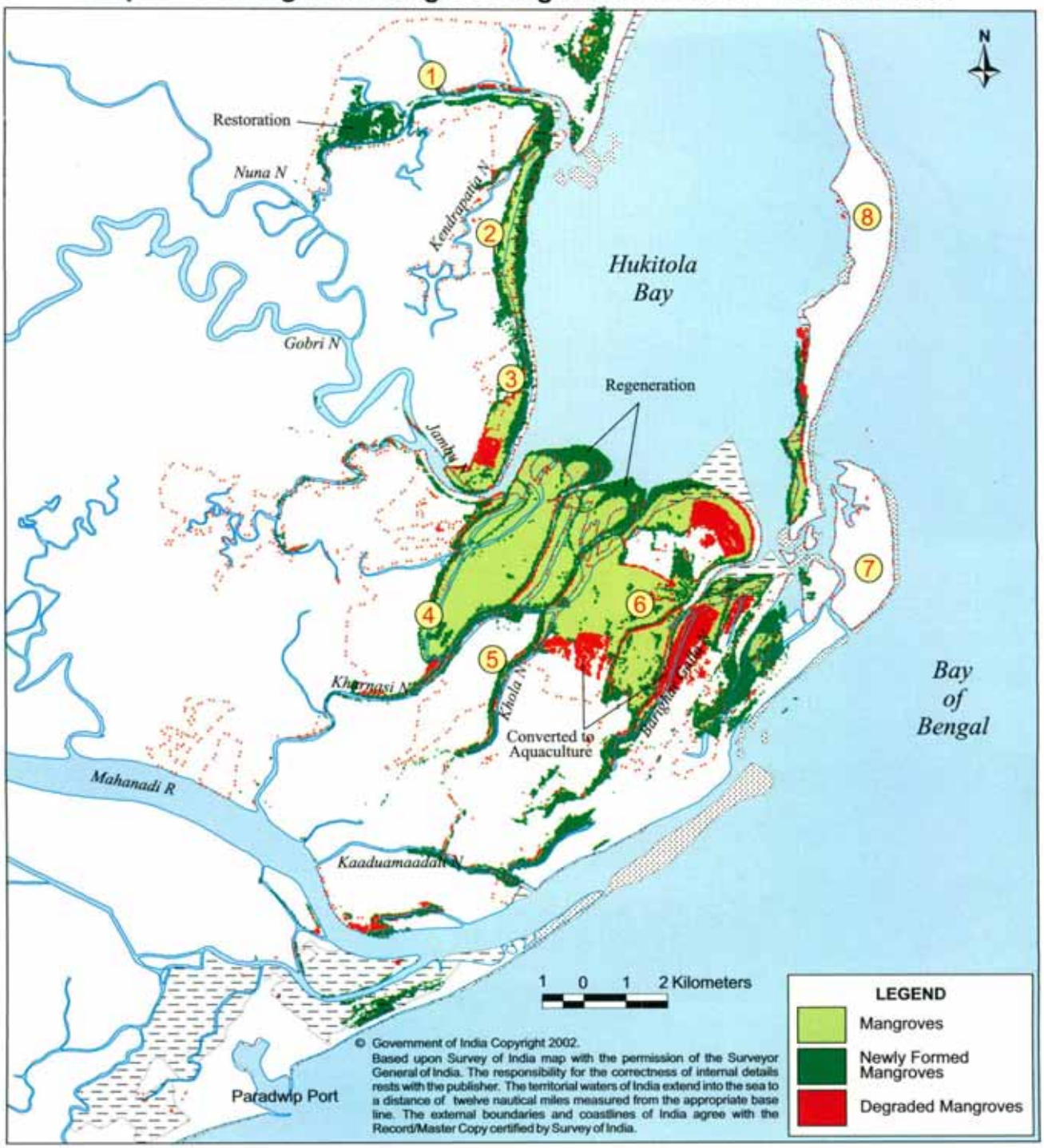
Formation of Panchayat level Forest Protection Committees (Regional Mangrove Protection Committee)

The main objective of forming the Panchayat level mangrove protection committee is to bring all the communities of the villages/hamlets or wards of a Panchayat into a common forum for the protection and management of the mangrove forest of that region. The responsibility of protection is however given to the communities of a particular hamlet or ward which is the project demonstration village. Three such Panchayat level Mangrove Protection Committees have been formed.

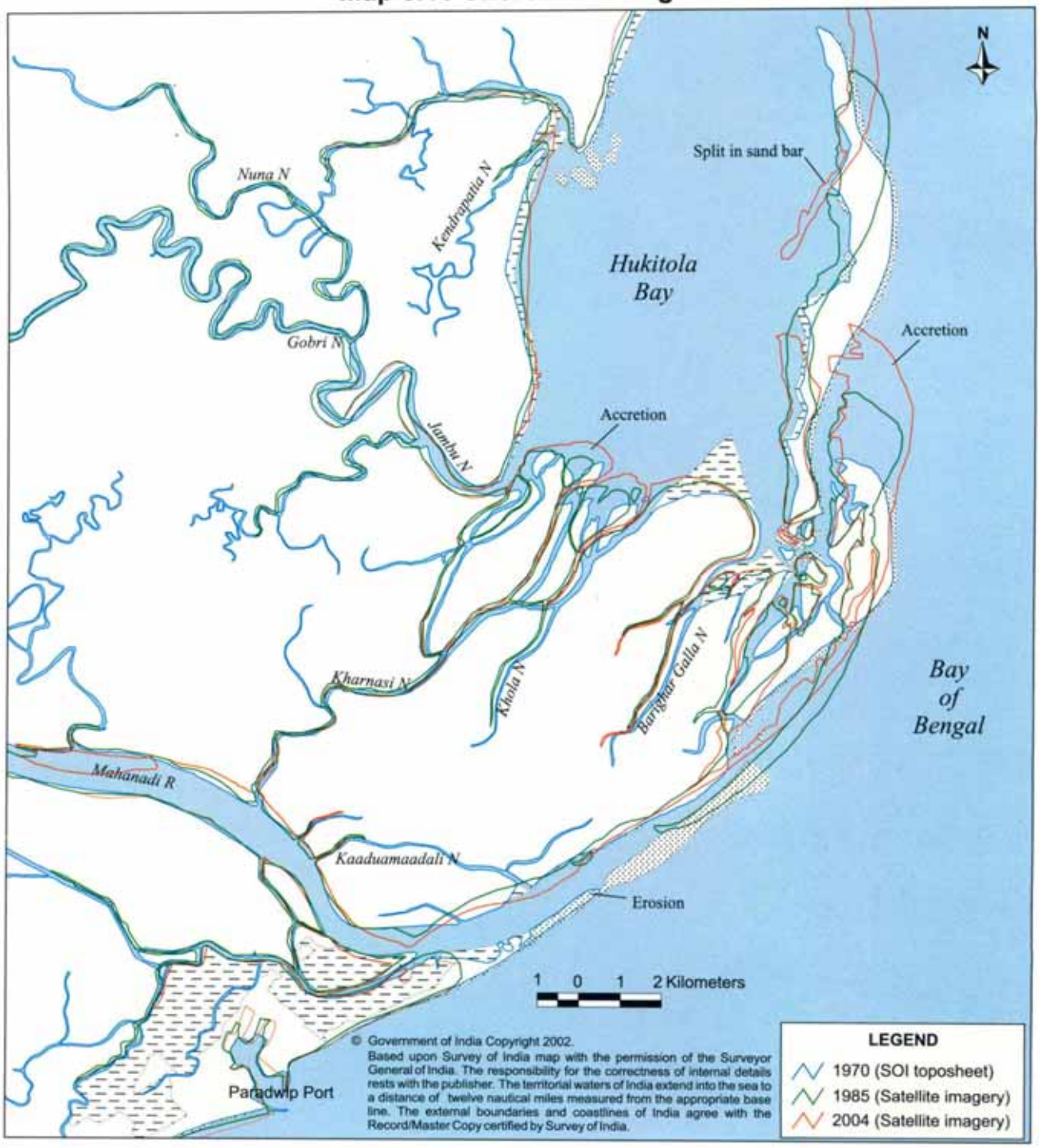
3.15 Changes in mangrove vegetation between 1985 and 2004

The remote sensing data of Landsat 5 TM for the year 1985, IRS IC LISS III for the year 1996 and IRS P6 LISS III for the year 2004 were analysed digitally for the temporal study of mangrove forests. Between 1985 and 1996 the mangrove forest cover has reduced from 3,953 to 3,306 ha (Map 3.15) even though there is considerable regeneration in the northern side (towards sea) in Bhitar karnasi and Bhahar karnasi forest blocks. This was mainly due to the conversion of mangrove wetlands for aquaculture and agriculture purposes in Kansardia forest block and degradation due to erosion in Hatamundia forest block.

Map 3.15 Changes in mangrove vegetation between 1985 and 2004



Map 3.16 Shoreline changes



Between 1996 and 2004 the mangrove forest cover has increased from 3306 ha to 3594 ha. This was mainly due to natural regeneration and restoration. The restoration was taken up by the Forest Department of Orissa and MSSRF with the participation of local communities. In Kantilo forest the increase is due to MSSRF restoration. Along the sea side there was a reduction due to erosion. In Hatamundia forest casuarina plantation has emerged.

3.16 Shoreline changes

Many natural processes like seawater currents govern the geomorphologic dynamics of shorelines over a period of time and river sediment loads. These habitat dynamics play a key role on the mangrove assemblage pattern and its community interactions. High erosion of the shoreline was evident in the mapped period in the south side of the Mahanadi mangrove wetland. Earlier (1970), the Mahanadi river was confluencing the sea directly by running northeast, parallel to the coastline. The 2004 remote sensing data shows that the Mahanadi opens straight into the sea from the northwest to the southeast and the spit that was present earlier is now detached and has joined the mainland.

It is also evident from the remote sensing data of 1985 and 2004 that the Hukitola island now has been split into two and the southern part of the split portion is now completely covered with mangroves and has become a part of the core mangrove wetland. Due to heavy sediment discharge from the tributaries of the Mahanadi there was mudflat accretion, as was evident at the bay face at Bhitar Karnasi and Kajalpatia and mangroves have colonized these accredited areas. A detailed study on the impact of shoreline changes on the Mahanadi mangrove wetland is needed for proper long-term management.

Figure 25. Shoreline in Hukitola island

Map 4.1 Landsat 5 TM Remote Sensing imagery of Devi mouth - 1985

Chapter 4

Devi mouth mangrove wetland

The river Devi is a distributary of the Mahanadi river separating from it near Cuttack. The Devi mouth mangrove wetland is located in the southernmost part of the Mahanadi delta in the district of Jagatsinghpur. It lies between 20° 05' and 20° 10' N latitude and between 86° 15' and 86° 25' E longitude. The mangrove vegetation is luxuriant near the estuaries of the Devi river and in the Protected Forest along the creeks of Boruan nadi of Bitikolia estuary. The sheltered mudflats along the Bitikolia estuarine region are covered by sparse mangrove vegetation inside the Protected Forest.

Figure 26. Devi Mangroves

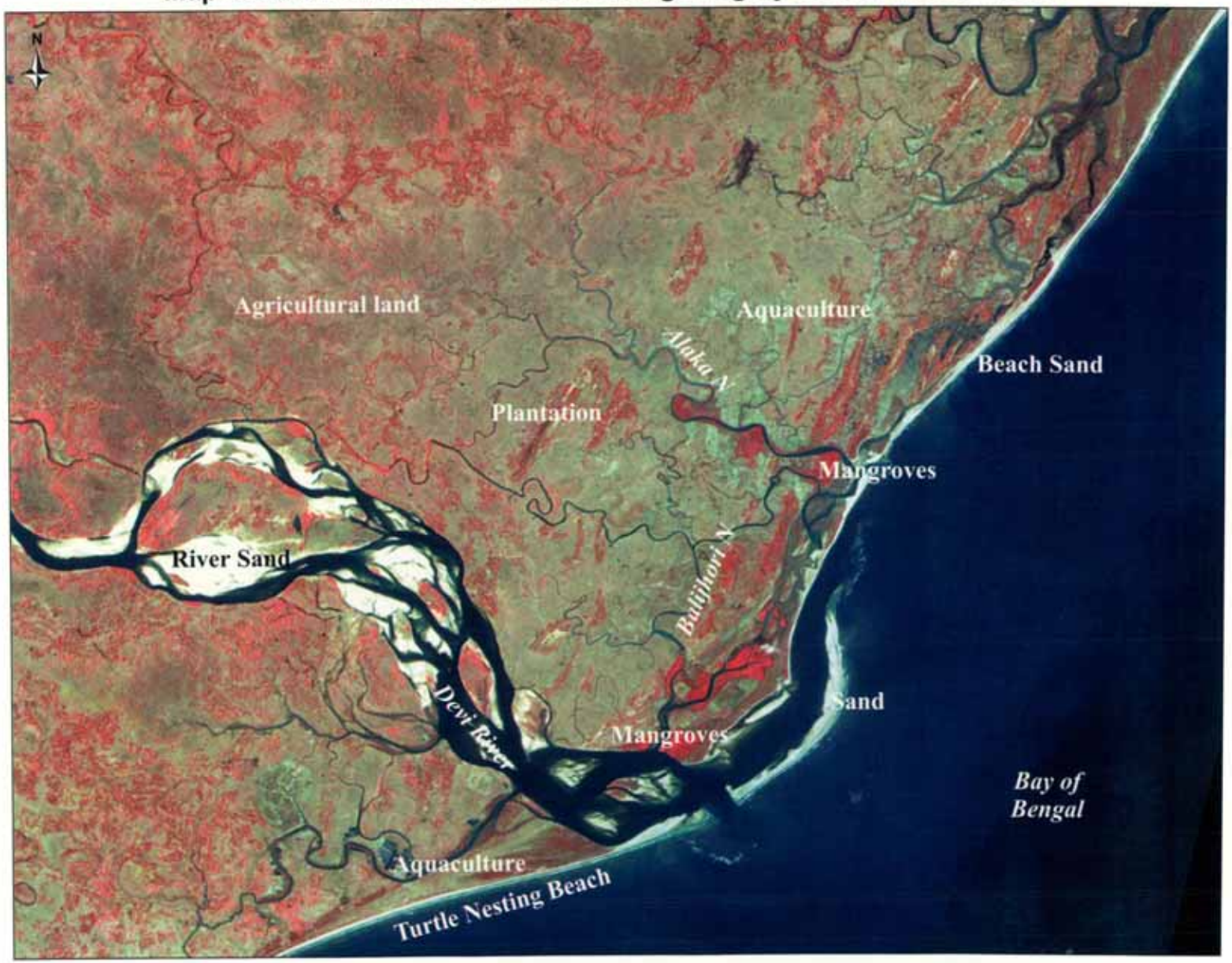
4.1 Remote Sensing imagery

The remote sensing imagery of the Devi river mouth mangrove wetland acquired from Landsat 5 TM and IRS P6 LISS III for the years 1985 and 2004 respectively were used for the preparation of various thematic maps. In the 2004 imagery the mangrove wetland is shown in bright red colour with a smooth texture whereas other vegetation such as casuarina plantations, coconut plantations and paddy fields are in dark red to red colour with coarse to medium texture. The fallow lands and harvested areas are greenish blue colour in the imagery. The sandy beach along the coastline, sand spit and sand deposition along the river course are identified by white to yellowish white colour with a smooth texture.

4.2 Forest Blocks

The Devi mouth mangroves come under Kujanga range of Rajnagar Division. There are three forest areas that are termed as "Protected Forest". There is no Reserve Forest in Devi mouth. A large mangrove area with plant diversity is found in the Bandar forest beat. It is termed as "undemarcated mangrove forest" because of a dispute over the ownership of this forested area between the Revenue Department and the Forest Department.

Map 4.2 IRS P6 LISS III Remote Sensing imagery of Devi mouth - 2004



Map 4.3 Forest Blocks

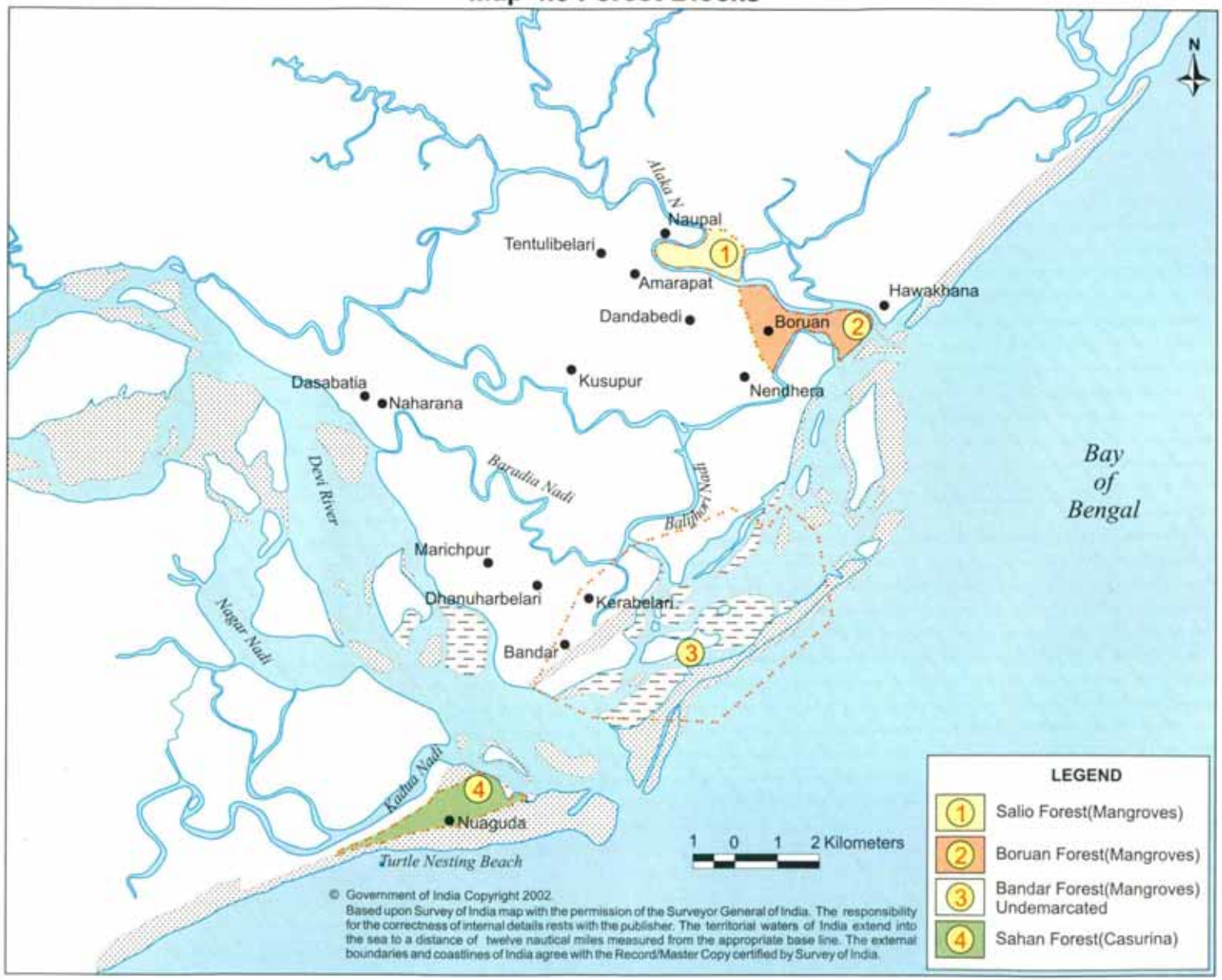


Table 8. Status of Mangrove Forest in Devi mouth wetlands

S.No.	Name	Status	Area (ha)
1.	Salio forest	Protected Forest	41.60
2.	Boruan forest	Proposed Reserve Forest	274.08
3	Bandar forest	Undemarcated Forest	700.00

4.3 Flora of the mangrove forest

The Devi mouth mangrove wetland is characterized by the presence of 15 exclusive mangrove species such as *Avicennia officinalis, Avicennia marina, Avicennia alba, Acanthus ilicifolius, Aegiceras corniculatum, Excoecaria agallocha, Rhizophora apiculata, Bruguiera cylindrica, Bruguiera gymnorrhiza, Ceriops decandra, Sonneratia apetala, Aegialitis rotundifolia, Phoenix paludosa, Kandelia candel* and *Lumnitzera racemosa.*

Heritiera fomes is also present in small numbers as an indicator of the existence of luxuriant mangroves in these areas in the past. Mangrove grasses such as *Cyperus malcensis, Myriostachya wightiana* and *Fimbristylis ferrugenea* and the wild rice *Porteresia coarctata* are also present in these mangroves. Associate mangrove species such as *Derris trifoliata, Dalbergia spinosa* and *Caesalpinia nuga* are commonly present along with *Suaeda maritima, Suaeda monoica* and *Sesuvium portulacastream.*

Salio Forest Block

Along the Bitikolia riverbank, the dominant species is *Phoenix paludosa* in association with *Myriostachya wightiana* and *Acanthus ilicifolius,* while *Aegiceras corniculatum* and *Ceriops decandra* which are found occasionally.

In the islet of Kajala Pota the dominant species is *Acanthus ilicifolius* forming homogenous patches. *Aegiceras corniculatum, Derris trifoliata, Dalbergia spinosa, Avicennia alba, Excoecaria agallocha, Caesalpinia nuga* and *Phoenix paludosa* are moderately distributed. The coppice trees of *Heritiera fomes* are rare. In the mud flats *Suaeda maritima, S. nudiflora, Sesuvium portulacastrum* and *Fimbristylis ferruginea* are common.

Figure 27. Fimbristylis ferruginea

Boruan Forest Block

In this forest block, the dominant species are *Phoenix paludosa, Avicennia alba* and *Excoecaria agallocha.* At places *Phoenix paludosa* is found in pure stands. *Ceriops decandra, Aegialitis rotundifolia* and *Bruguiera gymnorrhiza* are sporadically distributed.

Near Nendhera, along the Bitikolia river, a small patch of forest comprising *Avicennia officinalis, A. alba, Ceriops decandra, Aegiceras corniculatum, Excoecaria agallocha* and *Acanthus ilicifolius* is found. *Kandelia candel* is sporadically present.

In this block the mangrove forests are highly degraded due to biotic interference of high magnitude. The areas are suitable for restoration of mangroves with the participation of the local community.

Figure 28. Phoenix paludosa

Bandar Forest Block

Dhanuharbelari

Near the ferry ghat of Dhanuharbelari village, a "Point Bar" or "Breeded Bar" is observed. According to the villagers a village named "Bali Pontal" existed in this spot. Gradually, due to change in the course of the Devi river, the village was drowned. This area is somewhat elevated and partially inundated during high tide. *Acanthus ilicifolius* and a few individuals of *Excoecaria agallocha* represent the remnants of past vegetation. *Fimbristylis* and *Panicum* spp. cover the ground flora. In the muddy areas *Cyperus malacensis* and *Myriostachya wightiana* occur commonly.

Along the banks of the River Devi, patches of vegetation are observed, especially at sandy places. The vegetation includes *Ipomoea pescaprae, Carissa spinarum, Calotropis procena, Opuntia stricta, Pandanus tectorius* and *Eugenia bracteata.* Recently the plantation of *Casuarina equisetifolia* has been undertaken near the villages.

In the muddy river bank, old stumps of *Avicennia* spp. and *Heritiera fomes* are observed, indicating the past existence of mangrove vegetation in this area.

Figure 29. Myriostachya wightiana

Sahebdia

Near Bandar village, another "Point Bar" known as Saheb Dian or Raigachha dia is present. The name "Raigachha dia" has been given because of the dominant species of the area "Raigachha" (*Rhizophora* sp.), which was present in the recent past. At present, the vegetation is represented by *Myriostachya wightiana, Fimbristylis ferrugenea* and *Porteresia coarctata. Acanthus ilicifolius* and *Avicennia* sp. are sporadic. Saplings represent *Avicennia* sp. only.

Khakrapadia

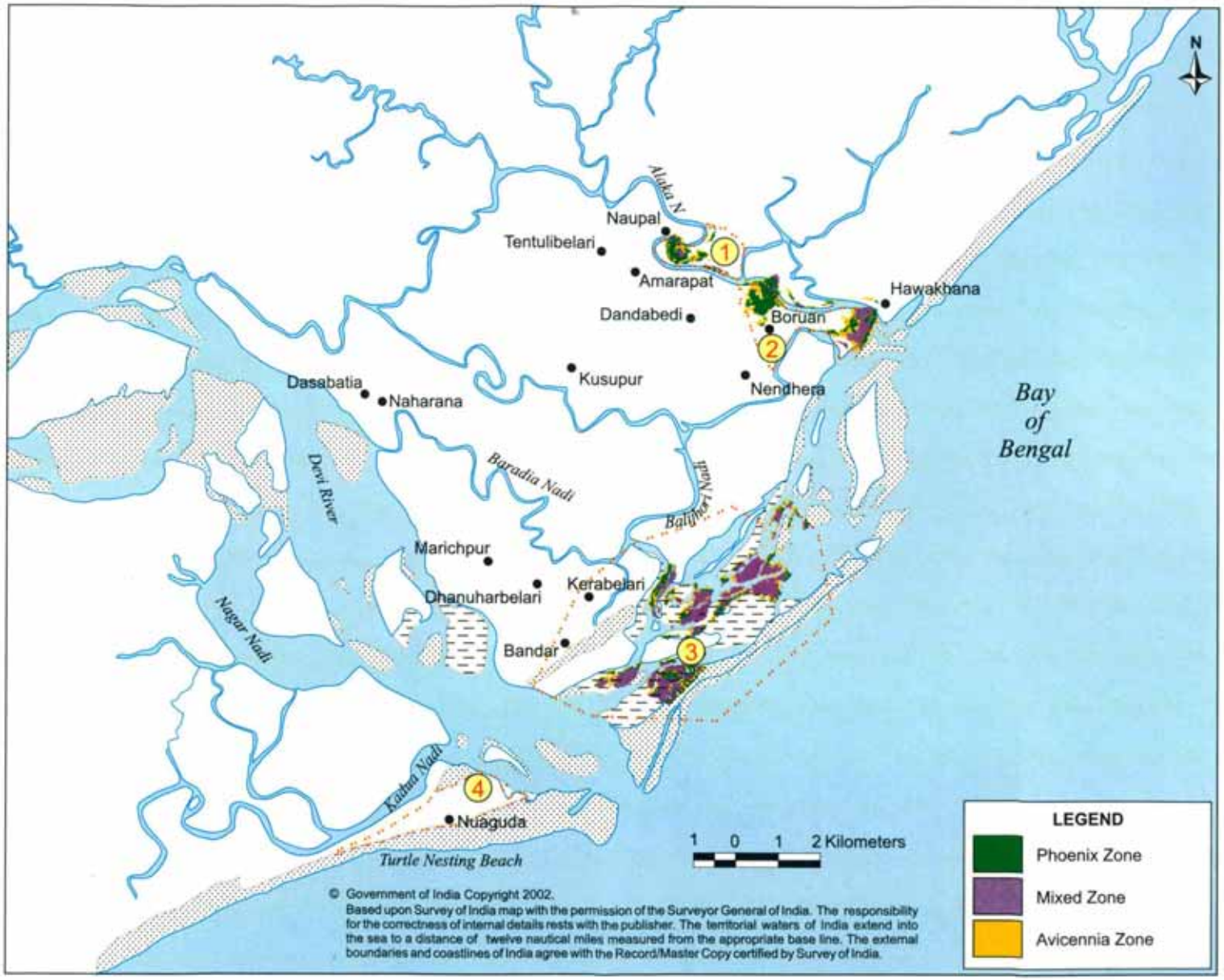
Khakrapadia exhibits a degraded patch of mangrove vegetation represented by *Avicennia officinalis, Sonneratia apetala, Aegiceras corniculatum, Ceriops decandra, Acanthus ilicifolius, Excoecaria agallocha, Myriostachya wightiana, Porteresia coarctata,* etc.

Nadia Khia

Species like *Avicennia alba, Sonneratia apetala, Avicennia marina, Avicennia officinalis, Excoecaria agallocha* etc. are sporadically present. The forest exhibits sparse vegetation. *Bruguiera gymnorrhiza* is found occasionally.

Figure 30. Aegiceras corniculatum

Map 4.4 Mangrove species zonation



Adipal

Bruguiera cylindrica, Aegiceras corniculatum, Avicennia marina, Ceriops decandra, Excoecaria agallocha, Avicennia alba, Sonneratia apetala, Myriostachya wightiana, Acanthus ilicifolius etc. are moderately found along the fringes of creeks and channels.

Sukhiadia

Along the river banks, *Acanthus ilicifolius, Avicennia alba, A. marina, Aegiceras corniculatum, Rhizophora apiculata, Myriostachya wightiana* and *Porteresia coarctata* are commonly observed.

Mangroves of the Devi river mouth are, in general, in a much-degraded state. The remnants of past vegetation are observed along the creeks and fringes of Devi river. The mangrove vegetation is represented by species like *Acanthus ilicifolius, Excoecaria agallocha, Cyperus malacensis* and *Myriostachya wightiana.* In some places, old stumps of *Avicennia* sp. and *Heritiera fomes* are found as reminders of the past existence of mangrove vegetation.

4.4 Mangrove species zonation

The remote sensing digital data for the year 2002 was used for zonation mapping (Map 4.4). In the Devi mouth mangrove wetlands, the zonation or spatial distribution pattern of flora shows three distinct zones namely *Avicennia* zone, mixed zone and pure *Phoenix* zone. The *Avicennia* zone occurs in the fringe area of the tidal creeks. It is characterized by the presence of dense evergreen trees of *Avicennia officinalis.*

In the Bandar forest block *Avicennia officinalis* is dominant, followed by *Acanthus illicifolius, Aegiceras corniculatum , Ceriops decandra, Caesalpinia nuga , Avicennia marina, Sonnertia apetala* and *Avicennia alba.*

In the Salio and Boruan forest blocks, pure patches of *Phoenix paludosa* are seen distinctly in the *Phoenix* zone. Other species such as *Avicennia alba, Avicennia officinalis, Acanthus illicifolius, Ceriops decandra, Aegiceras corniculatum, Haritiera fomes* and coppices of *Lumnitzera racemosa, Aegialitis rotundifolia* and *Kandelia candel* are restricted to the mixed zone.

4.5 Soil properties

Soil in the littoral zones is sandy and muddy along the coast, creeks and channels. The soil properties of the Devi mouth mangrove wetland vary in the forests of Boruan, Salio and Bandar. The Bandar mangrove forest is inundated most of the time whereas the Salio and Boruan forests do not get regular inundation, particularly during November to March, but are flushed thoroughly during the summer spring tides. This creates a suitable soil condition for the *Phoenix paludosa* to come up as a pure stand. The summer spring tide inundation of the trough-shaped portion in the degraded area is responsible for the high salinity.

4.6 Hydrological conditions

Tidal amplitude

In the water bodies of the Salio mangroves, tidal amplitude is about 1.5 m, which does not show any major variation in different seasons. In the Bandar area, the spring tidal amplitude is 1.9 m while the neap tide is about 0.46 m. A lagoon found near the mangrove wetland of the Devi mouth is deep, ranging from 1 m to l0 m in depth. The western part of this lagoon is shallow, while the eastern part is deep.

Sources of fresh water and tidal water

The Devi mangrove wetland receives inflow of fresh water during the southeast monsoon from June to August through the drainage of the Mahanadi delta by the Devi, Alaka and the Balijhori rivers. From November to May, fresh water discharge into the mangrove forest is negligible. This is due to negligible rain during this season and the construction of a barrage at Cuttack. The Salio and Boruan forest blocks get fresh water mainly from the Alaka river, while Bandar gets fresh water from the Devi and Balijhori rivers. The Devi mangrove forest receives tidal water from two mouth points, namely the Hawakhana mouth and another near Bandar.

Salinity

It is observed that during the monsoon season, fresh water condition exists in the entire estuary, except near Hawakhana, which is located close to the sea. During the post monsoon season, the salinity varies from 11 to 20 ppt in all stations except at Hawakhana. During the pre monsoon season or dry period, the salinity is uniformly high (above 22 ppt) in all places of the mangrove wetland.

4.7 Wood and fishery resources

The harvestable forest resources in the Devi mouth mangrove wetland are very limited. The mangrove wetland is characterized by the presence of a vast lagoon which extends from the Dhanuharbelari in the south to Ghosaghar in the north for about 300 km. About 2,025 fishing families of 24 settlements depend on this lagoon for their livelihood. The data available with the Fisheries Department indicates that during 1997-98 and 1998-99 about 537 and 241 metric tonnes of fish was harvested respectively from this area. There is a fish jetty at Bandar village. Men fish in the lagoon or in the deep sea and sell their catches through middlemen. Women collect crabs and sell them at the Balipatana market; some women sell dry fish. The fishing population consists mainly of Bengali migrants and people belonging to scheduled castes. The people from Bandar, Dhanuharbelari, Kaliakan, Balidiha, Salio, Naupal, Dandabedi, Nendhera, Bramhanadiha and Rahan depend on the mangroves for their livelihood.

Figure 31. Crab

Figure 32. Scampi

4.8 Socio-economic conditions

The socio-economic profile of the user villages of the Devi mouth mangrove wetland was prepared on the basis of the results obtained through Rapid Rural Appraisal.

Mangrove user villages

According to the Rapid Rural Appraisal conducted in the region, people belonging to 51 hamlets of 30 revenue villages live around the Devi mouth mangrove wetland. Five villages namely, Amarapat, Naupal, Dhanuharbelari, Kerabelari and Bandar were selected as demonstration villages for implementing the Joint Mangrove Management model because they are more dependent on the mangrove wetlands.

As shown in Table 9, the total number of households is 6218 and the population of mangrove user villages and hamlets is 42,506. Out of the 51 hamlets, 19 are fishing hamlets and people of the remaining 32 hamlets are partially dependent on fishing. Agriculture, daily wage labour, prawn collection are the other secondary occupations. The literacy rate in the demonstration villages is more when compared to the Mahanadi area . The literacy rate for men is 28 % and that of the women is 17 %. Throughout the year the fisher folk of all the fishing villages are engaged in fishing in the mangrove wetlands, the lagoon and the deep sea and women are engaged in the collection of crabs and prawns.

Figure 33. Mangrove user village

Map 4.5 Mangrove user villages

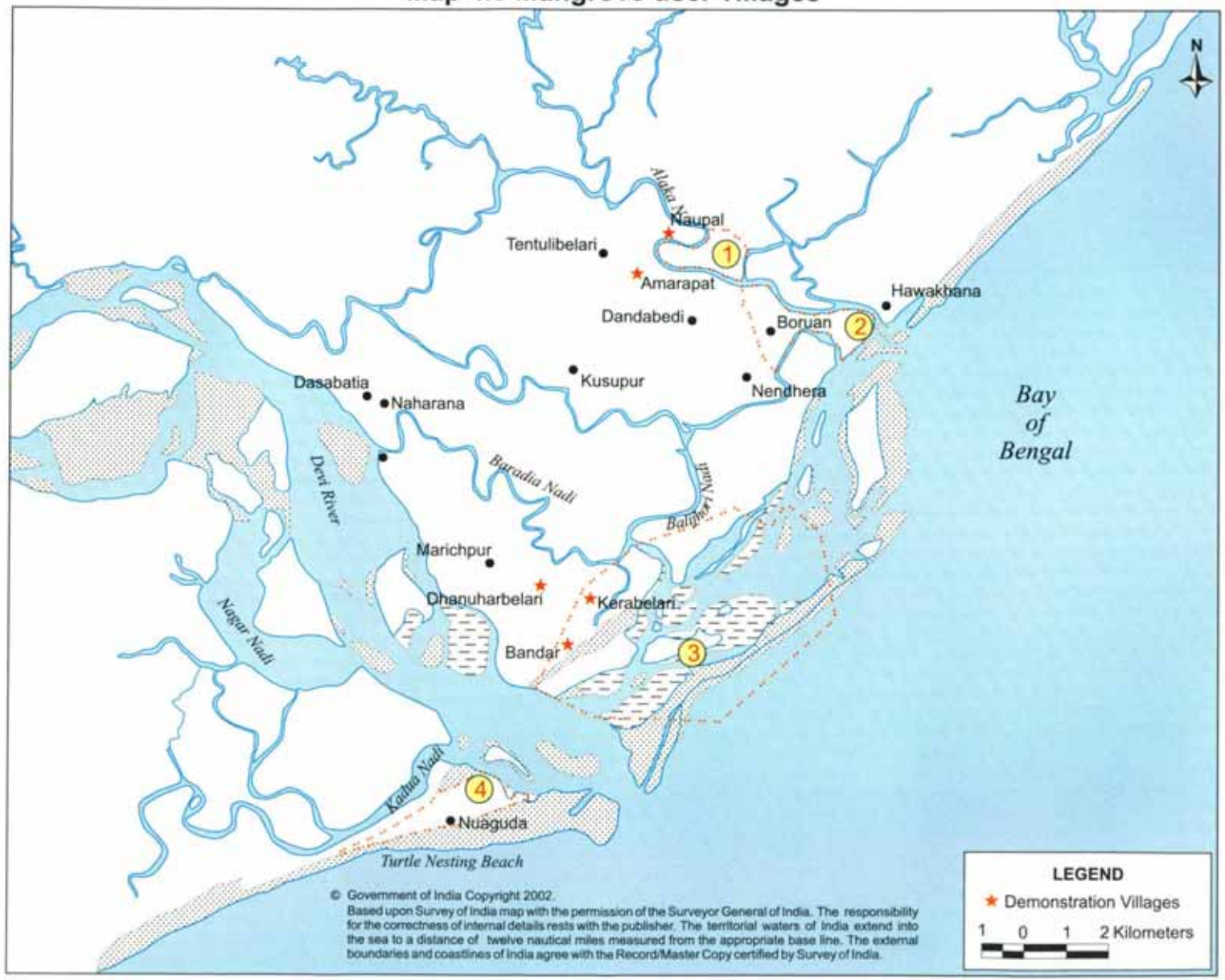
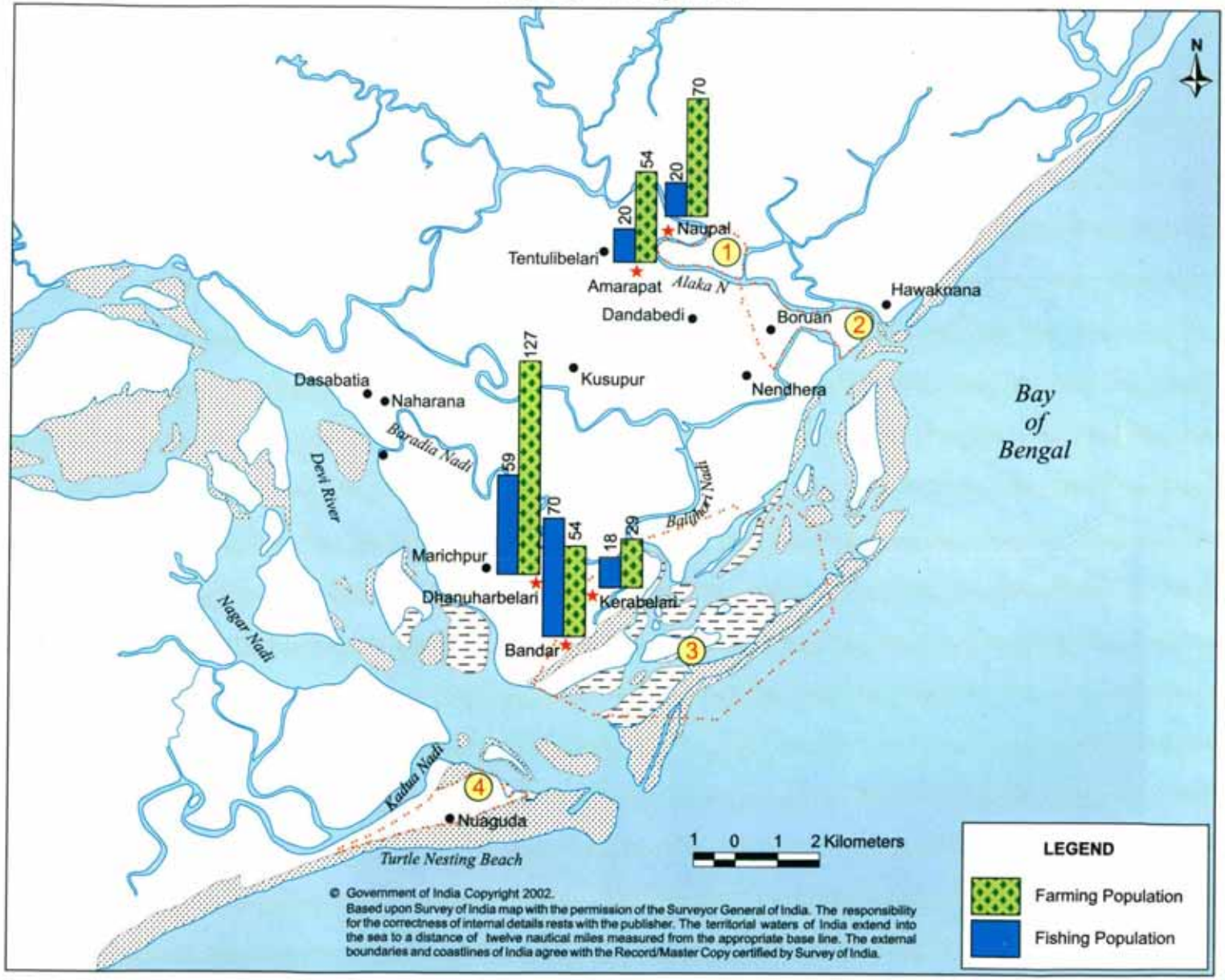


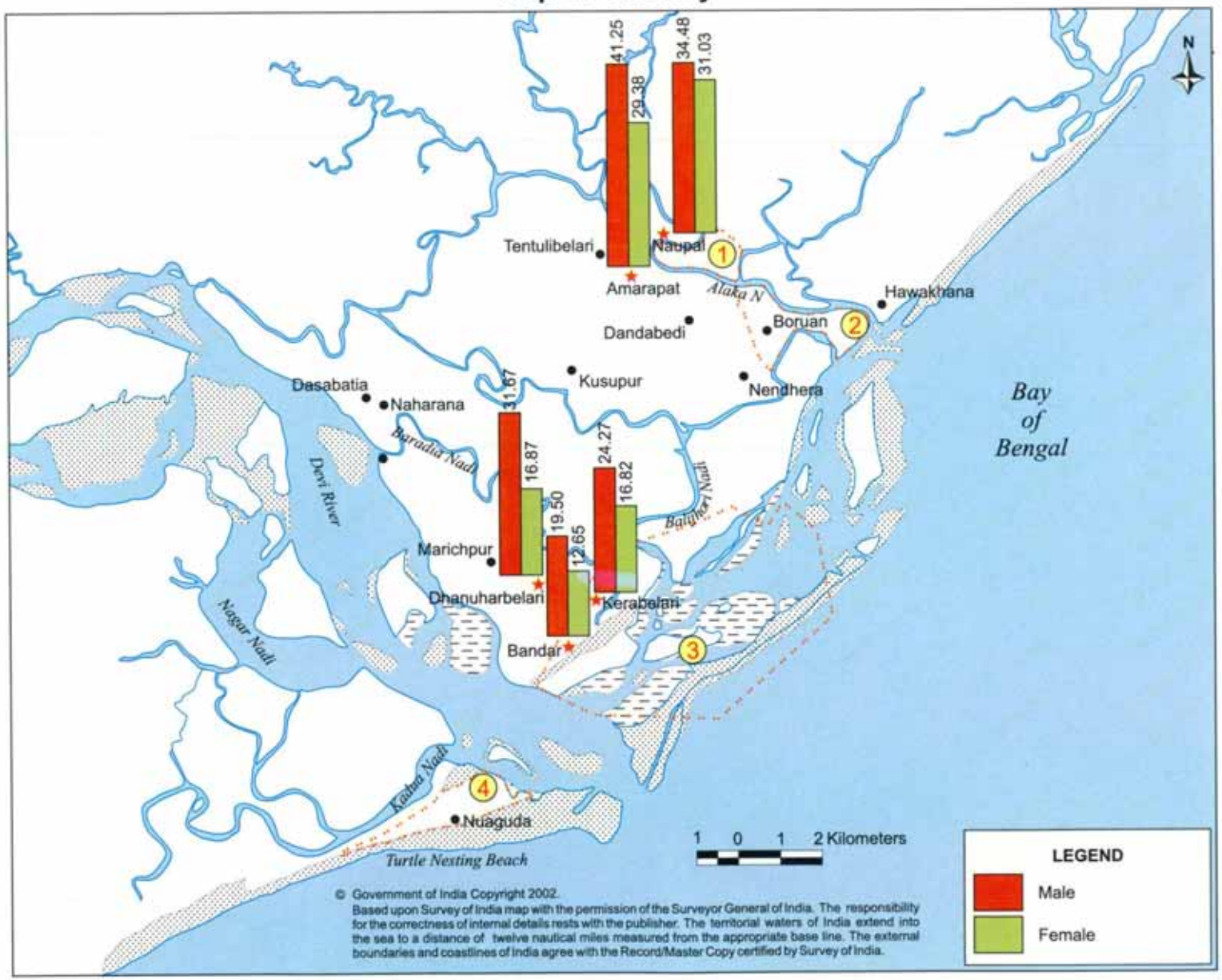
Table 9. Details of mangrove user villages and hamlets

Village	Hamlet	Total households	Total population	Occupation
Kaliakana	Kaliakan	175	850	Fishing
Balidiha	Balidiha	185	1300	Fishing
Nagar	Nagar	215	1700	Fishing
Nuagada	Nuagada	520	5500	Fishing
Jhalinki	Jhalinki	100	750	Fishing
Biluamunduli	Biluamunduli	61	550	Fishing
Ala Sahi	Ala Sahi	220	1450	Fishing/ Agriculture
Pata Sundarpur	Pata Sundarpur	85	990	Fishing
Tarasahi	Tarasahi	140	970	Fishing
Dhanuharbelari	Bandar	124	846	Fishing/ Agriculture
	Karabelari	39	309	Agriculture
	Dhanuharbelari	86	1200	Fishing/ Agriculture
Marichpur	Marichpur	300	2000	Fishing/ Agriculture
Phulapatana	Phulapatana	72	780	Fishing/ Agriculture
Balipatana	Balipatana	220	1530	Fishing/ Agriculture
Podana	Podana	86	680	Agriculture
Patarpada	Patrapada	156	935	Animal Husbandry/ Agriculture
Bagheipur	Bagheipur	130	630	Animal Husbandry/ Agriculture
Baradia	Baradia	172	1440	Fishing /Agriculture
Keruan Pada	Keruan pada	48	262	Animal Husbandry/ Agriculture
Lchhapur	Lchhapur	72	535	Fishing/ Agriculture
Balijori	Balijori	100	800	Fishing/ Agriculture
Phulabelari	Phulabelari	120	760	Fishing/ Agriculture
Naharana	Naharana	300	1560	Fishing/ Agriculture
Dasabatia	Dasabatia	160	855	Agriculture
Balipantala	Balipantala	250	2000	Fishing
	Nuapal	31	174	Agriculture/Fishing
Tentuli belori	Amarapat	31	160	Fishing/Agriculture
	Chhaghria	20	120	Agriculture
	Subarnpur	100	588	Agriculture
	Nagarpada	70	320	Agriculture
Kusupur	Kusupur	100	620	Agriculture
	Pariabilli	60	310	Fishing/ Agriculture
	Thoriabase	35	195	Fishing/ Agriculture
	Dandabedi	64	366	Fishing/ Agriculture
	Kakansi	22	130	Fishing/ Agriculture
	Nendhera	70	439	Fishing/ Agriculture
	Deokani	67	395	Fishing/ Agriculture
Salio	Salio	135	675	Fishing/ Agriculture
	Ghosaghar	200	1122	Fishing/Agriculture
	Bhajakhia	70	380	Agriculture
Gadaharishpur	Patana	80	372	Agriculture
	Suakunda	70	365	Agriculture
Brahnadiha	Malagada	70	428	Agriculture
	Jaganathpur	65	512	Agriculture
	Khaitikiri	40	300	Agriculture
	Bramhanadiha	100	760	Agriculture
Anantapur	Anantapur	200	988	Agriculture
	Bhuasuni	120	600	Agriculture
	Dahanikana	112	685	Agriculture
	Bahakana	50	300	Agriculture

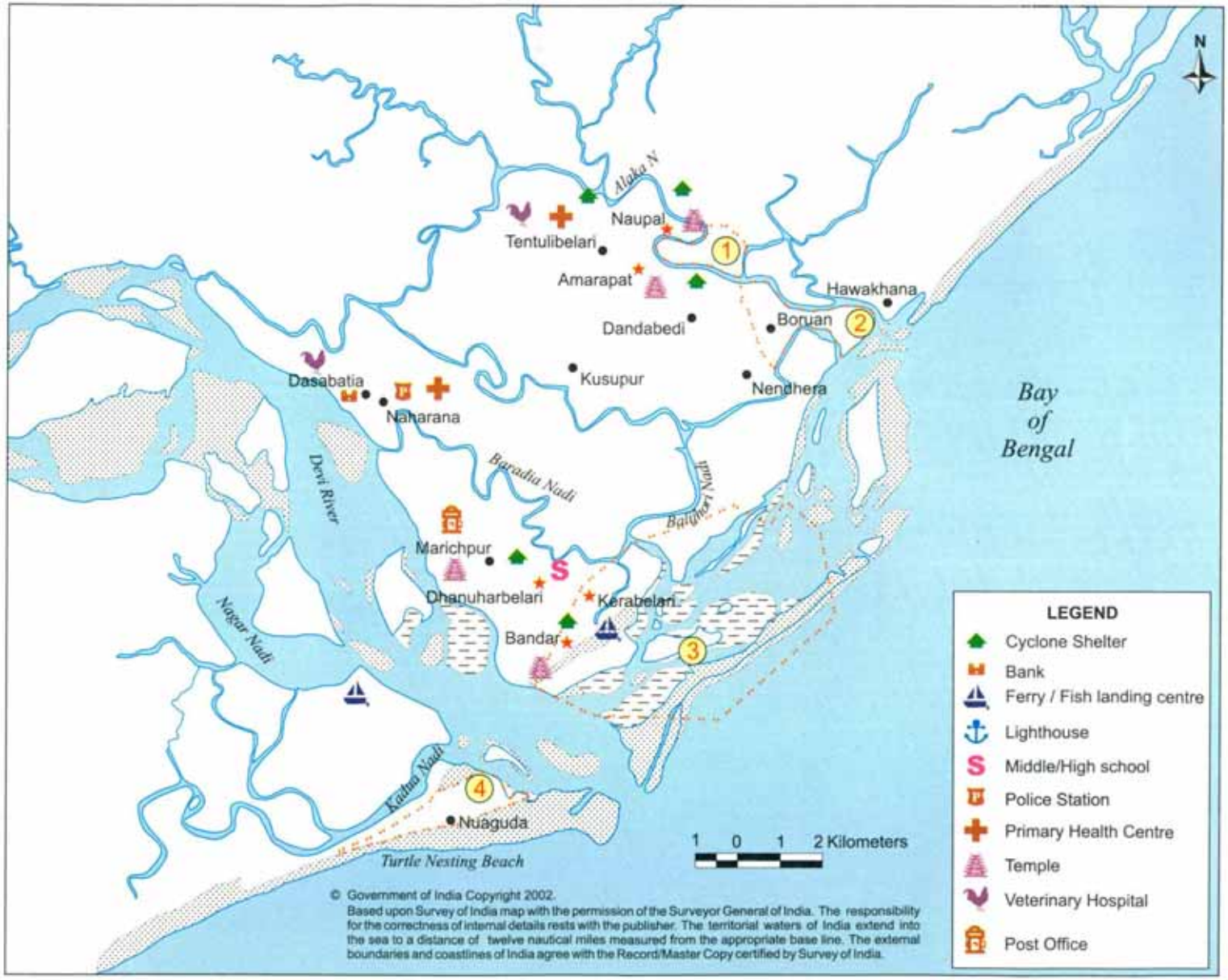
Map 4.6 Occupation



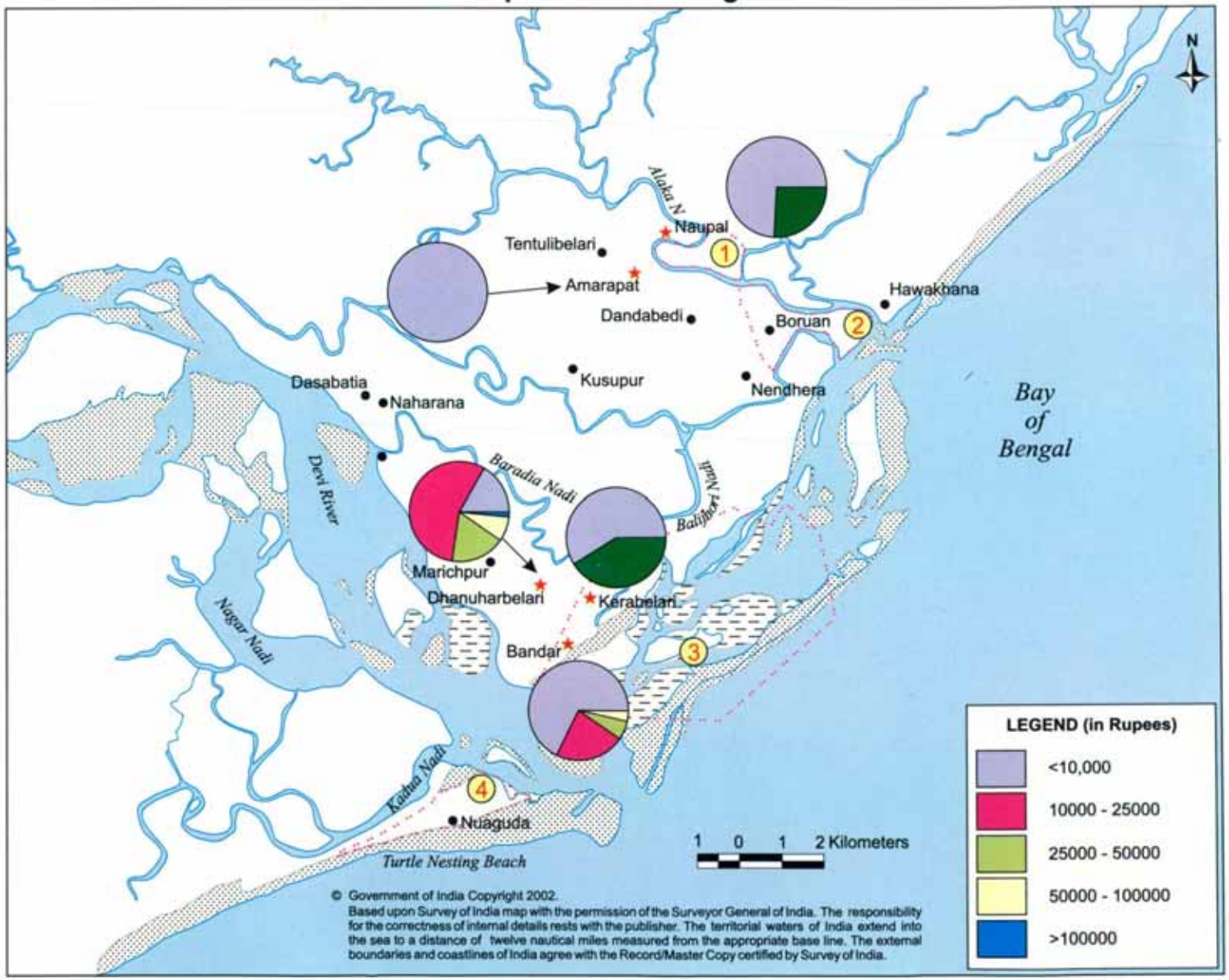
Map 4.7 Literacy



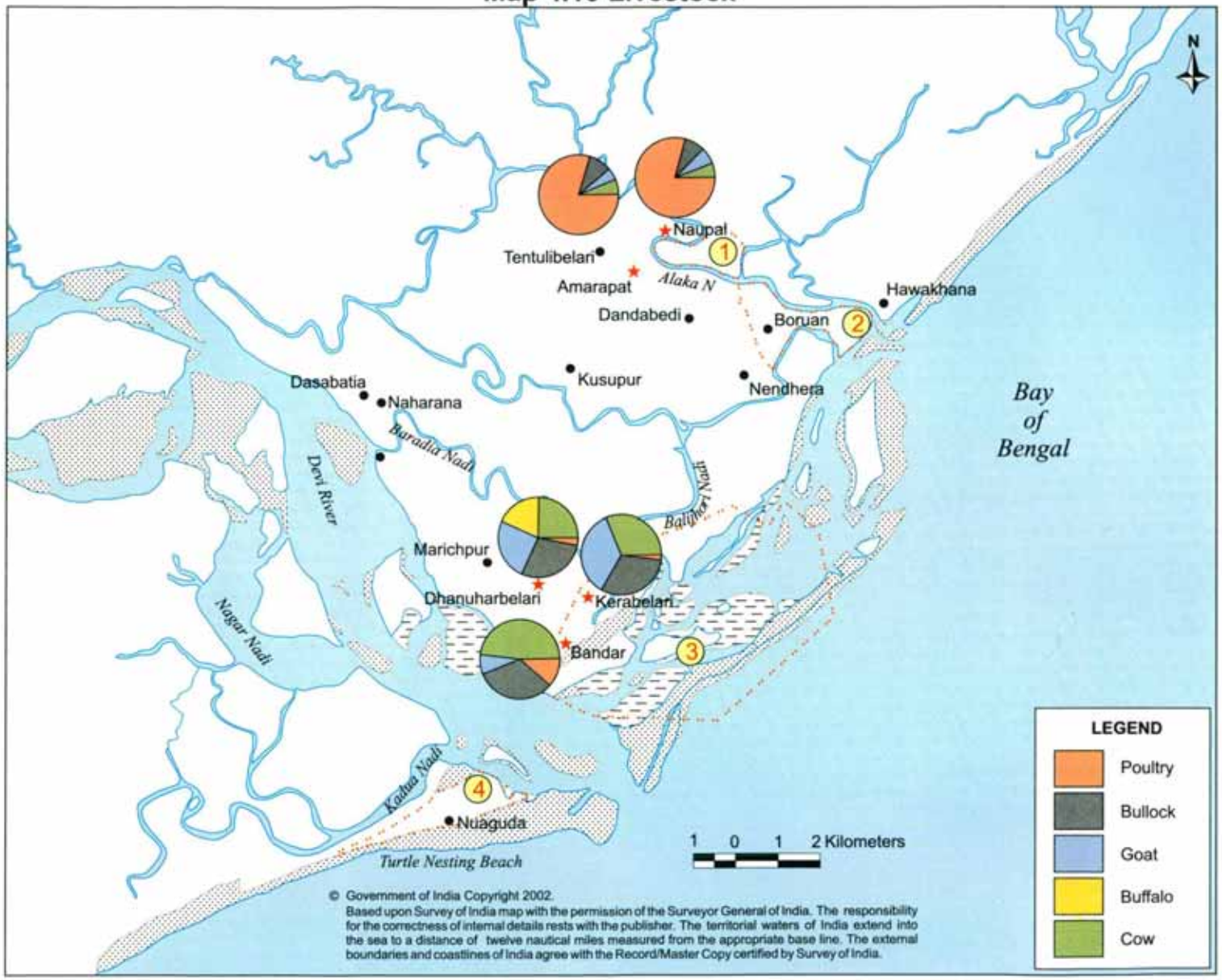
Map 4.8 Infrastructure



Map 4.9 Income range



Map 4.10 Livestock



Infrastructure

All the demonstration villages in the Devi mouth site are connected by weather-ravased roads and many places are connected by footpath. There are 2 multipurpose buildings in Naupal and Amarapat, which were constructed by MSSRF with the participation of LJSS. All villages are without electricity. A Bank, Primary Health Centre, Veterinary Health Centre and Police Station are located as far as 20 to 30 km from the demonstration villages. Earlier, there was the problem of collecting drinking water in all the villages and people had to go about 2 km to fetch water, but now drinking water is available in all the demonstration villages, due to the interventions made by the project.

Income range and income sufficiency

The incomes in the five demonstration villages are of different categories. The annual income is less than Rs 10,000 in about 39% of the total households. The annual income of 49% of the households ranges between Rs.10,000 to 25,000 and for 11% of the households, it is between Rs.25,000 to 50,000. About 4% of the households earn more than Rs.50,000. An income of more than Rs.1,00,000 is very low, about less than 0.25%. Regarding income sufficiency 85% feel that the annual income is insufficient and remaining 15% of the families feel that their income is sufficient.

4.9 Livestock

In the mangrove user villages livestock are owned by the farming community to get milk and manure and for ploughing. The total heads of livestock in the user hamlets is about 1,564, of which 1,183 are cattle, 276 are goats and 105 are buffaloes.

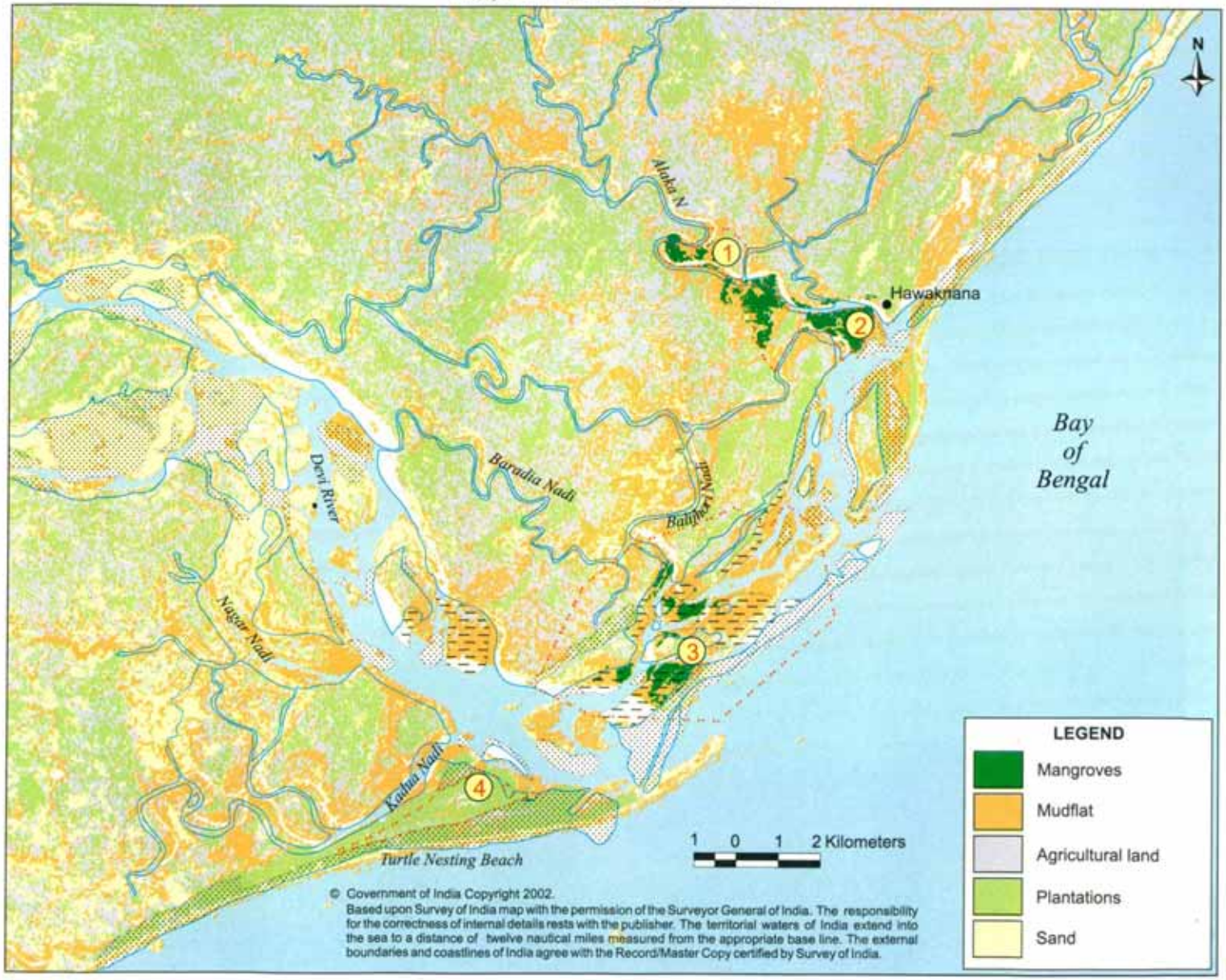
4.10 Landuse around mangroves

Cropping pattern

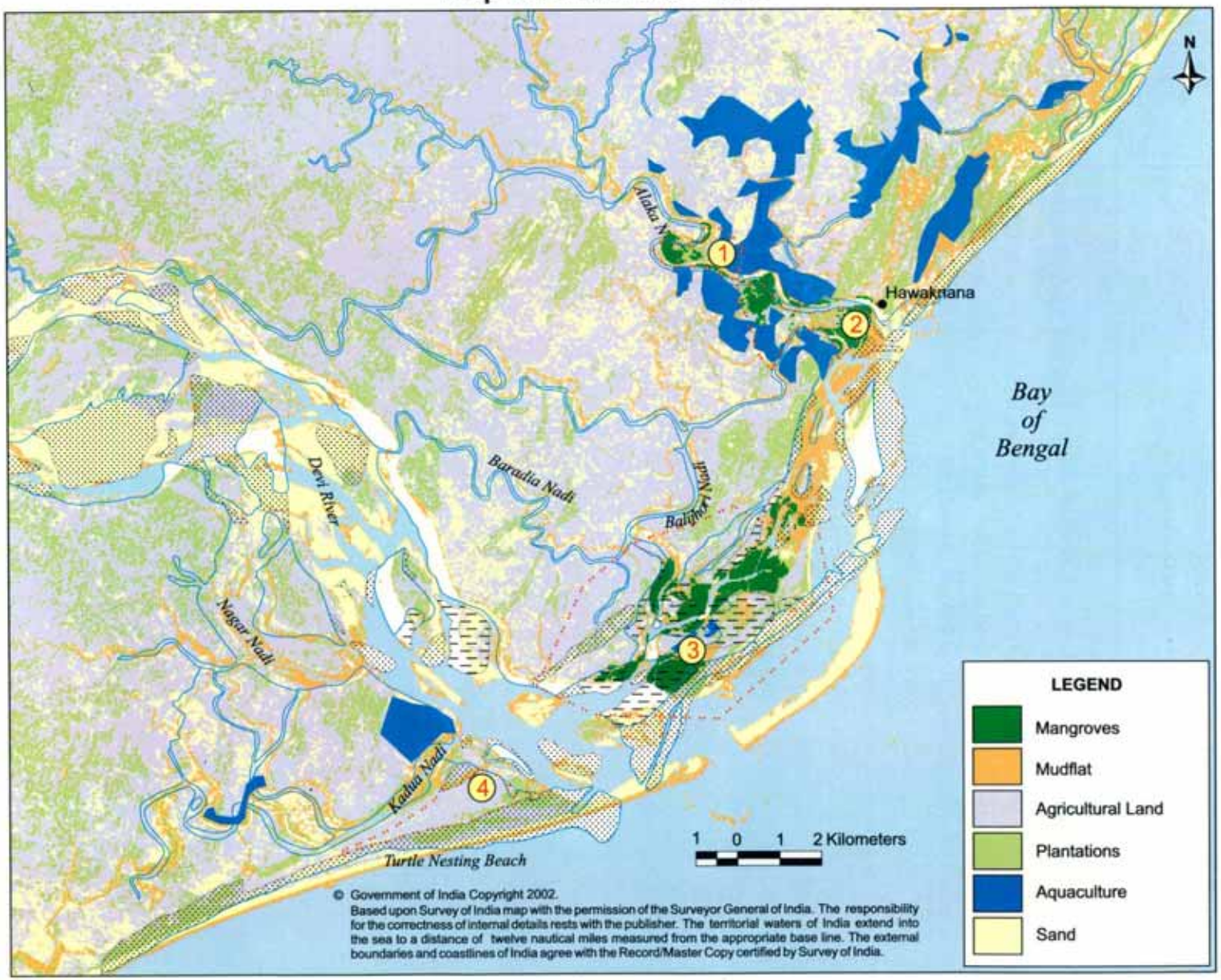
Agriculture is the major land use around the mangrove villages and paddy is the major crop. It is cultivated only once during the monsoon from June-November. The crop is mainly rain-fed. Coconut is planted in the homestead. Vegetables like brinjal, potato, pumpkin, ladies finger, tomato and green leafy vegetables are grown in the kitchen gardens. A few farmers also cultivate beetle vine.

Figure 34. Paddy field after harvest in Bandar

Map 4.11 Landuse - 1985



Map 4.12 Landuse - 2004



Aquaculture

Most of the prawn farms are close to mangrove forest. The total area of these farms is about 500 ha. The prawn farms in and around Devi mouth mangrove wetlands were started in 1978 after a saline embankment was made by the Irrigation Department to check saline water intrusion into the agricultural field. Now many agricultural lands are being converted into prawn farms.

Figure 35. Aquaculture

4.11 Dependency

Grazing

About 2,500 buffaloes and 300 cattle are grazed in the Devi mouth mangrove wetlands. The pressure of grazing has increased due to the development of prawn farm in the grazing grounds. The buffalo owners of Keruanpada, Bhagheipur , Dhanuharbelari, Bandar, Tentulibelari, Bramhanadiha and Salio depend mainly on mangrove forest for grazing and the pressure increases during the rainy season.

Figure 36. Grazing in the mangrove areas

Fire wood collection

The fisher folk from the 21 hamlets collect firewood from the mangrove wetlands. Some villagers also occasionally collect large amounts of firewood from the mangrove forest, especially during community religious functions. A few persons collect and sell the poles of *Bruguiera cylindrica* and *Bruguiera gymnorrhiza* for house construction. The availability of casuarina along the coast has reduced the firewood dependency on mangroves to a large extent. The poles and branches from *Aegiceras corniculatum* and *Ceriops decandr*a are used for fencing. The people of Marichpur, Bandar, Balijori and Phulapatana depend mainly on *Bruguiera* poles for house construction.

Figure 37. Firewood collection

Fishing

About 188 households of the demonstration villages fish in the Devi mouth mangrove wetland and adjacent sea (Table 10). Almost all of them are artisan fisherfolk using small non - mechanized boats and mechanized boats for fishing. The Orissa Fishery Department and some private agencies gave financial support to the fishermen to purchase boats for fishing. In the mangrove wetlands, fishing is allowed freely but during the turtle nesting period, fishing is restricted. Apart from these, women from the fishing villages are engaged in crab and prawn collection from the mangroves. About 100 women enter the mangrove forest daily for crab collection.

Figure 38. Fishing in the canals

Table 10. Fishing and farming population in the demonstration villages

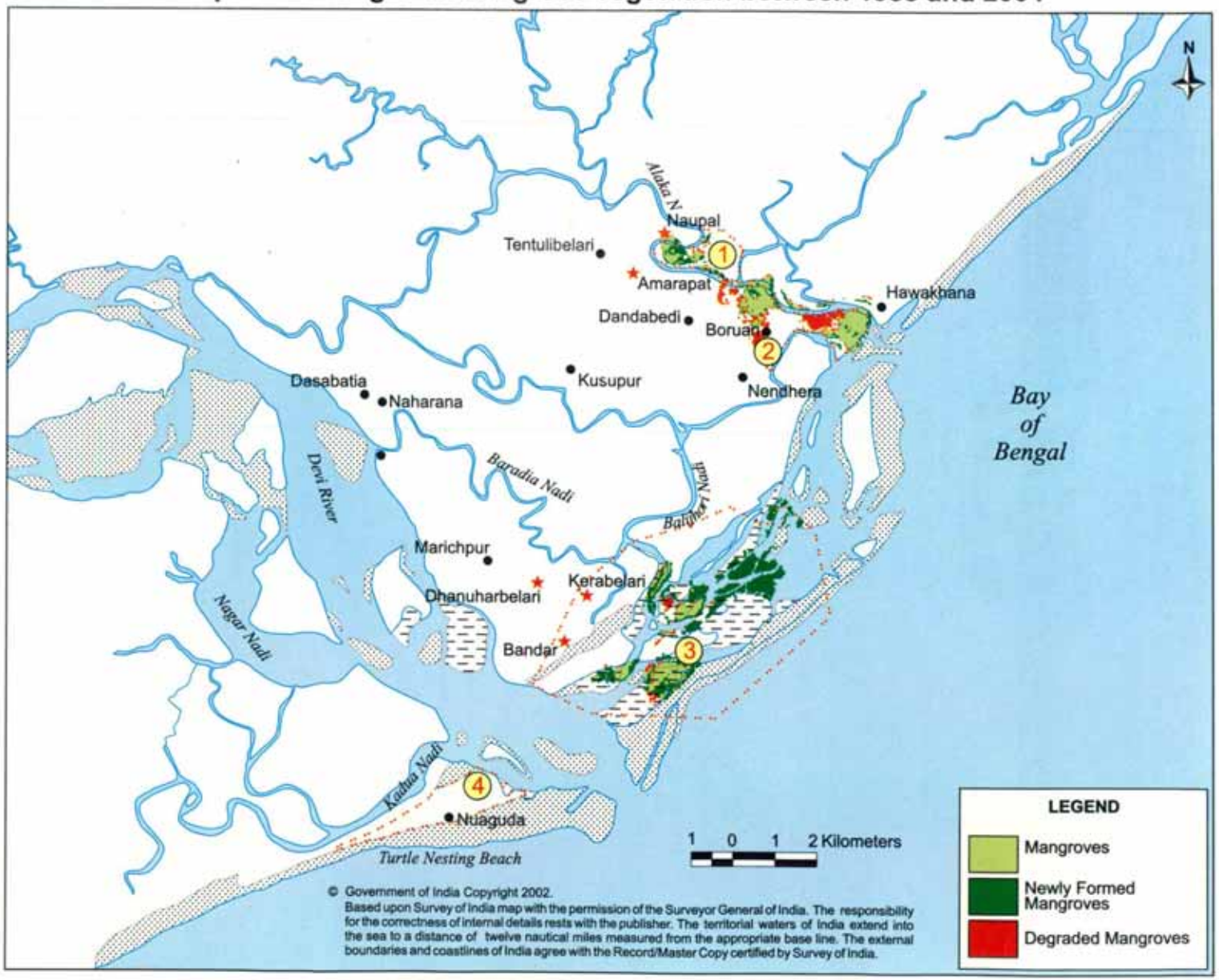
Sl. No.	Village	Fishing	Farming	Total
1.	Dhanuharbelari	59	127	186
2.	Bandar	70	54	124
3.	Naupal	20	70	90
4.	Amarapat	20	54	74
5.	Kerabelari	18	29	47
	Total	**187**	**334**	**521**

Types of Net

The fisher folk living around the Devi mouth mangrove wetlands use the following types of nets for fishing in the mangrove waters.

1. *Munduli Net* : It is a kind of push net used by the women to collect prawns along the river banks.
2. *Binti* : This net is used for catching larger prawns from the river and small creeks. The length of the net is about 22 m.
3. *Bhaunri* : It is a cast net used to catch fish in the open mangrove waters.
4. *Chhandi Jal*: Gill net of about 100 to 200 m in length, mainly used to catch fish in the larger canals and rivers.
5. *Ghai net* : Another type of gill net spread across the entire breadth of the rivers to catch prawn and fish. The length of the net is about 200 to 300 m.
6. *Masoori Net*: This stake net is fixed in the tidal creeks and channels using wooden poles to catch both prawn and fish.

Map 4.13 Changes in mangrove vegetation between 1985 and 2004



4.12 Causes of degradation

Devi mouth mangroves are degraded due to various problems, some of which are similar to the other mangrove sites. The main causes are as follows:

- Conversion of mangrove wetland into agriculture and aquaculture
- Cutting down the mother trees leading to poor chances for natural regeneration
- Use of drag net for fish and prawn, which affect the seedlings of the mangrove species
- Cutting of mangrove trees for genuine basic needs of community for firewood, house construction, preparation of agricultural implements, etc.
- Blocking the flow of tidal water by prawn farm operators

4.13 Restoration and redevelopment

Restoration of degraded mangrove areas was taken up in collaboration with four Village Level Institutions (Luna Jungla Samrakshana Samiti - LJSS) in Naupal, Amarapat, Dhanuharbelari and Kerabelari in the Devi river. Apart from afforestation, gap filling was carried out through canal intervention in 15 ha on an experimental basis.

Figure 39. Mangrove nursery for restoration

Table 11. Details of restoration and MMU site

Sl. No.	Demonstration Village	Area restored (ha)	Area under MMU (ha)
1.	Dhanuharbelari & Kerabelari	37	101
2.	Amarapet & Naupal	46	50

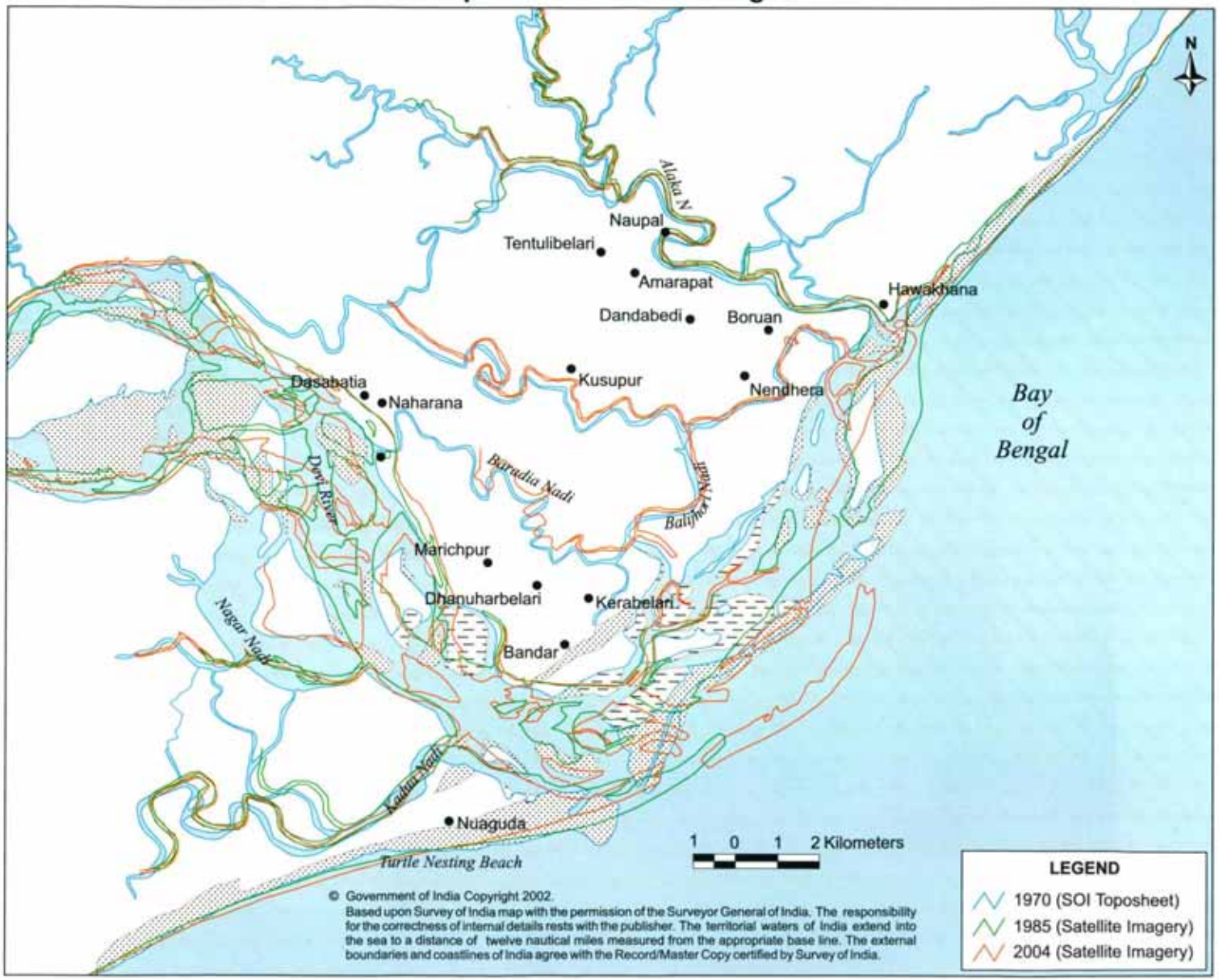
4.14 Changes in mangrove vegetation between 1985 and 2004

The remote sensing data of Landsat TM for the year 1985 and IRS P6 LISS III for the year 2004 were digitally analyzed for the temporal study of the mangrove forest. Between 1985 and 2004 the mangrove forest cover has increased from 258 ha to 421 ha (Map 4.13). This was mainly due to restoration conducted jointly by the people MSSRF and the Forest Department as well as due to natural regeneration. Near Bandar village, large areas of mud flats have been formed in recent times, which are suitable for mangrove plantation.

4.15 Shoreline changes

Comparative studies indicate that shoreline changes occur mainly around Devi mouth, which show a complex pattern of erosion and accretion. This has led to the disappearance of some of the mudflats and formation of new mudflats. The phenomenon of mudflat formation is mainly due to high discharge of sediments by the Devi river. On the seaward side also there is a high dynamic process, which lead to the formation of a long sand spit. For example, in 1985 a very small sand spit was observed in the mouth region of the Devi river which had grown into a large spit by 2004. A detailed study of the impact of these changes on the mangrove wetlands of the Devi mouth is necessary to prepare long-term mangrove conservation and management plans.

Map 4.14 Shoreline changes



Map 5.1 Landsat 5 TM Remote Sensing imagery of BWLS - 1985

Chapter 5

Bhitarkanika Wildlife Sanctuary

Bhitarkanika Wildlife Sanctuary (BWLS) is the second largest contiguous mangrove forest in India. It is located on the east coast of India between the latitudes 20° 30' - 20° 50' N and the longitudes 86° 45' - 87° 10' E and lies in the northeast of the Mahanadi delta in Kendrapara district. The sanctuary is bounded by the Dhaamra river in the north, the Hansua in the west and the Bay of Bengal in the east and south. The sanctuary includes the Gahirmata beach, which is one of the world's largest Olive Ridley turtle rookeries. BWLS is also found to have the highly dense salt water crocodiles *Crocodylus porosus*. The total area of the BWLS is about 672 sq.km with a core area of 141.44 sq.km. The *Ramsar Convention* recognized the sanctuary as a site for wetland conservation on 19th August 2002.

5.1 Geomorphology

The northern portion of the Mahanadi delta forms the Bhitarkanika Wildlife Sanctuary, which comprises sandy beaches, mudflats and dense mangrove forest and is interrupted by a number of small creeks and streams. The entire coast has flat sand spits with a number of small sand dunes of about 0.5 1.0 m in height covered with beach vegetation. As a result of high wind action some dunes have grown up to 20 m in height.

5.2 Remote Sensing imagery

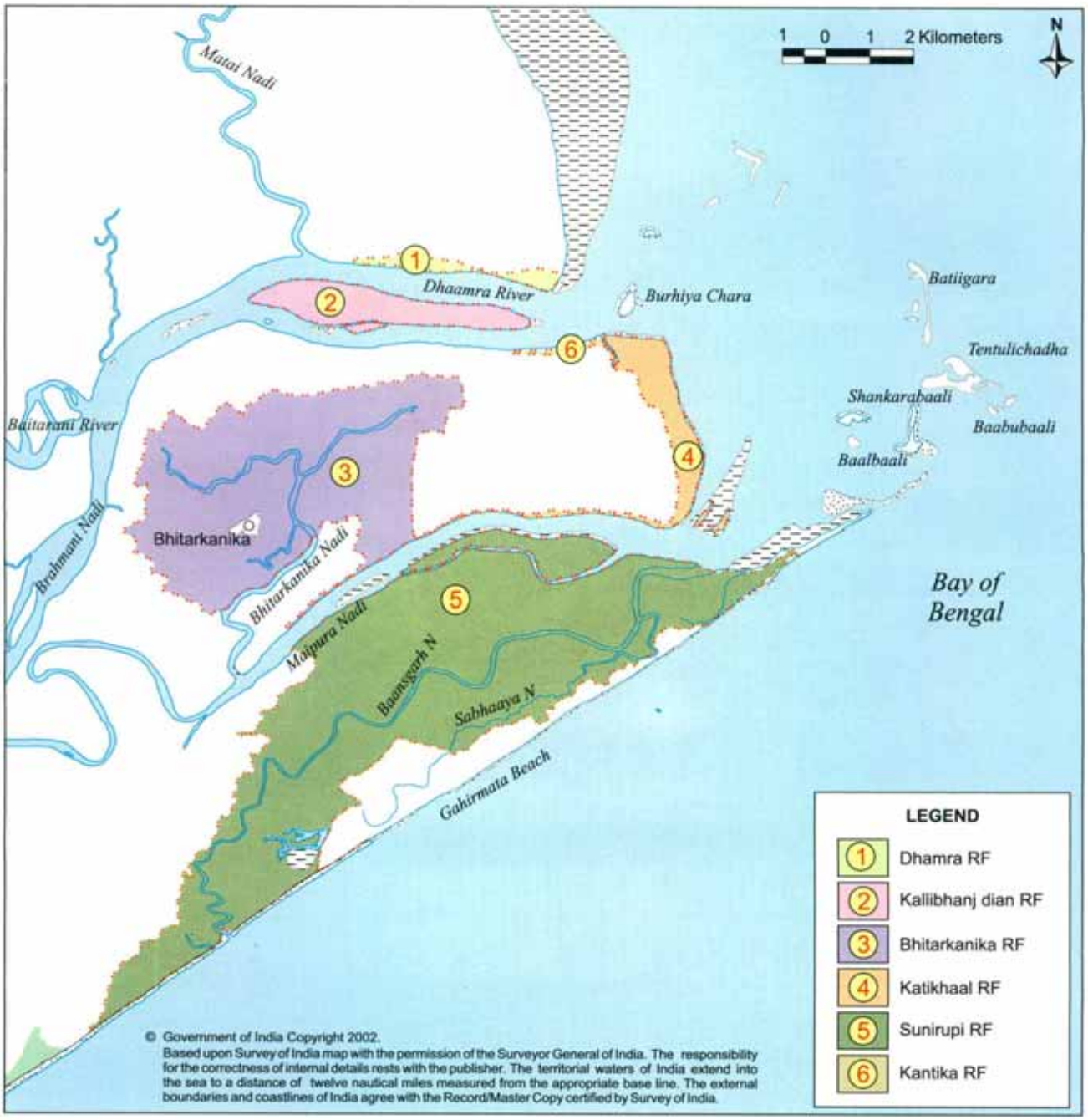
A large extent of mangrove vegetation can be seen from the remote sensing imagery of Bhitarkanika, along with water stagnated mudflat areas near Gupti. The diversity of mangrove species is very high in Bhitarkanika and spatial distribution of these species is also distinct, due to differences in ecological niches. The distribution pattern of different species can be seen in the remote sensing imagery by the bright red, dark red and brownish red colours with smooth texture spread over the forest area. A linear stretch of casuarina plantation can be noticed along the Gahirmata beach. The rest of the area is pale gray in colour and shows the cultivable area, which was fallow at the time of remote sensing data acquisition. The different shades of blue in the Baitaranai, Hansua and Patasala rivers show the sediment load in these rivers. The gray colour features show the tidal flats around the small island in the Baitarani river mouth and along the nearby shoreline. A linear stretch of agricultural plantations can also be noticed between the agricultural areas.

5.3 Reserved Forests

Bhitarkanika mangrove vegetation is very thick and difficult to penetrate. Out of the 215 sq.km of mangrove forests of Orissa, Bhitarkanika has 202 sq.km. The Kendrapara district has 184 sq.km and Bhadrak district has 18 sq. km of mangrove vegetation cover (State Forest Report, 1999). The entire forest is managed by the Mangrove Forest Division, Rajnagar under the control of Chief Wildlife Warden (CWLW), State Forest Department, Orissa.

Map 5.2 IRS P6 LISS III Remote Sensing imagery of BWLS - 2004

Map 5.3 Reserved Forests



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The area was under *Kanika Zamindari* up to 1952. After the abolishment of the zamindari system Bhitarkanika forest land was handed over to the Revenue Department, which managed it till 1957. It was then transferred to Athgarh Forest Division in 1961 and declared as Protected Forest. In April 1975 the forest in Kendrapara district along with a stretch of 35 km long coast, with an area of 672 sq.km was notified as Bhitarkanika Wildlife Sanctuary. In 1988 the Government notified its intention of declaring a part of the territory of the BWLS as a National Park through notification no 8F (5) 53/88 22904/FFAH dated 3rd October 1988 under section 35 of the Wildlife (Protection) Act 1972. In 1988, a separate Mangrove Division, with headquarters at Rajnagar, was created, which is responsible for the management of the entire mangrove wetlands of Orissa including BWLS. In September 1998, a 145 sq.km sanctuary area with villages and human habitation, was notified as Bhitarkanika National Park.

5.4 Flora of the mangrove forest

According to Kanvinde (2003) the mangroves of Bhitarkanika comprises 70 species, including mangroves and their associates with 4 species of *Brugeira*, 3 species each of *Avicennia, Sonneratia, Heritiera, Rhizophora* and *Xylocarpus*. One endemic mangrove species, *Heritiera kanikensis* is also found in the sanctuary. The mangrove species are mostly concentrated along the network of creeks and channels, and extend from the sheltered bay to the elevated banks of the upper riparian zone, where the composition of the mangrove community is different due to the presence of non-mangals and transitory mangals. Patnaik and Choudary (1989) classified the Bhitarkanika vegetation into mangal and salt brush formations.

Mangals

They are similar to those of the Sundarbans and are classified into three categories namely, eumangals, semi-mangals and transitional mangals.

1. Eumangals: These are typical mangrove taxa that survive in periodic water logging and adapted for high salinity variation and poor soil aeration. The dominant trees of this type are *Rhizophora apiculata, R. mucronata, Avicennia officinalis, Bruguiera gymnorrhiza, Ceriops decandra, Aegiceras corniculatum, Sonneratia apetala* and *S. caseolaris*. The bushy undergrowth is composed of *Acanthus ilicifolius* and *Acrostichum aureum*. The eumangals are generally evergreen and show a high degree of morphological and reproductive adaptations. Almost pure formations of *Porteresia coarctata*, a dominant grass element are gregarious along the banks, which are submerged during the high tide.
2. Semi-mangals: They exhibit various adaptations characteristic of halophytes and in many cases they do not have pneumatophores and are not viviparous. They grow close to riverbanks and creeks. The main elements are *Heritiera fomes, Cerbera manghas, Cynometra mimosoides, Xylocarpus granatum, Excoecaria agallocha* and *Tamarix indica*. The second layer of the vegetation is mainly composed of *Acanthus volubilis, Salicornia brachiata* and *Suaeda maritima*.
3. Transitional mangals: They have the features of halophytes but are well adapted to more terrestrial habitats. Many of them are deciduous and few are evergreen. They are found in areas of less tidal action and low salinity. The common species found in transitional mangroves are *Hibiscus tiliaceus, Excoecaria agallocha, Flagellaria indica, Ponga pinnata, Clerodendrum inerme, Derris trifoliata* and *Salvadora persica* and shrubs such as *Synostemon bacciforme* and *Syzigum ruscifolum*.

Salt brush formations

They are sandy vegetation found along the littoral tract of Satbhaya and Gahirmata areas, composed of shrubby and herbaceous elements such as *Spinifex littoralis, Cyperus anrenarius, Hydrophylaz maritima, Ipomea pes-caprae, Launea sarmentosa, Gisekia pharmacoidess, Suadea maritima, S. monoica* and *Vetiveria zizanoides.*

5.5 Mangrove species zonation

Bhitarkanika is India's largest mangrove forest, in terms of species diversity and variations in ecological factors. The major species found in the sanctuary area are *Avicennia marina, A. officinalis, Bruguiera gymnorrhiza, Ceriops decandra, Kandelia candel, Lumnitzera racemosa, Sonneratia apetala, S. caseolaris, S. alba, Xylocarpus granatum* and *X. moluccensis.* The associated species like *Cyperus exaltatus, Derris scandens, Hydrophylax maritima, Sesuvium portulacastrum, Suaeda maritima* are also found. The phytosociological study conducted in four forest blocks of the Bhitarkanika Wildlife Sanctuary by Mishra and Kanvinde (1997) identified two macrohabitats in the sanctuary as Habitat A consisting of Bhitarkanika and Dangmal forest blocks and Habitat B comprising Thakurdia and Kakarnasi Blocks. Habitat A has pure patches of less saline tolerant species like *Excoecaria agallocha, Heritiera fomes* and *Ceriops decandra* while Habitat B, which is closer to the Bay of Bengal has high saline tolerant species such as *Avicennia marina, Aegialites rotundifolia, Aegiceras corniculatum* and *Sonneratia caseolaris.*

The endangered species namely *Merope anulata*, the rare species namely *Heritiera kanikensis* and *Amoora cuculata* and vulnerable species like *Cerbera manghas, Sacrolobus carinatus* and *Sonneratia caseolaris* (Biswal and Choudhury, 1993) should be conserved as a long term measure for management of mangrove biodiversity.

5.6 Fauna

The diversity in fauna is also very high in BWLS. The rich mangrove vegetation, wetlands, mudflats, estuarine areas, islands and coastline provide habitat diversity for the occurrence of large number of animals and fishes. There are several species of mammals, birds, amphibians, reptiles, fishes, molluscs, crustaceans and other invertebrates, that live in Bhitarkanika. There are about 172 birds, 44 reptiles, 26 mammals and 5 amphibians recorded in the BWLS. Among mammalian fauna, the leopard (*Panthera pardus*) once thrived in this area, but its existence is now doubtful. The other important mammals are wild boar, monkey, spotted deer, sambar and fishing cat. Bhitarkanika mangroves provide feeding, perching and nesting grounds for a variety of resident, local and long distance migratory birds. Bhitarkanika Wildlife Sanctuary is one of the important areas where a number of rare and endangered reptilians thrive in good numbers. It holds the largest population of endangered estuarine crocodiles in India. The Forest Department of Orissa established a Saltwater Crocodile Research and Conservation Centre in Dangmal in 1975 with the purpose of quickly multiplying the population of this endangered reptiles, using the grow and release technique. The mass nesting or *Arribada* (a Spanish term for mass arrival) of Olive Ridley turtles has been taking place for several decades at Gahirmata beach, which is about 35 km long. A minimum of 50,000 to a maximum of 740,000 female turtles visit this beach for nesting every year. Mass nesting occurs usually once or twice in a nesting season during the period from late December to April. Another interesting reptile present in Bhitarkanika is the highly poisonous King Cobra. Bhitarkanika is also well known for its lizard population. It is a home for the largest Indian lizard, called water monitor.

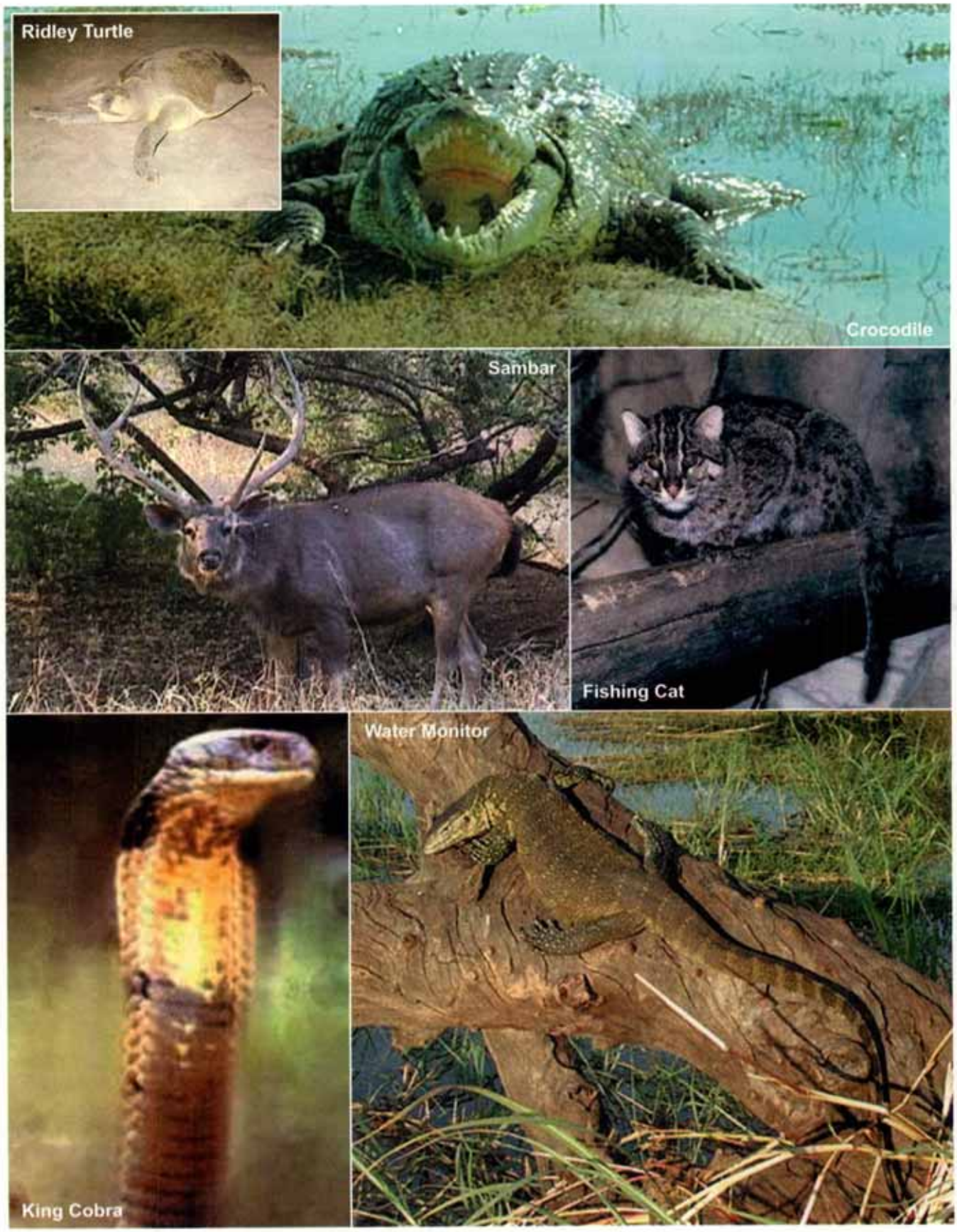


Figure 40. Fauna of Bhitarkanika Wildlife Sanctuary

5.7 Soil properties

The Bhitarkanika region is covered with sediments of flood plain deposits of sub-recent origin and pleistocene forms. Due to regular inundation through tidal action the soil is mostly clayey loam and highly slushy. The surface soil is composed of silt loam and clayey loam and is about 3 to 4 m in depth. The soil, though well aerated, is saline. In the elevated areas away from the creeks and channels the soil is more sandy and comparatively less moist and saline. The soil pH varies from 6.3 to 7.3. Due to constant deposition of humus the soil is fertile even though it is saline.

5.8 Hydrological conditions

The area is influenced by high tides and low tides twice a day at an interval of 12 hours. The tidal amplitude ranges from 2 - 3.5 m upstream and 3.5 - 6 m near the river mouths. The salinity along Gahirmata coastal area ranges from 21.1gm/l in monsoon to 33.7 gm/l in summer.

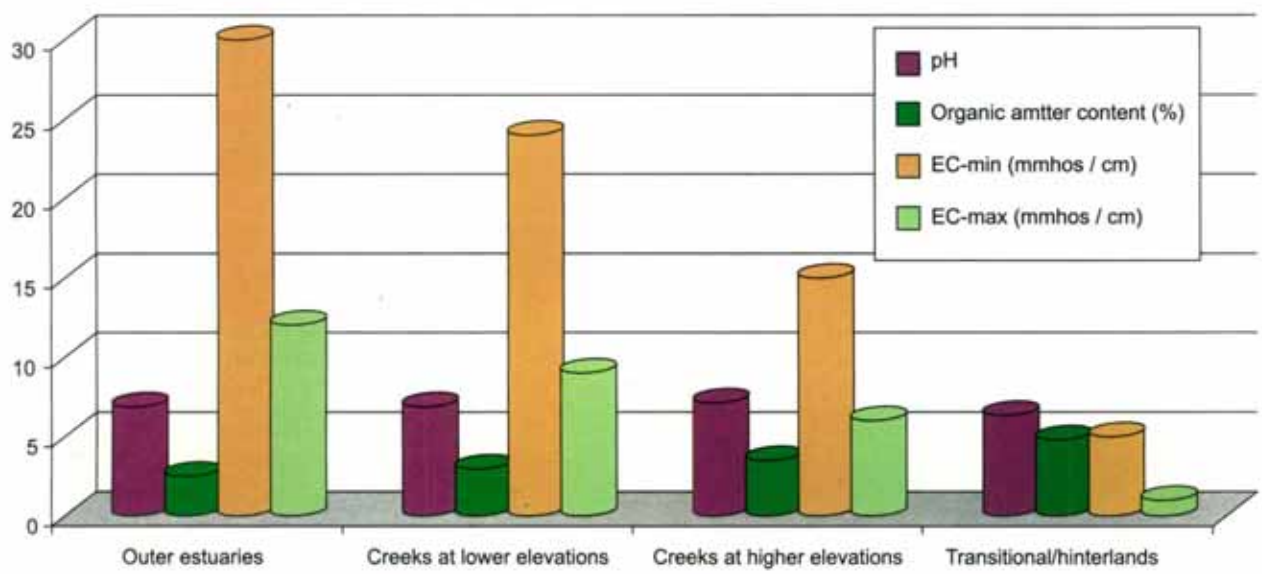


Figure 41. Soil characteristics

5.9 Wood and Fishery resources and utilization pattern

The Bhitarkanika Wildlife Sanctuary is rich in wood, fodder and fishery resources. The local community extensively extracts firewood from the mangroves. According to Chadha and Kar (1999) about 40 villages in the BWLS depend on the mangroves for their firewood needs. They estimated that out of 14 kg of firewood requirement per day about 12 kg is extracted from the mangroves. They also estimated that about 20% of the village population are engaged in firewood collection, gathering of leaves and bark etc.

Local communities also use almost all mangroves species for house construction, fencing and for making farming implements. All parts of the Phoenix tree are used in house building. It is one of the most extracted timber resources. Since better quality timber (e.g. *Heritiera* sp.) is available only in the interior core area of the sanctuary, extraction of timber from these species is restricted.

As the mangroves are the major source of fishes, barricade fishing that is practiced damages the mangrove forests as wood is cut for poles. Poles that need to be used in barricade fishing are approximately 150 - 200 in

number, which is equal to about 0.1 ha of the forest. The poles of *Heritiera fomes, Ceriops decandra, Avicennia officinalis, A. alba, Aegiceras corniculatum, Bruguiera gymnorrhiza, Excoecaria agallocha* and *Lumnitzera racemosa* are used for barricade fishing and these poles are collected seasonally. The wood logs of *Phoenix paludosa, H. fomes, A. officinalis, Intsia bijuga, Sonneratia apetala, Xylocarpus molluccensis* and *X. mekonngensis* are also used for the construction of boats (Sheela *et al*, 1997).

Mangroves are also used by the local communities as grazing grounds. Local communities leave their animals in the protected areas, especially along the fringe areas, to graze either on mangroves or grasses. The area grazed and the damage caused to the natural forests has not been estimated and there is a need to define fodder needs of the cattle of the villages located within the Bhitarkanika Wildlife Sanctuary.

Two important non timber forest products, namely honey and grasses for basket and mat weaving are available in the Bhitarkanika mangroves abundantly. About 35 *Adivasi* households living in Dangmal village are actively involved in honey and wax collection. They have been collecting honey for generations. They do not depend totally on honey collection for their livelihood. Since 1975, after the area was declared a Wildlife Sanctuary, these people collect and sell their honey and wax only to the Forest Department at the rate of Rs. 25 per kg. Good quality honey is collected mainly in the flowering season of *Aegiceras corniculatum* and *Ceriops decandra*. Table 12. shows the amount of honey and wax collected from the Bhitarkanika Wildlife Sanctuary in the recent years.

Table 12. Details of honey and bee's wax collected from Bhitarkanika

Year	Honey (kg)	Bee's wax (kg)
1996	4500.0	95.75
1997	4100.8	126.00
1998	1900.9	52.30
1999	1400.4	47.15
2000	800.63	34.00
2001	--	88.00

Source: Divisional Forest Office, Rajnagar 2001

Every household within the Bhitarkanika Wildlife Sanctuary makes baskets, mats, hand fans and other items from the leaves and the bark of mangroves. The bark fiber of *Flagellaria indica* is used for rope making and the leaves of *Phoenix paludosa* are used for weaving mat. People belonging to Schedule Castes make beautiful mats and baskets out of the grass *Myriostachya wightiana*. They collect 20 kg of this grass every 7 days, which is enough to make four large baskets. The price of the baskets varies from Rs. 4 to 40 depending on the size. The Forest Department issues forest passes for this resource harvest. They face the danger of being attacked by crocodiles while they collect the grass.

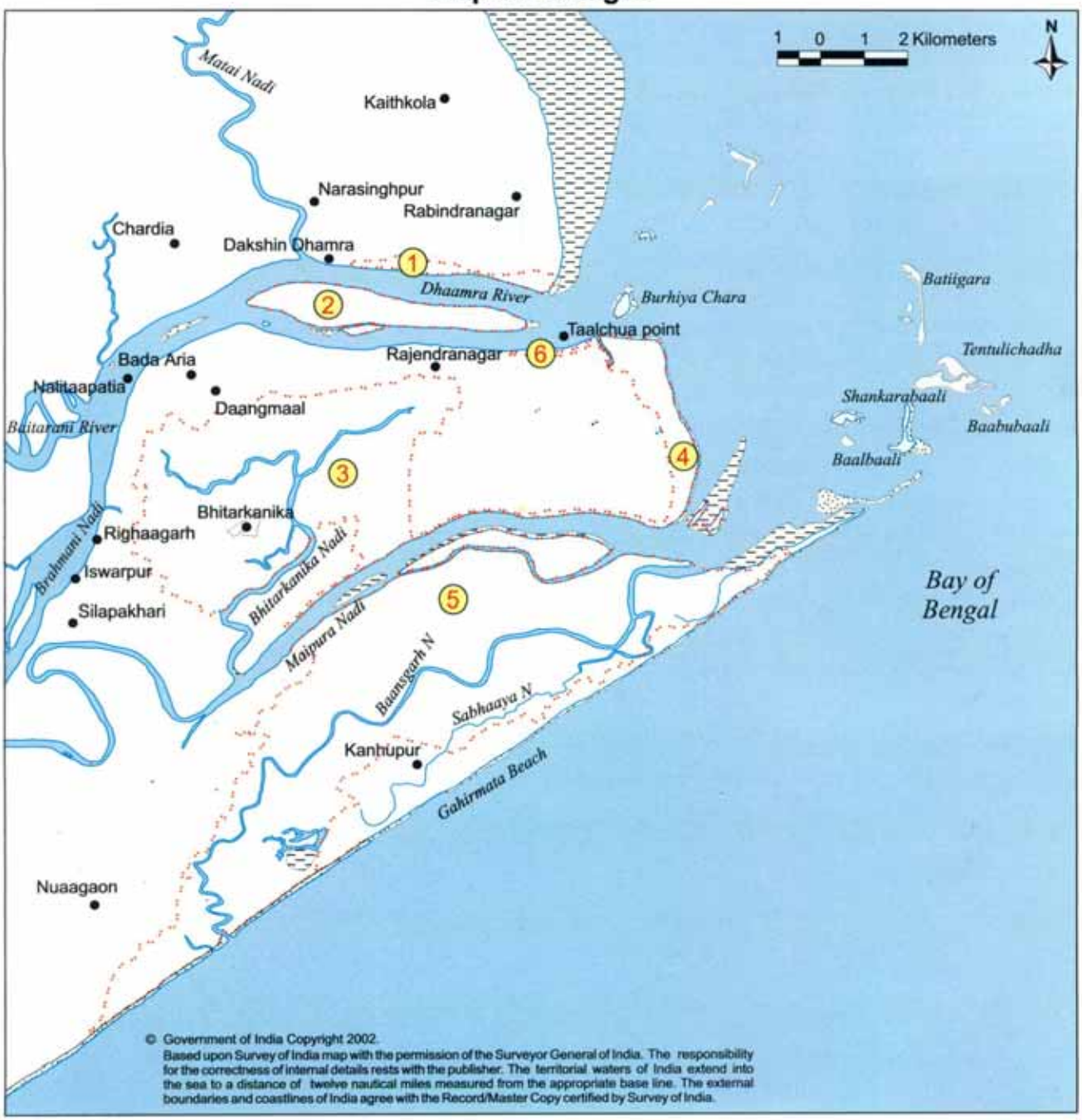
In addition, local communities use a variety of mangrove species in traditional medical practices to cure rheumatism, asthma and skin disease.

The Bhitarkanika mangroves are rich in fishery resources. The common fishes found in the mangroves are *Liza, Mugil, Lates, Polnemus, Sciaena, Setipianna, Pengasium, Hilsa* and *Etroplus.* Prawns like *Penaeus* and *Meapenaeus* and *Scylla* crab are commonly found. Fishing is done both for household consumption and marketing. People owning small boats called "*donga*" (rowing boat) catch fish from 5 to 100 kg per day and sell it for Rs. 15 to 40 per kg. Those owning larger mechanized boats (*butbuti*) go deeper into mangroves and catch about 300 kg of fish per day. These larger boats are used to transport fish from the catching area to the landing centres for marketing since road transport is underdeveloped. The fisher women of Bhitarkanika area also fish in the mangroves. They catch about 2 to 20 kg of fish per day with small round nets. Local communities use a variety of gear to catch fish within the mangroves. Table 13 shows utilization of mangrove resources by the local community. A detailed study of the mangrove resources and their utilization pattern is needed to prepare and implement developmental plans for the fishing villages located within the Bhitarkanika Wildlife Sanctuary.

Table 13. Utilization of mangrove resources

Resource	Utilization	Impact on Community
Leaves	Fodder for cattle	Surplus milk sold commercially
	Fertilizer, Mat making	Higher productivity
		Household use and for selling
Wood	Firewood	Household use and for selling
	Agricultural implements	Used in farms
	Boat making	Fishing and transportation
	Bridge across small creeks	Accessibility
	Thatching	Household use
Bark fibers	Rope making	Household use and for selling
Naalia grass	Mat and basket making	Household use and for selling
Fruits	Consumption	Utilized in times of absolute shortage of food
Tide	Collection of young shrimps during high tide	Sold to shrimp farmers
Fishes	Fishing and aquaculture	Household use and for selling
Honey	Food and medicines	A source of income

Map 5.4 Villages



5.10 Socio - economic conditions

There are more than 100 villages in and around the sanctuary with a total population of more than 41,296, (Kanvinde, 2003). A study of the populations of these villages for the past few decades shows that most of them are immigrants who have settled here after two different events, one following the partition in 1947 and the other after the Bangladesh liberation war in 1971. The original people of the area are a tribe of honey gatherers and hunters who know the forest intimately. Local communities cultivate paddy and also engage in fishing for subsistence and marketing. Paddy yield is very poor, with about 0.8 to 1 ton per ha which may be due to poor soil conditions.

5.11 Landuse around mangroves

The mangrove forest is the largest land cover of the sanctuary and the next major land use is agriculture. Most of the areas around the mangroves are under paddy cultivation. Cultivation is done either as single crop or double crop. The total agricultural area is 240 sq.km of which 62 % is under double crop while the remaining 38 % is cultivated during the Kharif season. About 10 sq.km of marshy land is found between the mangroves and terrestrial land. Casuarina plantation is also found along the Gahirmata coastline. In and around the sanctuary area, the major rivers that enrich the mangrove forest are Baitarani, Hansua and Patasala.

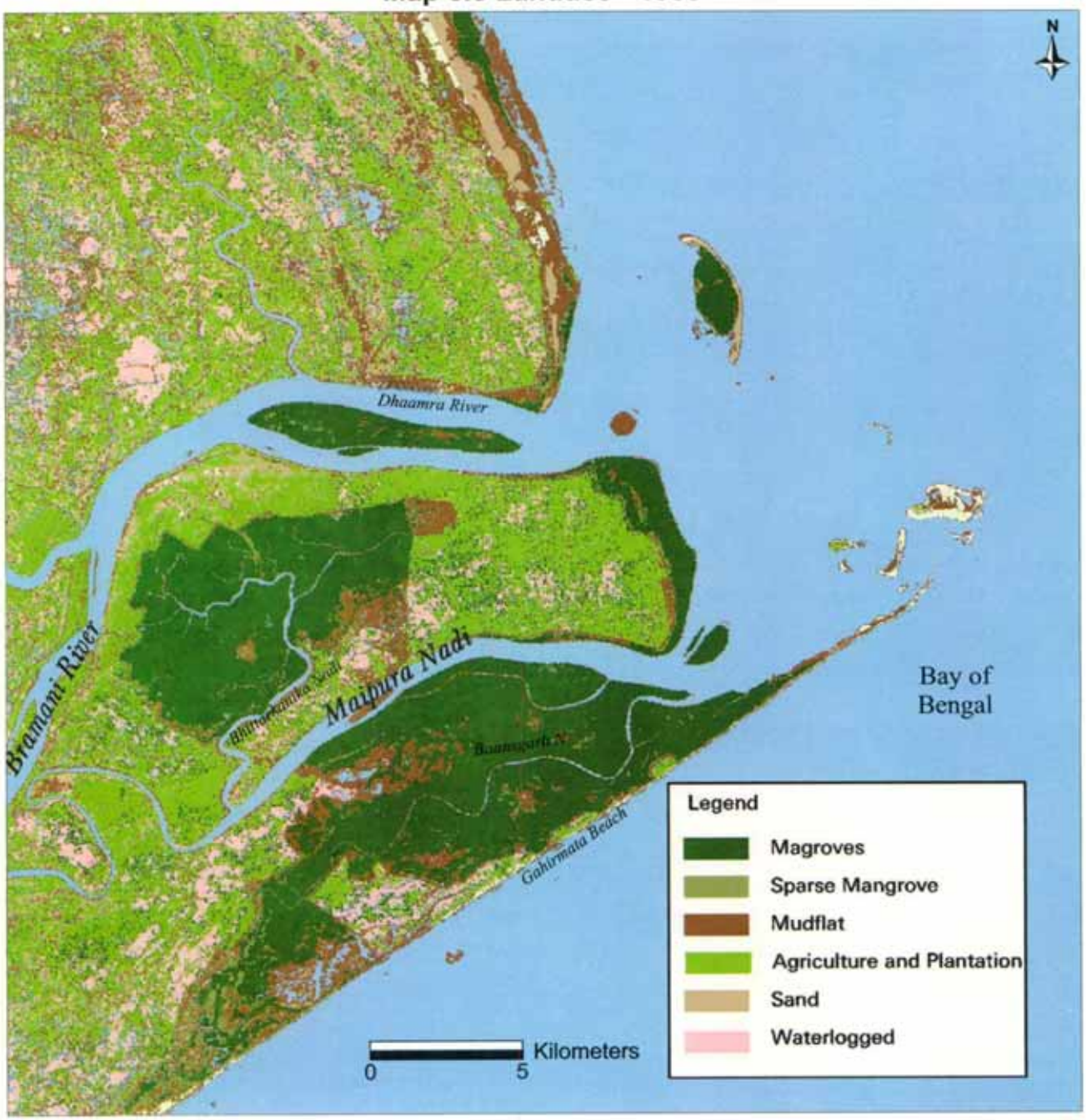
5.12 Changes in mangrove vegetation between 1985 and 2004

There has been no large-scale change in the mangrove forest cover between 1985 and 2004. About 561 ha of mangrove vegetation has increased, from 13,617 ha in 1985 to 14,178 ha in 2004. Changes in the mangrove vegetation are found in the island near the Dhaamra river mouth. The island had mangroves of about 437 ha in 2004, which was around 266 ha in 1985. The increased mangrove vegetation both in the core area and in the islands are naturally formed vegetation.

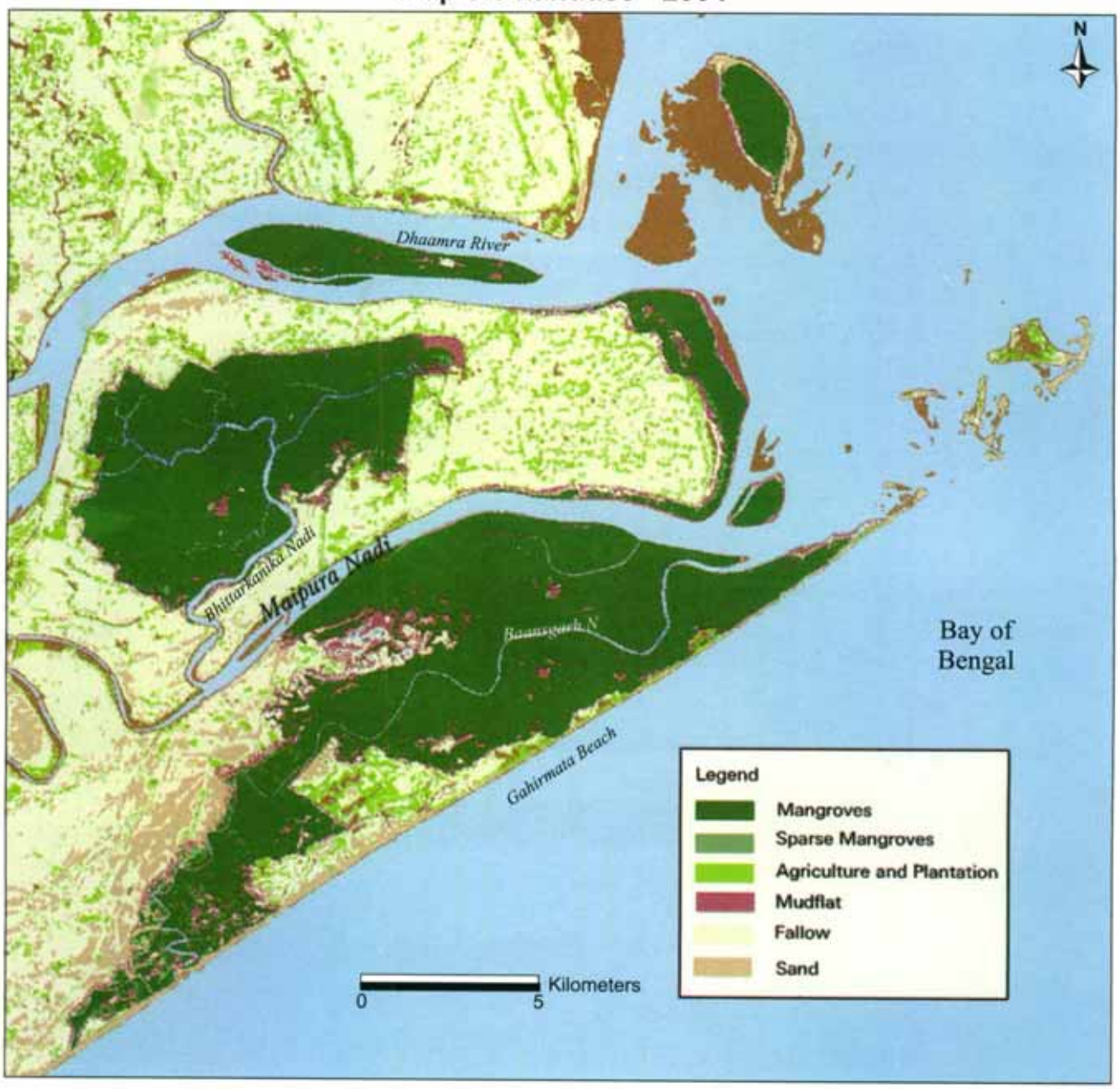
5.13 Shoreline changes

Most of the changes have occurred only near the river mouths, while the coastline has remained the same from 1970 to 2004, as the map 5.7 shows. The end of the Gahirmata beach at the mouth has broken after 1986 and a long sand bar has developed along the beach. The Buriyachara island near the mouth was not found in 1985. The Batiigara island has shrunk and moved towards the mainland. The small group of islands (about 50 m in length) seen in 1970 have combined and grown to a length of 5 km in 2004. The river course has undergone some changes around Kaalibanjdian RF in Dhaamra. The width of the Mainpura river has reduced near the estuarine region between 1975 and 2004 due to siltation through river discharge. Small islands along the rivers have joined the main land.

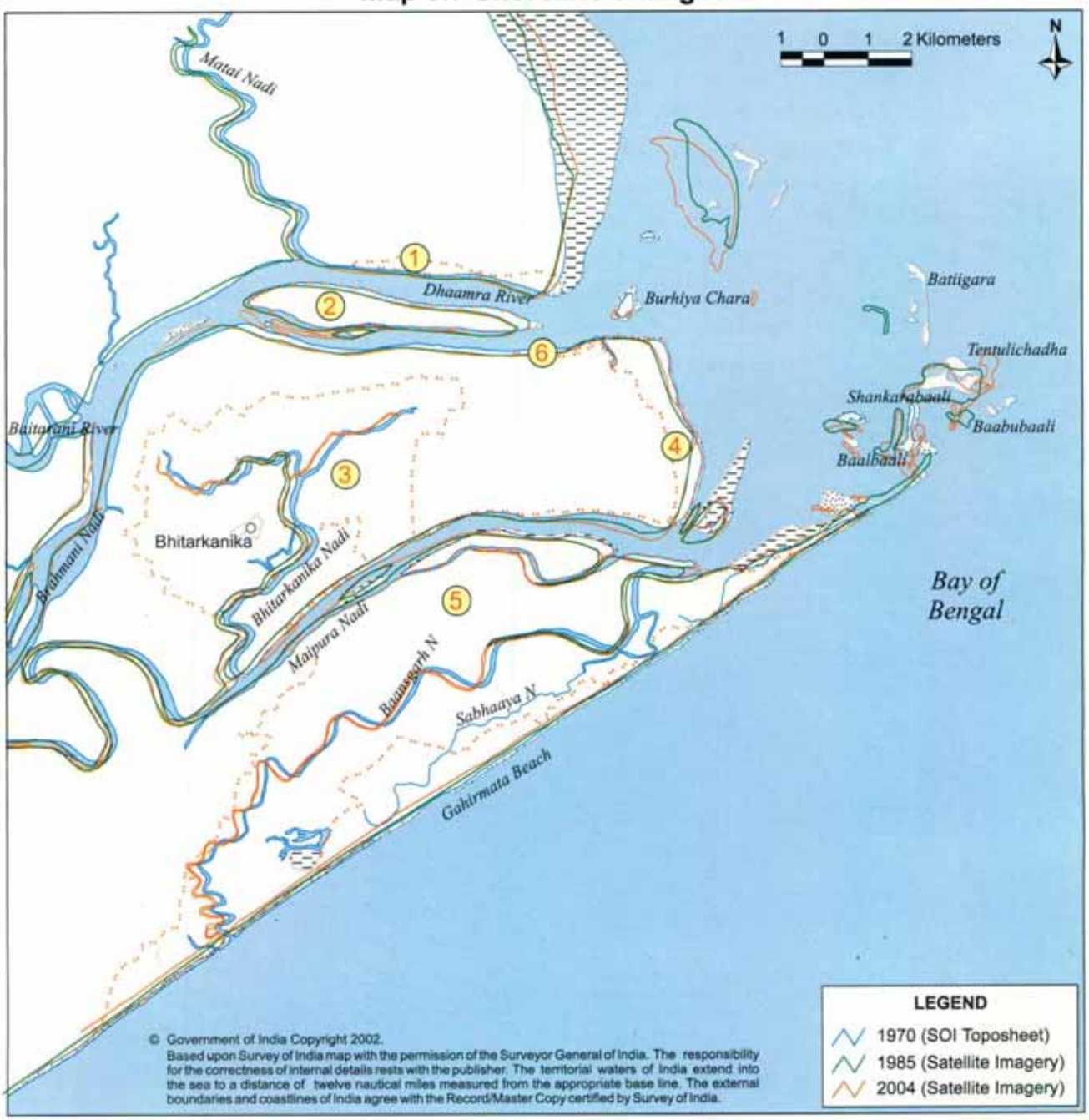
Map 5.5 Landuse - 1985



Map 5.6 Landuse - 2004



Map 5.7 Shoreline changes



Chapter 6

Long Term Management

Maintenance of fresh water flow

The species diversity and population density of each species of mangroves are directly related to the spatial and temporal flow of the river water. Reduction in the quantity and periodicity of fresh water flowing into mangrove wetlands affects the diversity as well as biomass of the plant community through increasing water and soil salinity. For example, the amount of fresh water flowing into Pichavaram mangrove wetland in Tamil Nadu has reduced from 73 TMC (Thousand Million Cubic feet) per year in the 1930s to 31 TMC in the1980s and 3 to 5 TMC in the 1990s. This has resulted in the disappearance of saline-sensitive species such as *Cynometra ramiflora*, *Xylocarpus granatum*, *Kandelia candel*, and *Sonneratia apetala* in different periods of time, and the highly saline sensitive species having disappeared in the beginning years of reduction and others in the later period. A similar observation has also been made in the Indian part of the Sundarban mangrove wetland where the population of species such as *Heriteira fomes* have reduced drastically due to reduction in fresh water flow. The same is the case in the Krishna mangrove wetlands of Andhra Pradesh. Such destruction to the species diversity of the mangroves of Mahanadi and Bhitarkanika, which are considered important mangrove genetic resource centers, can be avoided if steps are taken to prevent any reduction in the quantity and periodicity of fresh water flowing into these mangrove wetlands. Periodical monitoring of these parameters in conjunction with diversion of fresh water in the upstream would be helpful in designing programmes to prevent such a calamity.

Aquaculture and mangroves

Another important cause for reduction in mangrove cover in Orissa is due to the diversion of mangrove forests for aquaculture and agriculture. Hence, a clear policy on land use around mangrove wetlands will play an important role in the long-term conservation of the Mahanadi and Bhitarkanika mangrove wetlands.

Participatory approach

The grass root level institutions namely, Luna Jungla Samrakshana Samitis (LJSS) has been formed in the Mahanadi and Devi mouth villages for participatory management of mangroves at the initiative of the Coastal Wetlands: Mangrove Conservation and Management project. These institutions working with the Forest Department restored 413 ha of degraded mangroves and are conserving 1,061 ha of verdant mangroves by forming Mangrove Management Units.

These village institutions protect these mangrove management units by means of a mechanism called "*Thengapalli*" and social fencing. *Thengapalli* is a method of protection of mangroves through which the villagers protect the forest in turns by holding a *lathi* (stick). This system is popular among the communities and requires the participation of the entire village. The stick is carried while patrolling and protecting the mangrove forests and handed over to the other batch the next day. Through this system, the entire village protects the forest in the true spirit of community participation.

Another unique method of managing mangrove forests in Orissa initiated in the mangrove project implemented jointly by MSSRF and FD is by forming Regional Forest Protection Committees (RFPC's). In this mechanism two or three villages i.e. the Luna Jungla Samrakshana Samitis join together and form RFPC to protect the mangroves collectively and also to solve inter-village conflicts or disputes. Members of the LJSS, *Panchayats* (local level administrative institutions) and other community leaders constitute the membership. The above mechanisms have proved to be effective in the conservation and management of mangroves in Orissa. The policy guidelines on management of mangroves in Orissa could adopt these mechanisms in the management of mangroves in future.

A mangrove management policy should offer people with viable alternatives for their dependency on mangroves for firewood, fencing, fodder, fishing poles and house construction. A number of mangrove water-based alternatives can be identified and implemented. A sustainable method of mangrove harvesting should also be evolved. Participatory patrolling by members of LJSS and the staff of the Forest Department, and strict and systematic vigilance, are essential for better mangrove management.

Demarcation of the revenue lands, forest areas and mangroves has to be clearly established for better conservation of mangroves in Orissa. The concept of Proposed Reserved Forests is another option, which can help in long-term management of mangroves in Orissa.

In order to address the issues of mangrove management in India a draft guideline for Joint Mangrove Management has been formulated in consultation with a number of in service and retired officials of the Forest Department of West Bengal, Orissa, Andhra Pradesh, Tamil Nadu and Gujarat as well as other stakeholders.

REFERENCES

1. Additional Director of Fishery Report, Orissa, 2000.
2. Banerjee, L.K. and Rao, T.A. 1990. *Mangroves of Orissa Coast and their Ecology.* Bishen Singh Mahendra Pal Singh, Dehra Dun, India. pp 116.
3. Biswal, A.K. and Choudhury, B.P. 1993. *Bhitarkanika Wildlife Sanctuary, Exploitation and Management.* NeoBotanica vol. 1, pp 17-22.
4. Chadha,S. and Kar,C.S. 1999. *Bhitarkanika: Myth and Reality.* Natraj Publishers, Dehra Dun. pp 388.
5. Daniels, R. J. R. and Achariyo, L.N., (editors), 1997, *Rejuvenation of degraded mangrove and Development of seed banks at Bhitarkanika.* Final technical report submitted to NORAD by M.S. Swaminathan Research Foundation, Chennai, India. pp 122.
6. De la Cruz, A.A. 1979. *Mangroves and estuarine vegetation in Southeast Asia.* Biotrop. Spec. Publ. No: 10, pp.125-138.
7. FAO. 1994. *Mangrove forests management guidelines.* pp 46, 169-191
8. Fisher, P. and Spadling, M.D. 1993. *Protected Areas with Mangrove Habitat.* Draft Report. World Conservation Centre. Cambridge, UK. pp 60.
9. Forest Survey of India.1987, 1997 and 1999. *The state of Forest Report.* Ministry of Environment and Forests, New Delhi.
10. Government of India, 1987. *Mangroves in India Status Report.* Ministry of Environment and Forests, New Delhi. pp 52-55.
11. Hemal S. Kanvinde. 2003. *Bhitarkanika* In: *Bioresources status in select coastal locations.* National Bioresource Development Board (Department of Biotechnology) Govt. of India and M.S.Swaminathan Research Foundation, Chennai, India. pp 177-200.
12. Mahalik N.K. 2000. *Mahanadi delta. Geology, Resources and Biodiversity.* ATI Alumini Association, New Delhi.
13. Mishra. P. K., Nayak. S. S. and Das. S. R. 1997. *Fisheries in Mangrove ecosystem: Case Study of Bhitarkanika mangrove forests: Orissa.* M. S. Swaminathan Research Foundation, Chennai, India.
14. Mishra, P. K. and Hemal S. Kanvinde. 1997. *Fisheries in Mangrove ecosystem: Case Study of Bhitarkanika mangrove forests: Orissa.* M. S. Swaminathan Research Foundation, Chennai, India.
15. Patnaik, S. N. and Choudhury, B.P. 1989. *Present status and future development of Mangrove vegetations in Bhitarkanika.* Indo-US workshop on wetlands, Mangroves and Biosphere reserve. Govt. of India, Ministry of Environment and Forest, New Delhi. pp 89-95.
16. Prasanakumar and Manojkumar Sanavada. 1999. *Orissa Mangroves,* BIGVAN DIGANTA, Bhuwaneshwar, p.p. 43-46.
17. Ravishankar, T., Gnanappazham, L., Ramasubramanian. R., Sridhar, D., Navamuniyammal, M. and Selvam, V. 2004. *Atlas of Mangrove Wetlands of India Part 2 Andhra Pradesh.* M. S. Swaminathan Research Foundation, Chennai, India.

18. Selvam, V., Gnanappazham, L., Navamuniyammal, M., Ravichandran, K.K., and Karunakaran, V. M. 2002. *Atlas of Mangrove Wetlands of India Part 1 Tamil Nadu.* M. S. Swaminathan Research Foundation, Chennai, India.

19. Sheela, S., Mishra, P. K. and Hemal S. Kanvinde, H. 1997. *Indigenous knowledge and use of Mangrove species amongst the people of Bhitarkanika sanctuary.* In: Daniels, R. J. R. and Achariyo, L.N. (eds.). *Rejuvenation of degraded mangrove and Development of seed banks at Bhitarkanika.* Final technical report submitted to NORAD by M.S. Swaminathan Research Foundation, Chennai, India.

20. Sinha, B.N. 1999. *Geography of Orissa.* N B T, New Delhi, India. pp 351.

21. *State of Forest Report.* Forest Survey of India, Dehra Dun. 1999.

22. Walsh, G.E. 1874. *Mangroves: A review. Ecology of Halophytes.* R. J. Reinhold and W. H. Queen (ed.). New York Academic Press. pp 51-174.

23. WCMC. 1992. *Global biodiversity: status of the earth's living resources.* Chapman Hall, London. pp 585.

24. World Resources Institute. 2000. World resources 2000-2001: *People and Ecosystems, the fraying web of life.* World Resources Institute, Washington DC. pp 389.

25. http://www.orissagov.nic.in

26. http://www.wrmin.nic.in/riverbasin/mahanadi.htm

27. http://www.flmnh.ufl.edu