ATLAS OF MANGROVE WETLANDS OF INDIA

Part 2 - Andhra Pradesh

T. Ravishankar
L. Gnanappazham
R. Ramasubramanian
D. Sridhar
M. Navamuniyammal
V. Selvam

M. S. Swaminathan Research Foundation
Chennai, India

M.S. Swaminathan Research Foundation
3rd Cross Street, Institutional Area,
Taramani, Chennai - 600 113, India.

Telephone : + 91(44) 22541 229
+ 91(44) 22541 698

Fax : + 91(44) 22351 319

E-mail : msswami@mssrf.res.in
executivedirector@mssrf.res.in

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FOREWORD

The multi-functionality of mangrove ecosystems is now widely recognized. They serve as barriers to coastal storms, conservers of soil, supporters of sustainable fisheries, providers of medical products and fuel wood and fodder, habitats of wide range of flora and fauna, sources of genes for sea water tolerance and above all as the flagship of nature's ecological security system in coastal estuaries. MSSRF with support from the India - Canada Environment Facility, has been engaged in fostering the sustainable management of mangrove wetlands in the states of Tamil Nadu, Andhra Pradesh, Orissa and West Bengal during the last 6 years. This project has yielded valuable results on the quantitative and qualitative aspects of mangrove wetlands with particular reference to the impact of anthropogenic pressures on the ecosystem on the one hand, and the benefits arising from ecorestoration and mangrove rehabilitation programmes on the other. The data have been compiled in the form of GIS maps which have formed the basis for a series of Atlases. The first Atlas of Mangrove wetlands of Tamil Nadu was published in 2002. The present Atlas gives detailed information on the mangrove wetlands of both Godavari and Krishna river basins of Andhra Pradesh. The Atlases have been designed as tools for public policy and public action. I hope this atlas will be used to not only conserve the unique mangrove wetlands of Andhra Pradesh but also to enhance their coverage and beneficial social, spiritual, environmental and economic impact.

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Chennai
December 2003

M. S. Swaminathan

M. S. Swaminathan

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CONTRIBUTORS

M.S. Swaminathan Research Foundation

Dr. T. Ravishankar	:	Ethnobotanist and Principal Scientist
Dr. R. Ramasubramanian	:	Mangrove Ecologist
Ms. L. Gnanappazham	:	GIS Specialist
Ms. M. Navamuniyammal	:	GIS Specialist
Dr. D. Sridhar	:	Mangrove Ecologist
Mr. Md. Najeebullah Shariff	:	Social Scientist
Mr. S. Sankaramurthy	:	Former Project Director
Prof. S. Chelliah	:	Former Project Director
Mr. K. Johnson	:	Former Project Officer
Mr. D. Ramakrishna	:	Former Hydrogeologist
Mr. M. M. Jeelani	:	Former Agronomist
Mr. N. Srinivasa Rao	:	Former Social Scientist
Dr. Md. Maqbool	:	Former Agronomist
Dr. R. Krishnamurthy	:	Former GIS Specialist

Andhra Pradesh Forest Department

Mr. A.V. Joseph	:	Conservator of Forests
Mr. Ramesh Kalghatghi	:	Conservator of Forests
Mr. Hitesh Malhotra	:	Additional PCCF
Mr. H.C. Mishra	:	Conservator of Forests
Mr. N. Varaprasada Rao	:	State Silviculurist
Mr. N. Bhujanga Rao	:	Forest Range Officer

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ABBREVIATION

EDC	:	Eco-Development Committee
RRA	:	Rapid Rural Appraisal
PRA	:	Participatory Rural Appraisal
MSSRF	:	M. S. Swaminathan Research Foundation
MMU	:	Mangrove Management Unit
JMM	:	Joint Mangrove Management
JFM	:	Joint Forest Management
FD	:	Forest Department
VSS	:	Vana Samrakshana Samithi
RF	:	Reserve Forest
VLI	:	Village Level Institution
IRS	:	Indian Remote Sensing Satellite
LISS	:	Linear Image Self Scanning System
TM	:	Thematic Mapper
IUCN	:	International Union for the conservations of Nature and Natural resources
FSI	:	Forest Survey of India

ATLAS OF MANGROVE WETLANDS OF INDIA

Part 2 - Andhra Pradesh

Chapter 1

Introduction

Mangroves are plants that occur along the inter- tidal zones of tropical and subtropical areas between 32° N and 38° S, mostly on the eastern coast of continents. Mangrove forests cover the areas between low and high water levels. The plant communities of the mangrove wetlands are able to survive in estuarine conditions and adapt to the environment through unique characteristics – stilt roots, viviparous seeds, salt glands, salt-excluding mechanism, thick cuticles (wax coated leaf surfaces), leathery leaves and pneumatophores (roots for breathing).

They perform many protective, productive and economic functions. Mangrove forests near estuarine areas act as a barrier against cyclones and mitigate their effects. They prevent storm water from entering the mainland and prevent soil erosion along the coastal areas. Mangrove wetlands serve as spawning and nursery grounds for many economically important estuarine/marine fishes and shellfishes; their impact on ecology is equally significant: they harbour many resident and migratory birds.

Though the mangrove ecosystem is highly productive and has multiple uses, mangroves suffered serious neglect till very recently. They are undergoing widespread degradation due to a combination of physical, biological, anthropogenic and social factors. Human-induced stresses and factors - such as unscientific management practices, changes in water quality, soil salinity, diversion of fresh water upstream, and conversion of mangrove wetlands for aquaculture, salt pans and other land use practices – have reduced mangrove vegetation. The reduction in fresh water flow into the mangrove ecosystem has generated conditions of hypersalinity, and reduced the transportation of sediments that would create new areas for mangrove extension. Species diversity is declining with the increase in salinity; this is manifest from the extinction of many low saline tolerant mangrove species. Mangrove wetlands have also been degraded by indiscriminate destruction of mangrove resources and clear-felling of mangrove forest. Recently, unsustainable collection of prawn seeds for supply to aqua farms has affected prawn and fishery resources in mangrove wetlands. Result: fishery recruitment levels have fallen, and the livelihoods of local fishermen have been affected.

1.1. Distribution of Mangroves

Globally, mangroves are distributed across tropical and subtropical forests; they are predominant in the tropical region. Asia and Australia present the greatest diversity in mangrove species. Out of 18 million hectares of mangrove forests, more than 40 % are found along Asian coasts. Large populations of mangroves are found in Indonesia and Brazil and in the Sundarbans of India and Bangladesh. (Table 1 & 2).

The world's mangroves can be divided into eastern and western groups. The eastern group covers the region from the west and central Pacific to the southern end of Africa. The western group covers the American and African coasts of the Atlantic Ocean, the Caribbean Sea and Gulf of Mexico or the west coast of Africa and the coastal regions of North and South America. The eastern group has five times more mangrove species than the western group.

Table 1 Estimates of mangrove areas given by various authors

Region	World Mangrove Atlas 1997	IUCN (1983)	Fisher and Spalding (1993)
South and Southeast Asia	75,173	51,766	76,226
Australasia	18,789	16,980	15,145
The Americas	49,096	67,446	51,286
West Africa	27,995	27,110	49,500
East Africa and Middle East	10,024	5,508	6,661
Total	181,077	168,810	198,818

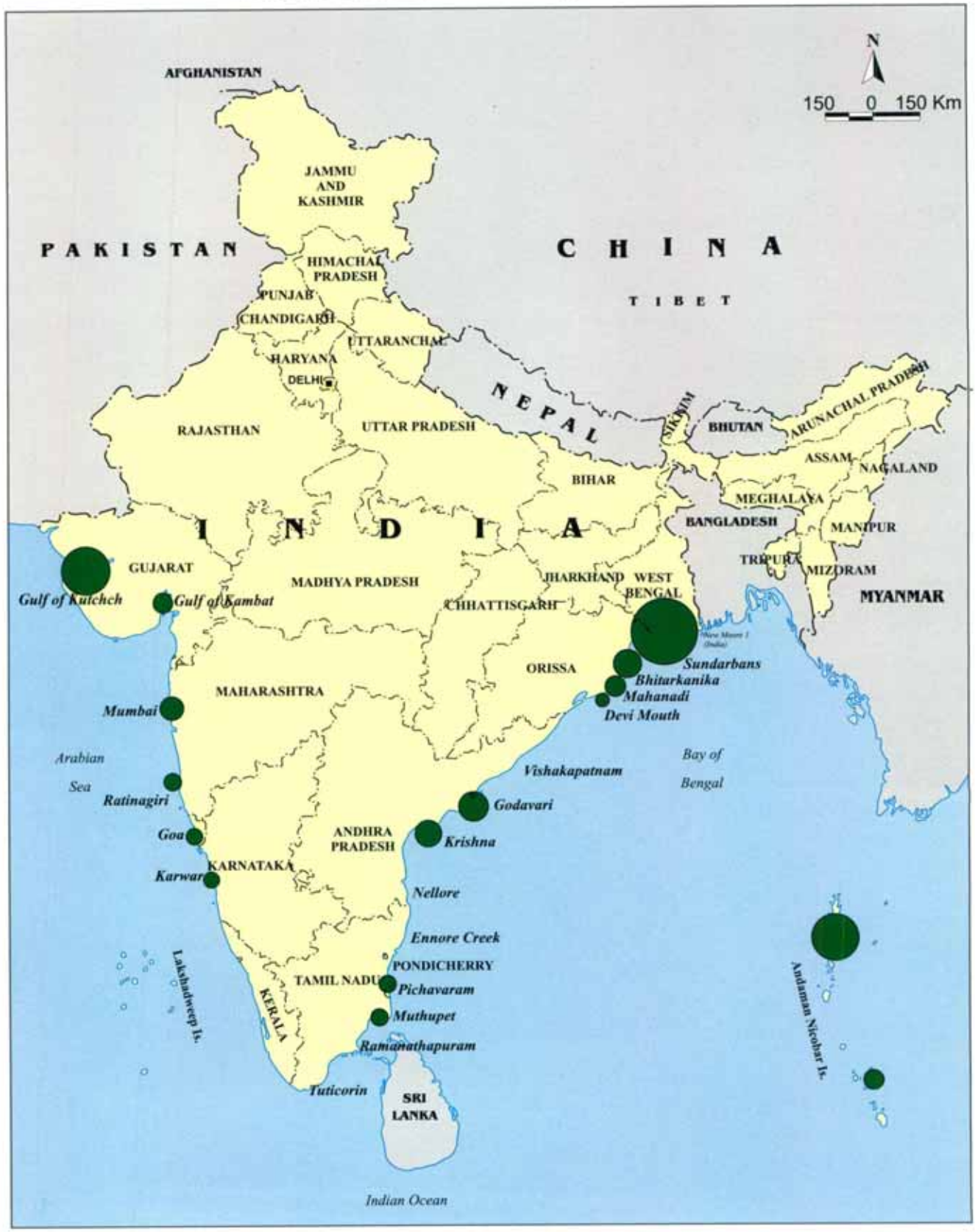
1.2. Mangroves of India

Estimates of the area of India's mangrove wetlands range from 5,00,000 ha. (Forest Survey of India, 1998) to 6,81,000 ha. (Sidhu, 1963). The major mangrove wetlands are located along the East Coast. On the west coast, they are predominant in Gujarat. Along the east coast, the tidal amplitude as well as the volume and periodicity of fresh water inflow decrease from Sundarbans in the north to Muthupet in the south. Correspondingly, the species diversity and area of mangrove wetlands also decrease from north to south, indicating the influence of fresh water inflow and tidal amplitude on the health and wealth of mangrove wetlands (Selvam, 2003) (Table 2). Mangrove wetlands of India can be classified into a) tide-dominated (Sunderbans and Mahanadi mangroves), b) river dominated (Godavari, Krishna, Muthupet, Pichavaram mangroves) and c) drowned river valley (Gujarat mangroves) (Selvam, 2003).

Table 2 Area of Mangrove Vegetation in Coastal States of India

Sl. No.	State	Place	Area in sq. km. (FSI 1999)
1.	Tamil Nadu	Muthupet	12
2.	Tamil Nadu	Pichavaram	9
3.	Andhra Pradesh	Krishna	156
4.	Andhra Pradesh	Godavari	241
5.	Orissa	Devi mouth	10
6.	Orissa	Mahanadi & Bhitarkanika	205
7.	West Bengal	Sundarbans	2,125
8.	Gujarat	Gulf of Kutchch	994
9.	Gujarat	Gulf of Kambat	32
10.	Maharashtra	Mumbai	96
11.	Maharashtra	Ratnagiri	12
12.	Goa	Goa	5
13.	Karnataka	Karwar	3
14.	Andaman & Nicobar Islands	Nicobar	37
15.	Andaman & Nicobar Islands	Andaman	929
	Total		4,866

Map 1.1 Distribution of Mangroves in India



Chapter 2

Mangrove Wetlands of Andhra Pradesh

Andhra Pradesh has a geographical area of 2,76,000 sq.km, of which 63,770 sq.km. or 23% is under forests. Mangrove forests account for only 582 sq.km, representing only about 0.9% of the State's total forest area. An advantage Andhra Pradesh enjoys is that most of the east- flowing rivers in the heart of the state bring in copious supplies to the coast from the Western and Eastern Ghats and the Deccan Plateau. Some 40 major, medium and minor rivers flow through the State. Of these, the most important rivers are the Godavari, the Krishna, the Pennar and the Vamsadhara. Mangroves are found in the estuaries of these rivers but extensive mangrove wetlands are present only in the Godavari and Krishna deltaic regions. The Godavari mangroves are located in the Godavari estuary of East Godavari district and the Krishna mangroves on the Krishna estuary of Krishna and Guntur districts. Apart from these estuaries, mangroves are also found in small patches along the coasts of Vishakapatnam, West Godavari, Guntur and Prakasam districts.

2.1. Floristic diversity of Mangroves of Andhra Pradesh

Floristically, the mangroves of Andhra Pradesh are moderately rich in diversity. Thirty five species of mangroves occur in the Godavari and Krishna estuaries. Of these 16 are true mangroves which require both sea water and river water. Nineteen associated species (plants that can survive both in terrestrial and estuarine conditions) occur in these wetlands, as Table 3 shows.

Table 3 Mangrove species found in Andhra Pradesh

S.No.	Plant species and Family	Telugu Name	Habit	Status
	True mangroves			
1.	*Aegiceras corniculatum* (L.) Blanto MYRSINACEAE	*Guggilam*	Tree	Abundant
2.	*Avicennia alba* Bl. AVICENNIACEAE	*Elava mada*	Tree	Common near the seaward side
3.	*A. marina* (Forsk.) Vierh. AVICENNIACEAE	*Thella mada*	Tree	Common
4.	*A. officinalis* L. AVICENNIACEAE	*Nalla mada*	Tree	Common
5.	*Bruguiera cylindrica* (L.) Bl. RHIZOPHORACEAE	*Urudu*	Tree	Common in the Gaderu river mouth
6.	*Bruguiera gymnorrhiza* (L.) Savigny RHIZOPHORACEAE	*Kandriga*	Tree	Less frequent
7.	*Ceriops decandra* (Griff.) Ding Hou RHIZOPHORACEAE	*Thogara*	Tree	Common
8.	*Excoecaria agallocha* L. EUPHORBIACEAE	*Thilla*	Tree	Common in landward side
9.	*Lumnitzera racemosa* Willd. COMBRETACEAE	*Thanduga*	Tree	Common in landward side

S.No.	Plant species and Family	Telugu Name	Habit	Status
10.	*Rhizophora apiculata* Bl. RHIZOPHORACEAE	*Ponna*	Tree	Abundant
11.	*R. mucronata* Lamk. RHIZOPHORACEAE	*Ponna*	Tree	Less common
12.	*Scyphiphora hydrophyllacea* Gaertn. f. – RUBIACEAE	*Narathanduga*	Tree	Rare and Endemic
13.	*Sonneratia alba* J. Smith SONNERATIACEAE	*Pedha Kalinga*	Tree	Rare
14.	*S. apetala* Buch. –Ham SONNERATIACEAE	*Kalinga*	Tree	Common
15.	*Xylocarpus granatum* Koen. MELIACEAE	*Senuga*	Tree	Rare – Occurs only in Krishna Mangroves
16.	*X. moluccensis* (Lamk.) M. Roem. MELIACEAE	*Senuga*	Tree	Rare
	Mangrove Associates			
17.	*Acanthus ilicifolius* L. ACANTHACEAE	*Allchi*	Shrub	Common in less saline areas
18.	*Aeluropus lagopoides* (L.) Trin POACEAE	—	Herb	
19.	*Caesalpinia crista* L. CAESALPINIACEAE	*Rakkisi*	Vine	Common in less saline areas
20.	*Clerodendrum inerme* Gaertn. VERBANACEAE	*Pisingi*	Tree	Common
21.	*Dalbergia spinosa* Roxb. FABACEAE	*Chillinga*	Shrub	Common in less saline areas
22.	*Derris trifoliata* Lour. FABACEAE	*Nalla theega*	Vine	Common in less saline areas
23. banks	*Fimbristylis ferruginea* (L.) Vahl. CYPERACEAE	—	Herb	Low saline areas near river
24.	*Hibiscus tiliaceus* L. MALVACEAE	*Attaka nara*	Tree	Common in landward side
25.	*Ipomoea pes-caprae* (L.) Sweet CONVOLVULACEAE	-	Vine	Common in sandy shores
26.	*Ipomoea tuba* L. CONVOLVULACEAE	*Thellateega*	Vine	Common in less saline areas
27.	*Myriostachya wightiana* (Nees ex.Steud) Hook. f. POACEAE	*Dhabba gaddi*	Herb	Common in less saline areas
28.	*Porteresia coarctata* (Roxb.) Tateoka POACEAE	*Yelugaddi*	Herb	Along the river mouths and accreted areas
29.	*Salicornia brachiata* Roxb. CHENOPODIACEAE	—	Herb	Common in degraded areas
30.	*Sarcolobus carinatus* Wall. ASCLEPIADACEAE	*Balaboddi theega theega*	Vine	Common
31.	*Sesuvium portulacastrum* (L.) L. AIZOACEAE	—	Herb	Common in sandy areas
32.	*Suaeda maritima* (L.) Dumort CHENOPODIACEAE	*Elakura*	Herb	Common in degraded areas
33.	*S. nudiflora* (Willd.) Moq. CHENOPODIACEAE	*Elakura*	Herb	Common in degraded areas
34.	*Tamarix troupii* Hole TAMARIACEAE	*Palivelu*	Tree	Only in Rathikalava RF
35.	*Thespesia populneoides* (Roxb.) Kostel MALVACEAE	*Ganguravi*	Tree	Common in landward side

Map 2.1 Distribution of Mangroves in Andhra Pradesh

2.2. Rivers of Andhra Pradesh

The Godavari

The Godavari is the second-largest river in India and the largest in South India, with a catchment area of 3,12,812 sq.km. The Godavari originates at Triambakam near Nasik in Maharashtra in the Western Ghats, 1,067 meters above sea level and journeys 692 km. before entering Adilabad district in Andhra Pradesh. It then flows through the districts of Nizamabad, Karimnagar, Warangal, Khammam, East Godavari and West Godavari. It is fed by number of tributaries, notably the Pranahita, the Penganga, Wardha, Waiganga, Kinnerasani, Manjira, Sabari and Indravati. The Prahanita contributes to 40% of the Godavari waters, the Indravati to 20%, the Sabari to 10% and the Manjira to 6%. Almost two-thirds of the catchment of the Godavari flows into the Bay of Bengal after traversing 1465 km. 22.62% of the catchment area lies in Andhra Pradesh.

The river flows through Eastern Ghats at Polavaram in West Godavari district. At Dowleswaram near Rajahmundry in East Godavari district, Sir Arthur Cotton constructed a barrage; in the downstream the river divides into two branches, the Gautami Godavari and Vasishta Godavari. The Vasishta Godavari again bifurcates into Vasishta and Vainateya Godavari (Map 2.3) The Godavari delta is formed in between these rivers. The barrage water is used to irrigate some 4,10,000 hectares in both East and West Godavari Districts.

Within the mangrove area, the Gautami Godavari joins the Bay of Bengal at two places, near Bhairavapalem and near Kothapalem. The Gautami Godavari is connected to the Kakinada Bay by two major canals - the Corangi canal at Yanam, and the Gaderu canal, which has its origin at Bhairavapalem. Numerous other small canals such as the Chollangi creek and the Matlapalem canal feed the mangrove areas and eventually flow into the Kakinada bay, which is very shallow (0 - 4m depth). Vast areas of mudflats emerge during low tide in the Kakinada bay.

2.3. Godavari River Basin

The Godavari Basin extends over an area of 312,812 km^2, which is nearly 9.5% of India's geographical area. The basin lies in the states of Maharashtra (152,199 km^2), Andhra Pradesh (73,201 km^2), Madhya Pradesh (65,255 km^2), Orissa (17,752 km^2) and Karnataka (4,405 km^2).

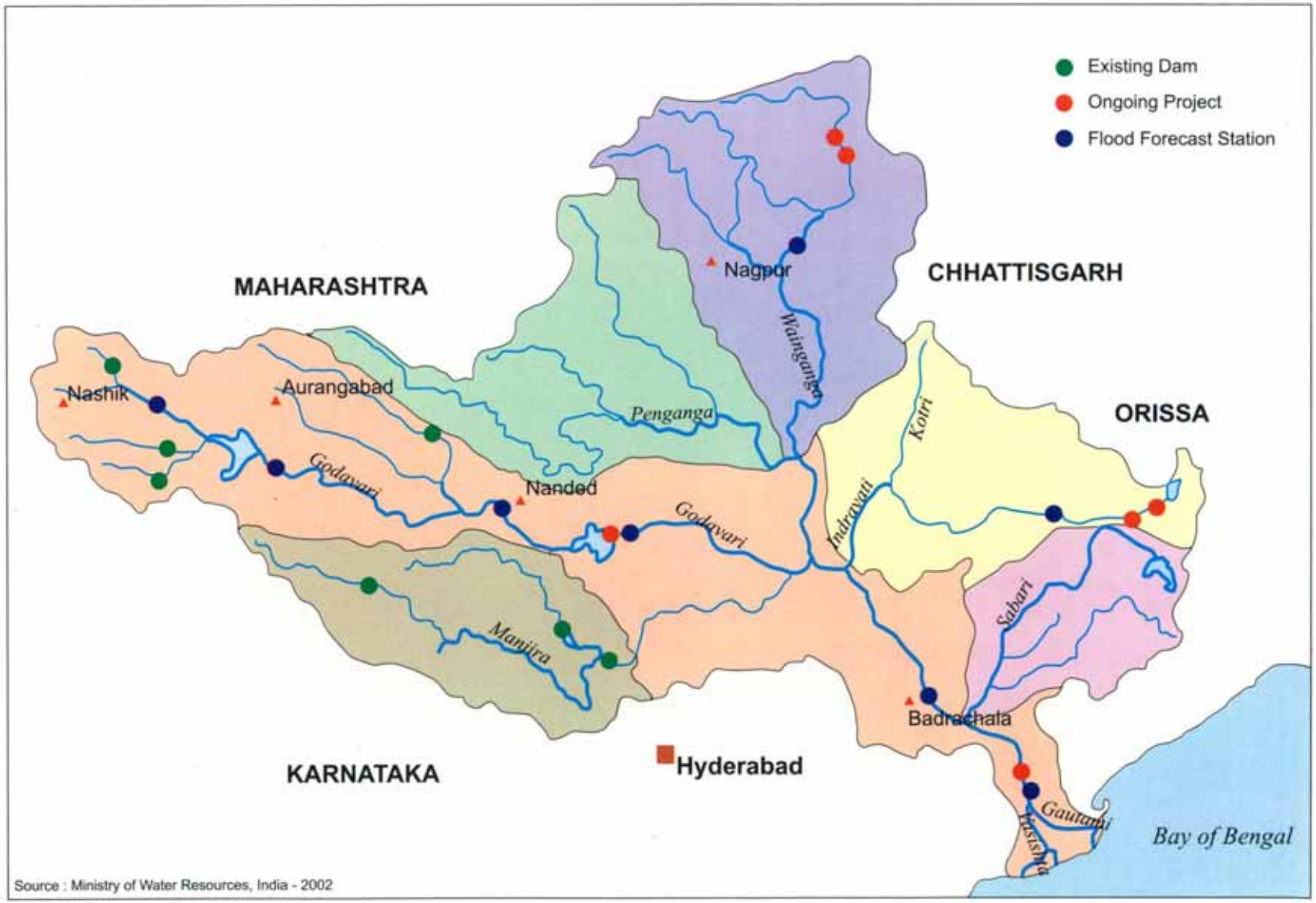
The Godavari basin consists of large undulating plains divided by low flat-topped hill ranges. The important soil types found in the basins are black soils, red soils, lateritic soils, alluvial, mixed soils and saline and alkaline soils.

The average annual surface water potential assessed in this basin is 110.5 km^3. Of this, 76.3 km^3 is usable water. The culturable area in the basin is about 18.9 million ha - 9.7% of the total culturable area in the country.

Surface water in the basin is used at present to the extent of 41.0 km^3. Live storage capacity in the basin has increased significantly since independence – from just about 1.6 km^3 in the pre-plan period, to 19.5 km^3. It would increase by over 10.6 km^3 on completing projects under construction, and by a further 8.2 km^3 if certain new projects are taken up.

Map 2.2 Rivers flowing through Andhra Pradesh

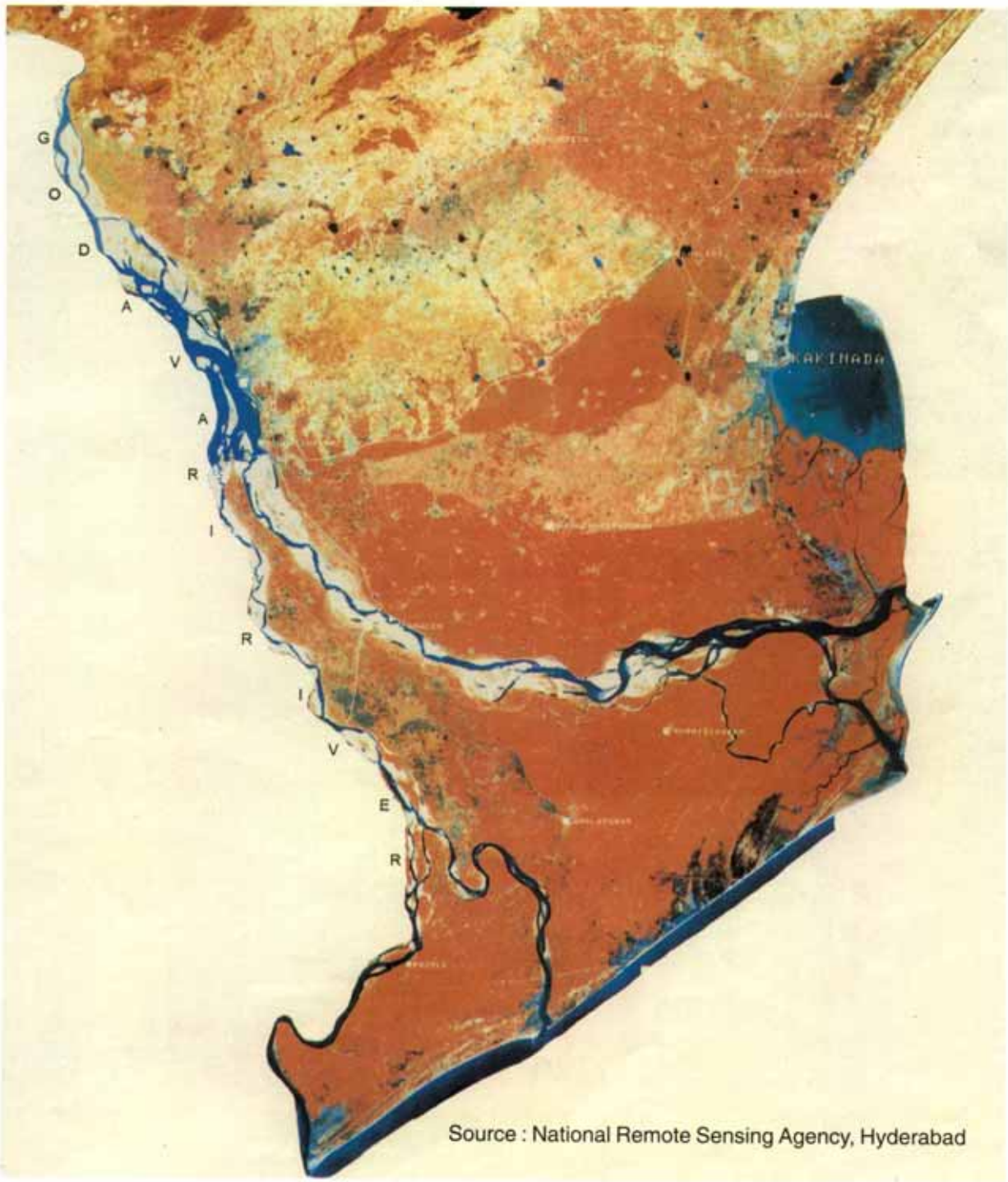
Map 2.3 Godavari River Basin



Discharge of Godavari Water into the Mangroves

Data on water discharge at the Dowleswaram barrage, obtained for the period 1969-1998, revealed that there is no significant variation in the discharge. However, monthly discharge data showed that the peak flow was during the southwest monsoon, because most of the catchment area receives rain then. The discharge starts declining during the northeast monsoon; in summer, the discharge is almost negligible.

Map 2.4 River Godavari



Source : National Remote Sensing Agency, Hyderabad

The Krishna

The Krishna is the second largest river in Andhra Pradesh. It originates from the mouth of a cow-icon in the ancient temple of Mahadev in Mahabaleshwar. From Mahableshwar into the Bay of Bengal is a 1,401 km journey. The river flows 780 km in Maharashtra before entering Andhra Pradesh. Its main tributaries are Koyna, Bhima, Ghataprabha, Mallaprabha, Tungabhadra, Yerla, Warna and Dudhganga. The river gets most of its water from the Western Ghats. The catchment area of the river is 2,58,948 sq. km, of which 29.45% is in Andhra Pradesh. The river flows through the districts of Satara, Sangli and Kohlapur in Maharashtra, Raichur and Gulbarga districts of Karnataka and Mahbubnagar, Nalgonda, Krishna and Guntur districts of Andhra Pradesh. The Krishna delta isn't as big as the Godavari delta; it bifurcates into the Nadimeru and Gollamattapaya very near the Krishna's mouth. As indicated in figure 1 average annual discharge from Krishna river is declining gradually.

2.4. Krishna River Basin

The Krishna River rises in the Western Ghats at an elevation of about 1,337 m just north of Mahabaleshwar, about 64 km from the Arabian Sea, journeys about 1,400 km before joining the Bay of Bengal.

The Krishna basin extends over an area of 258,948 km^2, nearly 8% of country's total geographical area. The basin lies in the states of Karnataka (113,271 km^2), Andhra Pradesh (76,252 km^2) and Maharashtra (69,425 km^2).

The average annual surface water potential assessed for this basin is 78.1 km^3. Of this, 58.0 km^3 is utilizable water. Culturable area in the basin is about 20.3 million ha – which constitutes 10.4% of the total cultivable area in all of India.

Surface water in the basin used at present is 50.0 km^3 in volume. Live storage capacity in the basin has increased significantly since independence. From just about 3.2 km^3 in the pre-plan period, the total live storage capacity of the completed projects has increased to 34.5 km^3. Substantial additional storage of over 4.9 km^3 would be created on completion of projects under construction. A further 0.1 km^3 of storage would become available when projects now being considered are taken up and implemented. This has resulted in considerable decrease in fresh water flowing into the mangroves. (Figure 1.)

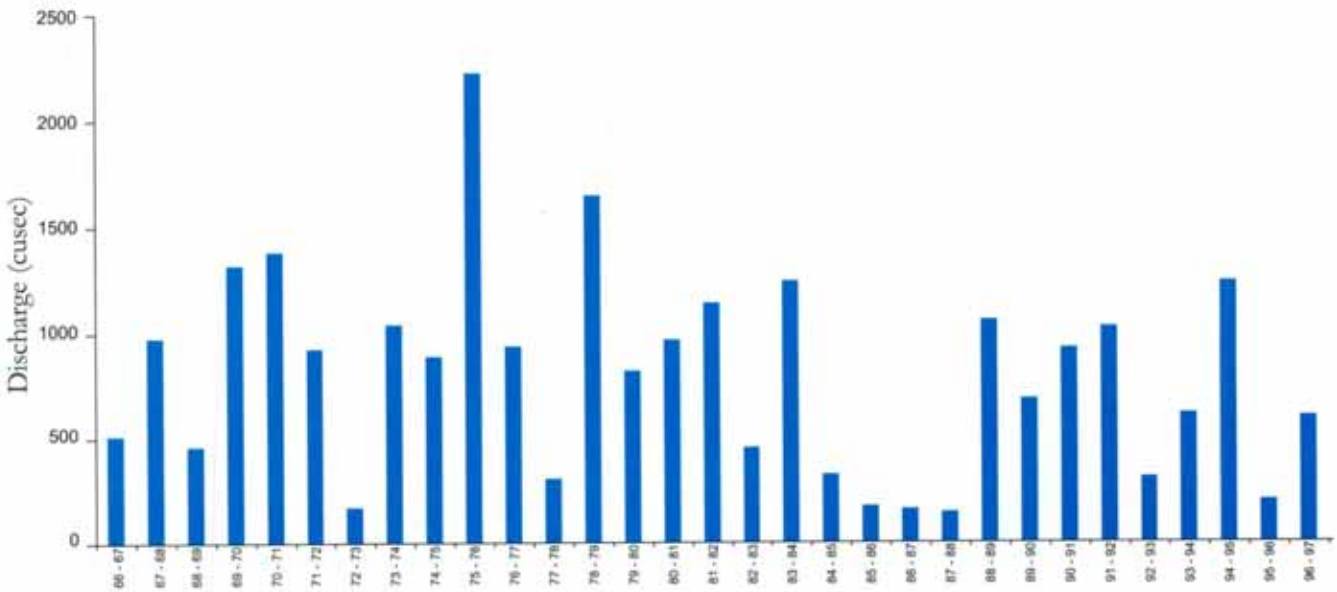
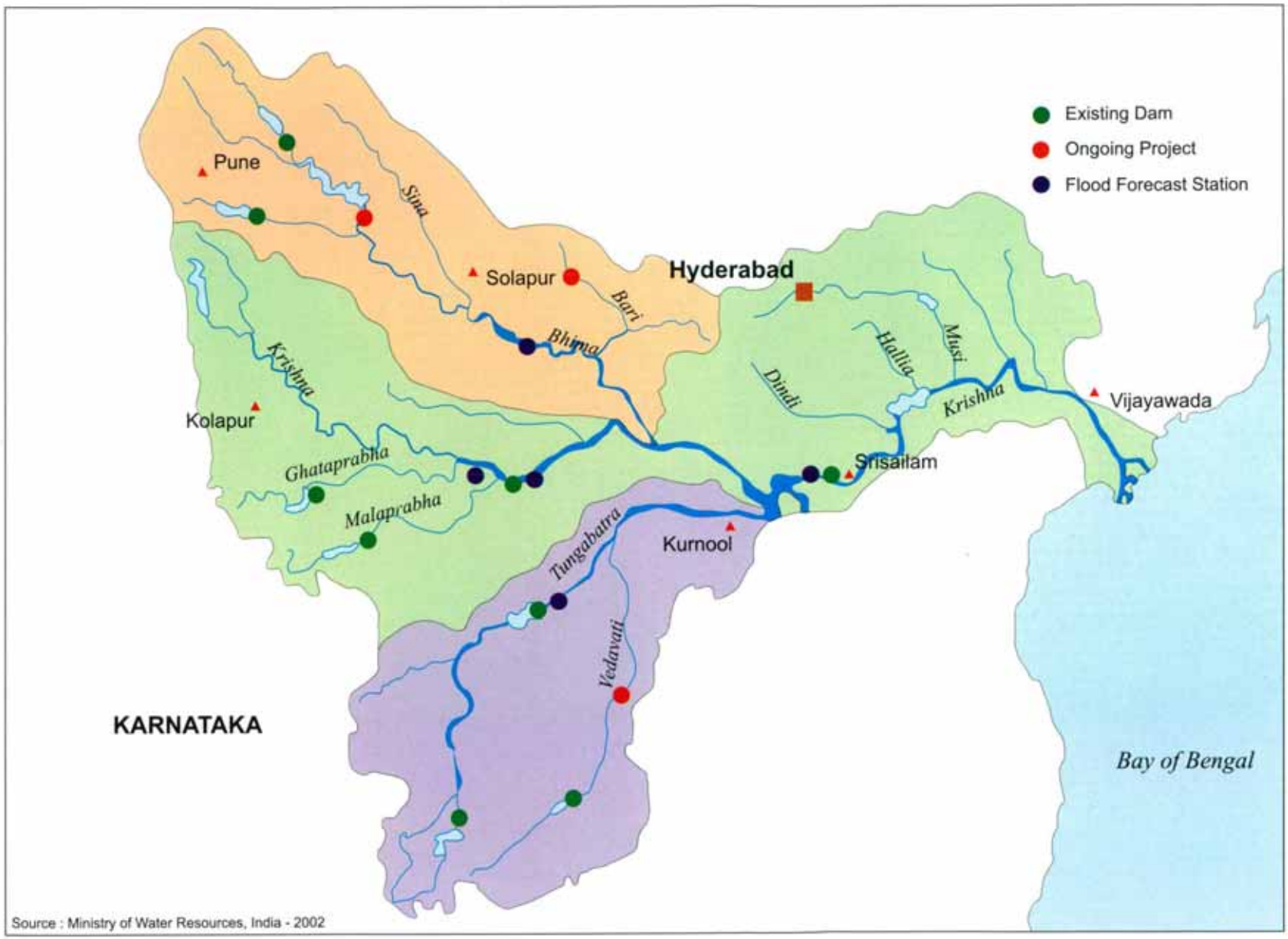


Figure 1. Average annual discharge of Krishna river at Vijayawada

Map 2.5 Krishna River Basin



Source : Ministry of Water Resources, India - 2002

Map 2.6 River Krishna

The Pennar

The Pennar, also known as Uttara Pinakini, enters Anantapur district of Andhra Pradesh after traversing 40 km from the Nandidurg hills of Mysore. Confluence into the Bay of Bengal occurs 29 km north of Nellore. The important tributaries of the Pennar are Jayamangali, Chitravati, Kunderu, Papagni, Sagileru, Cheyyuru, Boggeru and Biraperu.

The Vamsadhara

The Vamsadhara is the biggest of the river systems flowing from the Eastern Ghats into Bay of Bengal, and traverses mostly through Srikakulam district. Originating in Orissa, it runs through the Pulbani and Rayagada districts of Orissa and the Srikakulam district of Andhra Pradesh for 250 km. Its catchment area is 41,400 sq.km.

Rainfall

The rainfall in Andhra Pradesh is influenced by both the southwest and northeast monsoons. The southwest monsoon (June-September) provides the bulk of rainfall (68.5%), while the northeast monsoon of October-December accounts for 22.3%. The rest (9.2%) of the rainfall is received during winter and summer months. The influence of the southwest monsoon (602.26 mm) is predominant in coastal Andhra Pradesh; the northeast monsoon here provides 316.8 mm of rainfall. In the East Godavari district, the average total rainfall is about 1,160 mm (Figure 2). Average maximum and minimum temperatures recorded in Kakinada are 32.36° C and 24.4° C respectively.

This region has a tropical humid climate with the monsoon season commencing in June and extending up to December. The area receives a copious supply of freshwater during the southwest and northeast monsoons. Salinity during this period is very low (~5 ppt). From January, the weather is mainly dry and there is a steady progression in heat till the summer months (March to May).

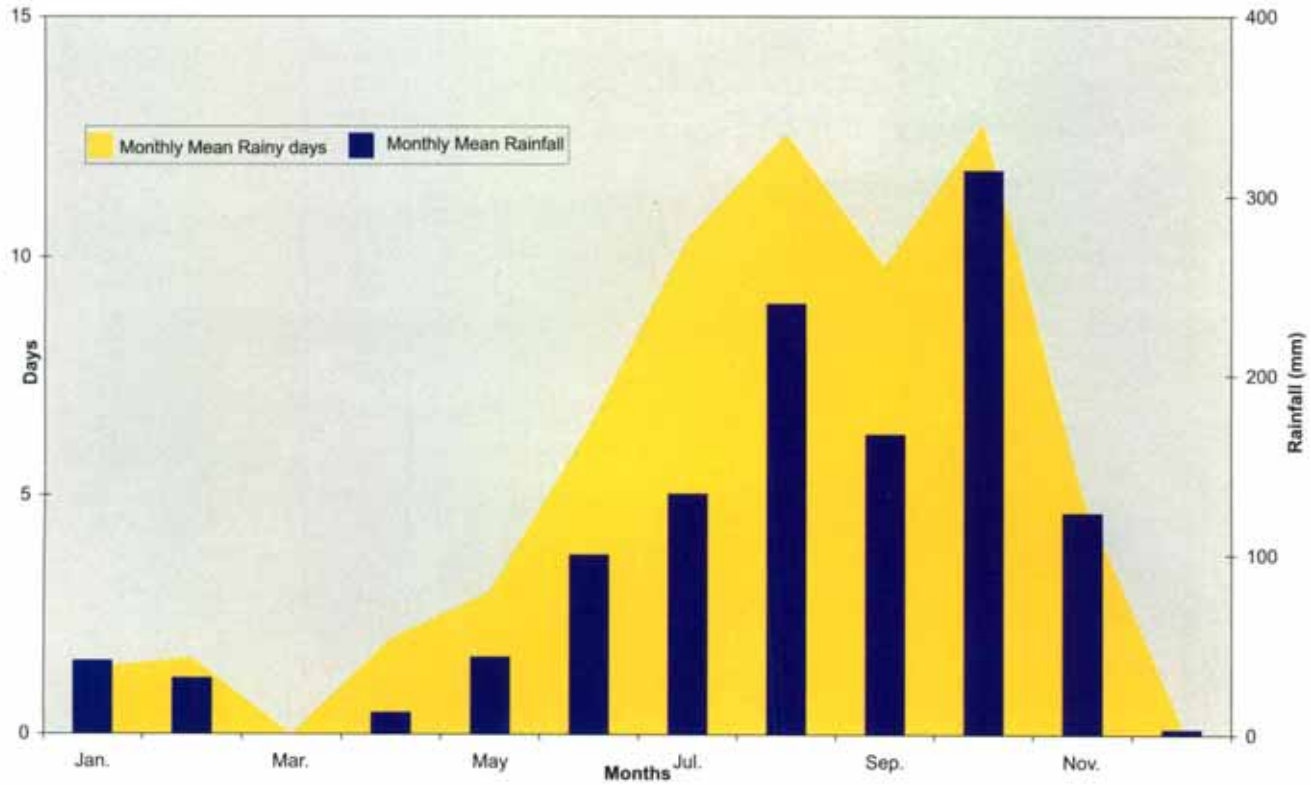
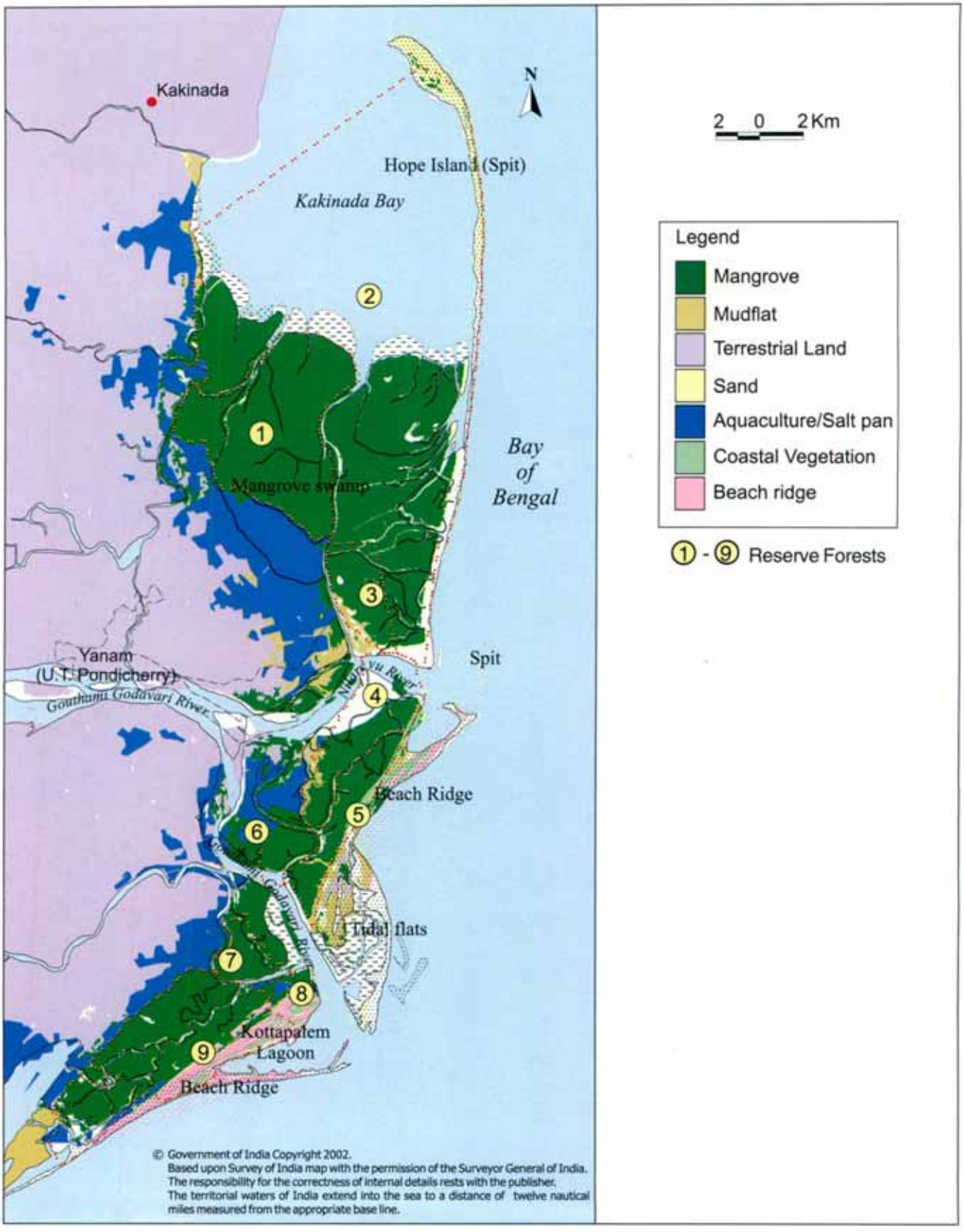


Figure 2. Rainfall (mm) and the number of rainy days in Tallarevu mandal, East Godavari district, 1998 - 2002

Map 3.1 Geomorphology



Chapter 3

Godavari Mangrove Wetland

3.1 Geomorphology

The geomorphology of the Godavari estuarine area (Map 3.1) shows the following features: rivers and channels, flood plain, natural levees, mangrove forest, tidal channels, tidal flats, lagoon, Kakinada Bay, sand spit, main land beach and sand dunes and paleo sand ridges. Natural levees of Godavari delta is well developed, which is about 500 m in wide and 2 m about the flood plain near Doweleswaram area. In the mangrove areas its width varies from 3 to 5 m and about 1 m in height. This prevents free flow of tidal water in some of the mangrove areas. The Kakinada Bay is another important geomorphological features of Godavari region, which appears to be compound and consists of estuaries adjoining lagoon. Sediments are brought into the bay are mostly silty clays and the finest and purest muds are deposited in the protected and deeper parts of the Bay. Most of the fine turbid material that has been in suspension along the flood tide is deposited on the tidal flats during the slack of high tide and these areas are suitable for colonization of new mangroves. It has been observed that rapid deposition of sediments has been taking place at the confluences of the distributaries of Godavari in general and of the Goutami in particular resulting in the formation of number of spits. Among them, the sand spit of Kakinada Bay including Hope Island is very interesting. According to the British Admiralty Chart the sand spit did not exist in 1857 but the 1878 chart shows the budding of this sand spit which has now grown to length of about 17 km with a head of about 5 km and tail of 12 km (Mishra, 1999). It protects the mangroves from ocean currents and forms a sheltered coastline. In the non-sanctuary area River water flow has decreased substantially in the Kothapalem mouth and change in the direction of the flow has led to the formation of sand bars near the river mouth.

3.2 Remote Sensing Imagery

Imagery from the Indian Remote Sensing Satellite (IRS) 1 D Linear Image Self-Scanning System (LISS) III was used to map the various land uses near the Godavari mangrove wetland.

The smooth bright red color indicates the dense mangrove forest of the delta. Density of mangrove cover is greater in the sanctuary area than in the non-sanctuary area that lies to its south. The small creeks and drainage system of the wetland can be clearly identified from remote sensing data. As we proceed toward the mainland beyond the Reserved Forest (RF) boundary, regular square or rectangular blocks in bluish gray or dark blue seen are aquaculture farms (Map 3.3) which is not practiced during 1986 (Map 3.2). A very wide spread of agricultural area is identified in red color which are identified as paddy fields and plantations. The shallow depth of the Kakinada bay is clearly seen as light blue darkens to blue in the direction of the sea. The temporal remote sensing data of the Godavari delta is used to monitor changes in the wetland. It enables the development of different thematic maps.

Map 3.2 Landsat 5 TM Remote Sensing Imagery of Godavari delta - 1986

Map 3.3 IRS 1D LISS III Remote Sensing Imagery of Godavari delta – 2001

Figure 3. Dense mangroves along Corangi river seen as bright red in Remote Sensing Imagery

3.3 Reserve Forests

The total area of the Godavari wetland, according to the Forest Department, is 316 sq.km, of which 235.7 sq. km is under the Coringa wildlife sanctuary (Management Plan - Coringa wildlife sanctuary, 1993). This sanctuary has three Reserved Forests (RF) – Corangi, Corangi Extn. and Bhairavapalem. Most mangroves in the sanctuary are not directly connected with the Bay of Bengal because of the 18 km long sand spit including the Hope Island. Tidal flushing of mangroves of the Coringa wild life sanctuary takes place through the Matlapalem *kalava* (canal), the Corangi river and the Gaderu river (the latter two rivers are distributaries of the Godavari). The other six reserve forests – Rathikalava, Masanitippa, Matlatippa, Balusutippa, Kothapalem and Kandikuppa – are situated on the southern side of the Nilarevu Godavari river (Table 4).

Table 4 Reserve forest areas in Godavari Wetland

Reserve Forest	Sanctuary area (hectare)	Non sanctuary area (hectare)
Corangi	4272	-
Corangi extension	18808	-
Bhairavapalem	1015	-
Rathikaluva	-	1762
Balusitippa	-	1300
Matlatippa	-	389
Masanitippa	-	546
Kottapalem	-	66
Kandikuppa	-	3984

Figure 4. Mangroves along Matlapalem canal

3.4 Flora of the mangrove forest

Vegetation in the Corangi RF indicates that *Avicennia marina* and *Excoecaria agallocha* are the dominant species. Along the creeks of Corangi river near Ramannapalem and Matlapalem, *Acanthus ilicifolius, Myriostachya wightiana* are seen, along with associated species like *Thespesia populneoides, Hibiscus tiliaceus* and *Clerodendrum inerme. Suaeda maritima* and *S. nudiflora* are common in degraded and partially degraded areas. In elevated areas where the soil is highly saline, the presence of *Salicornia brachiata* has been recorded, as also the presence of *Acanthus ilicifolius* and *Dalbergia spinosa* and climbers such as *Ipomoea tuba, Sarcolobus carinatus, Caesalpinia crista, and Derris trifoliata. Lumnitzera racemosa, Excoecaria agallocha* and *Avicennia marina* are found in the elevated areas. The mangrove species *Rhizophora apiculata, Xylocarpus moluccensis, Bruguiera cylindrica, Ceriops decandra* and *Bruguiera gymnorrhiza* are rarely found.

Figure 5. Mangroves along Ratikalava canal

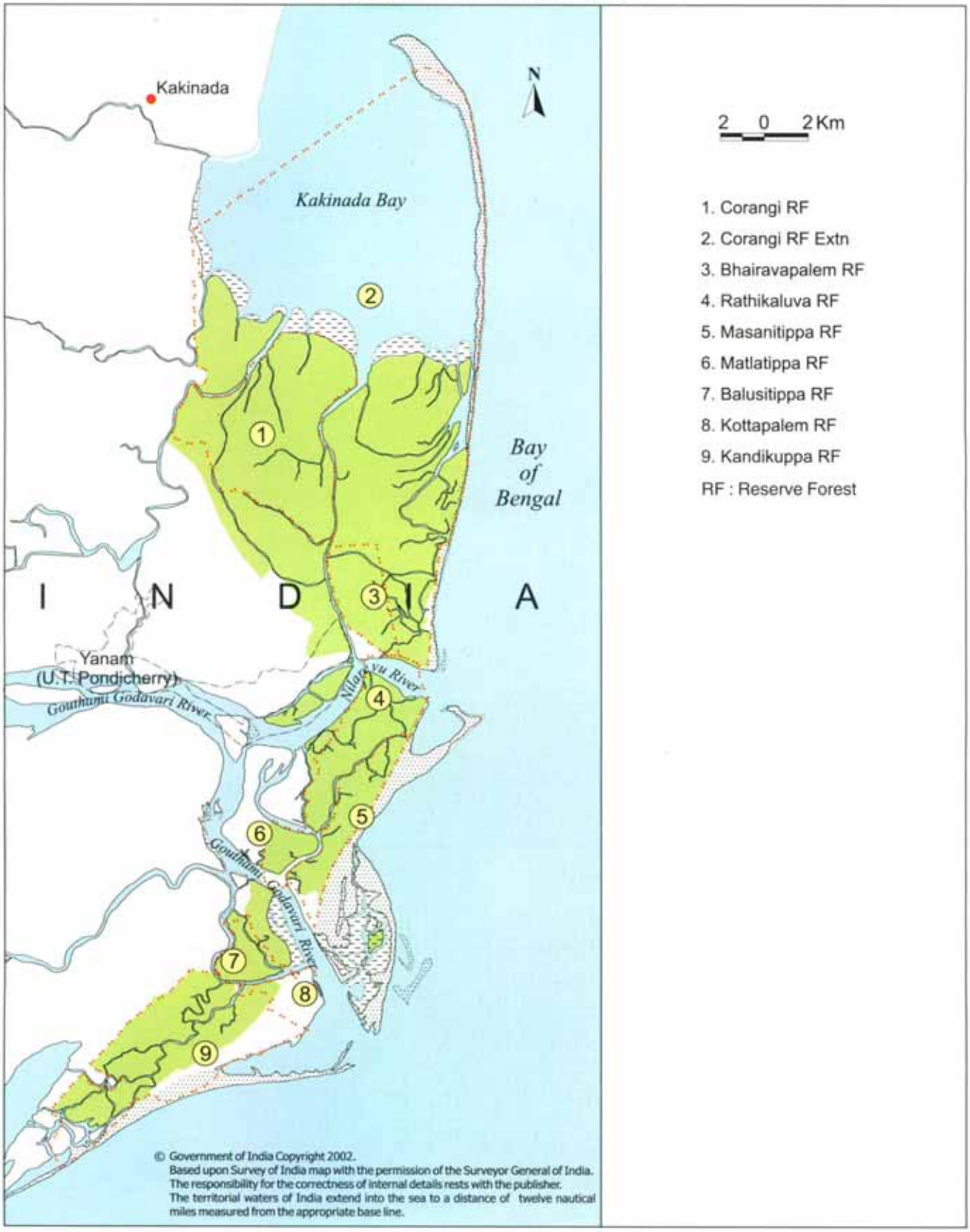
Figure 6. Dense mangroves near the Corangi river mouth

In Corangi Extension RF the areas along the Matlapalem creek and Gaderu creek are thick with vegetation. *Excoecaria agallocha* is the dominant species while *Avicennia marina* ranks next. The average height of the mangroves is about 4.5m. The zonation is not that conspicuous in the Gaderu riverside. On the eastern side of the Gaderu river, species such as *Bruguiera gymnorrhiza, B. cylindrica, Rhizophora apiculata, R. mucronata* and *Xylocarpus moluccensis* have been recorded. These species are either rare or absent in the Matlapalem canal side. *Sonneratia alba* has been recorded near the Gaderu river mouth, whereas species such as *Acanthus ilicifolius, Myriostachya wightiana,* and *Fimbristylis ferruginea* have been recorded along the creeks. *Suaeda* species and *Salicornia brachiata* have been found in degraded areas. *Sesuvium portulacastrum* is also abundant in this RF along with *Bruguiera cylindrica* near the Gaderu river.

Almost all species except *Scyphiphora hydrophyllacea* have been recorded in Bhairavapalem RF. *Excoecaria agallocha, Avicennia marina, A. officinalis, Aegiceras corniculatum* are the abundant species in this reserve forest. *Rhizophora apiculata, R. mucronata,*

Figure 7. Mangrove vegetation in Corangi RF

Map 3.4 Reserve Forest



Xylocarpus moluccensis, Sonneratia apetala, Bruguiera gymnorrhiza and *B. cylindrica* are seen along the creeks. Other species such as - *Derris trifoliata, Sarcolobus carinatus, Clerodendrum inerme* and *Dalbergia spinosa* have also been recorded. The soil of this RF is clayey near the Gaderu river, and sandy clay near the seaside. *Suaeda* spp. is noticed in degraded areas.

In Rathikalava RF *Rhizophora apiculata, R. mucronata, Xylocarpus moluccensis, Bruguiera gymnorrhiza, Avicennia marina, A. officinalis* and *Excoecaria agallocha* are the species that occur. Trees of *Rhizophora* and *Bruguiera* are seen along the creeks. *Rhizophora* trees are about 4 - 6m in height. Large trees of *Avicennia officinalis* are found in the RF. *Tamarix troupii,* a mangrove associate, is recorded in this RF along with *Thespesia populneoides. Hibiscus tiliaceus, Clerodendrum inerme, Suaeda* spp. and *Salicornia brachiata* occur in degraded areas. Also observed in degraded areas is stunted growth of *Excoecaria agallocha* and *Lumnitzera racemosa* and *Prosopis* invasion along the Saleru canal.

In Masanitippa RF tall trees about 5m in height of *Rhizophora apiculata* and *R. mucronata* are seen along the creeks. *Avicennia marina, Excoecaria agallocha* are the dominant species in this RF. *Sonneratia apetala, Bruguiera gymnorrhiza, Ceriops decandra, Lumnitzera racemosa and Bruguiera cylindrica* are also recorded in this RF. Large areas of mangroves are found to occur outside the RF on the Bay of Bengal side, which faces severe erosion due to oceanic currents and tidal action. *Prosopis* is also noticed in this area.

In Matlatippa RF fairly dense vegetation is found on the eastern side. The western side is elevated; further, there are no creeks to supply tidal water. Hence a large area on this side is degraded. The Forest Department has restored these areas. Species such as *Sonneratia apetala, Rhizophora apiculata, Bruguiera gymnorrhiza, Avicennia marina, Avicennia officinalis, Avicennia alba, Lumnitzera racemosa, Ceriops decandra* and *Xylocarpus moluccensis* have been recorded in this RF. Also recorded — climbers like *Derris trifoliata and Sarcolobus carinatus;* grasses such as *Porteresia coarctata and Myriostachya wightiana;* and shrubs like *Dalbergia spinosa* and *Acanthus ilicifolius.*

In Balusutippa RF large trees of *Avicennia officinalis* have been recorded. Some other species like *Avicennia marina, Rhizophora apiculata, R. mucronata, Bruguiera gymnorrhiza, Xylocarpus moluccensis* and *Ceriops decandra* have also been recorded. The vegetation is fairly dense in Kothapalem RF. *Scyphiphora hydrophyllacea* Gaertn. F (RUBIACEAE) a rare and endemic

Figure 8a. Aegiceras corniculatum

Figure 8b. Sonneratia apetala

Figure 8c. Excoecaria agallocha

Figure 8d. Bruguiera gymnorrhiza

species, has been recorded in this RF. Plants of the species are about two metres tall. About a hundred of them have been found near the Sacramento lighthouse. Along the entire East Coast it occurs only in this RF. *Excoecaria agallocha, Lumnitzera racemosa, Rhizophora apiculata, R. mucronata, Xylocarpus moluccensis, Bruguiera gymnorrhiza, Avicennia marina* and *A. officinalis* have also been recorded: they are about 4 - 5m in height. Climbers such as *Derris trifoliata* and *Sarcolobus carinatus* have also been recorded, as also shrubs like *Dalbergia spinosa, Clerodendrum inerme* and herbs such as *Suaeda* and *Salicornia.*

In Kandikuppa RF mangroves are notable for their health and rich diversity. True mangroves – such as *Rhizophora apiculata, R. mucronata, Bruguiera gymnorrhiza, Ceriops decandra, Xylocarpus moluccensis* — are found in the RF. *Excoecaria agallocha, Avicennia marina, Avicennia officinalis and Lumnitzera racemosa* have also been recorded in this RF.

Figure 8e. Scyphiphora hydrophyllacea – a rare mangrove

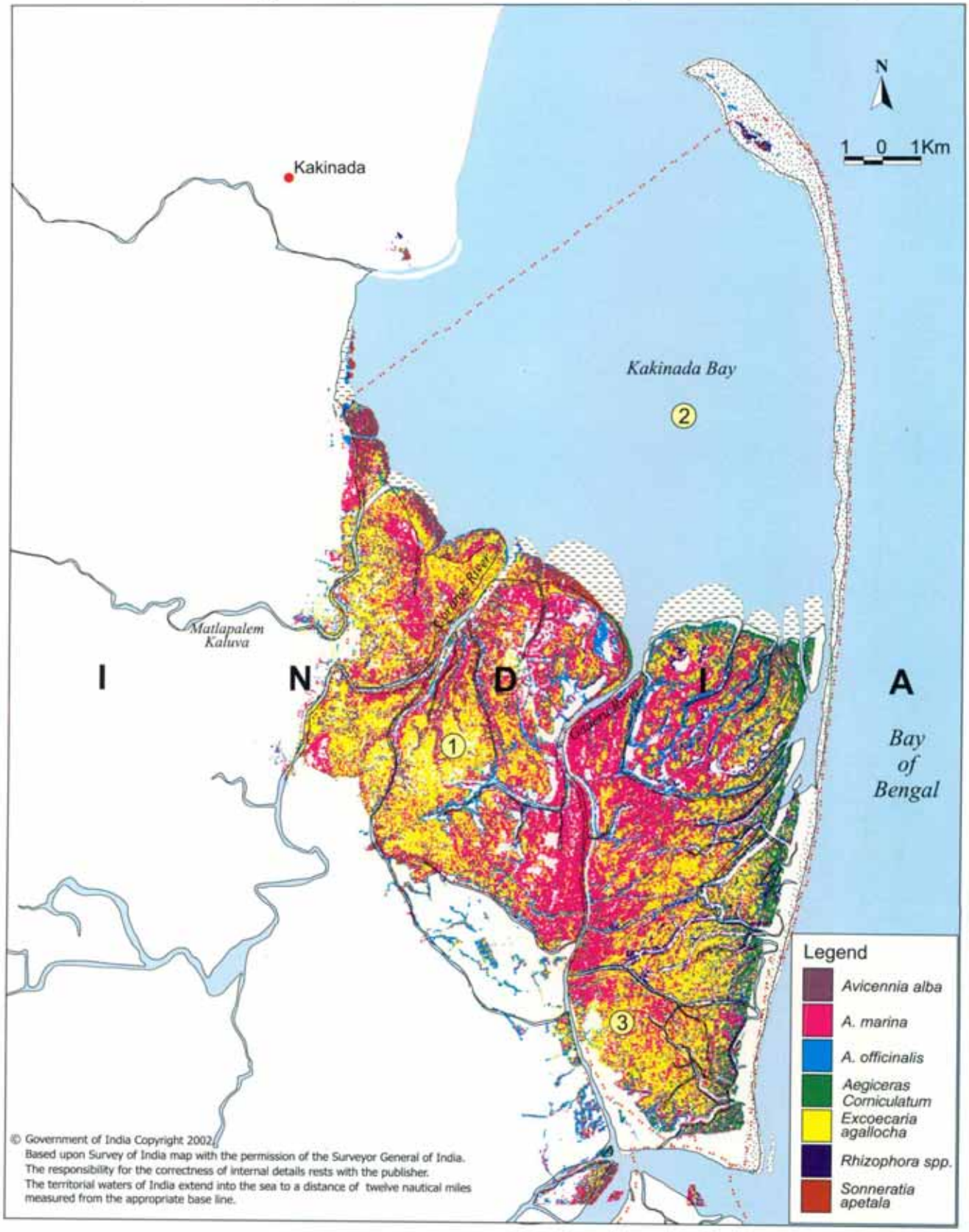
3.5 Mangrove species zonation

The vegetation near the mouth of the Corangi river and the Matlapalem kalava are distinct. *Porteresia coarctata* is found along with natural seedlings of *Avicennia alba* and *Sonneratia apetala* in the newly accreted areas (Figure 10). Pure stands of *Avicennia alba* are seen near the Kakinada Bay (Corangi river and Matlapalem kalava mouths). Next to this, towards landward, is *Sonneratia apetala.* Here onwards, the vegetation is found mixed with small patches of pure stands of *Excoecaria agallocha, Aegiceras corniculatum, Lumnitzera racemosa* and *Avicennia marina* (Map 3.5a and b). *Suaeda maritima* and *S. nudiflora* are seen in the degraded areas. *Rhizophora apiculata and R. mucronata* are found along creeks in Rathikalava RF, creeks in the Bhairavapalem RF and along creeks near the old light house in Corangi RF Extension.

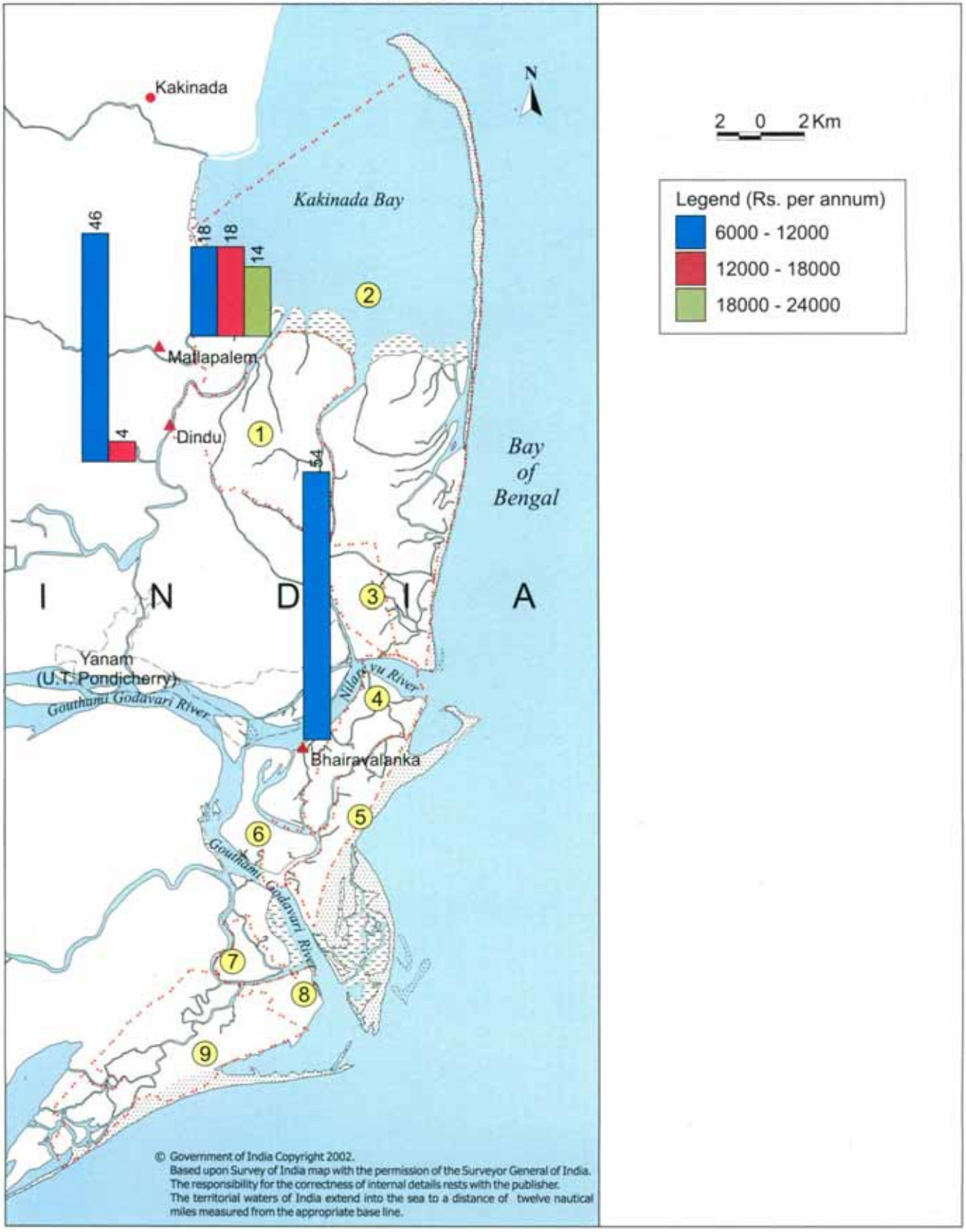
Figure 9. Mangrove zonation in Corangi RF

Figure 10. Zonation near Kakinada bay shows newly accreted mud, mudflat occupied by Porteresia coarctata and Avicennia alba

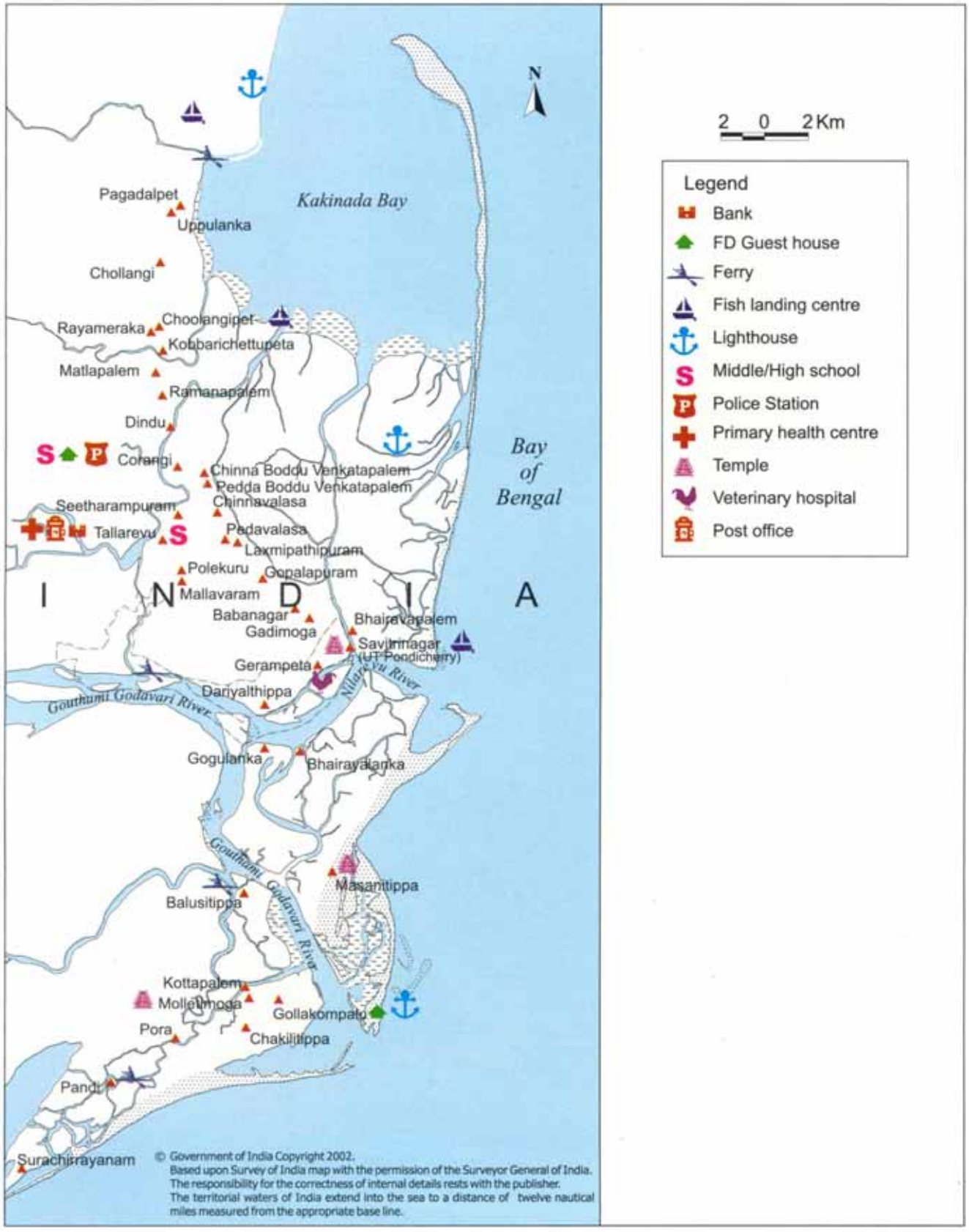
Map 3.5a Mangrove Species Zonation - Coringa Wildlife Sanctuary



Map 3.19 Income Range



Map 3.18 Infrastructure



Infrastructure

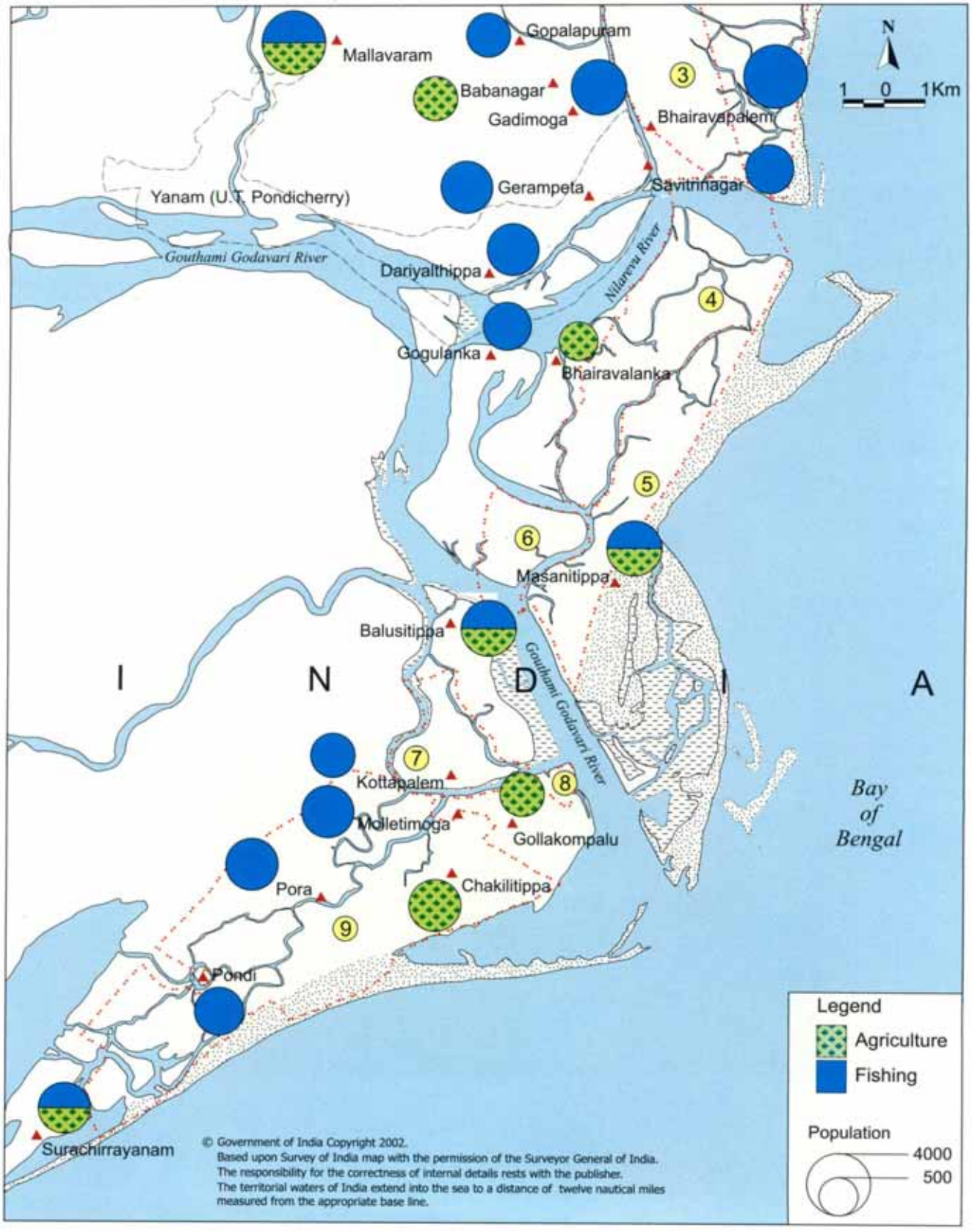
Most of the villages are well-connected by road. Almost all of them are equipped with cyclone shelters, primary schools, and post offices. Corangi has a police station, Forest Department guest house and engineering college. A high school, junior college, bank, primary health center and mandal (administrative office) are found in Tallarevu. Two lighthouses one at Kakinada and another near Kothapalem — are active, an abandoned lighthouse is found near Gaderu river mouth. An FD guest house is located in the Kandikuppa Reserved Forest near Kothapalem lighthouse (Map 3.18).

Income

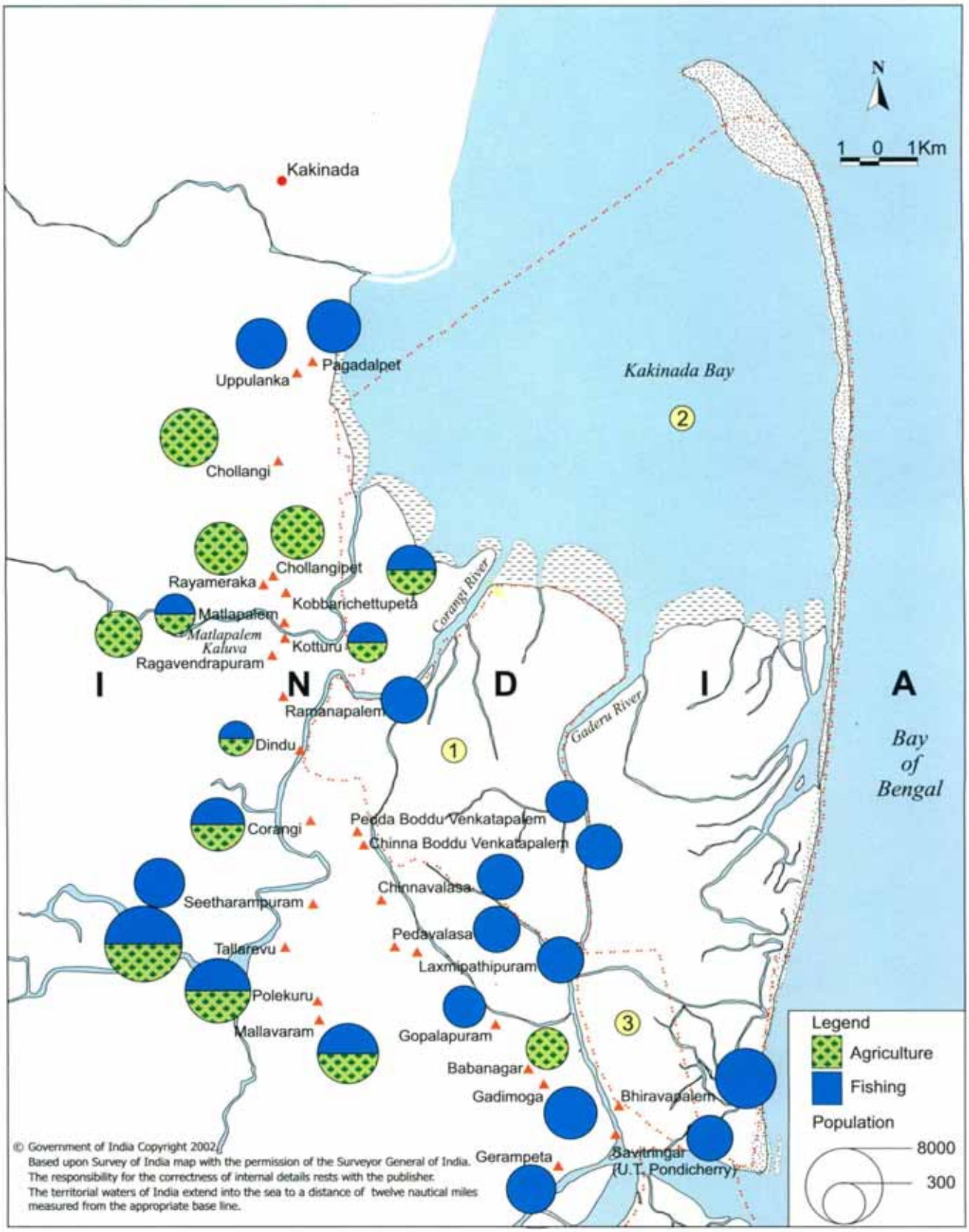
The RRA conducted in Mangrove user villages indicate in general, that incomes in the Godavari mangrove area range from Rs. 6,000 to 18,000 per year. Incomes of entire families in Bhairavalanka village range from Rs.6,000 to Rs.12,000 per year. In Matlapalem, 14 families have incomes ranging between Rs.18,000 and Rs.24, 000; 18 families earn between Rs 12,000 and Rs. 18,000 and other 18 Families earn below Rs. 12,000. In Dindu, 46 families earn between Rs.6,000 and Rs.12,000 and four families between Rs.12,000 and Rs.18,000. In Kobbarichettupeta, 79 families earn between Rs.12,000 and Rs.18,000 (Map 3.19).

Figure 17. Boat Repairing Centre – Dariyalthippa

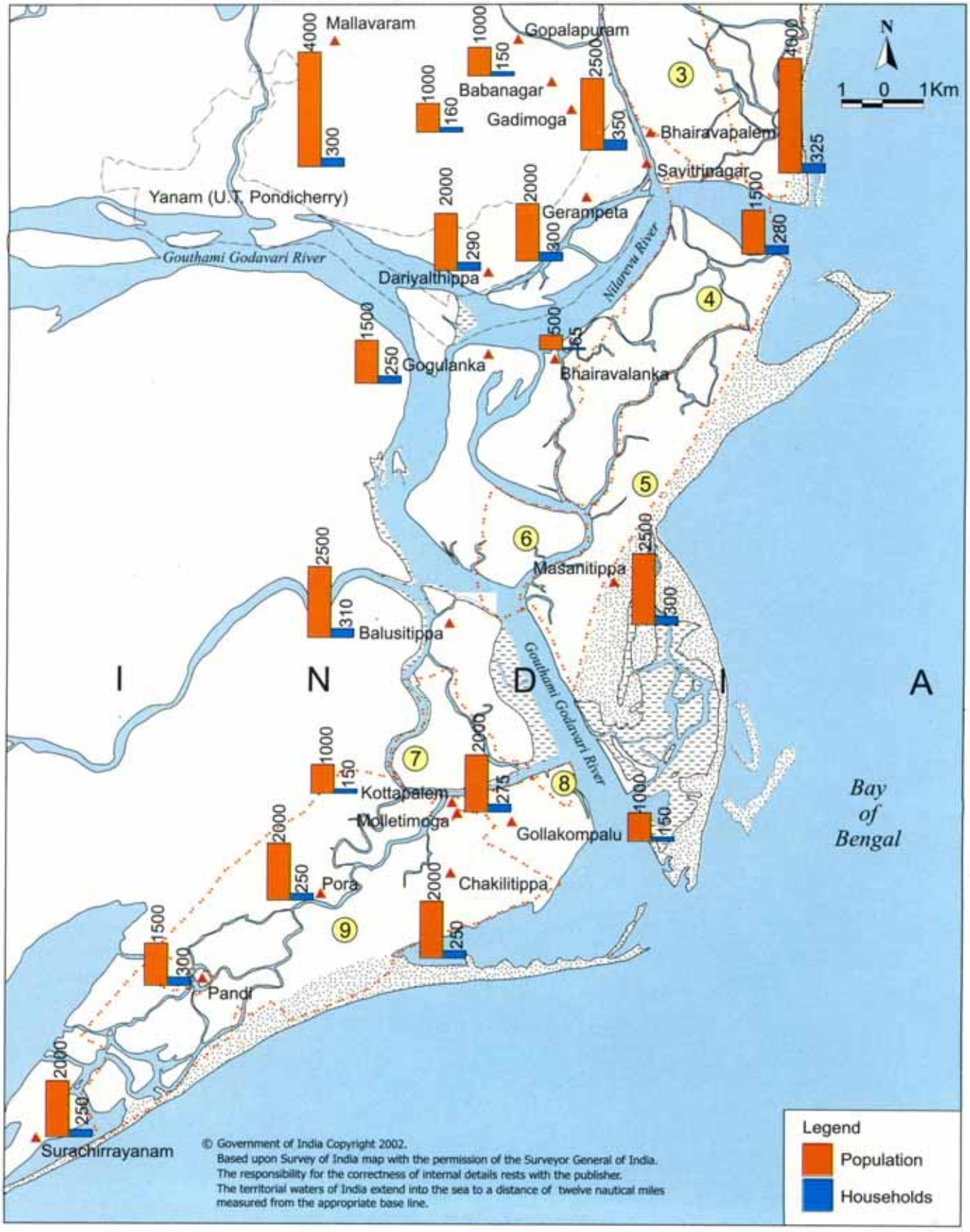
Map 3.17b Occupation- Non Sanctuary Area



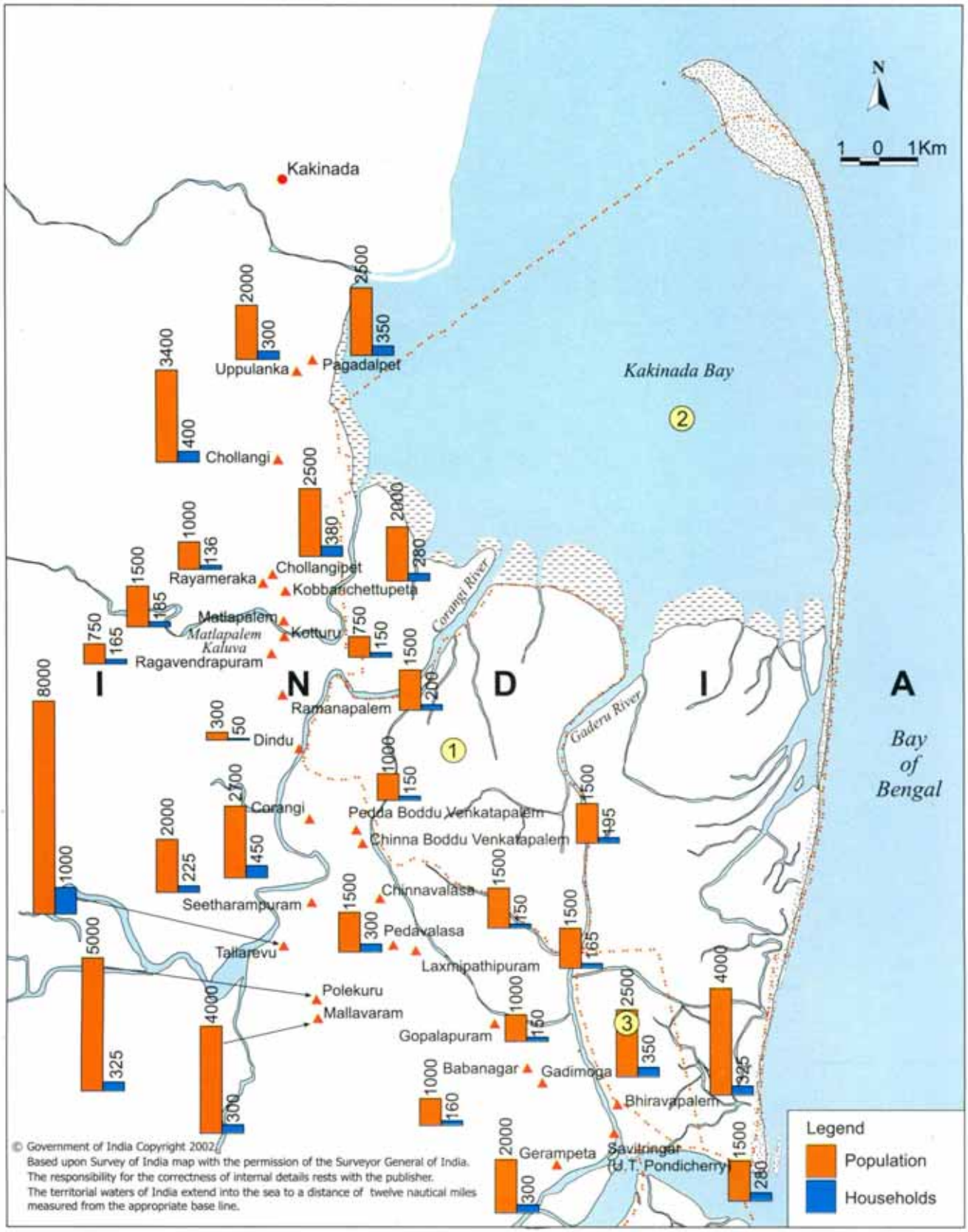
Map 3.17a Occupation - Coringa Wildlife Sanctuary



Map 3.16b Population - Non Sanctuary Area



Map 3.16a Population - Coringa Wildlife Sanctuary



Map 3.15 Mangrove User Villages

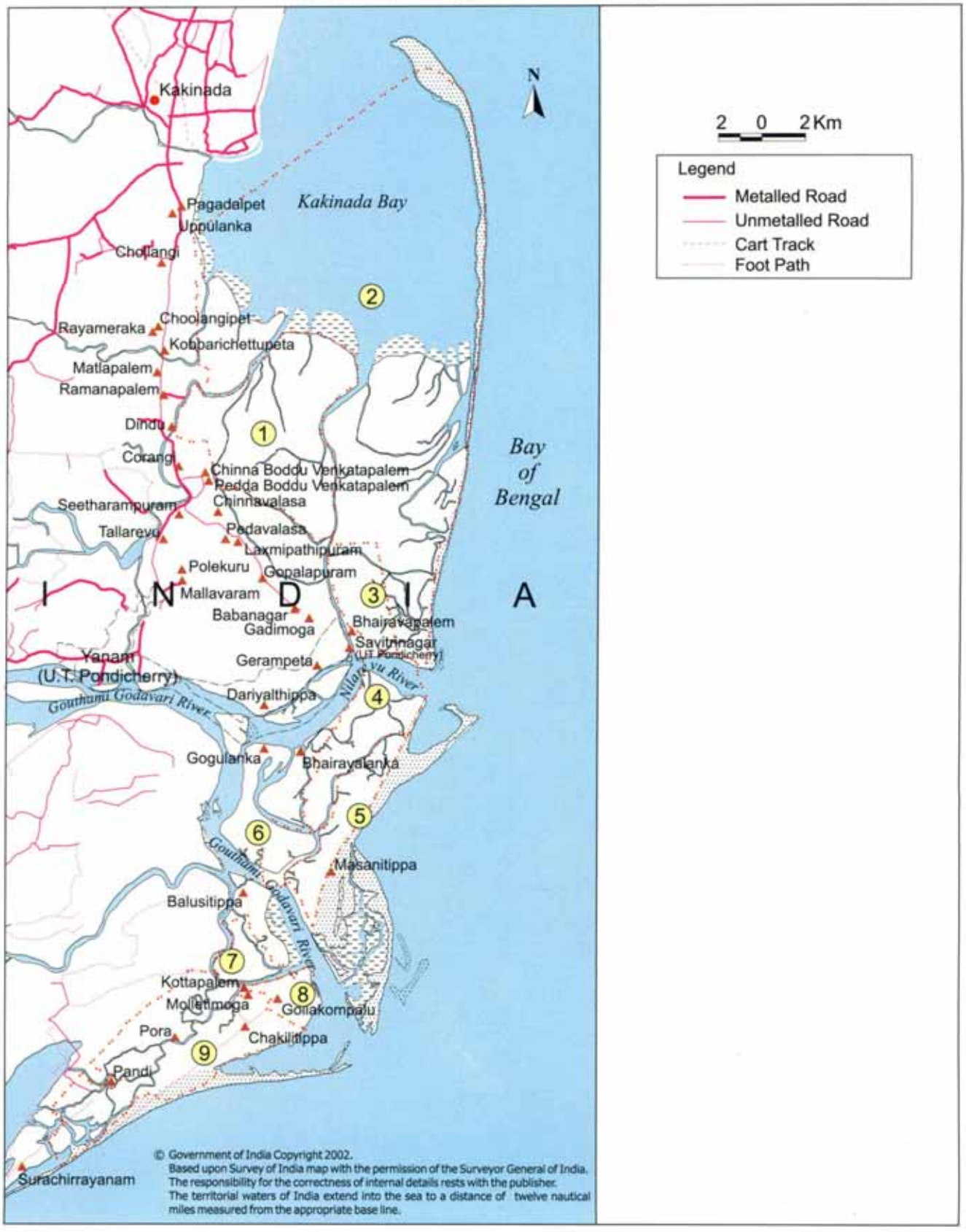


Table 6 Mangrove user villages in Godavari

Village Name	Population	House holds	Livestock	Occupation			Dependency	
				Fishing	Agriculture	Fuel	House	Grazing
Bhairavalanka	500	65	60	No	Yes	High	High	Medium
Gogullanka	1500	250	120	No	Yes	High	High	Medium
Kobbarichettupeta	2000	280	500	No	Yes	High	High	None
Matlapalem	1500	185	100	No	Yes	High	High	None
Ramannapalem	1500	200	50	Yes	No	High	High	None
Chinna Boddu Venkatayapalem	1500	195	75	Yes	No	High	High	None
Pedda Boddu Venkatayapalem	1000	150	75	Yes	No	High	High	None
Chinnavalasala	1500	150	70	Yes	No	High	High	None
Pedavalasala	1500	165	30	Yes	No	High	High	None
Gadimoga	2500	350	140	Yes	No	High	High	None
Bhairavapalem	4000	325	160	Yes	No	High	High	None
Dindu	300	50	70	Yes	Yes	High	High	None
Gopalapuram	1000	150	30	Yes	No	High	High	None
Kothapalem	1000	150	200	Yes	No	High	Low	None
Uppulanka	2000	300	30	Yes	No	High	Medium	None
Babanagar	1000	160	30	Yes	No	High	Medium	None
Chakilitippa	2000	250	100	Yes	No	High	Medium	None
Pandi	1500	300	80	Yes	No	High	Medium	None
Pora	2000	250	110	Yes	No	High	Medium	None
Pagadalapeta	2500	350	70	Yes	No	High	Medium	None
Dariyalatippa	2000	290	75	Yes	No	Low	Low	None
Gollakompalu	1000	150	380	No	Yes	Low	Medium	Low
Polekurru	5000	325	750	Yes	Yes	Low	Medium	Medium
Savitrinagar (UTPond	1500	280	75	Yes	No	Medium	High	None
Masanitippa	2500	300	75	Yes	Yes	Medium	High	None
Balusitippa	2500	310	90	Yes	Yes	Medium	High	None
Molletimogga	2000	275	60	Yes	No	Medium	High	None
Chollangi	3400	400	700	Yes	No	Medium	Low	None
Gerampeta	2000	300	40	Yes	No	Medium	Low	None
Ragavendrapuram	750	165	30	No	Yes	Medium	Low	None
Chollangipeta	2500	380	1200	No	Yes	Medium	Medium	High
Rayameraka	1000	136	400	No	Yes	Medium	Medium	High
Mallavaram	4000	300	700	Yes	Yes	Medium	Medium	High
Kotturu	750	150	40	Yes	Yes	Medium	Medium	None
Corangi	2700	450	300	Yes	Yes	Medium	Medium	None
Laxmipathipuram	1500	300	40	Yes	No	Medium	Medium	None
Surachirrayanam	2000	250	110	Yes	Yes	Medium	Medium	None
Seetharampuram	2000	225	300	Yes	No	Medium	None	Medium
Tallarevu	8000	1000	1200	Yes	Yes	Medium	None	Medium
Total	**79400**	**10261**	**8665**					

Figure 15. Fishery Resources of Mangrove Forest

Figure 16. Lime making from shells

3.9 Socio-economic condition

Mangrove user villages

The Rapid Rural Appraisal (RRA) exercise was conducted in 46 villages/hamlets, (Table 6) of which 39 villages (Map 3.15) are dependent on mangroves for fishing, firewood, fodder and timber for house construction.

Population and Occupation

A population of about 79,400 living in 39 mangrove-abutting villages uses the mangrove resources. There are 10,261 households in user villages, most of which engage in fishing (Maps 3.16a, 3.16b, 3.17a and 3.17b). The men fish, the women sell the fish. During the agriculture season, the fisherwomen serve as daily wage labourers in planting and harvesting crops.

Figure 13. Fishing Activity

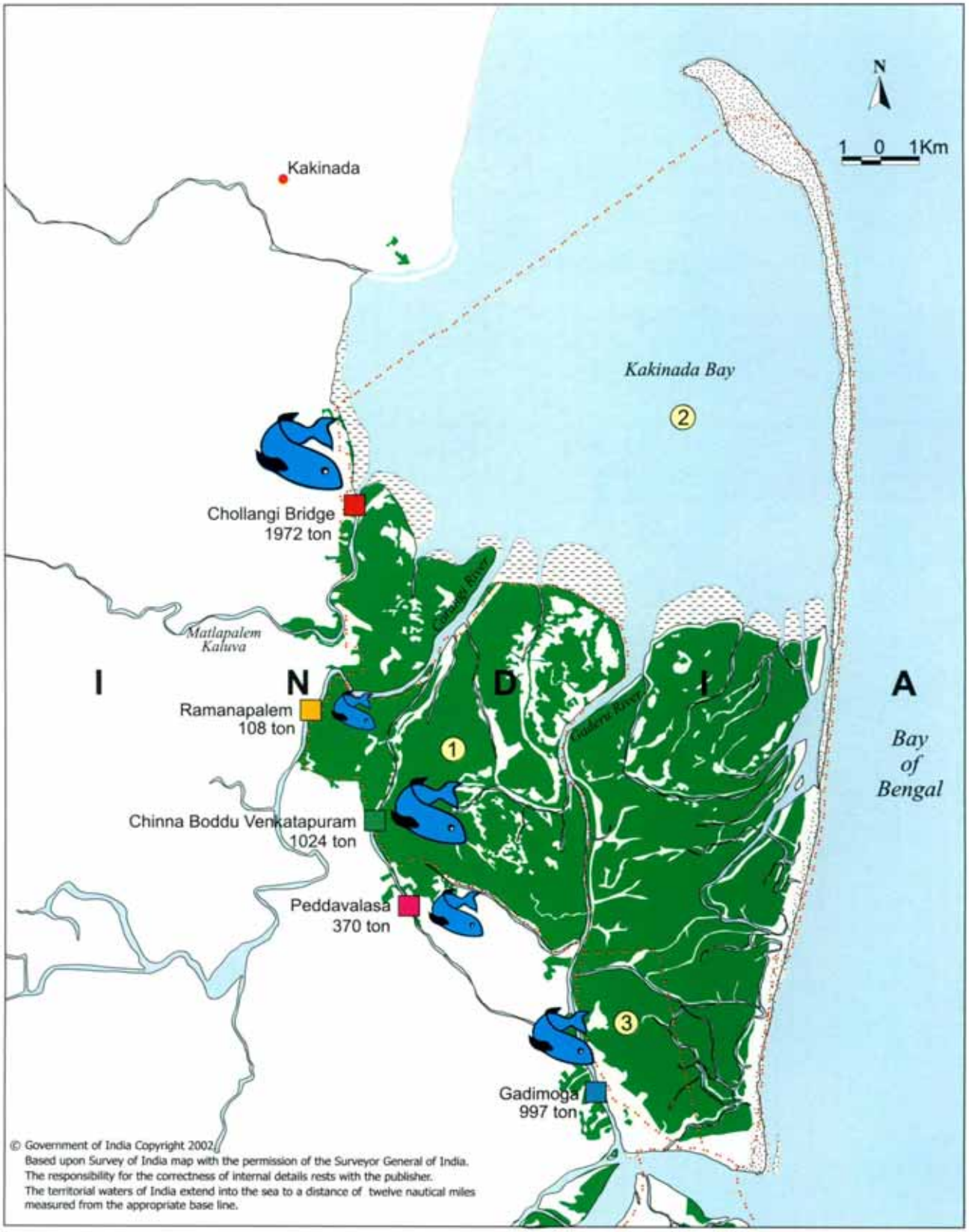
Figure 14. Fishery Resources of Mangrove Forest

Table 5 Particulars of Fishing Craft and Fish landing near Coringa Mangroves (2001 – 2002)

Village	Fish landing centre	No of boats	Fish landing in tonnes
Pagadalapeta Uppulanka Chollangipeta Matlapalem Kotturu	Cholangi bridge	582	1972.3
Ramanapalem	Ramanapalem	55	108.5
Pedda Boddu Venkatayapalem Chinna Boddu Venkatayapalem	Chinna Boddu Venkatayapalem	410	1024.15
Chinnavalasala Peddavalasala	Peddavalasala	350	370.5
Lakshmipathipuram Gadimoga	Gadimoga	210	997.1
Total		**1607**	**4472.55**

Figure 12. Collection of shells in Kakinada Bay

Map 3.14 Fishery Resources - Coringa Wildlife Sanctuary



3.8 Wood and Fishery Resources

Mangroves play an important role in coastal fisheries production. The fishermen community living in 39 villages use mangrove resources of Godavari mangroves for artisanal fishing. The mangrove areas are rich in crustacean, mollusks and finfish resources. Marine fisheries production in the East Godavarai district was 19,796 tons and 23,530 tons respectively during 1998-99 and 1999-2000 (Source: Commissioner of Fisheries, Andhra Pradesh), accounting for 36% of the total production of Andhra Pradesh. No data on fishery potential and landings from Godavarai mangroves are available.

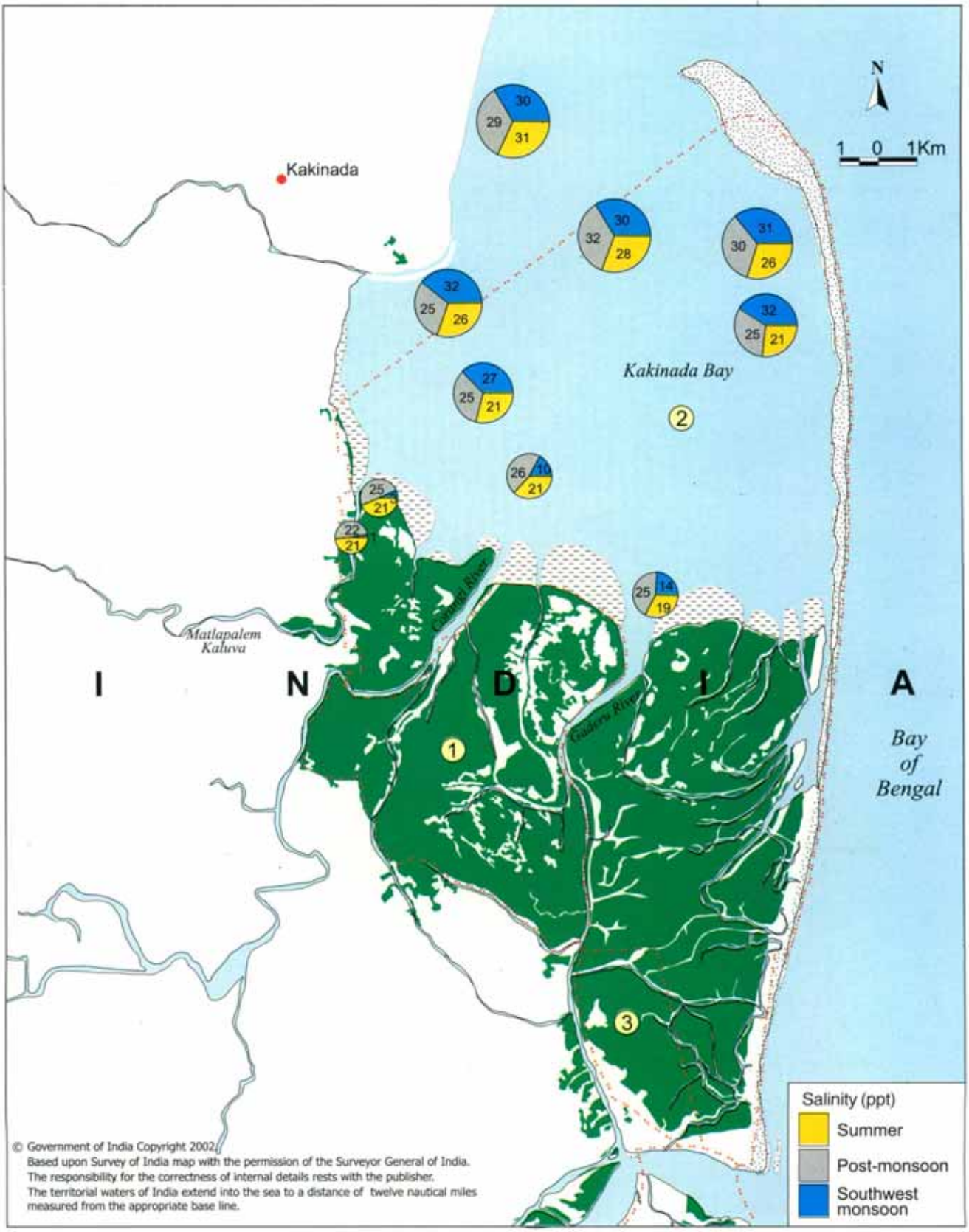
The prawn seed and juvenile resources of the Godavari mangrove ecosystem profoundly influence the artisanal fishery around Kakinada coast. But indiscriminate prawn seed collection in recent years has depleted fishery resources, leading to a ban on prawn seed collection and fishing curbs during the breeding season.

Kakinada Bay is rich in bivalve resources like *Anadara granosa, Placenta placenta* and *Meretrix meretrix* and gastropods like *Telescopium* spp. and *Cerethidium* species. Shells collected from the area are used for lime-making and are transported to Tamil Nadu for ornament-making. Crustaceans like prawns and crabs constitute a higher percentage of trawl landings at Kakinada (about 25% more) than in non-mangrove areas, where they account for between 9 and 15% (CMFRI). Five fish landing centers adjoining Coringa wildlife sanctuary account for nearly 4,472.55 tons (Table 5) of fishery resources per year (Department of Fisheries, Kakinada, 2001 - 2002) which includes catches from mangroves, Kakinada Bay and open sea.

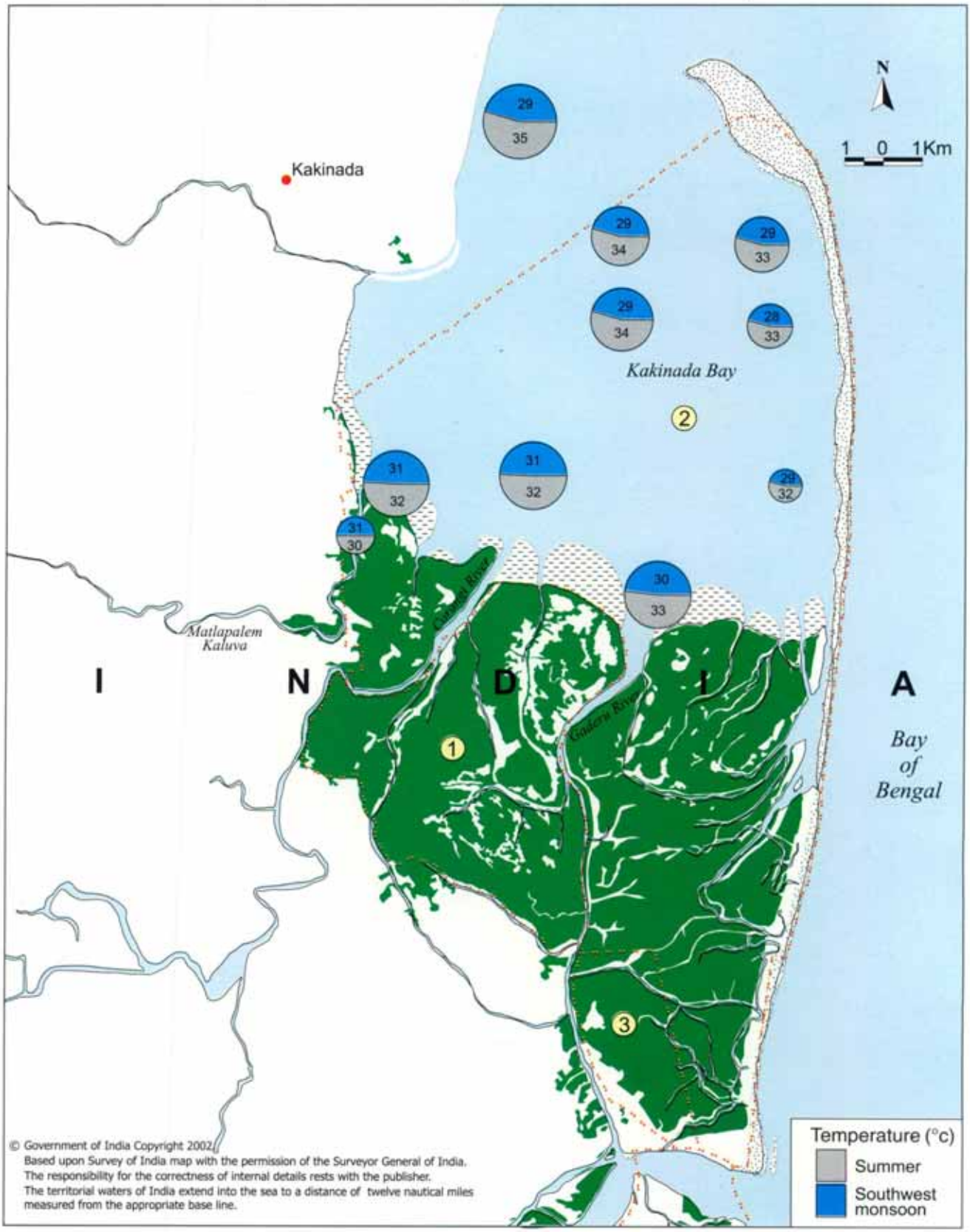
Local fishermen and the farming community depend on mangroves for firewood, fodder, fencing and timber for house construction. The *Porteresia coarctata* grass is used as fodder and the *Myriostachya wightiana* is used as thatching material. The bark of *Ceriops decandra* is used for coloring (dye) the fishing nets.

Figure 11. Myriostachya wightiana – Thatching grass

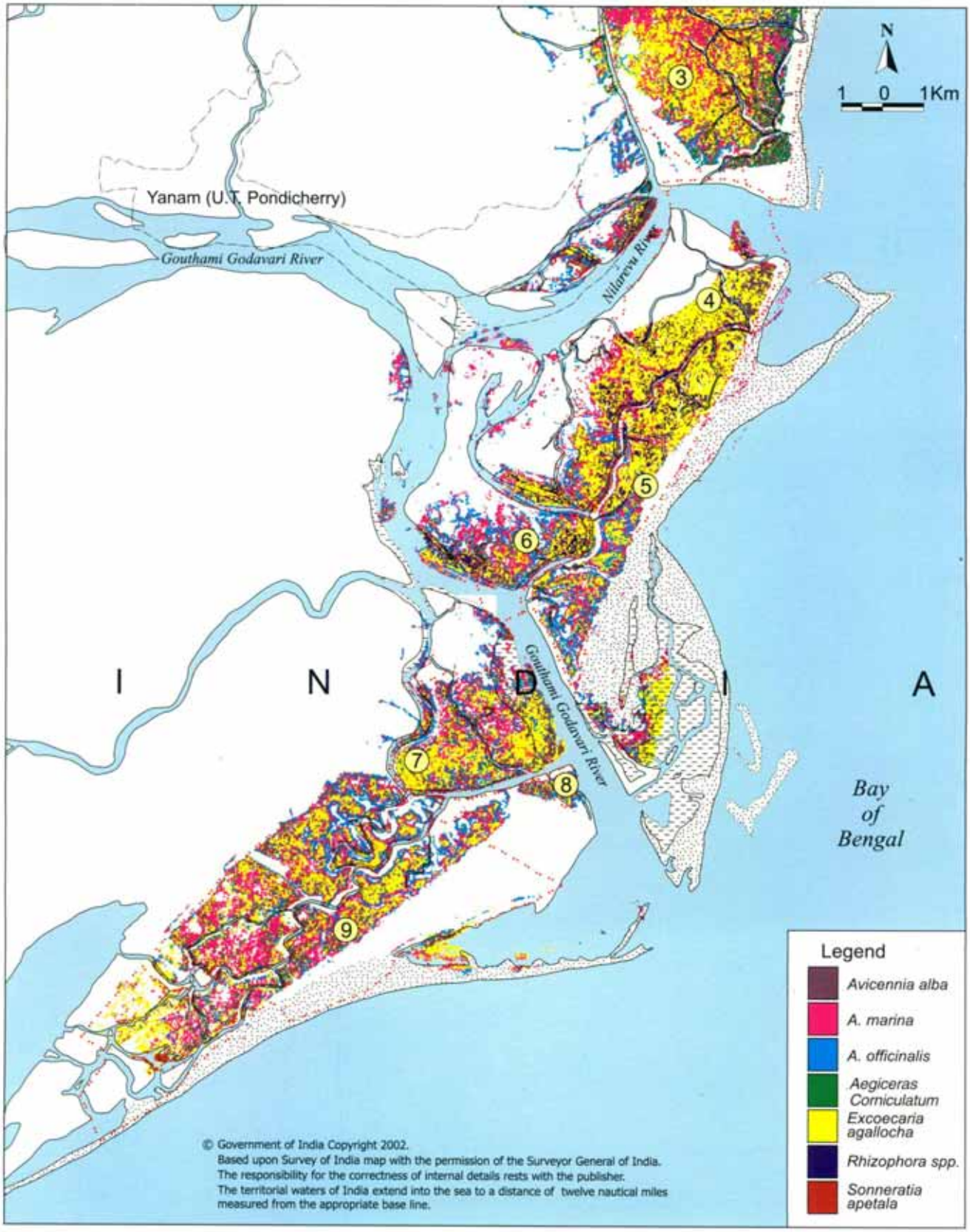
Map 3.13 Water Salinity in Kakinada Bay



Map 3.12 Water Temperature in Kakinada Bay



Map 3.5b Mangrove Species Zonation - Non Sanctuary Area



3.6 Soil Properties

Surface soil samples were collected from the mangroves and analysed for soil texture, nutrient status, soil salinity and pH. Soil collected inside the mangroves are predominantly clayey, whereas samples collected from near the shore area showed higher per-centage of sand and thus, can be classified as sandy-clay. The soil composition tests carried out by Uma Maheswara Rao et al. (1988) during 1985 showed values ranging from— 1 to18% sand, 7 to 63% silt and 15 to 90% clay.

The pH of the soil is alkaline, between 8 and 8.8. Organic matter is low in degraded areas and in creeks. In dense mangrove areas, the mean organic matter value is 2.71% (Uma Maheswara Rao et al., 1988). Similarly, in the study conducted by MSSRF, the organic carbon varied from "low" in degraded areas to "high" in dense mangrove areas. The phosphorus content is relatively low, while potassium levels are high.

3.7 Hydrological conditions

Tidal amplitude

Tidal variation in the Godavari mangroves was analyzed in two places, near Bhairavalanka and in Corangi river near Ramanapalem, for both monsoon and summer months. Near Bhairalanka it showed a maximum value of 0.80 m during the monsoon season and 0.50 cm during the summer period. In the interior mangroves, the tidal amplitude varied from 1.00 to 1.30 m during the summer and 0.20 m to 0.50 m during the monsoon season.

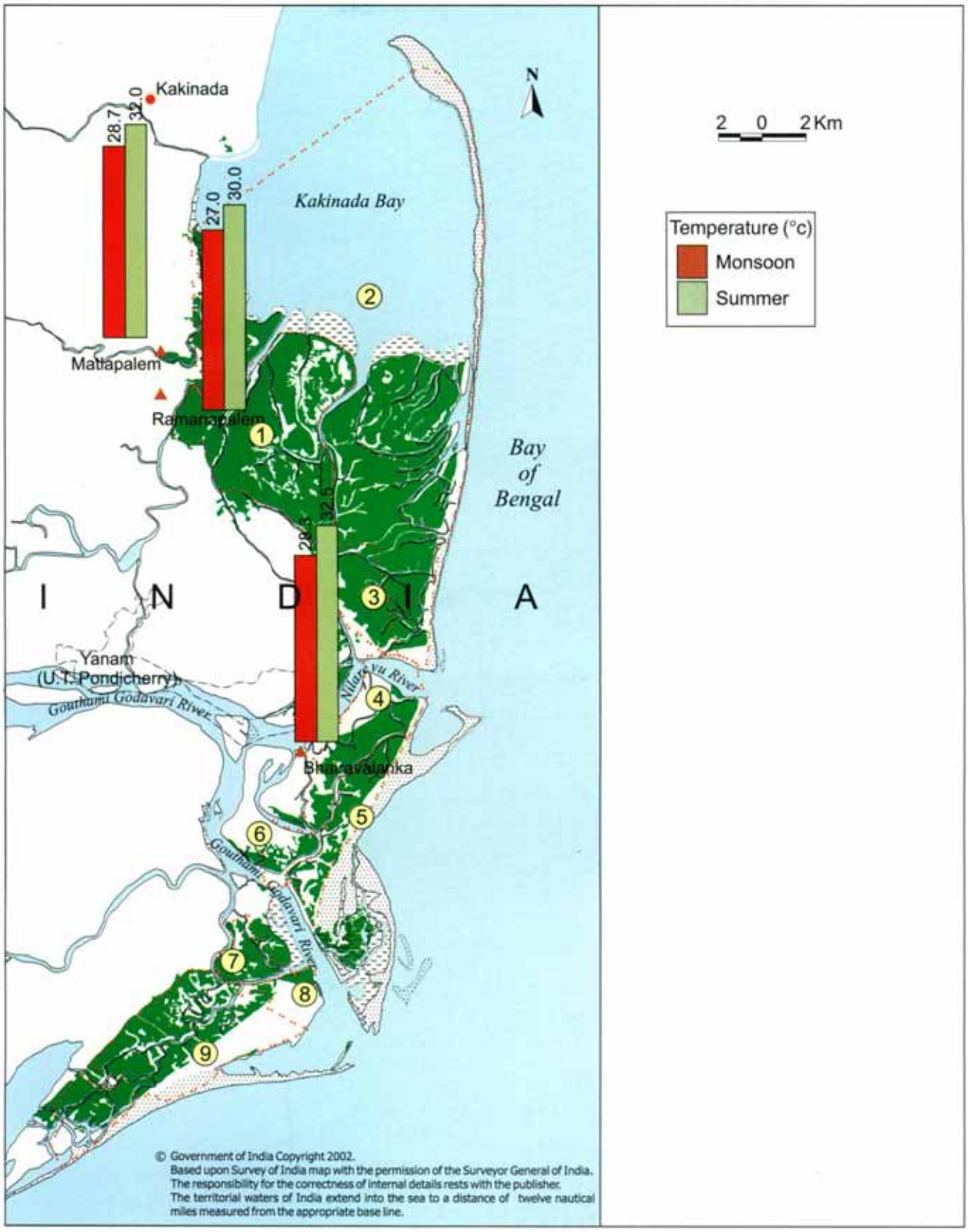
Salinity and Temperature

Variations in salinity and temperature were studied with an *in situ* salinity-temperature probe for over a period of 24 hours in the Saleru creek, near the Bhairavalanka during December, February and May. The salinity varied between 6 and 8 ppt (parts per thousand or grams per litre) during December, indicating the predominance of fresh water flow in the creek. Salinity in February varied from 26 to 30.5 ppt and from 21 to 29 ppt in May.

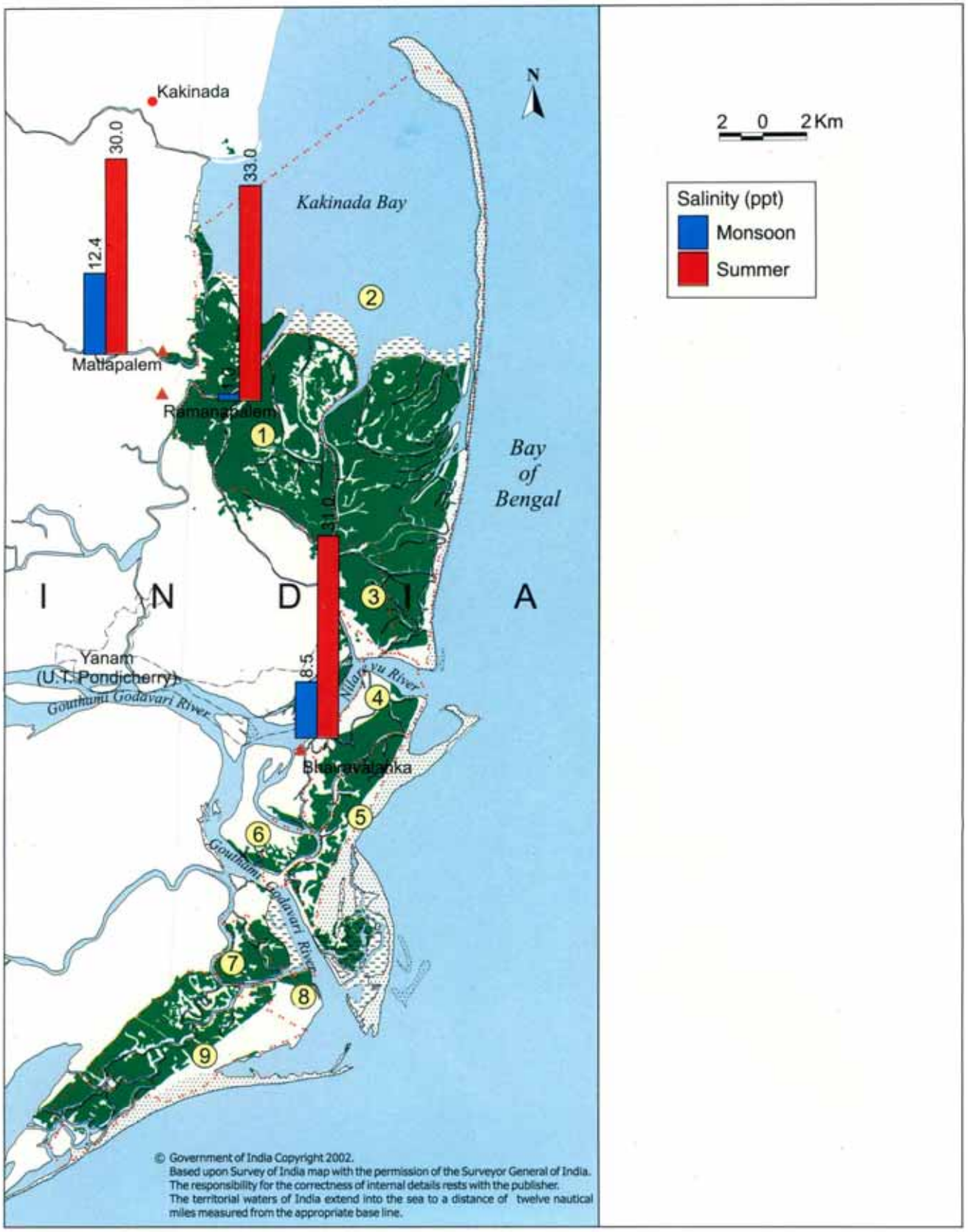
Salinity variations in Kakinada Bay were studied during May and August. Salinity during August varied from 11.7 ppt near the mangroves in the Kakinada Bay to 33.4 ppt near Hope Island. The salinity near the mouths of Corangi and Gaderu rivers is considerably low, only 9.5 ppt and 11.7 ppt respectively. This clearly indicated that Matlapalem canal, Corangi and Gaderu rivers discharge a considerable amount of fresh water into the Kakinada Bay. In the Matlapalem canal, salinity was between 1 and 3 ppt. The salinity ranged from 17 to 31 ppt., indicating that the Matlapalem creek receives fresh water even during during May. In Kakinada Bay the salinity varied between 19 and 31.3 ppt during May.

Temperature in December varied from 26 to 28°C in the creek and from 24 to 28.5 °C in February and in May, temperature varied from 30 to 32.5 °C. Temperature variations in the bay was between 28 and 31° C. Salinity in summer (May) varied from 19 ppt to 31.3 ppt. In Matlapalem creek, temperature during May varied from 27 to 36 °C. The wide variations in salinity and temperature indicated mixing of fresh water with seawater near the Matlapalem kalava.

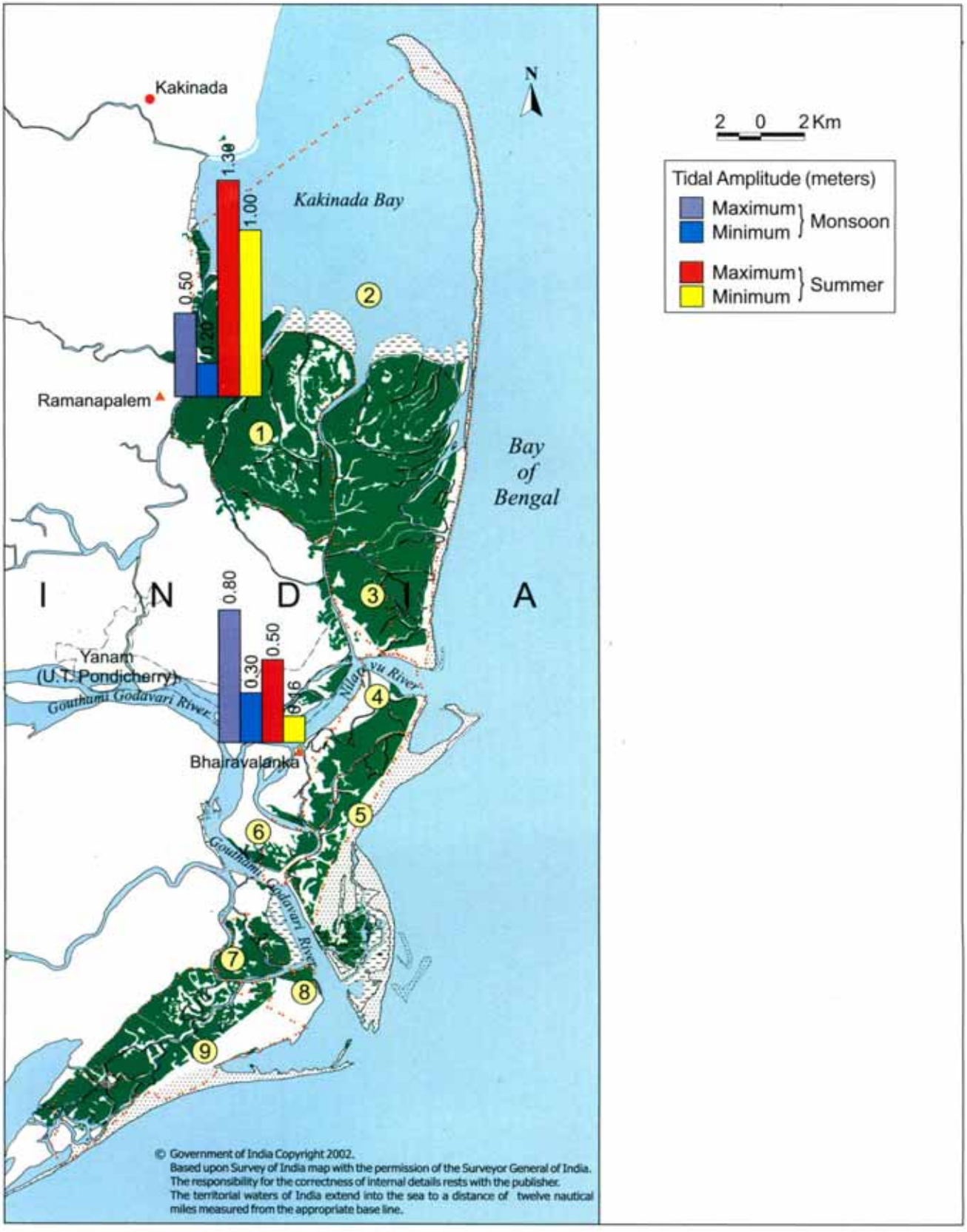
Map 3.11 Water Temperature



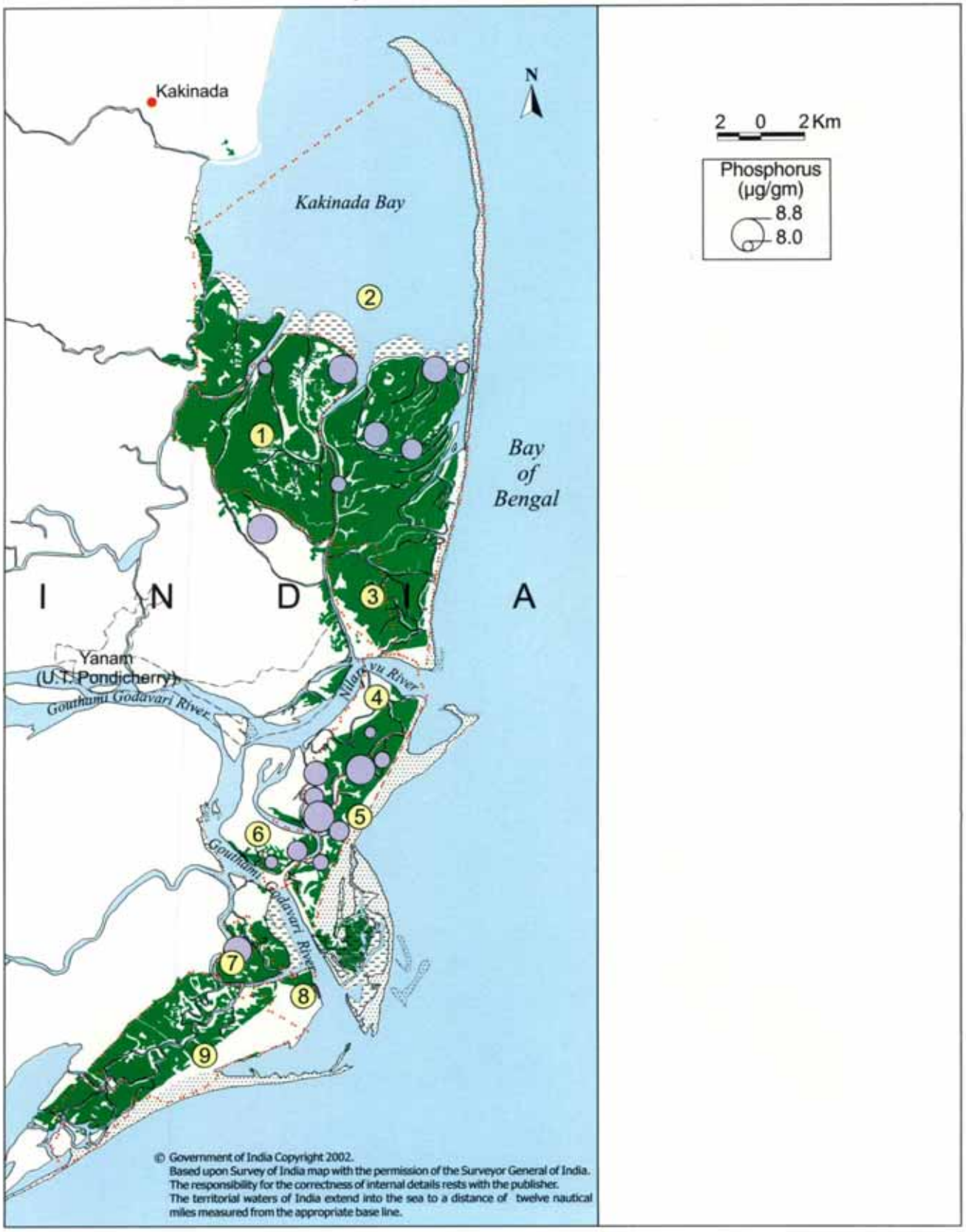
Map 3.10 Water Salinity



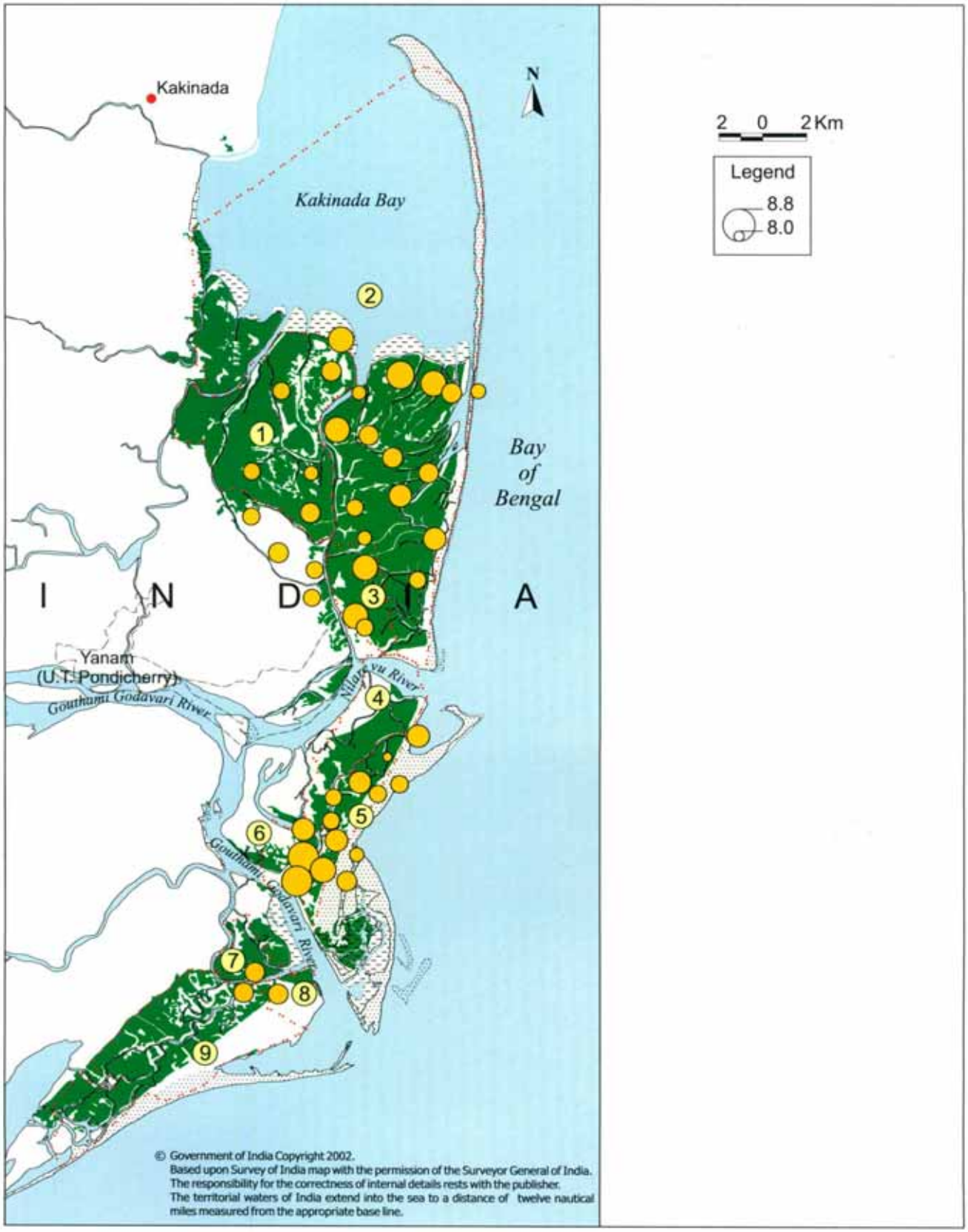
Map 3.9 Tidal Amplitude



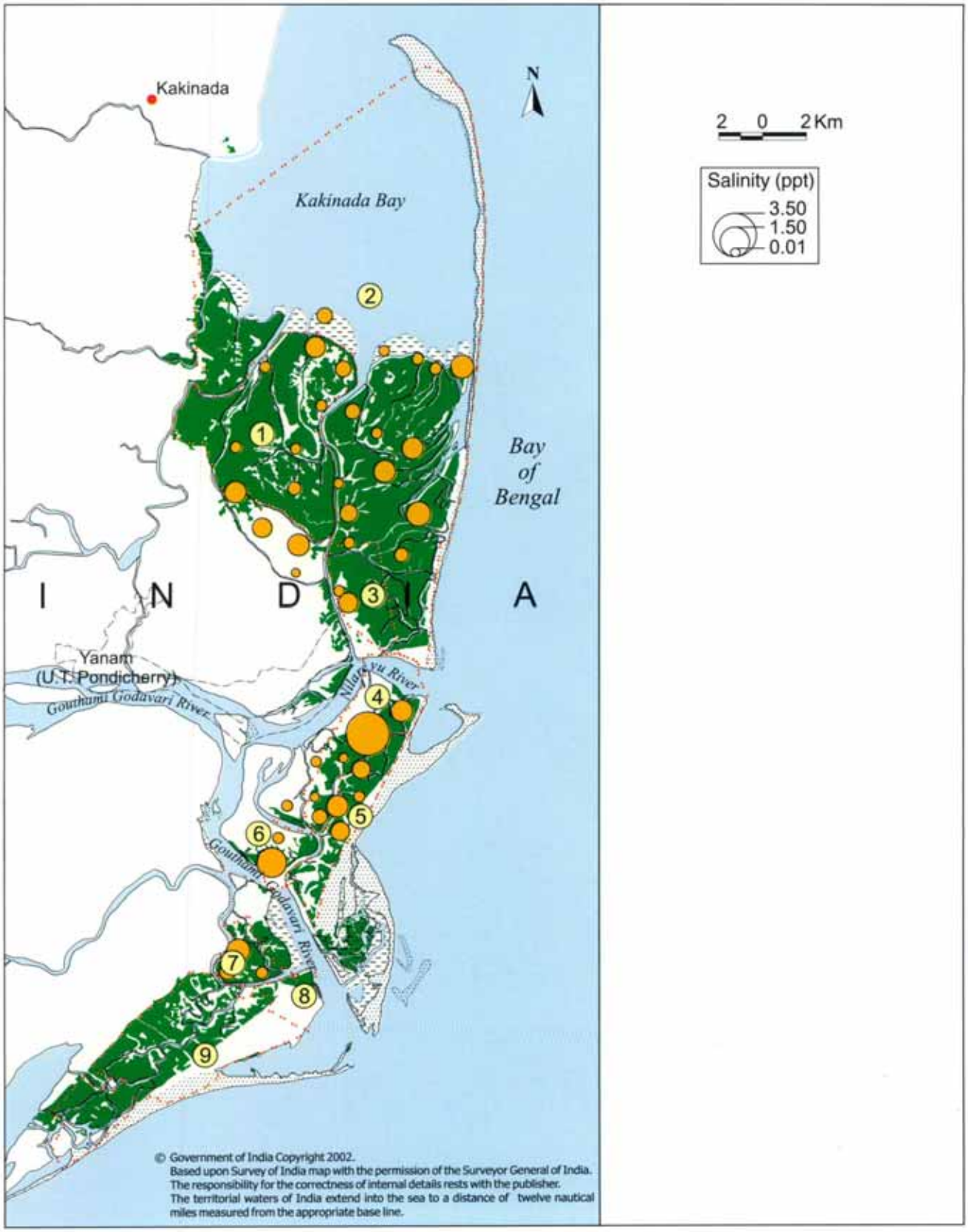
Map 3.8 Soil Phosphorus



Map 3.7 Soil pH



Map 3.6 Soil Salinity

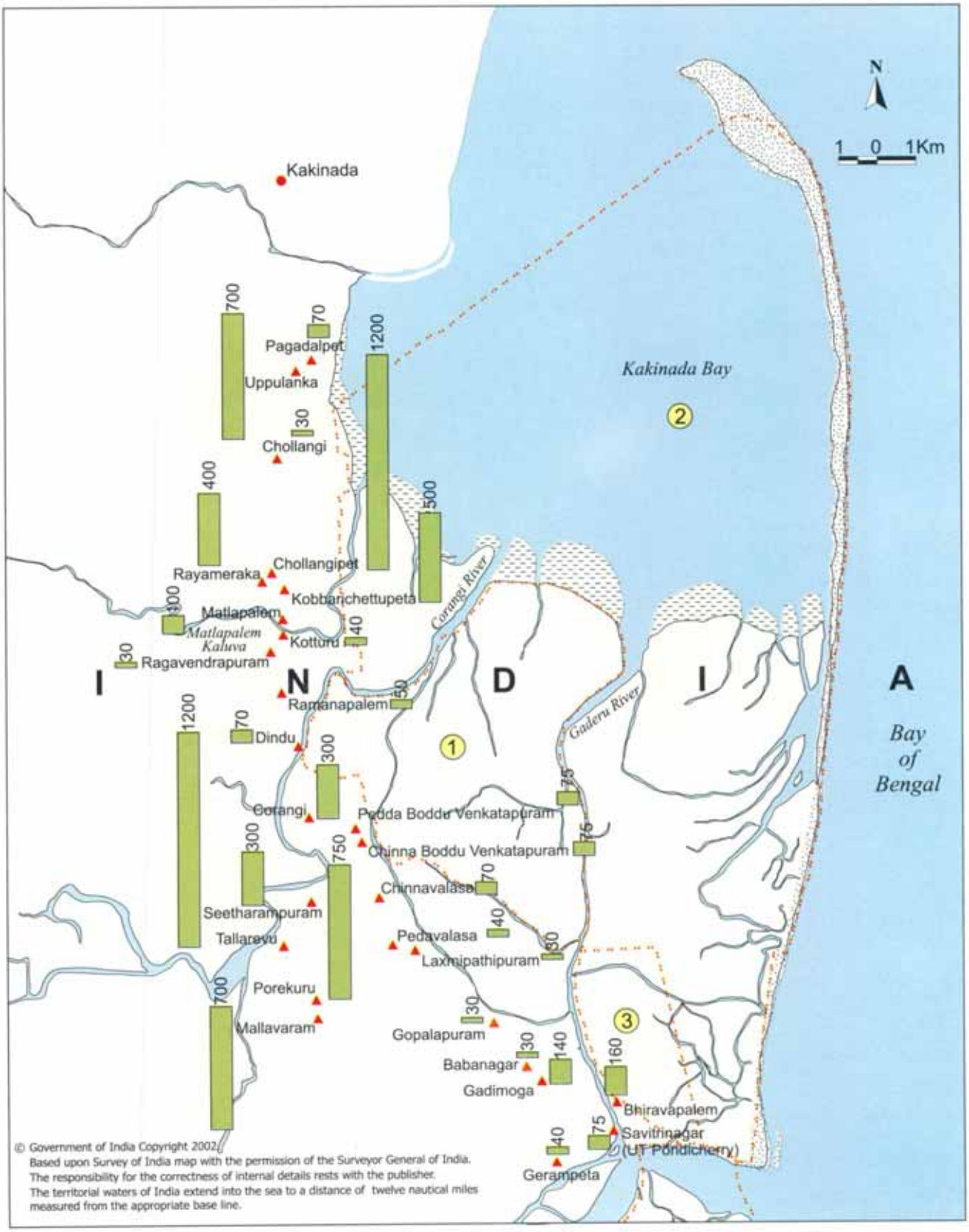


3.10. Livestock

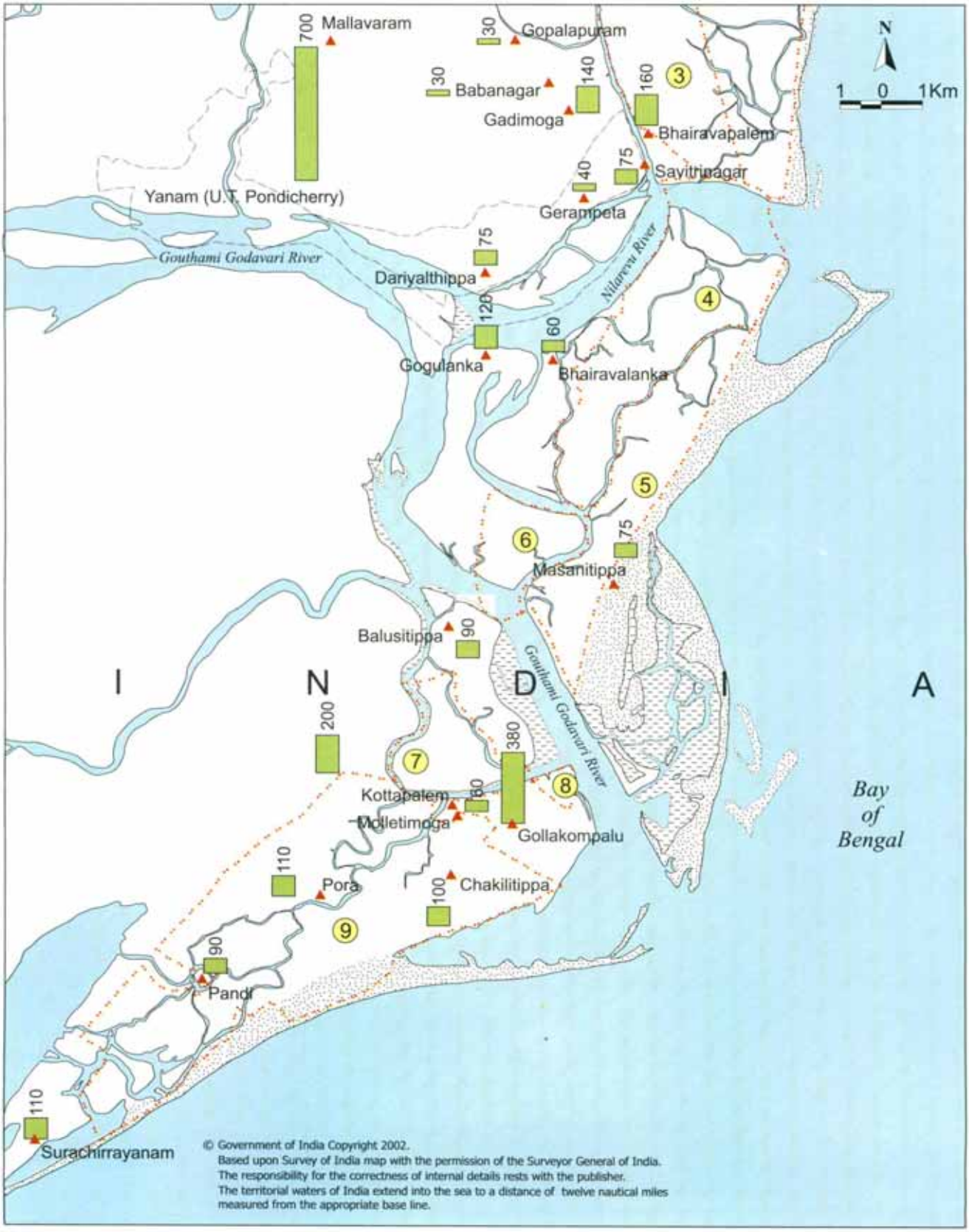
The farming community (Yadavas) in Chollangipeta, Ravimeraka, Polekurru, Mallavaram and Tallarevu use the mangrove forest for cattle grazing. Nearly 2,000 feral cattle, which are semi-domesticated, remain in the forest for the most part of the year (Map 3.20a and b). The people milk the cattle and bring in the milk once a day by boat. In summer they take fresh water for the animals from outside. Chopping of mangrove twigs for stall-feeding cattle and goat grazing are the other use of mangroves as fodder. Goats from nearby villages also graze in fringe areas. In the user villages nearly 8,665 livestock graze in agricultural fields in the fallow seasons and are stall-fed during the cropping seasons.

Figure 18. Semi domesticated feral cattle grazing in mangroves

Map 3.20a Livestock - Coringa Wildlife Sanctuary



Map 3.20b Livestock - Non Sanctuary Area



3. 11 Land Use around mangroves

Cropping, plantation and weeds

Coconut groves and paddy are synonymous with agriculture in this area. Canal-irrigated water from the Dowleswaram barrage helps cultivate paddy. In most places, paddy is cultivated twice and a legume crop once, both with irrigation support. The Forest Department of Andhra Pradesh planted casuarina under its shelterbelt program along the coast. Plantations of casuarinas are seen in Hope Island along the shore near Masanitippa, and in Kandikuppa RF near Sacramento lighthouse. The plantations are being raised by the Vana Samrakshana Samiti (VSS), a village level society formed under Joint Forest Management programme of the Andhra Pradesh Forest Department in the non-sanctuary area. Revenue from the plantations will be given to the village as per JFM guidelines. The high tidal mud flats along the Saleru creek near Bhairavalanka, where inundation is rare, Prosopis trees have invaded. Prosopis invasion is also noticeable near the river mouth of Gauthami Godavari.

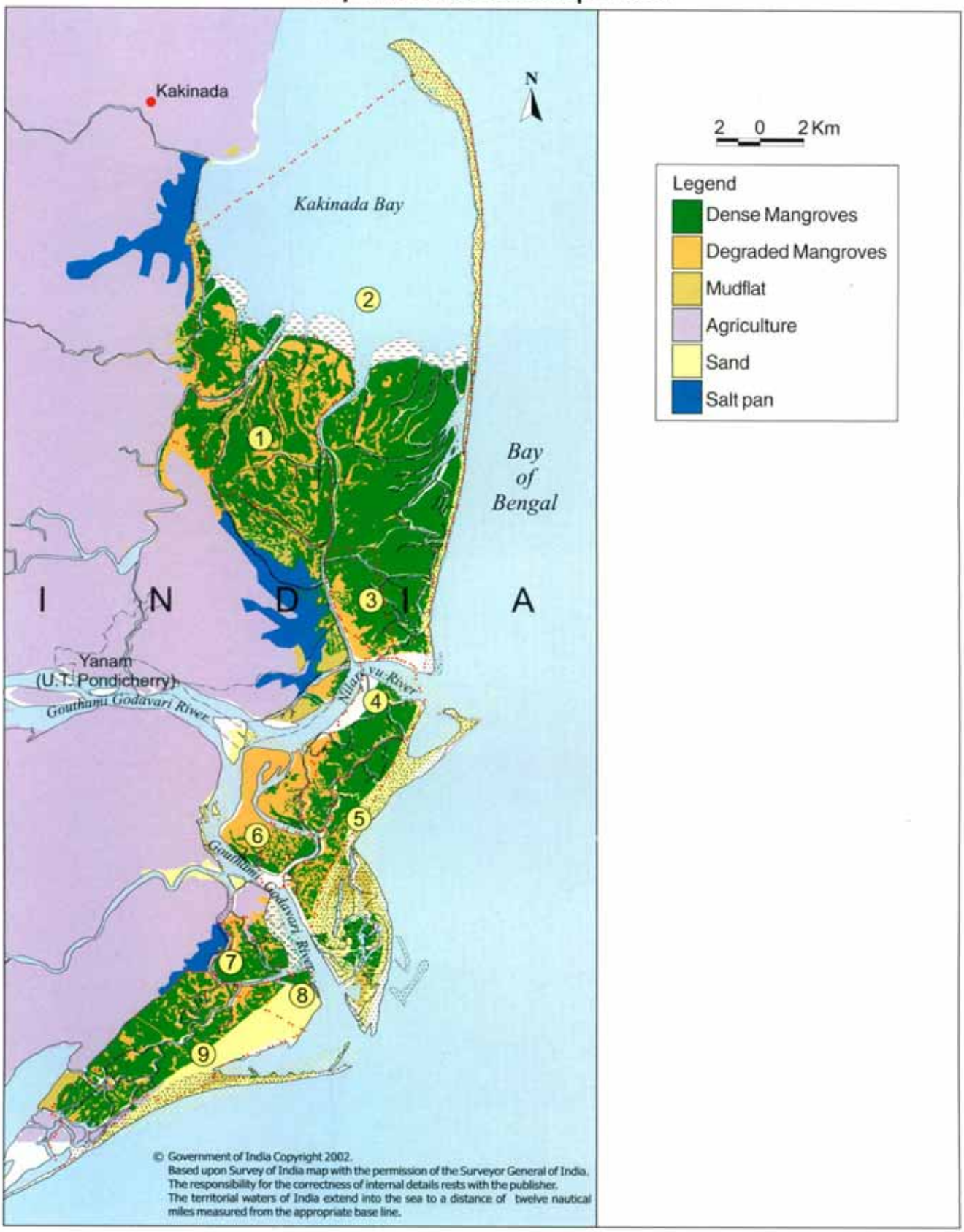
Figure 19. Agricultural Landuse – Paddy cultivation and Coconut plantation

Salt pan

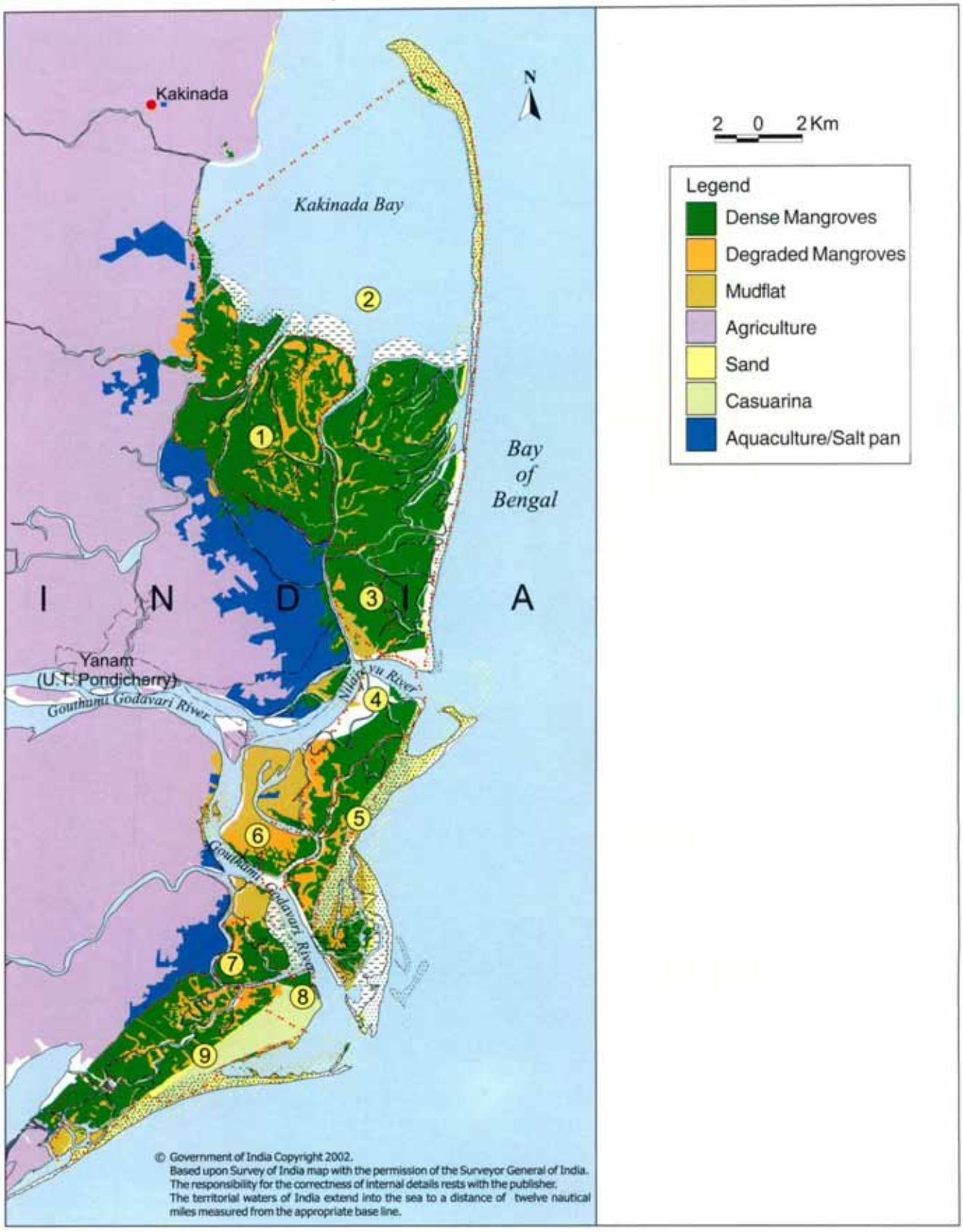
Some of the areas around mangroves are under salt production. Salt pans are found near Balusutippa RF and in the outskirts of Kakinada near Chollangi adjoining the mangroves, which are divided by the Kakinada-Yanam Road. The Chollangi creek supplies water for the salt pans.

Figure 20. Saltpan near Mangrove vegetation

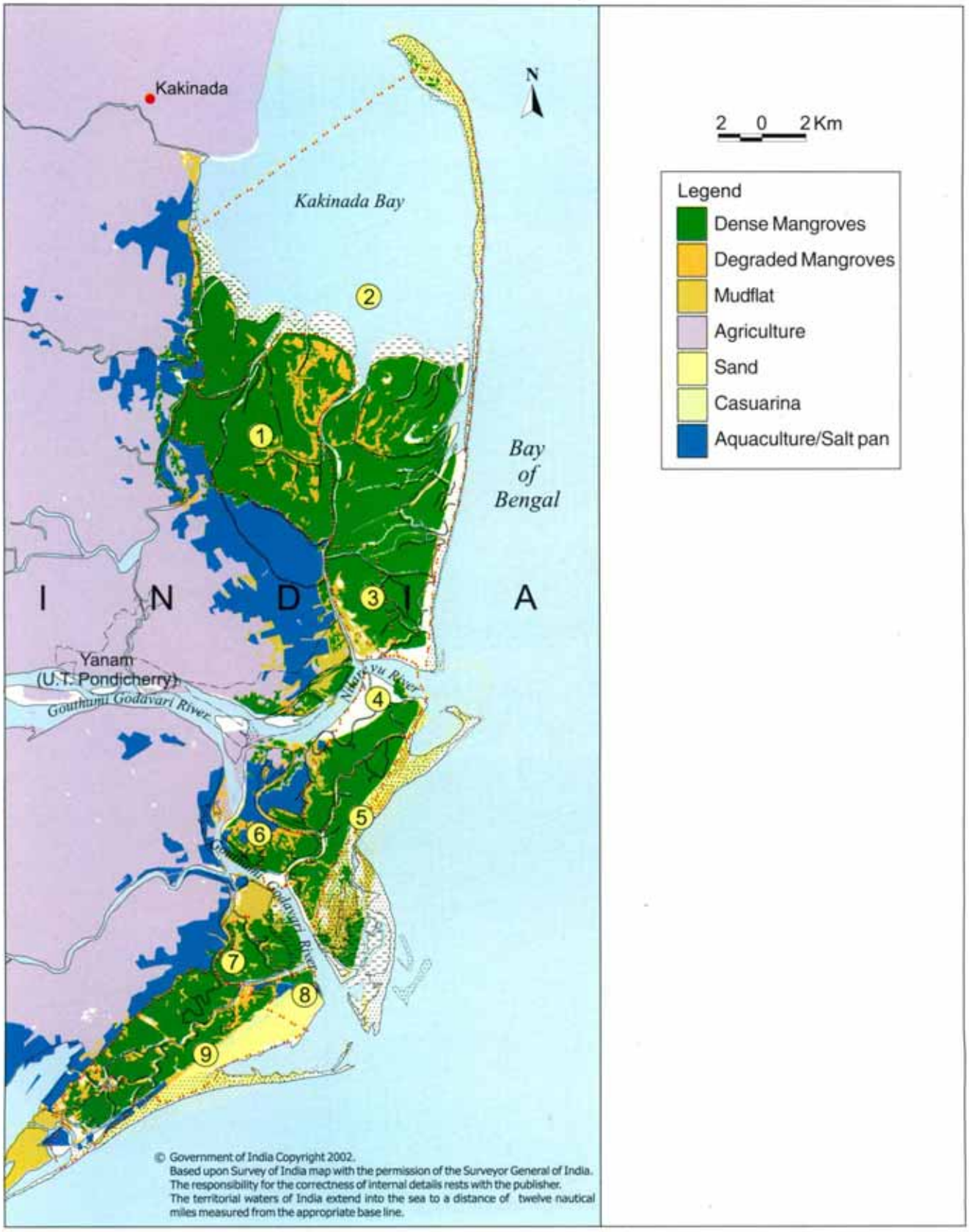
Map 3.21a Landuse Map - 1986



Map 3.21b Landuse Map - 1998



Map 3.21c Landuse Map - 2001



Aquaculture

In Andhra Pradesh, the extent of aqua farms has increased from 6000 ha in 1990 to 84,629 ha in 1999. Near to Godavari estuarine region alone, area of aqua farms has increased from 2006 ha in 1989 to 19239 ha in 1999 (Andhra Pradesh Remote Sensing Centre, 1999). A recent survey by the aquaculture sector found that about 5% of the shrimp farms in India have been constructed in former mangrove areas. (ADB/NACA, 1998). Mangrove conversion for prawn farming has been taken both for small scale extensive system as well as for large scale semi-intensive method of farming. In the Godavari delta, about 14% of the aquaculture farms have been constructed on mangrove lands located outside the reserve forests. Most of the lands owned by private abutting the mangroves are being converted to shrimp ponds. The rate of conversion of mangrove to shrimp ponds increased in the period 1997 to 1999. The increase in shrimp farming area led to an increase in shrimp production from 30,000 tones during 1990 to 102,000 tones in 1999. Shrimp farms are located very close to mangroves and revenue lands. Impact of discharge of effluents from aqua farms into mangrove wetlands has not been studied systematically. The study by Rangarao *et al* (2003) indicate that pollutants including effluents released from the aqua farms into mangrove canals are not flushed out completely due to existing water circulation pattern and tend to accumulate in the southern part bay where mangroves are located.

Figure 21. Aquaculture farms adjacent to mangrove vegetation

3.12. Dependency

Grazing

The farming community in Chollangipeta, Ravimeraka, Polekurru, Mallavaram and Tallarevu depend on the mangrove forests for feral cattle grazing. Apart from this, *Porteresia grass* and *Avicennia* twigs are used as fodder for stall-feeding the livestock. Goats from the nearby villages graze along the fringes of mangroves (Map 3.22a and b).

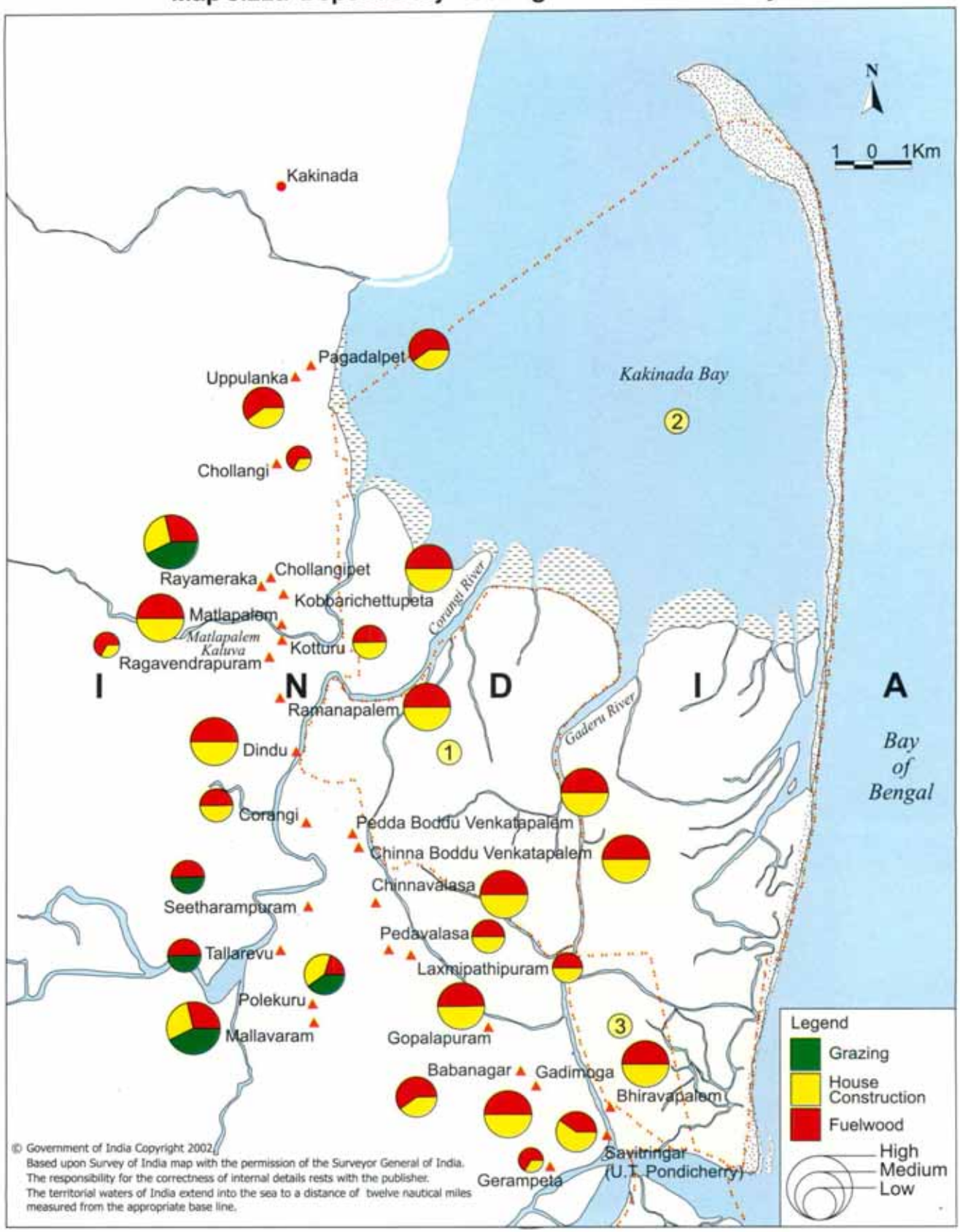
Firewood

Almost all villages depend on mangroves for firewood. However, the degree of dependency is high in fishing hamlets because of their close proximity to mangroves (Map 3.22a and b). *Avicennia marina, Avicennia officinalis* and *Aegiceras corniculatum* are the species which villagers tap for firewood. The Forest Department has permitted the collection of dry twigs and dead wood as firewood from the mangroves after the formation of village-level institutions such as EDC (Eco-Development Committee formed in Sanctuary areas) and VSS (Vana Samrakshna Samiti formed in non-sanctuary areas) under the Andhra Pradesh Forestry Project.

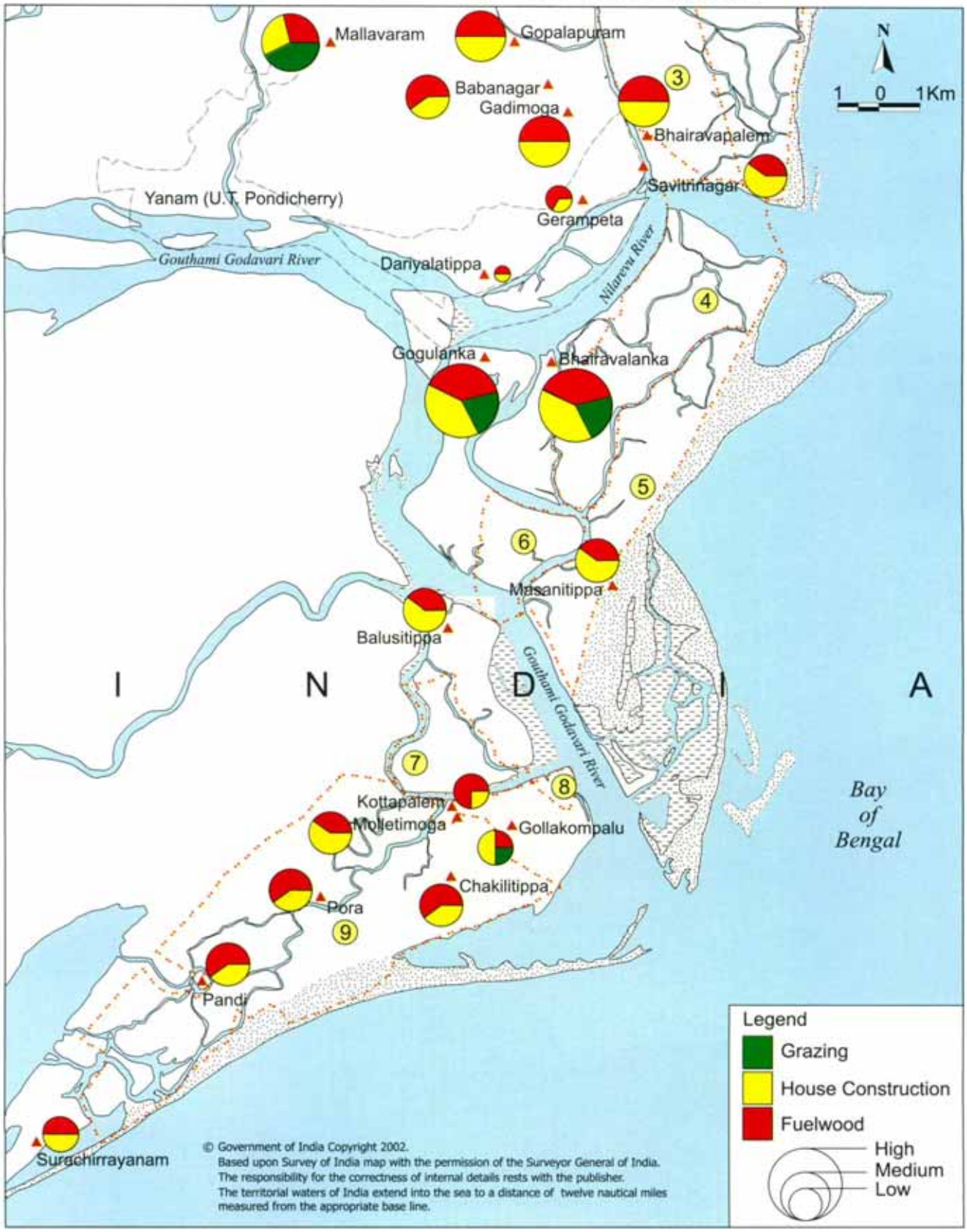
Figure 22. Women with headload of mangrove for firewood

Figure 23. Firewood transported by boats

Map 3.22a Dependency - Coringa Wildlife Sanctuary



Map 3.22b Dependency - Non Sanctuary Area



House Construction

The mangrove wood of a few species such as *Excoecaria agallocha, Bruguiera cylindrica, Avicennia marina* and *A. officinalis* is used for house construction. After the cyclone in 1996, tapping of mangrove wood for house construction has gone down, because many fishermen families have managed to construct houses in concrete with the help of government and other aid agencies. The project played a critical role in this development. Community wood lots have also been raised in villages to meet demand for it.

Figure 24. House constructed using mangrove wood and Palm leaves

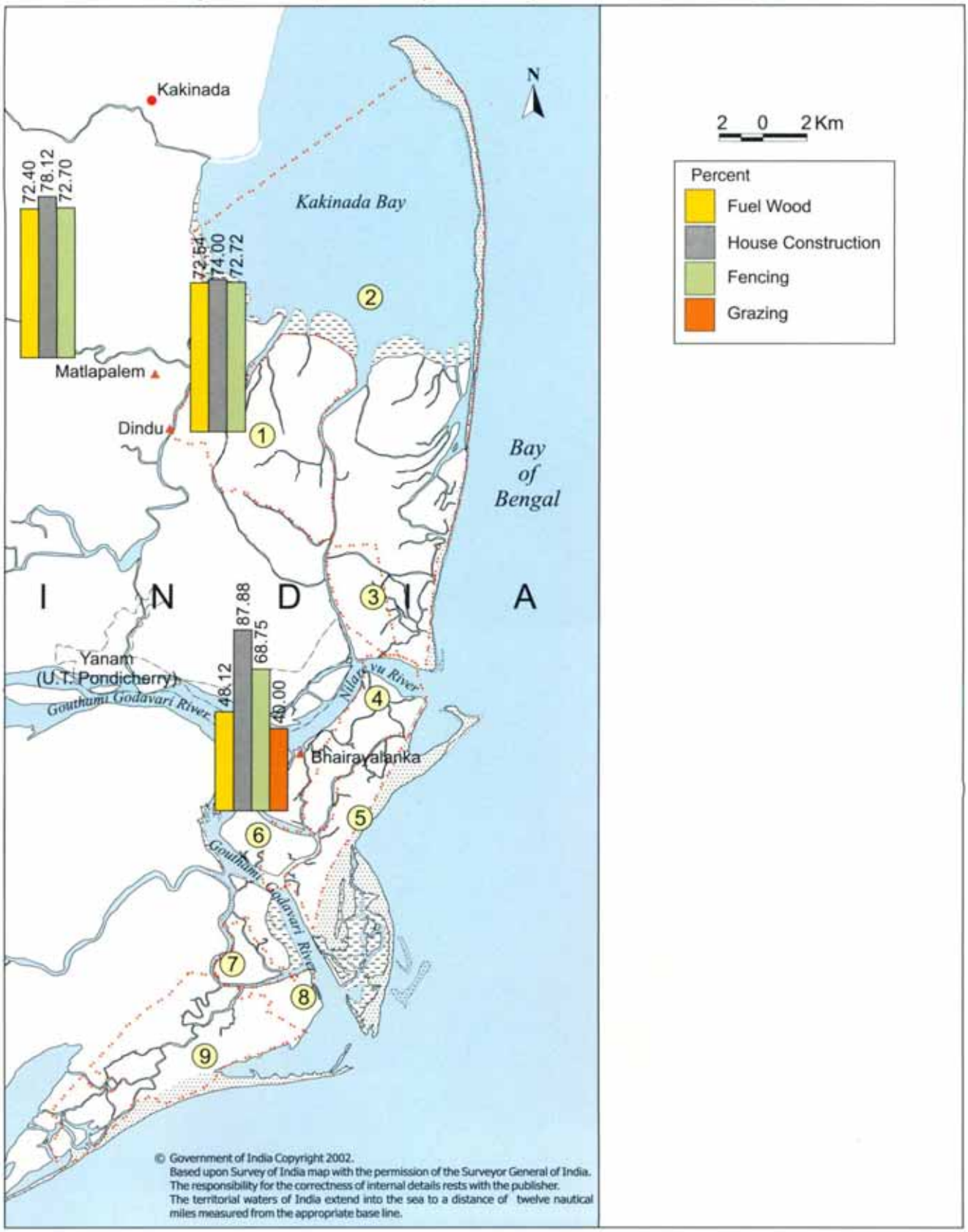
Fishing

Fishing is allowed in mangroves areas. But during the prawn breeding season, a ban on fishing has been imposed by the Fisheries Department because of the indiscriminate collection of fish and prawn seeds for aquaculture. (Fishermen collect prawn, fish and crab along with shells for their livelihood.) All fishing villages depend on mangroves for fishing; on the other hand, the farming community, particularly from Bhairavalanka and Gogullanka, engages in prawn seed and crab collection.

Figure 25. Fishing activity in the creek

Figure 26. Mangrove wood as fishing poles

Map 3.22c Dependency on Mangroves in JMM Villages



3.13. Causes of degradation

Before mangrove areas were constituted into forest blocks, most mangrove areas in East Godavari were under the control of private estate owners till estate abolition came in force. After this, the Andhra Pradesh Forest Department took over the management of mangrove and systematically felled mangrove trees under coupe felling system on a 25-year rotation period from 1933 to early 1970s. This unscientific management practices triggered the chain of reaction (Figure 27) leading to development of hypersaline condition, which is one of the main causes of degradation of Godavari mangroves. Apart from the management practice of coupe felling, other major causes of mangrove degradation include anthropogenic factors such as grazing by feral cattle, and collection of mangroves for firewood and fencing materials by villagers. Yet another cause is that the banks of rivers and creeks are relatively elevated because of sediment deposit along the banks whenever floods occur. Result: lack of tidal flushing in interior mangrove areas, leading to degradation, with only the fringe areas supporting mangrove growth. Areas adjoining the reserve forests with mangroves have been converted to aquaculture ponds.

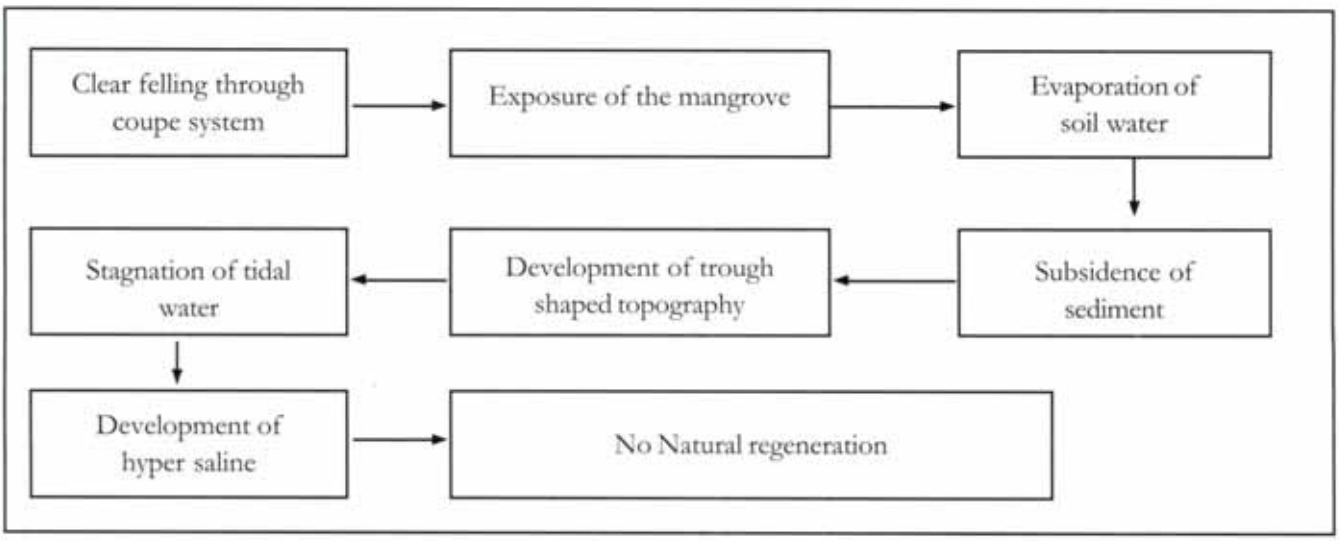


Figure 27. Biophysical changes caused by coupe felling

Figure 28. Degraded area with artificial canal

Figure 29. Mangrove wood cleared for house construction and fishing poles

Figure 30. Degradation due to deposition of sand

3.14 Present management practices

After starting to implement the World Bank-funded Forestry Project, the Forest Department formed Eco-Development Committees (EDC) and Vana Samrakshana Samithis (VSS) in mangrove areas. These local institutions have enabled joint implementation of mangrove conservation by the Forest Department, MSSRF and the local community. The entire Coringa Wildlife Sanctuary has been protected by 20 EDCs. Similarly, seven EDCs function in Krishna. These village-level institutions have been allotted "management areas" to help implement mangrove protection and conservation. Likewise, five village institutions (VLIs) in Godavari and three VLIs in Krishna are taking part in joint implementation, helped by local-level training.

3.15. Restoration and Redevelopment

Mangrove restoration activity on the lines of the Pichavaram model was initiated in degraded areas of the Krishna and the Godavari. The Andhra Pradesh Forest Department initiated restoration of mangroves in the Godavari in 1991 with a canal-digging exercise. The canals were dug perpendicular to the river, with side canals at right angles to the main canal. An exposure visit to the Pichavaram mangrove restoration area was organized for Forest Department staff. After this they started digging canals at 30^0 from the main canal. This method reduces the rate of siltation of canals and also facilitates easy flow of tidal water. The restoration of the Kobbarichettupeta Mangrove Management Unit was done jointly with the Forest Department. Canals in the plantations near Dindu raised by the Forest Department during 1995 have been reoriented for proper tidal flushing by the MSSRF.

Restoration of degraded mangroves was carried out in the Mangrove Management Units (MMU) of demonstration villages. An area of 520 ha. has been restored using the canal construction method in the Godavari and Krishna mangroves. The canals were designed in a trapezoidal shape with an angle of 45^0 to facilitate free flow of tidal water and fresh water. This is to reduce siltation. Of the 520 ha., 165 ha. were restored in the Godavari mangroves (Table 7), the rest in the Krishna mangroves. The restoration in Godavari was done by five village - level institutions (EDC and VSS) formed by the project in collaboration with the Forest Department. Restoration was undertaken only in RF areas in order to ensure sustainable maintenance by the Forest Department and Village Level Institutions. Such restoration not merely increases healthy mangrove areas, it also arrested further degradation of pristine mangroves adjoining the degraded patches. Canal construction in degraded areas expands the water body areas, and strengthens the resources of crab and other species. Training for nursery raising, canal digging and planting was conducted for the demonstration villagers. A community mangrove nursery was developed, and the saplings were used for planting in the restored area.

Replication of JMM model by NGOs trained in the project

Three NGOs — Coastal Community Development Program (CCDP) of Machilipatnam; Sangamithra Service Society of Vijayawada; and Sravanthi of Tallarevu – trained by the MSSRF unit at Andhra Pradesh, adopted the Joint Mangrove Management model and restored a mangrove area of 215 ha.

Figure 31. Topographical survey for restoration

Figure 32. Mangrove nursery for restoration

Figure 33. Digging of canals in the degraded area for tidal flushing

Figure 34. Planting of mangrove saplings along the canals

Table 7 Details of restoration and Mangrove Management Units - Godavari

Demonstration Village	Area Restored (ha)	Area under MMU (ha)
Matlapalem	5	502
Dindu	25	900
Kobbarichettupeta	35	3925
Gadimoga	25	900
Bhairavalanka	75	615
Total	**165**	**6842**

3.16 Changes in Mangrove vegetation between 1975 and 1986

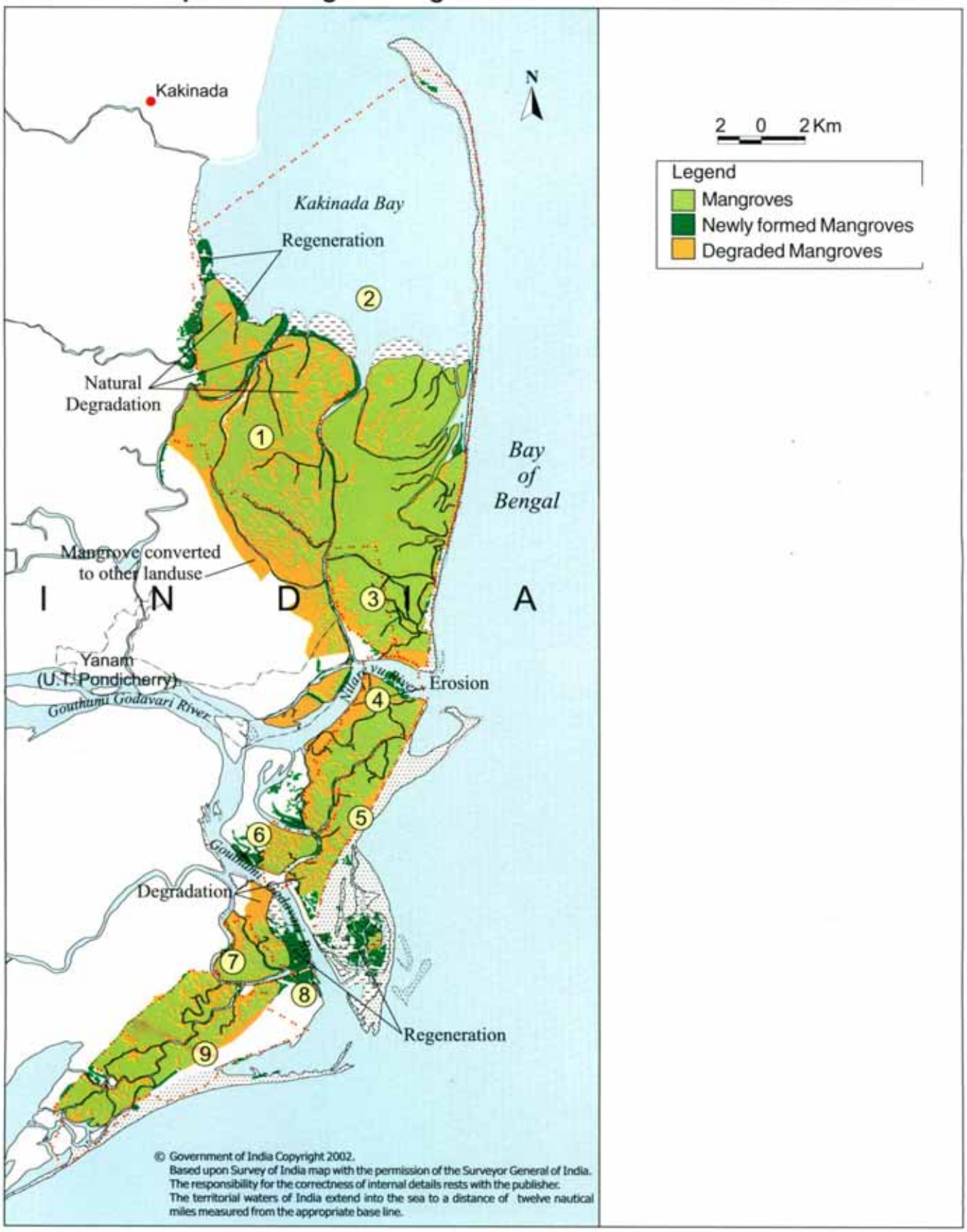
A comparison of mangrove areas in the 1975 Survey of India toposheet and the Landsat 5 TM remote sensing data of 1986 is revealing, what was indicated as core mangrove area in the Survey of India toposheet is found degraded in the 1986 Landsat 5 TM data. Chapter 3.13 discussed the reasons for such degradation. Mangrove vegetation found in the periphery of the sanctuary (boundary) near villages, is degraded due to anthropogenic pressure. Mangroves on the eastern side of the sanctuary along the Bay of Bengal are eroded due to tidal action. But at the same time, accretion in the Kakinada Bay increased the area of mangroves by about 350 ha. The accretion is due to sedimentation of alluvial deposits from the Corangi, Gaderu and Matlapalem river runoff.

Mangrove vegetation near the southern bank of Godavari river (Nilarevu river) in Rathikaluva RF has eroded because of floods during the southwest monsoon. The course of the river has changed too, resulting in further mangrove erosion. Two islands south of Gerampeta conspicuous for dense mangroves in the 1975 Survey of India map, look less impressive in the 1986 Landsat 5 TM data: mangroves are now thinner in the eastern side; other mangrove areas are changed to sandy.

But there are positive changes as well. In the northern side of the Kothapalem river mouth, the mudflats in 1975 show up as mangrove vegetation in 1986 with many patches of new mangroves. Similarly, along the Godavari river near Balusutippa RF the mudflats in 1975 now glow green with dense mangroves in 1986 (Map 3.23).

Figure 35. Erosion along the Corangi RF Extension, Mangroves facing Bay of Bengal

Map 3.23 Changes in Vegetation between 1975 and 1986



3.17 Changes in Mangrove vegetation between 1986 and 1998

A comparison of 1986 Landsat 5 TM data and 1998 IRS 1D LISS III data revealed an increase of about 680 ha which is mainly due to new mangrove growth in newly accredited mud flats. The 1998 data shows that about 450 ha of dense mangroves found outside the RF boundary in 1986 were converted into aquaculture farms.

Accretion in the Kakinada Bay area increased mangrove area by 412 ha and erosion along the shore in the eastern side of the sanctuary area reduced mangroves by 495 ha (Map 3.24). The erosion of mangroves along the southern bank of Nilarevu river increased further; The river is wider in 1998 than 1986. Mangroves near the northern side of the Kothapalem river mouth eroded on the seaward side and regenerated landward near Kothapalem village and in the lagoon near the Kothapalem lighthouse.

3.18 Changes in Mangrove vegetation between 1998 and 2001

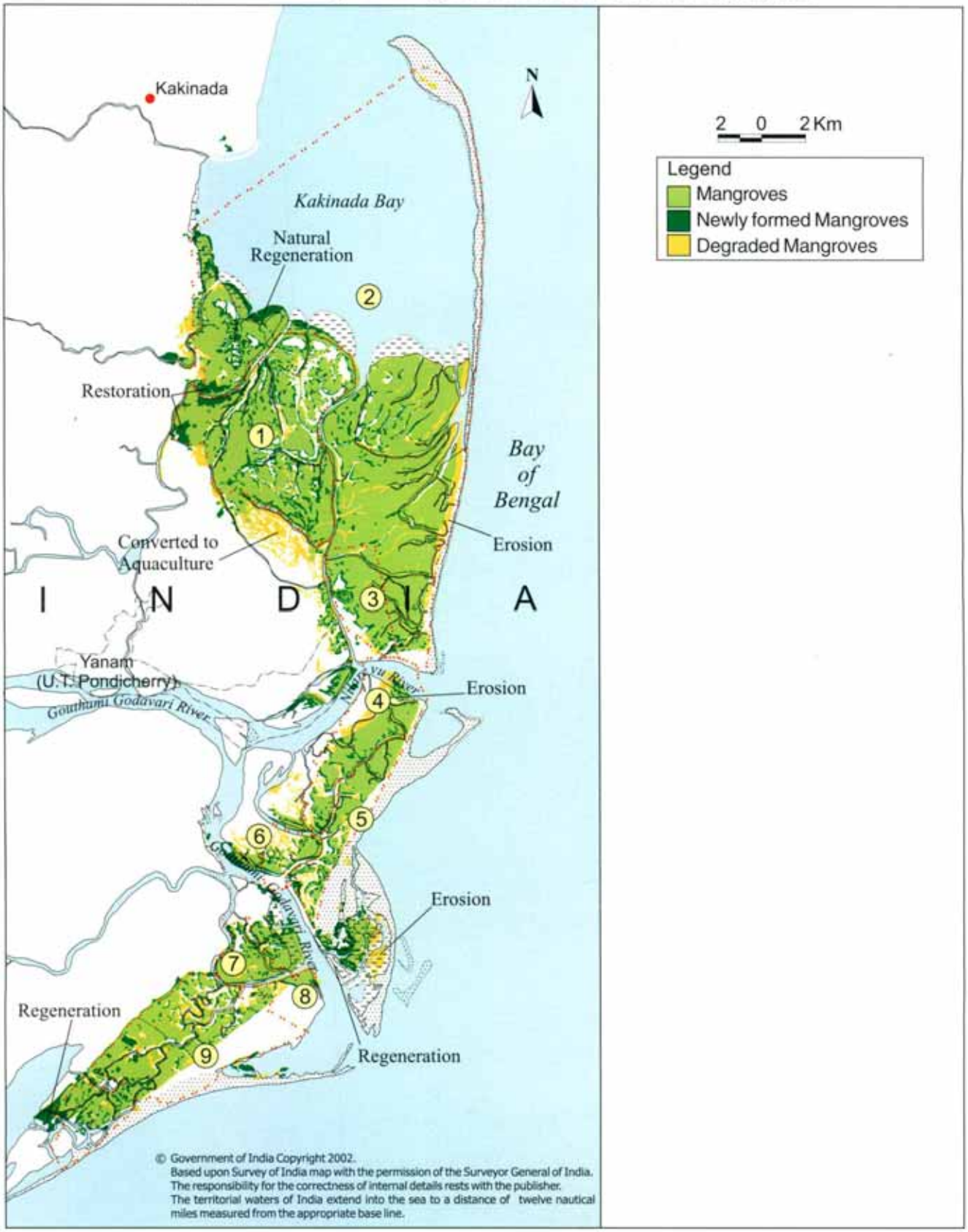
Mangroves that showed up as degraded in 1986 and 1998 satellite data are now found thinly covered with mangrove vegetation, by recently interpreted IRS LISS III data of 2001 (Map 3.25). The mangrove plantations (discussed in Chapter 3.14) organized by the Forest Department and by MSSRF under the ICEF-supported project "Coastal Wetland: Mangrove Conservation and Management" have helped to revive the degraded area. 2001 data has shown an increase in erosion along the Bay of Bengal in the eastern side of the sanctuary, also an increase in accretion in the Kakinada Bay. Mangroves in the accreted area near Uppulanka in the Kakinada Bay have increased (Table 8). The data shows an overall increase of 367 ha between 1986 and 2001 and this was mainly due to the effort of the Forest Department under Andhra Pradesh Forestry Project.

Table 8 Changes in Mangrove Area (in ha)

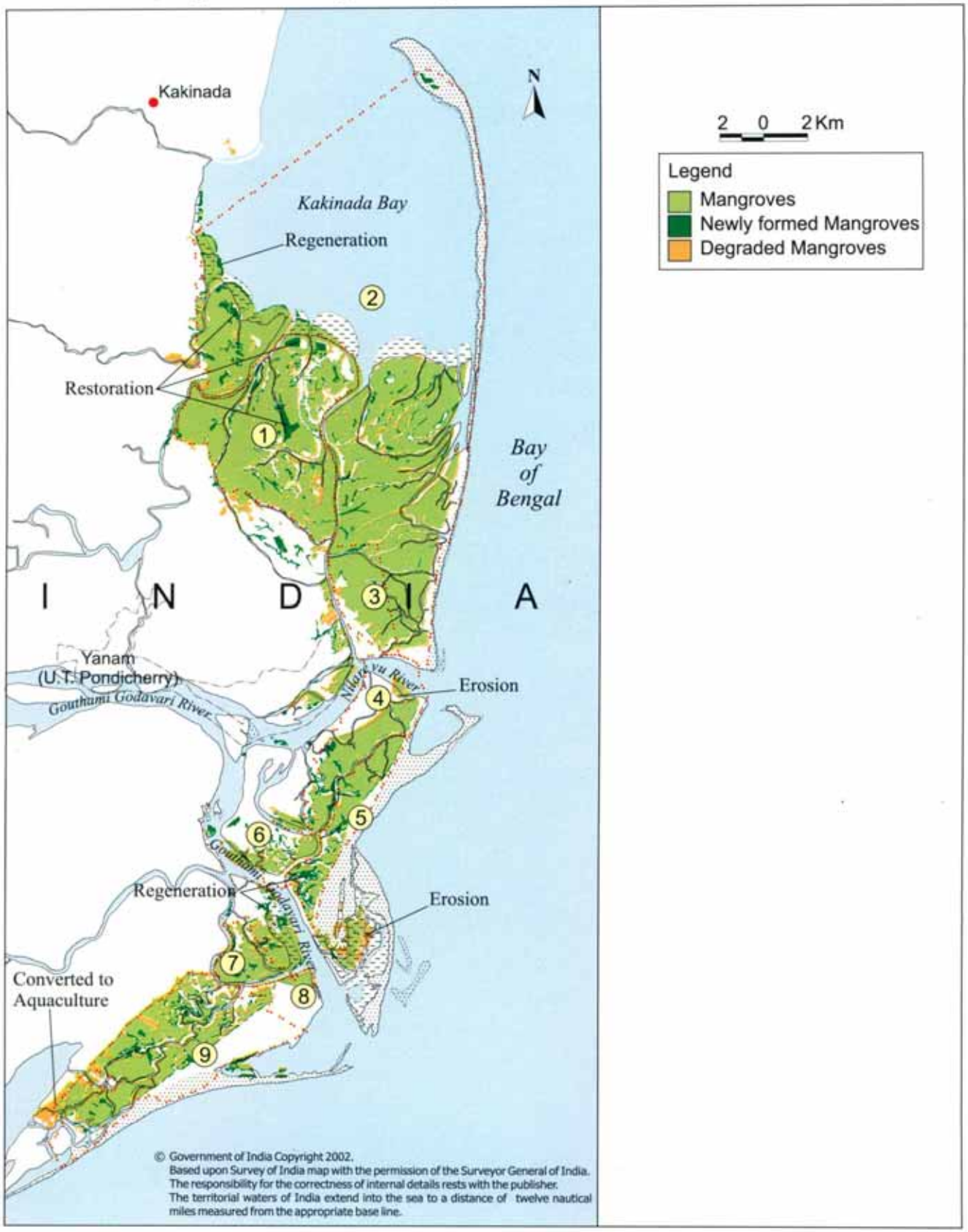
Description	Changes between 1986 and 2001
Restoration of mangroves and natural regeneration in the degraded areas	3275 (+)
Natural Regeneration in the accreted areas	223 (+)
Total increase	**3498 (+)**
Degradation due to Aquaculture/ Saltpan	658 (-)
Erosion	806 (-)
Degradation due to other causes – coupe felling, grazing and felling	1667 (-)
Total loss	**3131 (-)**
Net Increase	**367**

(-) Decrease in area (+) Increase in area

Map 3.24 Changes in Vegetation between 1986 and 1998



Map 3.25 Changes in Vegetation between 1998 and 2001



3.19 Shoreline changes

As shorelines and coastal belts are dynamic, temporal changes in the mangrove wetlands were mapped on the basis of the shoreline derived from the 1970 Survey of India toposheet and the remote sensing data of 1986 and 2001. Appreciable changes are seen in both the sanctuary and non-sanctuary areas. Accretion in Kakinada Bay is due to sediment deposit from the Gaderu and Corangi rivers (distributaries of Gauthami Godavari river). The deposit of sediments up to 300 meters towards the bay was noticed by comparing the latest data from earlier data.

The southern part of Kakinada port is eroded, but Hope Island is enlarging, and is extending north and northwest. The bay region has accretions from the north (near Uppulanka) to Gaderu river mouth in Corangi RF extension. Erosion was noticed from the Gaderu river mouth onwards up to the sand bar of Hope Island; also from the end of Hope Island up to the Nilarevu river mouth.

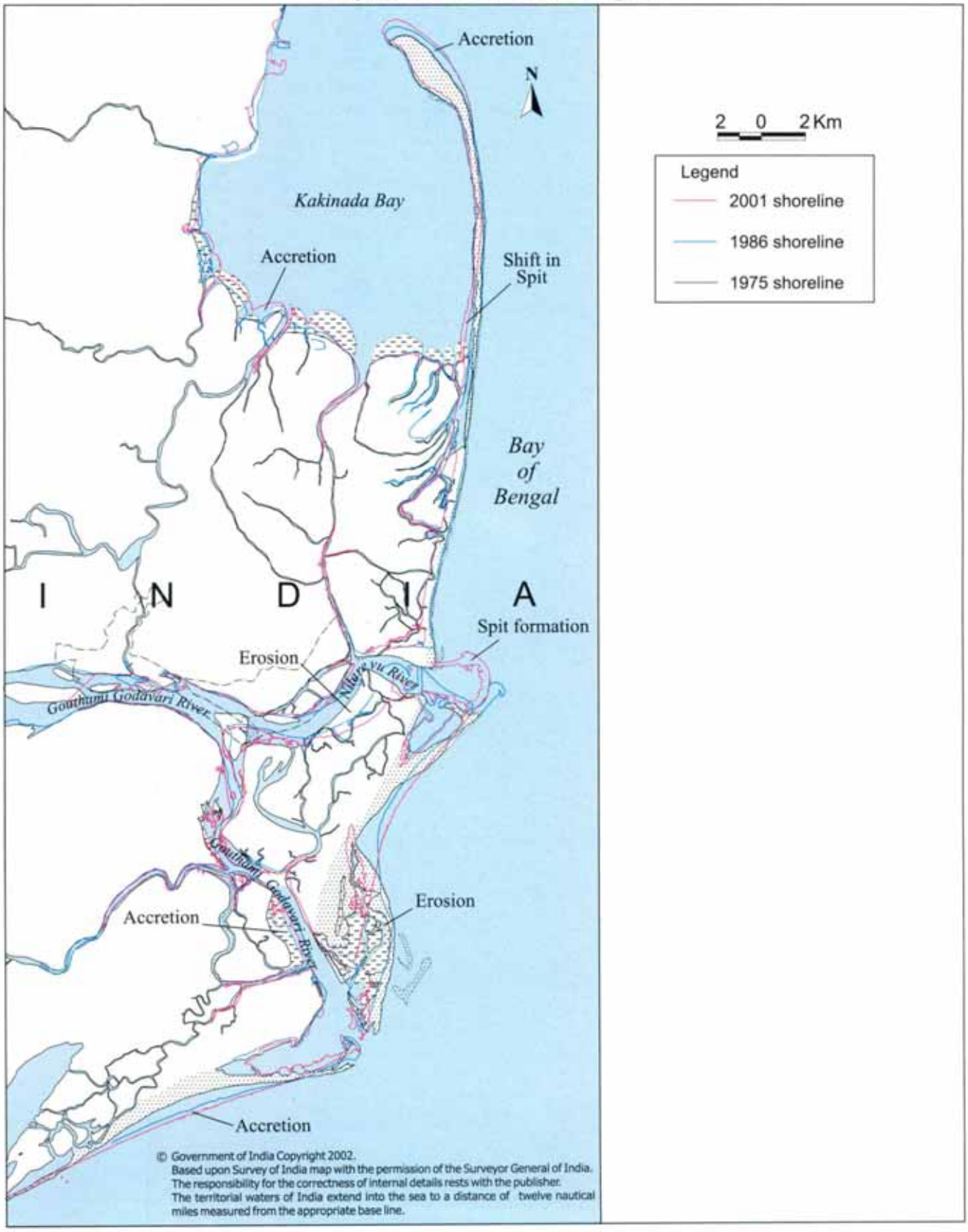
In the Nilarevu river mouth, the river course has changed a great deal from Yanam to the river mouth.

- The sand bed in the middle of the river has shifted southeast and joined the mainland near Gogullanka.
- The area under the Rathikaluva RF along the river has eroded to the extent of approximately 500 meters.
- The spit formation in the southern part of the Nilarevu river mouth has got extended northward. The river mouth has also shifted towards northeast from east.

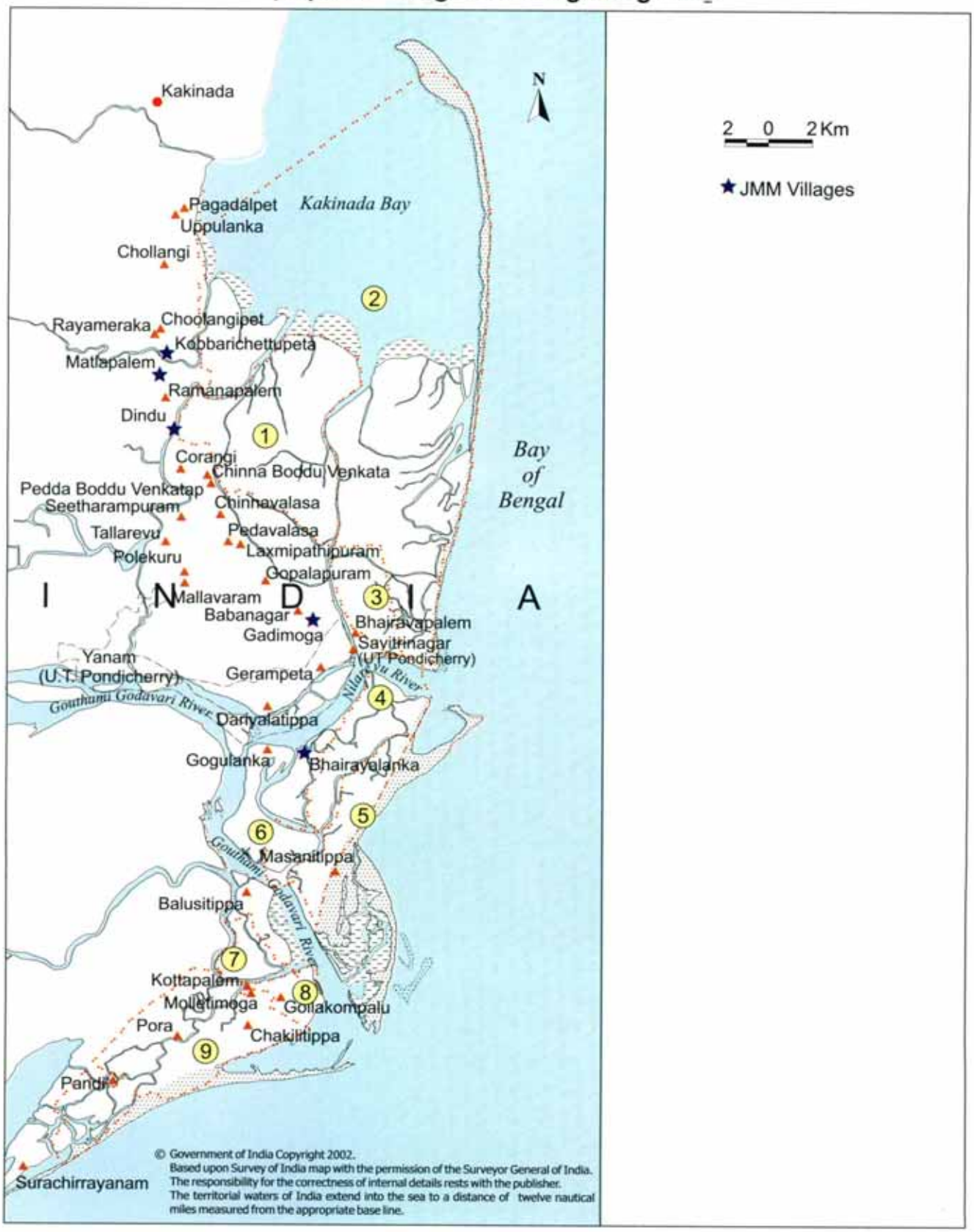
Unlike the sanctuary area, the southern part of the delta has acquired more accretions along its shoreline (northeast to Masanitippa). The non-reserve forest area south of the Masanitippa RF has eroded; the small mangroves found in this area have disappeared. The eroded material must have been deposited north of this area near Masanitippa. Accretion has also been noticed along the coastline southwest of the river mouth near Kothapalem village.

Coastline erosion has reduced both mangrove vegetation and beach sand. At the same time, accretion has led to an increase in the mangrove area in the Kakinada Bay (Map 3.26).

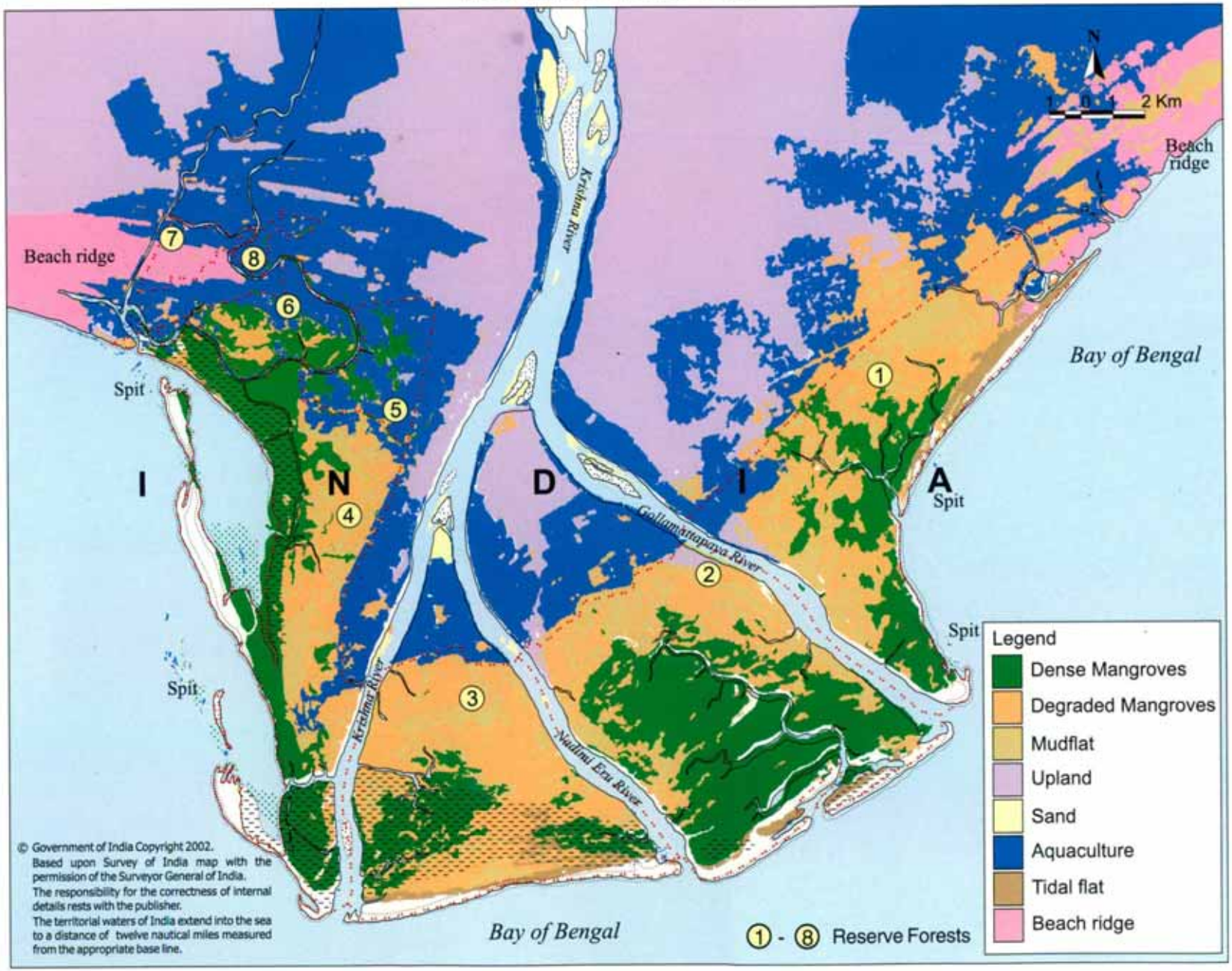
Map 3.26 Shoreline Changes



Map 3.27 Villages abutting Mangroves



Map 4.1 Geomorphology



Chapter 4

Krishna Mangrove Wetland

The Krishna mangroves in Andhra Pradesh are located in the coastal plains of Krishna delta. According to the Forest Department, the total area under mangroves is 5,000 ha. The Krishna mangroves lie between 15° 42' N and 15° 55' N in latitude and 80° 42'- 81° 01' E in longitude spread across Krishna and Guntur districts. The Krishna wildlife sanctuary has been established in a part of the mangrove wetland – the total area of this sanctuary is 19,481 ha (194.81) sq.km.; it includes Sorlagondi Reserve Forest (RF), Nachugunta RF, Yelichetladibba RF, Kottapalem RF, Molagunta RF, Adavuladivi RF and Lankivanidibba RF. They occupy the islands of the delta and the adjacent mainlands of both districts. A part of the mangroves is located far from the main mangrove area; it's near Machilipatnam on its eastern side and Nakshatranagar on its western side.

Fishermen in surrounding areas use the mangrove resources for fishing, house construction and firewood and to obtain fencing material for their houses. A devastating cyclone that hit the Machilipatnam coast during 1977 led to large areas of the forest getting degraded.

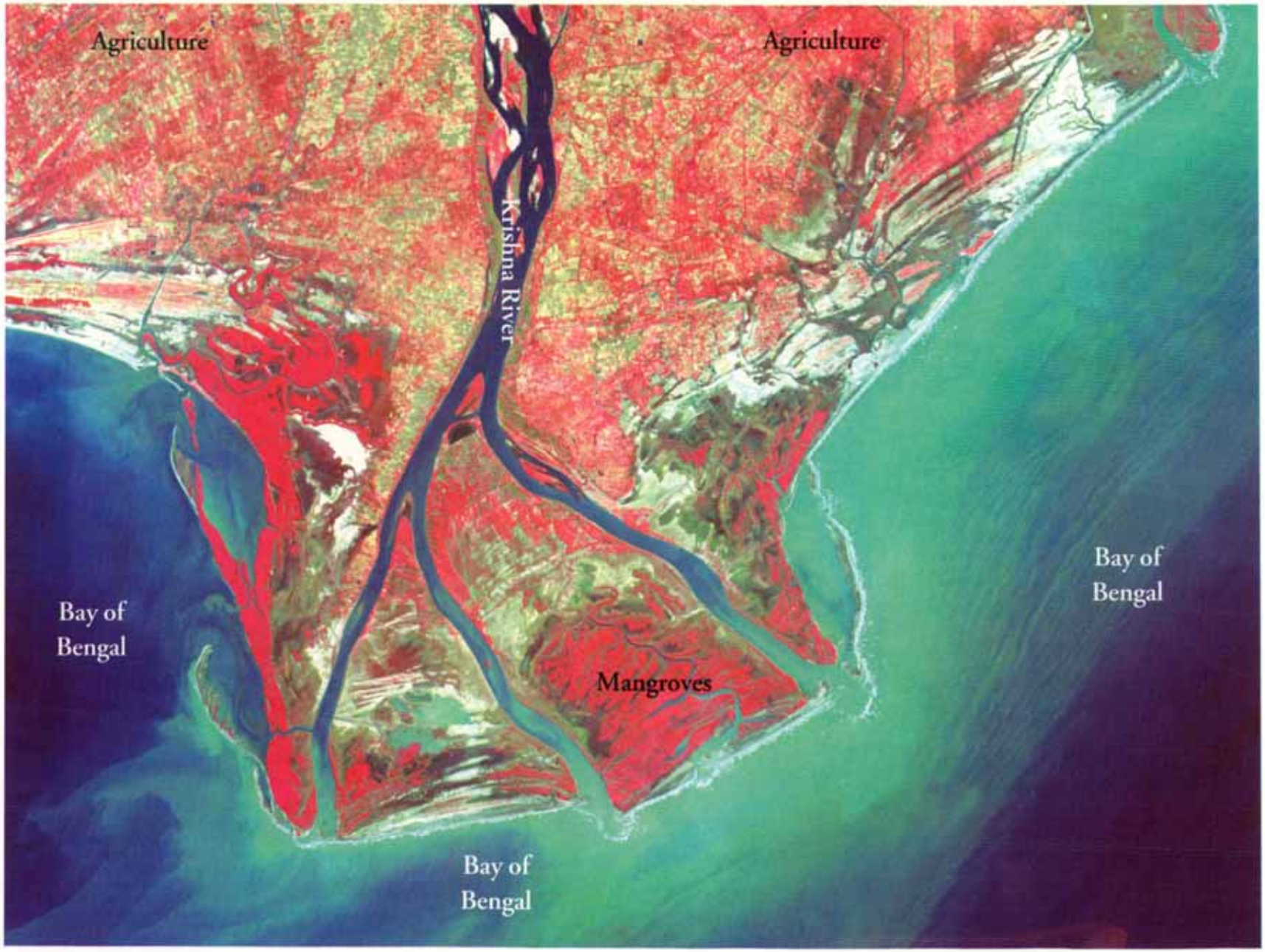
4.1. Geomorphology

Mangrove areas near the river mouth joining the sea are slightly elevated because of sand casting. This inhibits the entry of tidal water into the area, thereby affecting mangrove growth. This type of area can be seen near Nadimeru and Gollamattapaya. The area is elevated along the edges of the delta, whereas the middle area is low-lying and swampy. The delta can be clearly segregated from the mainland through the beach ridge running from east to west, north of the delta.

4.2. Remote Sensing Imagery

Remote sensing imagery of the Krishna delta (2001), as acquired from IRS 1D LISS III data, shows a wide bright red patch – mangrove vegetation in the delta. Most of the wetland and terrestrial area adjacent to the mangroves (dark blue to bluish gray) have been converted into aquaculture farms. Such farms also occupy some of the areas in Molagunta RF, Kottapalem RF Bit No. 1 and 2, Adavuladivi RF and the northern part of the Lankivanidibba RF as seen in 2001 (Map 4.3) which in not in 1986 data (Map 4.2). The northern part of the delta consists of farm fields that show up as fallow land in the imagery. Small mangrove islands (Lankivanidibba RF) are found on the western part of the delta's shoreline. In Yelichetladibba RF, a bluish gray strand indicates water stagnation. Remote sensing data from various satellite sensors of various years have been used in this atlas to prepare thematic maps of the wetland area and monitor changes in the mangroves of the Krishna delta.

Map 4.2 Landsat 5 TM Remote Sensing Imagery of Krishna delta - 1986



Map 4.3. IRS 1D LISS III Remote Sensing Imagery of Krishna delta - 2001

4.3. Reserve forests

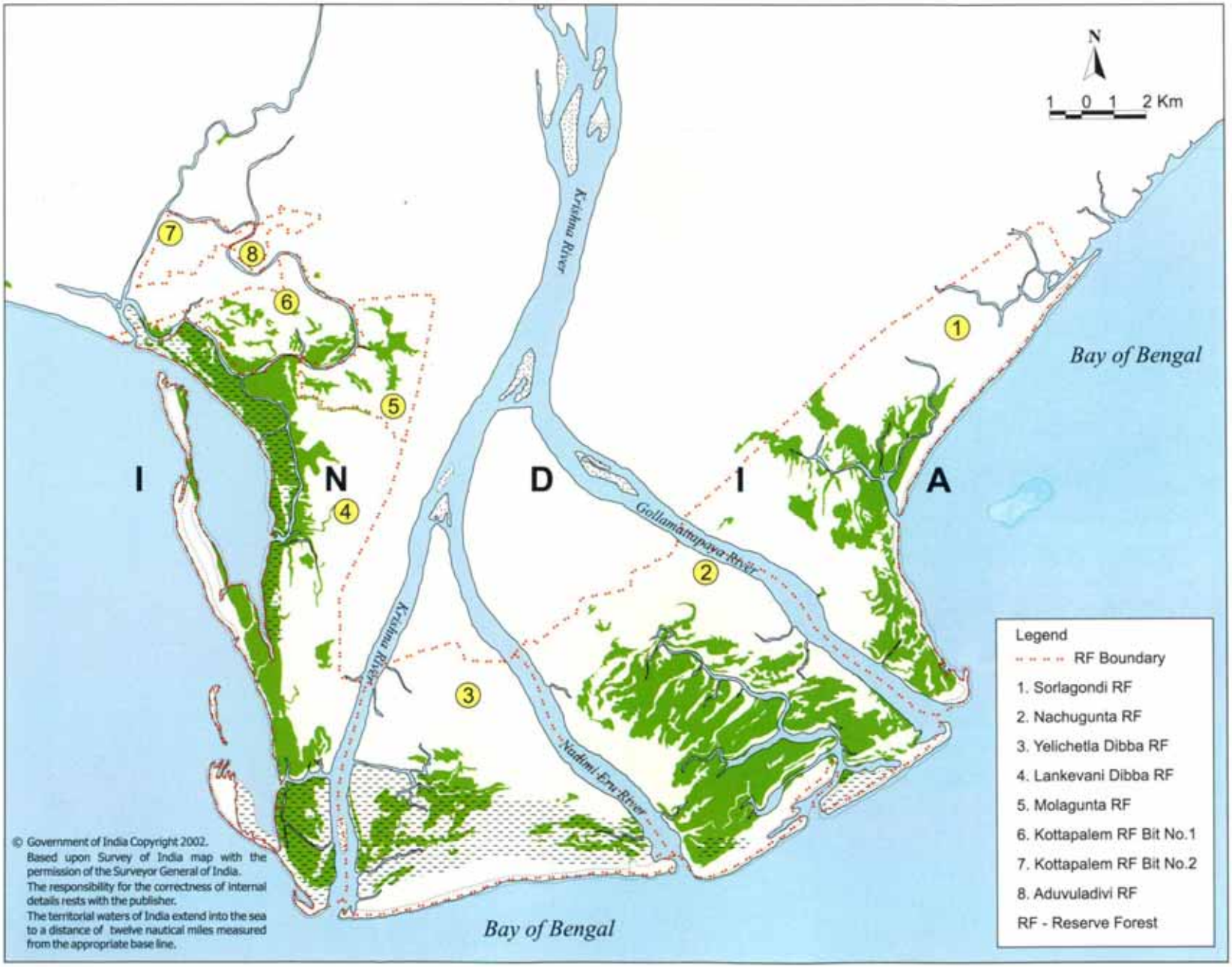
The vegetation in Sorlagondi RF is sparse (Map 4.4). The total area, as per the records of the Forest Department, is 5,199.40 ha. Of this, 1,292 ha. consists of dense mangroves. In the degraded area, the Forest Department and MSSRF have both carried out restoration of mangroves. The vegetation near the lighthouse is dense. *Avicennia officinalis, A. marina, Excoecaria agallocha, Aegiceras corniculatum* and *Rhizophora apiculata* have been recorded. *Suaeda maritima* and *S. nudiflora* are common in the degraded areas; *Excoecaria agallocha* and *Avicennia marina* also occur, in stunted form. *Acanthus ilicifolius* is seen along the sides of the creek and *Clerodendrum inerme* an associate species, has also been recorded. *Avicennia marina* and *Excoecaria agallocha* are the dominant species here. *Salicornia brachiata* is present in highly saline areas. Dense vegetation of *Prosopis juliflora* is seen in the uplands landward, and even near the Krishna river mouth. Nearly 500 ha of barren area near Gollalamoda has been utilized for aquaculture. The soil in this RF is clayey.

Figure 36. Avicennia marina in Sorlagondi RF

The total area of Nachugunta RF is 6,065 ha. of which healthy mangroves take up 2,873 ha. The species diversity in this RF is greater than in many others. Dense vegetation (*Rhizophora apiculata, Avicennia marina* and *Avicennia officinalis)* is seen along the canals. Prosopis invasion is conspicuous in some places along with mixed vegetation of *Exoecaria agallocha.* The mean height of the trees in this area is 4-5 m. Large areas of degraded mangroves occur near Zinkapalem village with stunted growth of *Exoecaria agallocha, Suaeda maritima* and *Avicennia marina.* The Forest Department and MSSRF have restored these areas. The dominant species are *Rhizophora apiculata* and *Avicennia marina.* Species such as *Exoecaria agallocha, Aegiceras corniculatum, Bruguiera gymnorrhiza* and *Acanthus ilicifolius* have been recorded. The soil is clayey as one goes landward, and sandy clayey near the shore.

Figure 37. Rhizophora mucronata in Nachchugunta RF

Map 4.4 Reserve Forest



The total area of Yelichetladibba RF is 3,714 ha. Dense mangroves occupy 751 ha. of this area. Large areas along the Nadimeru canal are under intensive aquaculture. The mangrove vegetation is sparse in the land area, but gets thicker seaward. The degraded areas are found elevated along canals and creeks; tidal water that entered during the spring tide and during floods stagnated and increased soil salinity, thus leading to degradation of mangroves. *Avicennia marina* is the dominant species. Species such as *Rhizophora apiculata, Bruguiera gymnorrhiza* and *Aegiceras corniculatum* have also been recorded. *Acanthus ilicifolius* is seen along the creeks. The soil is sandy towards the shore and sandy clay in the land area. *Suaeda maritima* and *S. nudiflora* are noticed in degraded patches and creeks; terrestrial species such as *Prosopis, Opuntia* and *Asparagus* have also been recorded.

Figure 38. Mangroves along the creeks of Yelichetladibba RF

Kottapalem RF is named after the village Kottapalem situated nearby. The total area of the RF is 1,554 ha, of which healthy mangroves occupy only 285 ha. Large areas of degraded patches near Vasalsink kalava have been converted into aquaculture farms.

Thick vegetation of *Avicennia marina, Rhizophora apiculata, Rhizophora mucronata* and *Bruguiera cylindrica, Bruguiera gymnorrhiza, Xylocarpus granatum* is seen along the canals. *Suaeda maritima* and *Salicornia brachiata* occur in abandoned aqua farms as well as in the degraded areas. Species such as *Ceriops decandra, Avicennia officinalis, Clerodendrum inerme, Sesuvium portulacastrum* and *Salicornia brachiata* have been recorded.

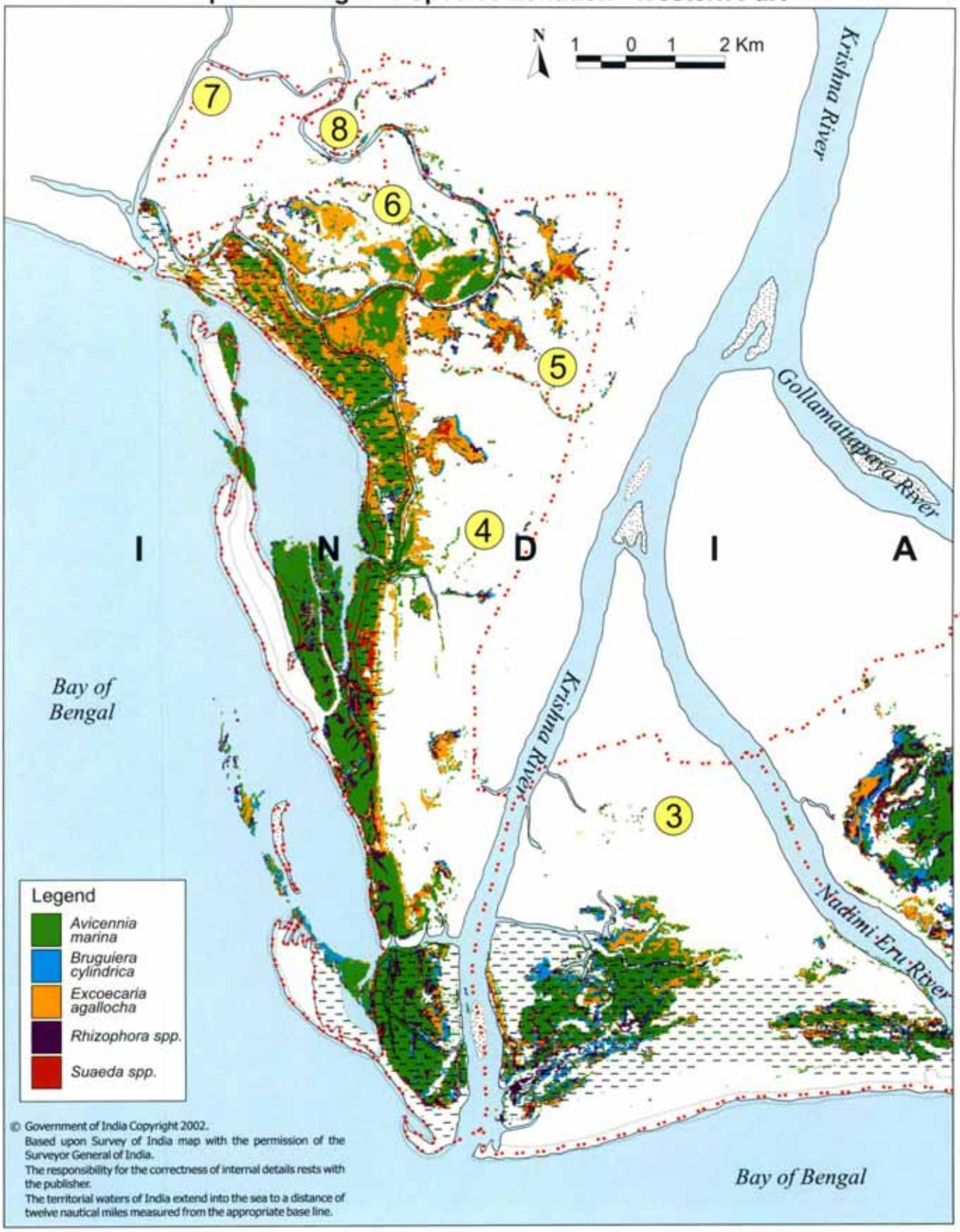
Figure 39. Avicennia officinalis

Figure 40. Rhizophora apiculata

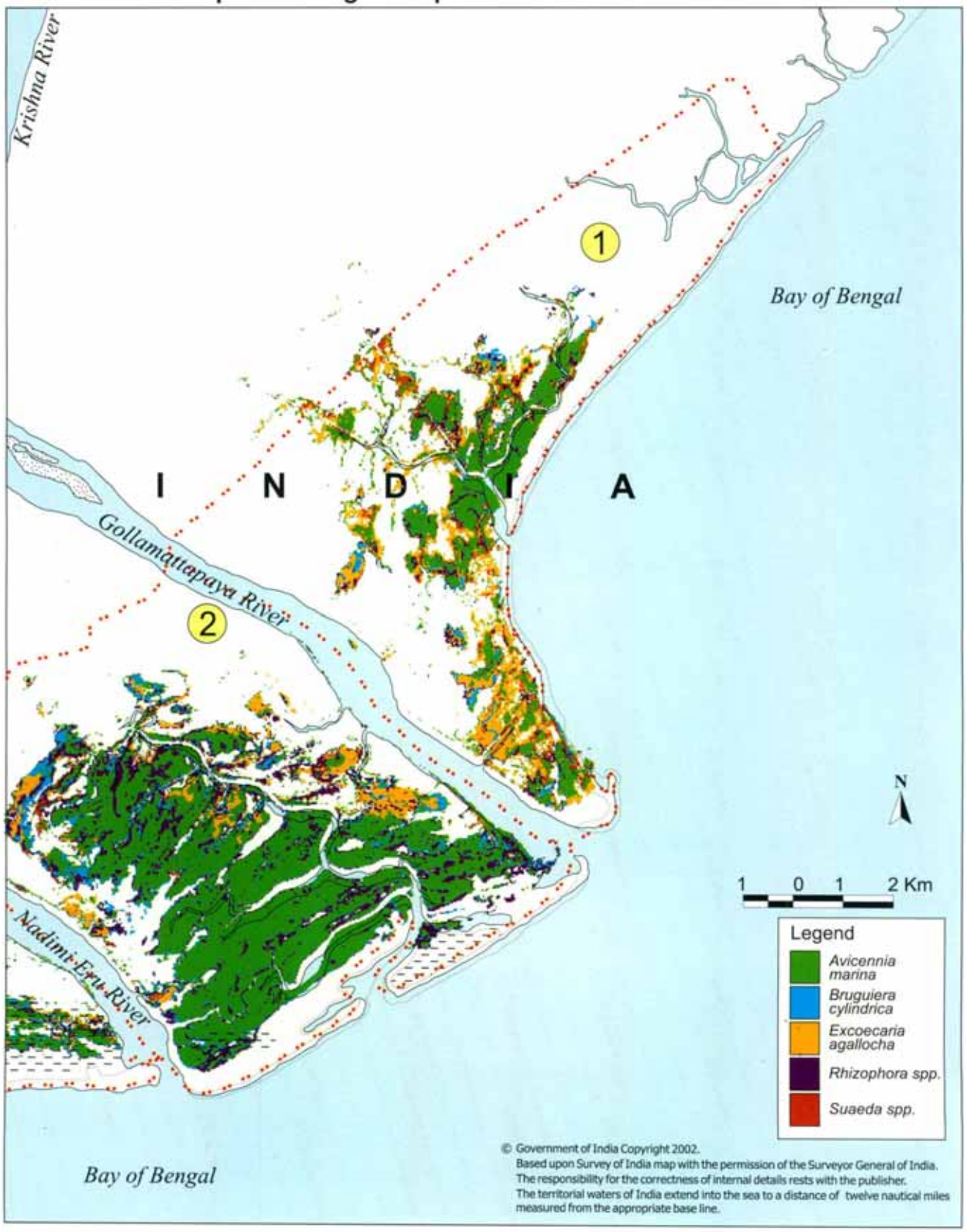
The total area under Lankivanidibba RF is 5,382 ha. of which 1,974 ha. is covered with thick mangrove vegetation. Species such as *Avicennia marina, A. officinalis, Xylocarpus granatum, Excoecaria agallocha, Ceriops decandra, Rhizophora apiculata* and *Bruguiera cylindrica* have been recorded. The vegetation is fairly thick. Large degraded areas are found in this RF. Anthropological pressure is noticed from villages nearby such as Molagunta, Kottapalem, Patur, Nakshatranagar and Lankivanidibba. The soil in this RF is clayey. *Prosopis* invasion is high in some areas.

Figure 41. Rhizophora mucronata found along the creeks of Lankivanidibba RF

Map 4.5a Mangrove Species Zonation - Western Part



Map 4.5b Mangrove Species Zonation - Eastern Part



4.4. Mangrove species zonation

Rhizophora apiculata, R. mucronata and *Bruguiera cylindrica* species are seen along the creeks of Sorlagondi RF (Map 4.6b) near the light house. An *Avicennia marina* zone occupies the area near the creeks. *Sueada* species are found in degraded areas. Likewise, in the Nachugunta RF, *Rhizophora apiculata, R. mucronata, Bruguiera gymnorrhiza and B. cylindrica* are observed along the creeks. *Avicennia* and *Exoecaria* zones stand in the adjoining area, while *Suaeda* and *Prosopis* are prominent in degraded areas. In the Lankivanidibba RF, *Rhizophora apiculata, R. mucronata, B. cylindrica and B. gymnorrhiza* are noticed along the creeks. *Rhizophora* are seen in large numbers along the seaward side (Map 4.5a).

4.5. Soil properties

The soil of the Krishna mangroves is clayey, and dominated by montmorillonite. The major riverbeds – Gollalamatapaya, Nadimeru and Krishna – are found to be clayey rather than silt. The overall soil texture may be classified as silty clay.

Soil samples were collected from both degraded and growth areas of the Krishna mangroves before taking up restoration work. The samples were analysed for soil salinity, pH, electric conductivity and other parameters including soil texture. The soil is mostly clayey inside mangrove areas, but sandy clayey in a few places. Soil salinity is greater in summer than in winter or the rainy season, because of the high rate of evaporation during summer. Soil pH in the areas studied ranges from 7 to 8.8, with an average of 8.0. The average is slightly higher in degraded areas. Organic matter content is low in degraded areas and creeks and slightly high in dense areas. The phosphorous content is low in general (Map 4.6 and 4.7).

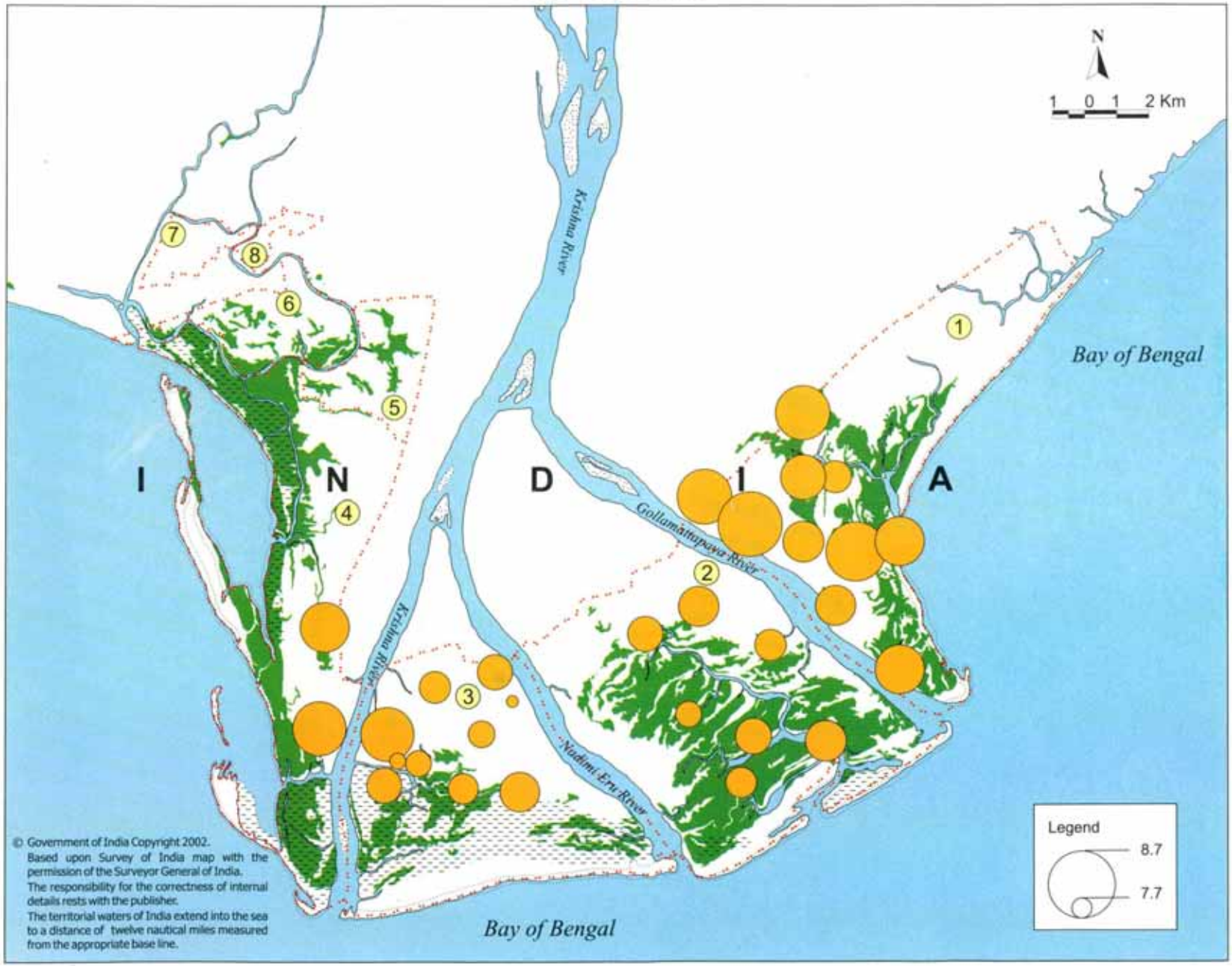
4.6. Hydrological conditions

Tidal amplitude

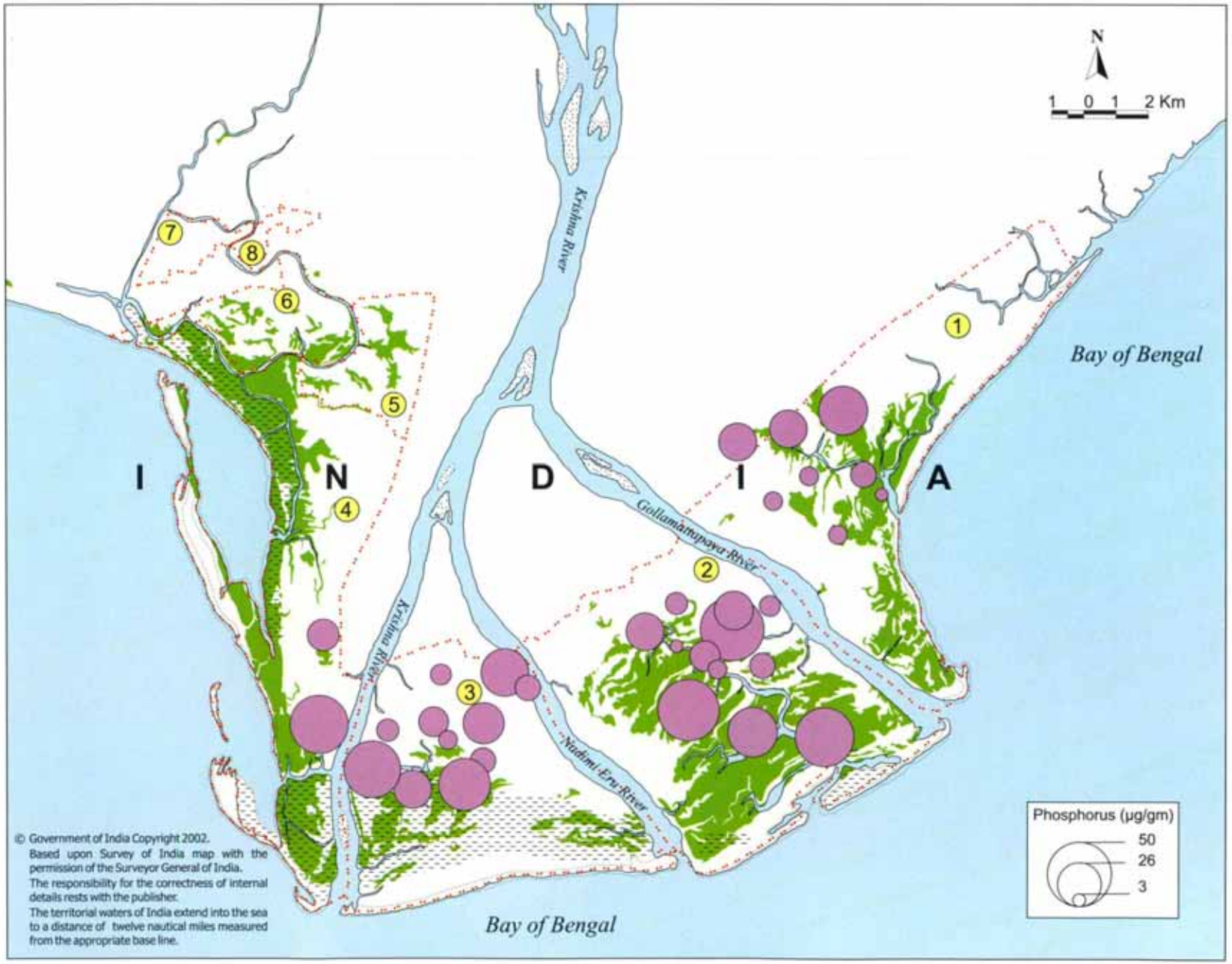
In the Krishna mangroves tidal amplitude was observed in 7 stations, 5 in the mangrove areas and 2 in the upstream (20 km from mangroves). In the upstream area tidal amplitude varied from 1.0 to 1.4 m and showed no conspicuous variation between monsoon and summer months. In some of the mangrove areas such as near Sorlagundi mangroves tidal amplitude was very less, ranging only from 0.15 m to 0.6 m. In some other mangrove areas such as Nadimeru and Gollamata tidal amplitude was relatively high ranging from 0.8 and 2.3 m (Map 4.8).

Figure 40. Data collection for tidal amplitude

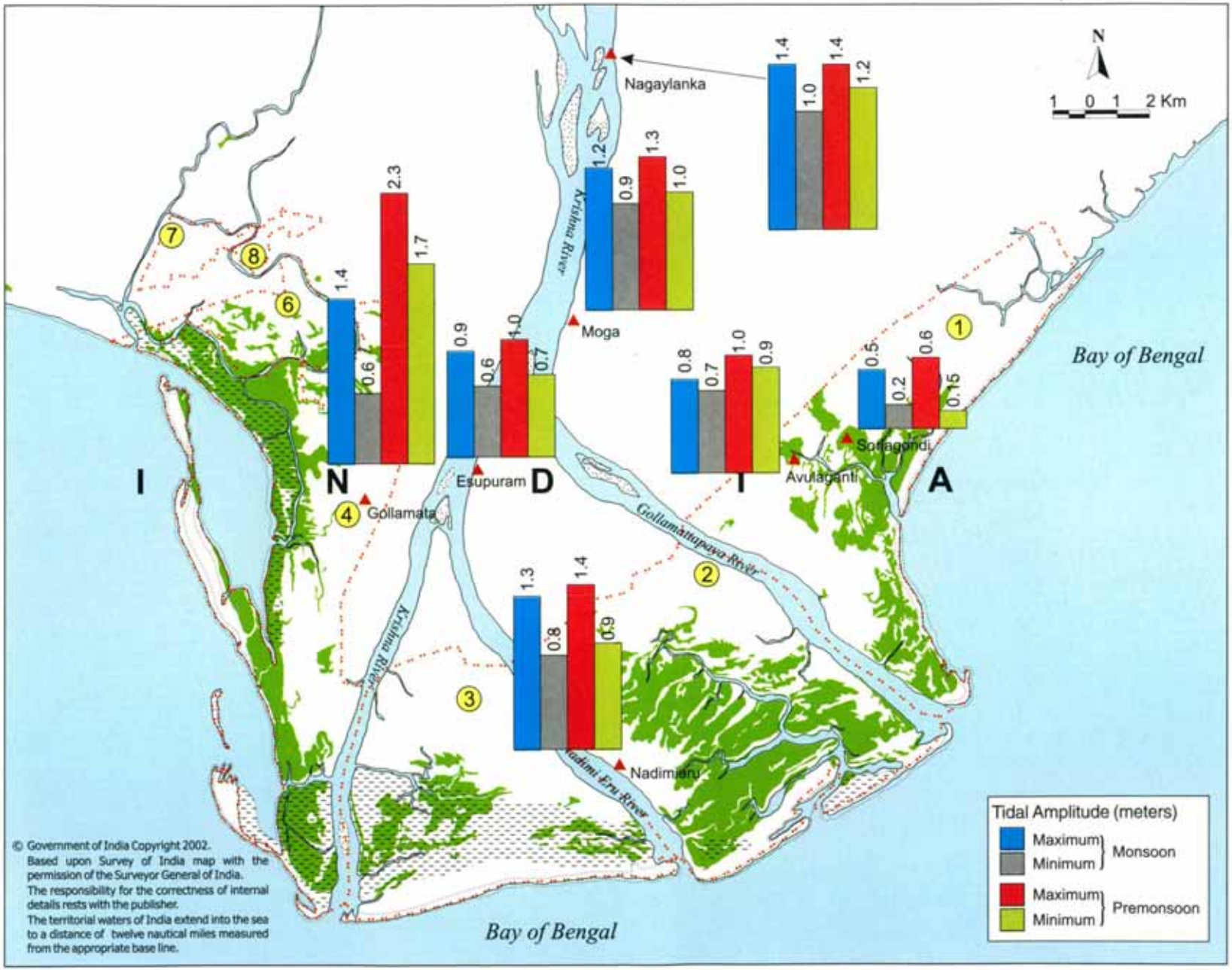
Map 4.6 Soil pH



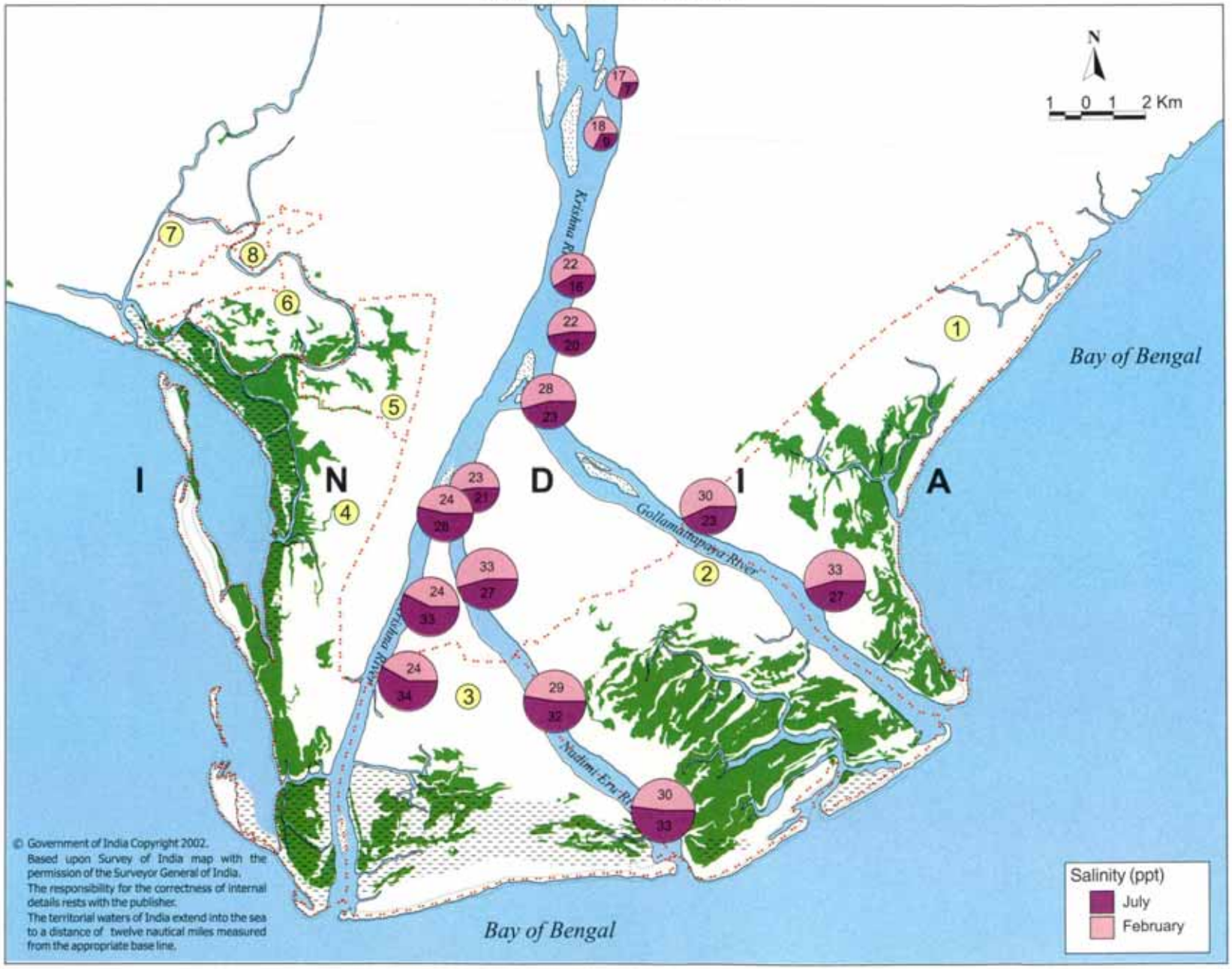
Map 4.7 Soil Phosphorus



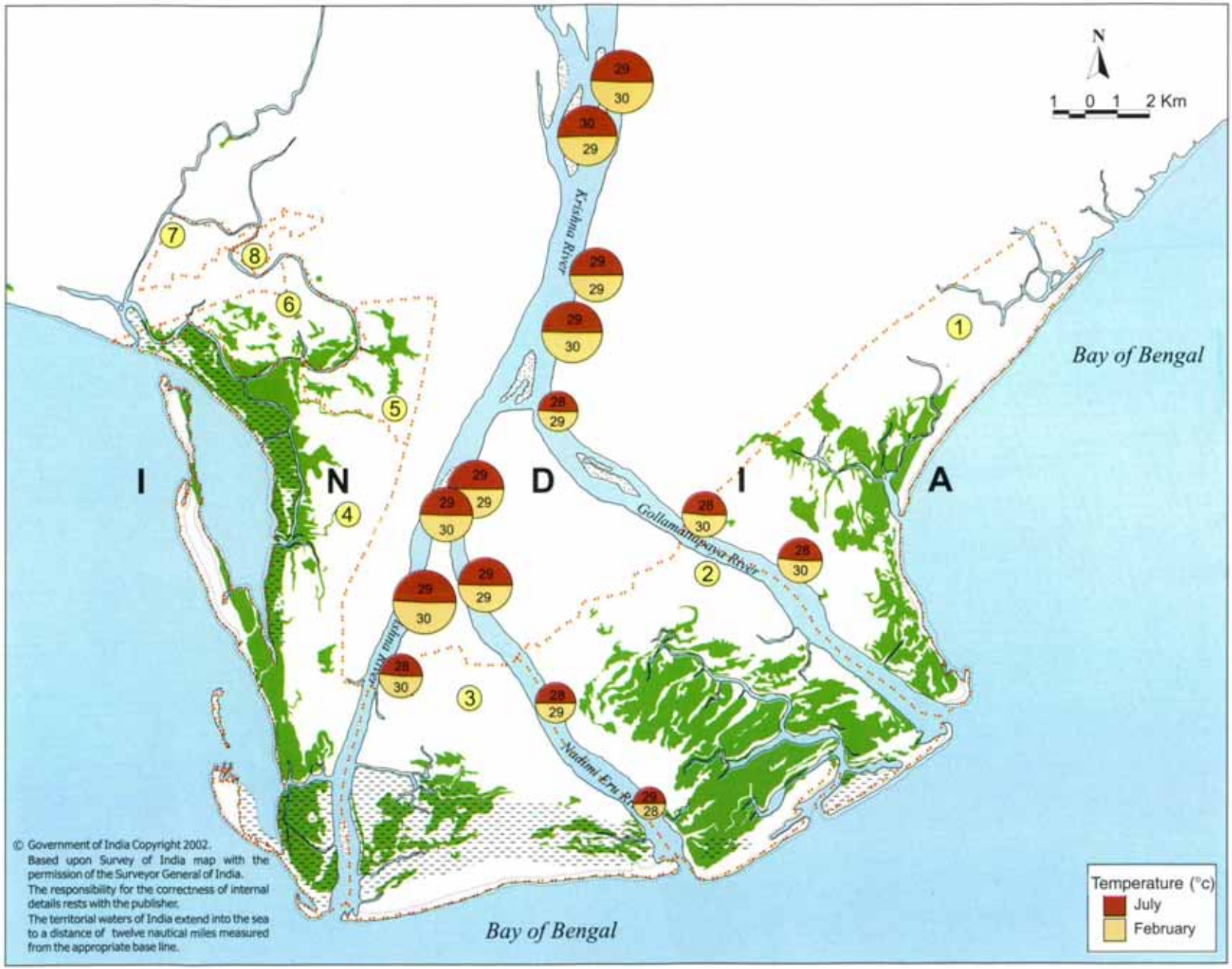
Map 4.8 Tidal Amplitude



Map 4.9 Water Salinity



Map 4.10 Water Temperature



Salinity and temperature

Salinity and temperature variations were studied during February and May in the creeks of Sorlagondi and Nakshatranagar (Map 4.9 and 4.10). Salinity variations in the mouth of Sorlagondi in February range from 23 to 32 ppt. The temperature ranges from 28 to 34°C. In May the salinity varies from 27 to 32 ppt and the temperature from 27 to 33°C. In Nakshatranagar, the salinity varies from 22 to 32 ppt regardless of the season. The temperature varies from 27 to 32 °C in February and 29 to 34 °C in May.

4.7. Wood and Fishery Resources

Dense Mangroves

Healthy dense mangroves can be seen near the light house in Sorlagondi RF, Nachugunta RF, Lankivanidibba RF, and Kottapalem RF. *Excoecaria agallocha, Avicennia marina* and *A. officinalis* are observed on the land. The middle zone is populated by *Avicennia marina, A. officinalis, Aegiceras corniculatum, Excoecaria agallocha, Rhizophora apiculata, R. mucronata, Bruguiera cylindrica, B. gymnorrhiza, Ceriops decandra* and *Xylocarpus granatum. Suaeda maritima, S. nudiflora* and *Excoecaria agallocha* can be noticed in mangrove areas of relatively low tidal inundation.

Mangroves are central to the lives of the artisanal fisher community that lives near these forests. The fisherfolk carry out subsistence fishing in the mangrove waters and collect prawn seed. The mangroves are source of firewood, fishing poles, timber for house construction, fencing materials for homes.

Figure 43. Status of restored mangroves in Sorlagondi

Casuarina Plantations

The Forest Department of Andhra Pradesh has planted casuarinas along the coast under its shelterbelt program. These plantations can be seen in Sorlagondi R.F. near Nali village.

Prosopis Invasion

Invasion by Prosopis in the mangrove area is prominent and pervasive all along the three main distributaries of Krishna River as well as in the interior of some of the mangrove forests. Dense Prosopis vegetation is observed along the Gollamatapaya river up to the river mouths of the Krishna.

Figure 44. Invasion of Prosopis in mangroves

Fishes

Fish species such as catfish, mullets, snappers, milkfish, carps, tilapia and mudskipper are common in mangrove areas. Snails, crabs, prawns and molluscs are also found. Prawn species such as *Penaeus monodon* and *P.indicus* are quite common. Many varieties of edible crabs live in mangrove areas, and giant fresh water prawns in swampy areas.

Figure 45. Dry fish and prawn for marketing

Figure 46. Prawn seed collection and selling

Figure 47. Crab collection in mangrove forests

4.8. Socio-economic condition

Mangrove User Villages

Socio-economic detail on the user villages of Krishna mangroves was collected by conducting a Rapid Rural Appraisal (RRA) and a baseline survey. The Baseline Survey was done in the villages of Dheenadayalapuram, Nakshatranagar, with the co-operation of the Churches' Auxiliary for Social Action (CASA) in Machilipatnam and the Gandhian Organisation for Rural Development (GORD) in Repalle. Information was also obtained from the Mandal Revenue Office.

The communities of 28 villages near the mangroves tap the resources (Map 4.11) of Krishna wetlands. The table below provides details of population, occupation and dependency on mangroves, obtained through the PRA.

Table 9 Mangrove User Villages in Krishna

Village Name	Population	Live stock	Major Occupation		Houses	Dependency			
			Agriculture	Fishing		Fuel	Fencing	House construction	Grazing
Yelichetladibba	1154	200	No	Yes	326	Medium	High	Medium	Medium
Nachugunta	1500	200	No	Yes	300	High	High	Medium	Medium
Zinkapalem	493	75	Yes	Yes	113	Medium	High	Medium	Low
Gollamondha	2500	200	Yes	Yes	450	High	Medium	Medium	Medium
Dheenadayalapuram	564	150	Yes	Yes	143	Low	Medium	Low	Medium
Sorlagondi	2500	400	Yes	Yes	400	High	High	Medium	High
Nali	1124	150	Yes	Yes	228	Medium	Low	Low	Medium
Sangameswaram	1201	400	Yes	Yes	300	Low	Medium	Medium	High
Pata Upakali	700	400	Yes	Yes	200	Low	Medium	Low	High
Lankivanidibba	3000	100	Yes	Yes	475	Medium	High	Medium	Medium
Mollagunta	2500	200	No	Yes	400	High	Medium	Medium	Medium
Tallatippa	300	40	No	Yes	110	Medium	High	Medium	Low
Nakshatranagar	809	50	Yes	Yes	250	High	High	High	Low
Sanjivinagar	550	200	No	Yes	150	High	High	Medium	Medium
Pattur	350	25	No	Yes	100	Medium	Medium	Medium	Low
Mandudupalem	400	75	No	Yes	115	Medium	Medium	Medium	Low
Varmapuram	630	65	No	Yes	145	Medium	High	Medium	Low
Zulu	2000	80	No	Yes	250	Medium	Low	Medium	Low
Edurumondi	2000	250	Yes	Yes	400	Medium	Medium	Medium	Medium
Kottapalem	2500	150	No	Yes	450	High	High	Medium	Low
Kottur	1400	100	No	Yes	300	Medium	Medium	Medium	Low
Dakshinasaradanagar	400	65	No	Yes	120	Medium	Medium	Medium	Low
Uttarasaradanagar	650	30	No	Yes	130	Medium	Medium	Medium	Low
Muktheswarapuram	370	65	Yes	Yes	125	Medium	Medium	Medium	Low
Kattava	450	150	No	Yes	100	Medium	Medium	Low	None
Kallipalaem	500	70	Yes	Yes	160	Low	Low	Medium	Medium
Kumaripalem	520	40	Yes	No	120	Low	Medium	Medium	Low
Total	**31065**	**3930**			**6360**				

Population and Occupation

Twenty eight villages with 6,360 houses and a total population of 31,605 abut the mangroves (Map 4.12a, b, 4.15a and b). These villages depend for their livelihood on mangrove resources. Fishing is the major occupation, but the people also work as agricultural labourers during the lean season. The literacy rate of men and women respectively is 87% and 66% in Dheenadayalapuram, 36% and 51% in Zinkapalem and 48% and 38% in Nali.

Map 4.11 Mangrove User Villages

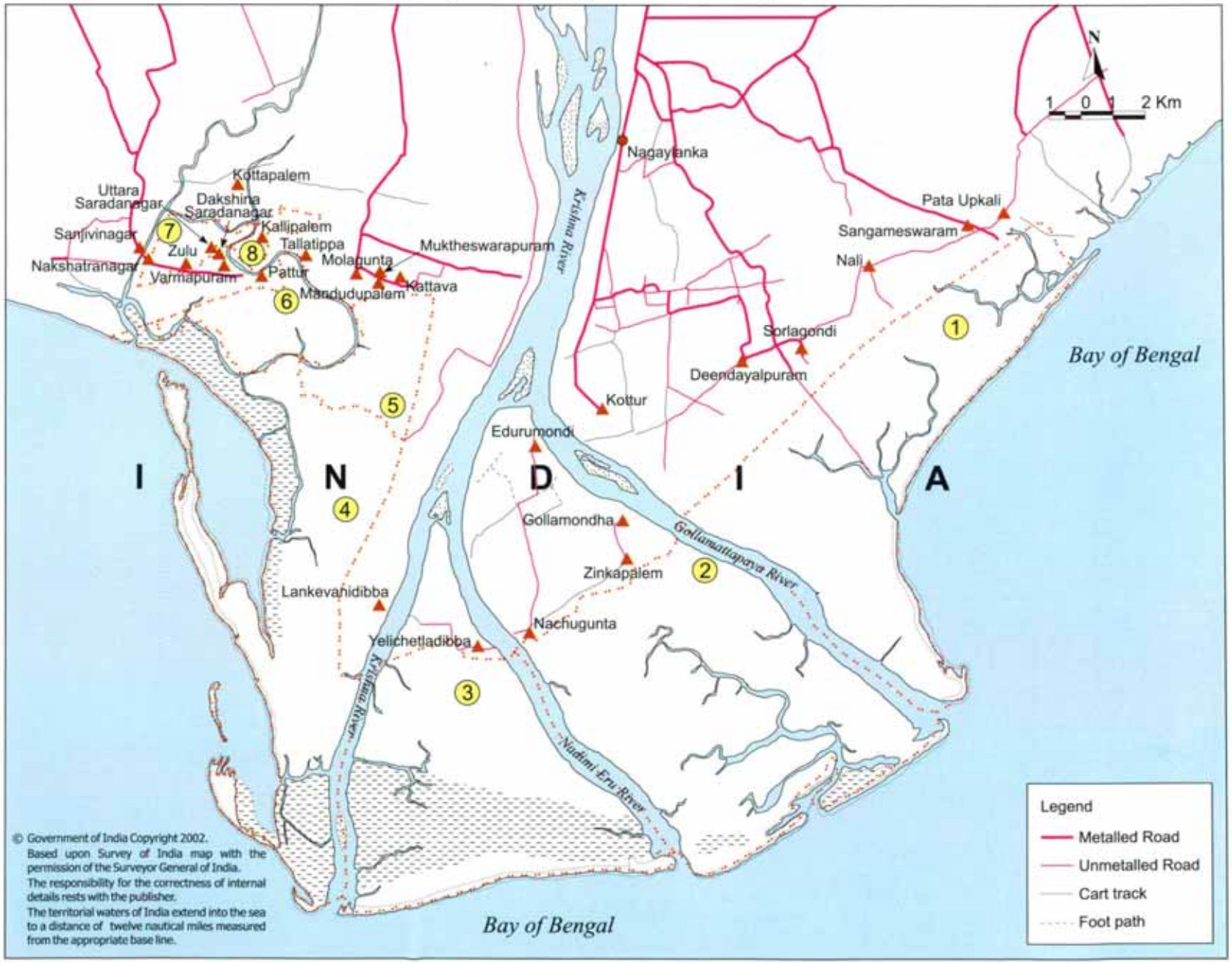


Figure 48. Fishing – A major occupation in Krishna Delta

Figure 49. Zinkaplem - one of the user villages near Nachchugunta RF

Infrastructure

Coastal villages in the interior of Krishna and Guntur districts are accessible by road. If a cyclone strikes, cyclone shelters aren't too far. The people can easily access the forest range office, the Primary Health Center, the police station, the local high school, bank and Mandal office.

The facilities in coastal villages situated along the river bank are limited to cyclone shelters, a primary school and Public Health Centers. A light house is situated in the Sorlagondi RF near Gollamattapaya river, and a guest house owned by the Forest Department at Nagayalanka (Map 4.14).

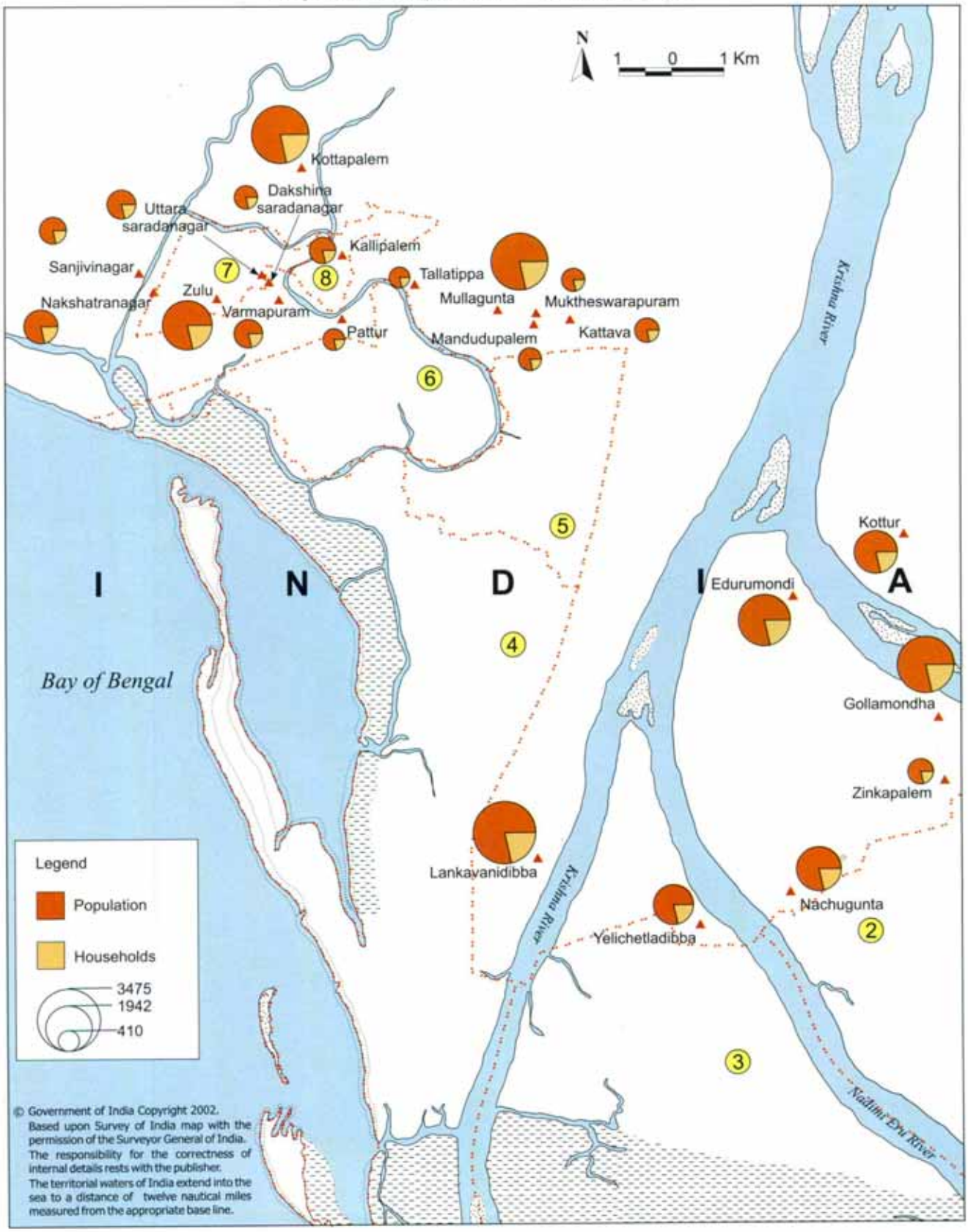
Income range

The average annual income of the villages mentioned above ranges from Rs. 18,000 to Rs 24,000. 55% of the families feel that their income is not sufficient, but 45% consider it sufficient (Map 4.15).

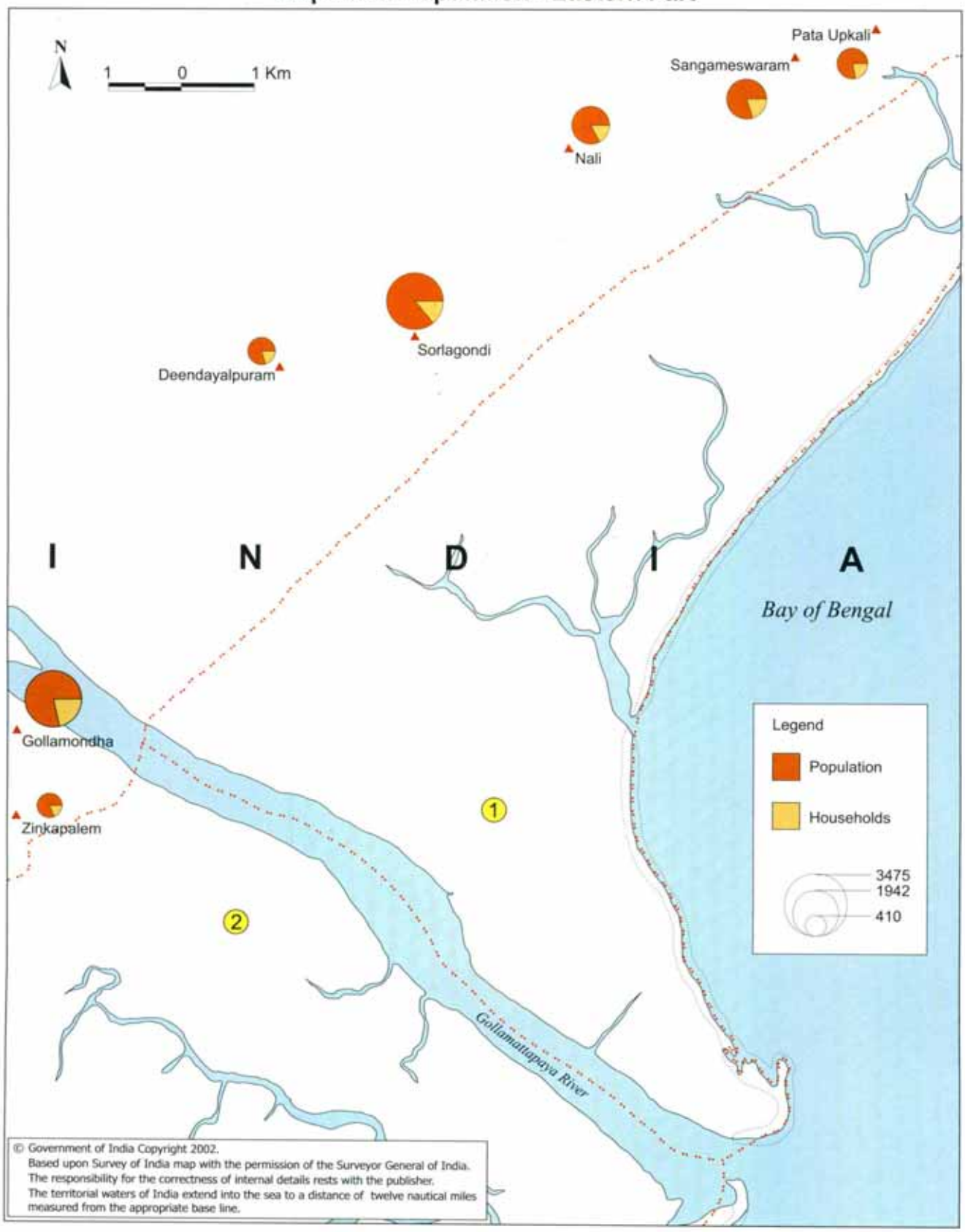
Livestock

There are 3,930 buffaloes and cows in all the villages. They depend partially on mangroves for fodder (Map 4.16a and b).

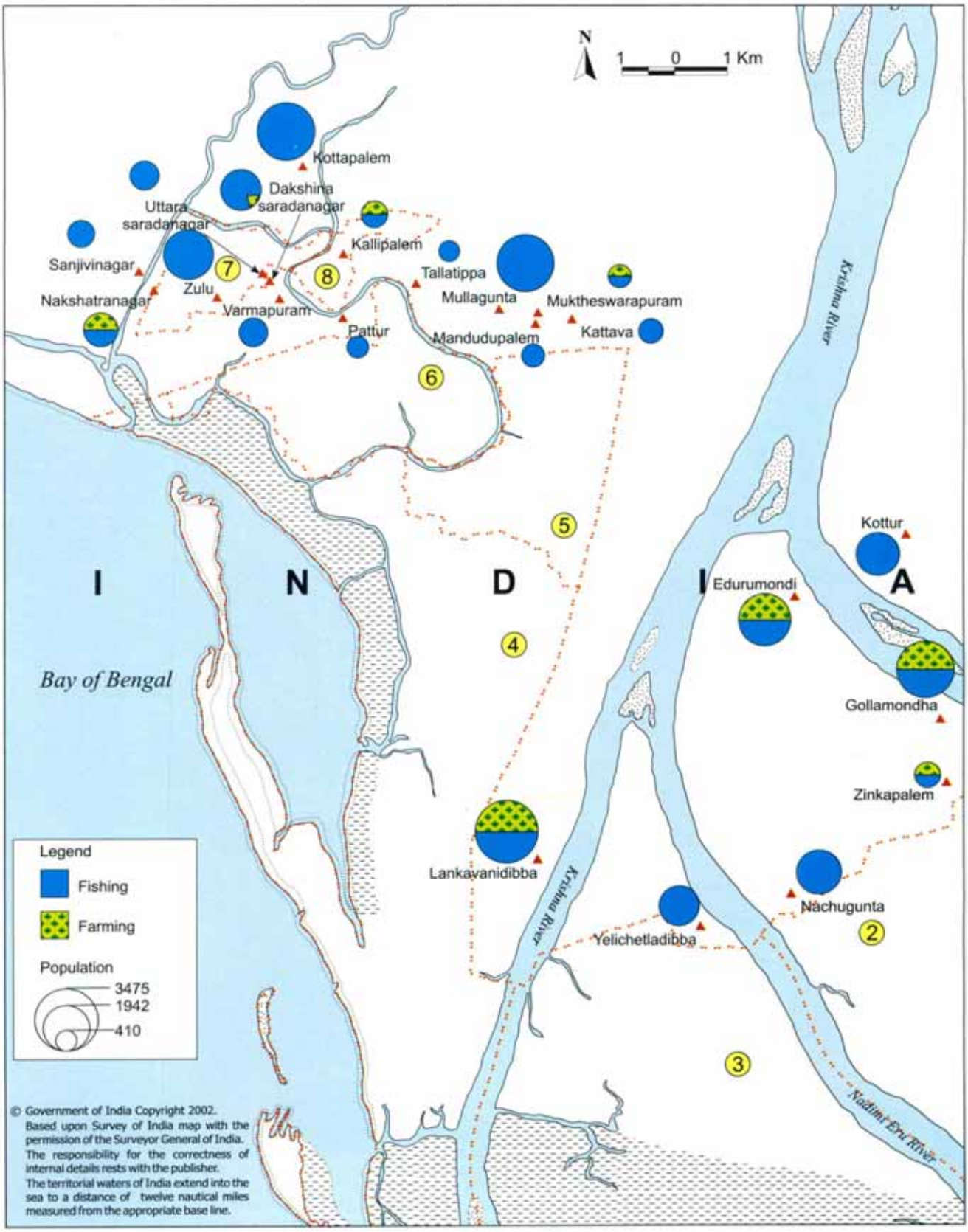
Map 4.12a Population - Western Part



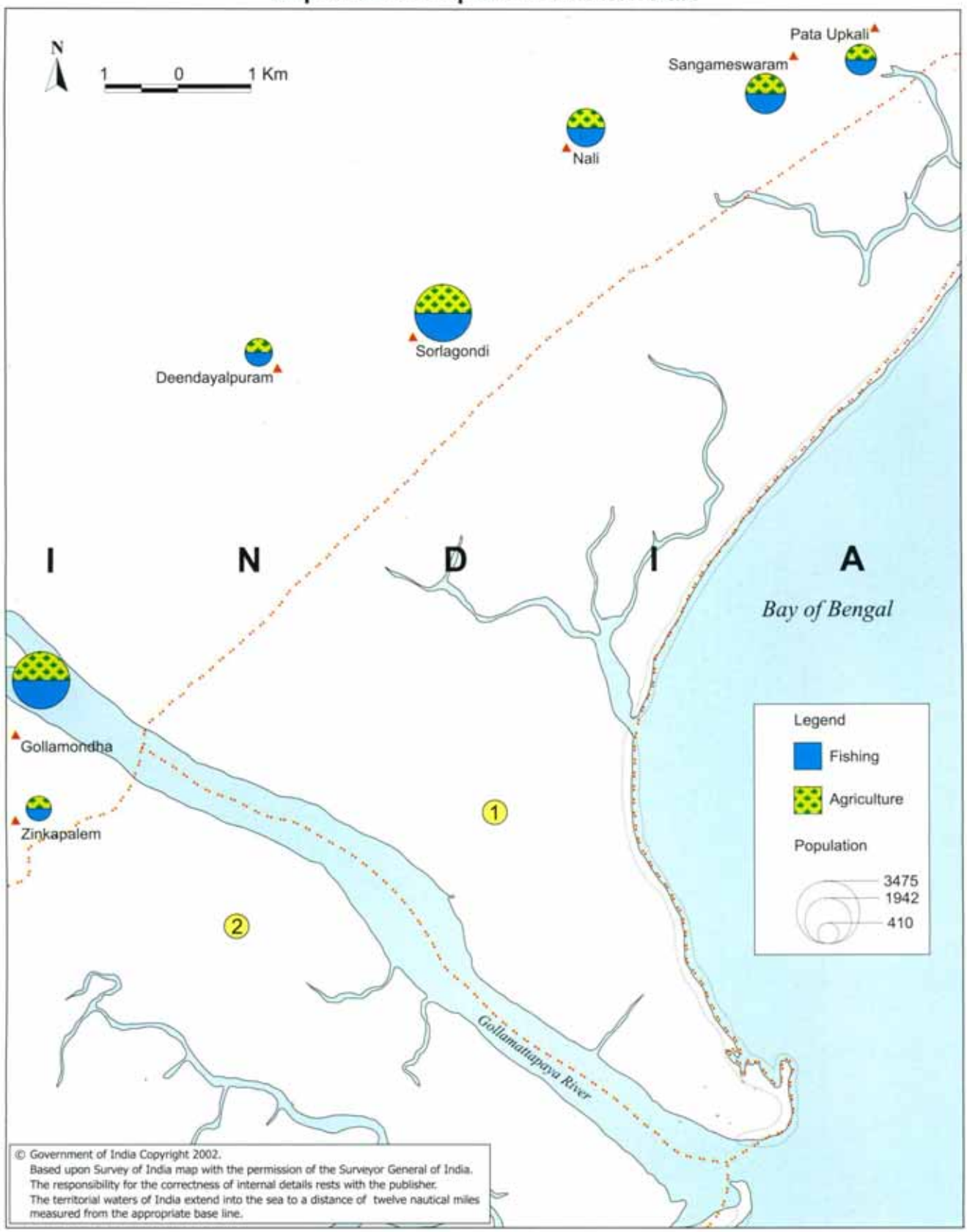
Map 4.12b Population - Eastern Part



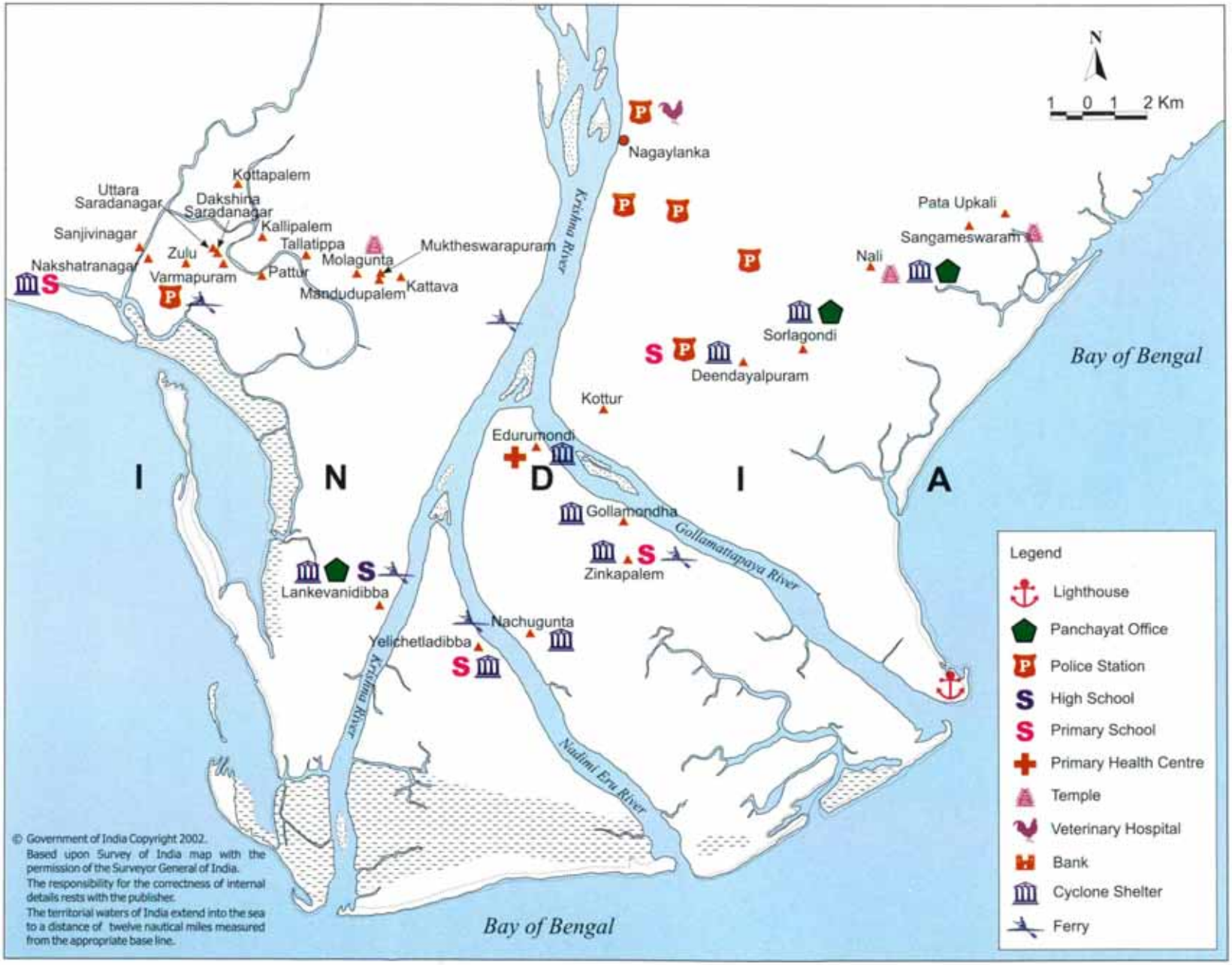
Map 4.13a Occupation - Western Part



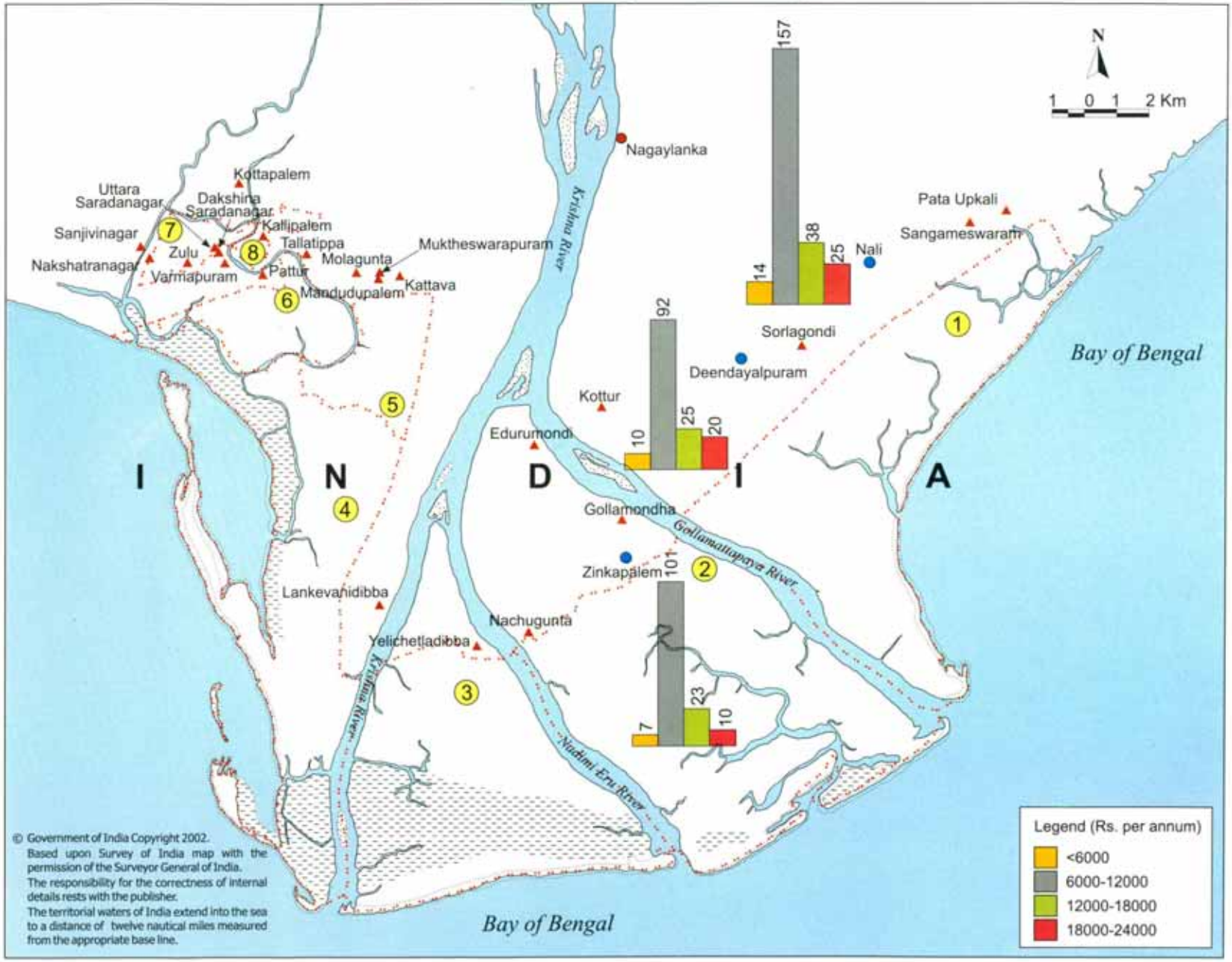
Map 4.13b Occupation - Eastern Part



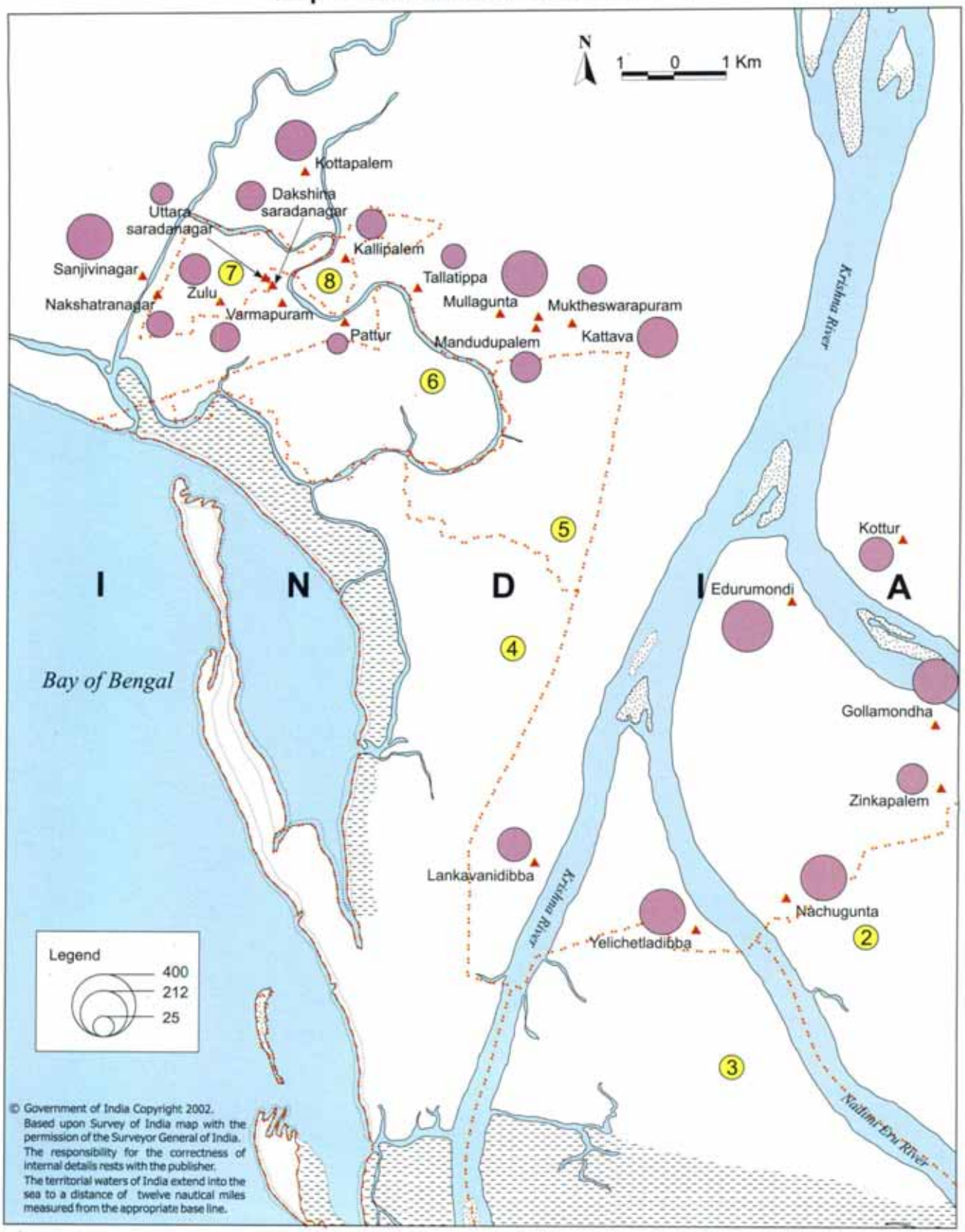
Map 4.14 Infrastructure



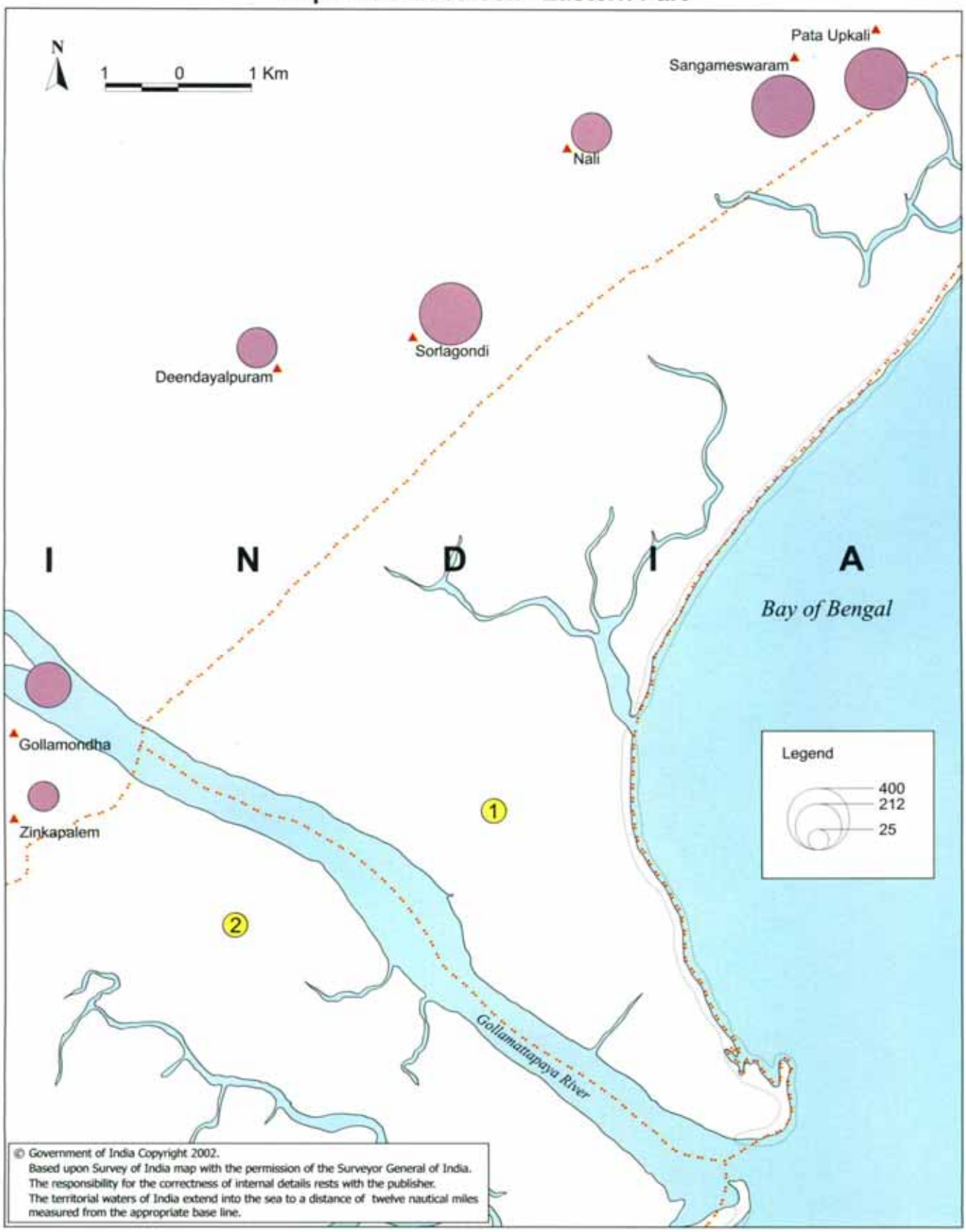
Map 4.15 Income range in JMM Villages



Map 4.16a Livestock - Western Part



Map 4.16b Livestock - Eastern Part



4.9. Land use

The wetland region covers mangrove vegetation, mudflat, and water bodies such as rivers, streams, canals, creeks and sand; inland uses include aquaculture and agriculture farms with paddy as major crop. Some of the aquaculture farms set up during the early 1990s were abandoned in recent years. Intermediate wetland and upland zones are covered with *Prosopis* and sand spread along the river course.

Cropping pattern

Paddy is the major agricultural crop cultivated in coastal villages near mangrove areas. It is irrigated mainly by canals of the river Krishna. The Forest Department has raised casuarina plantations under its shelterbelt programme along the coast near Sangameswaram, Pata Upakali and Nali. The returns from these plantations are used to help the villages.

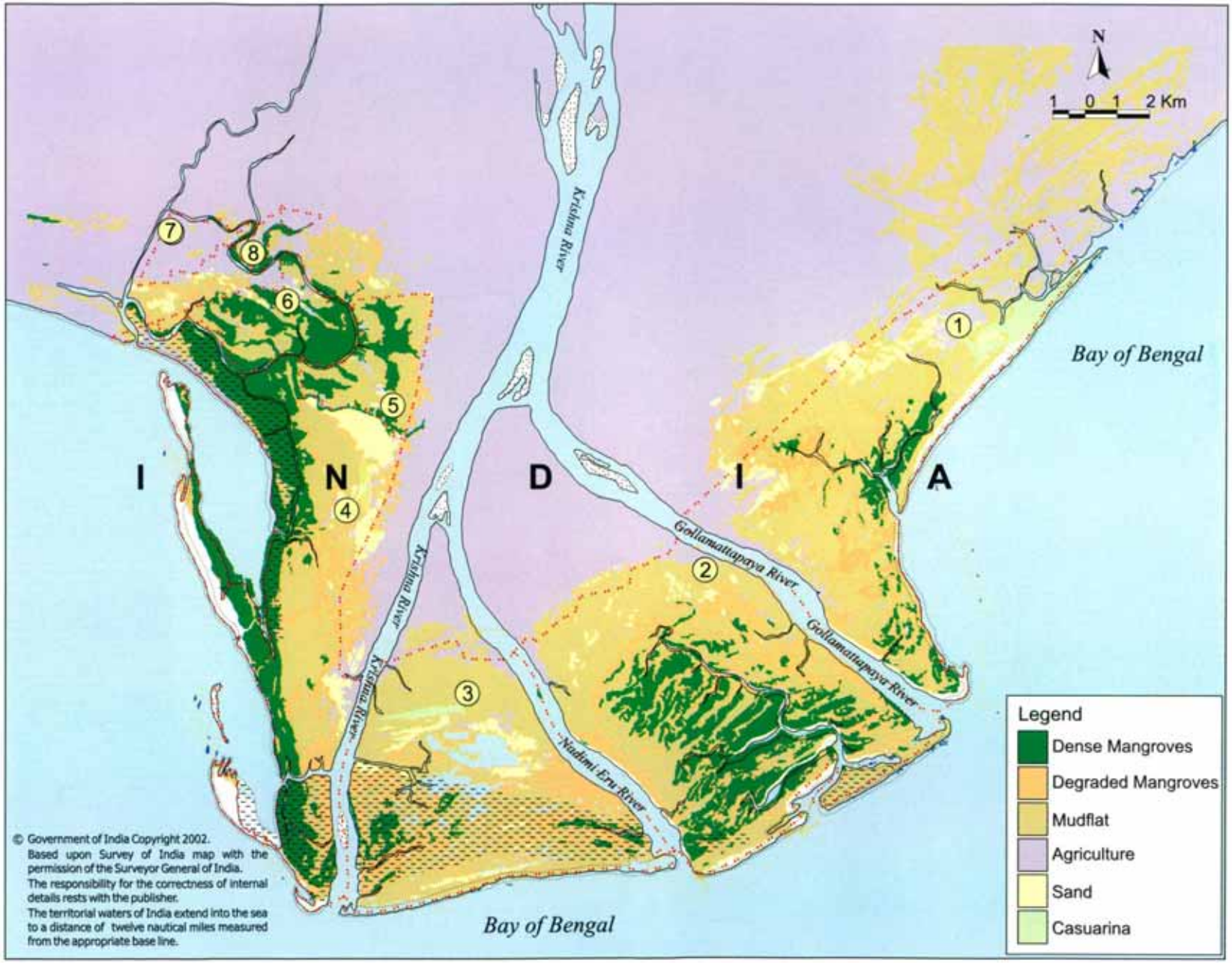
Salt pans

Some revenue areas are used as salt pans. This can be seen near Sorlagondi RF adjoining the reserved forest.

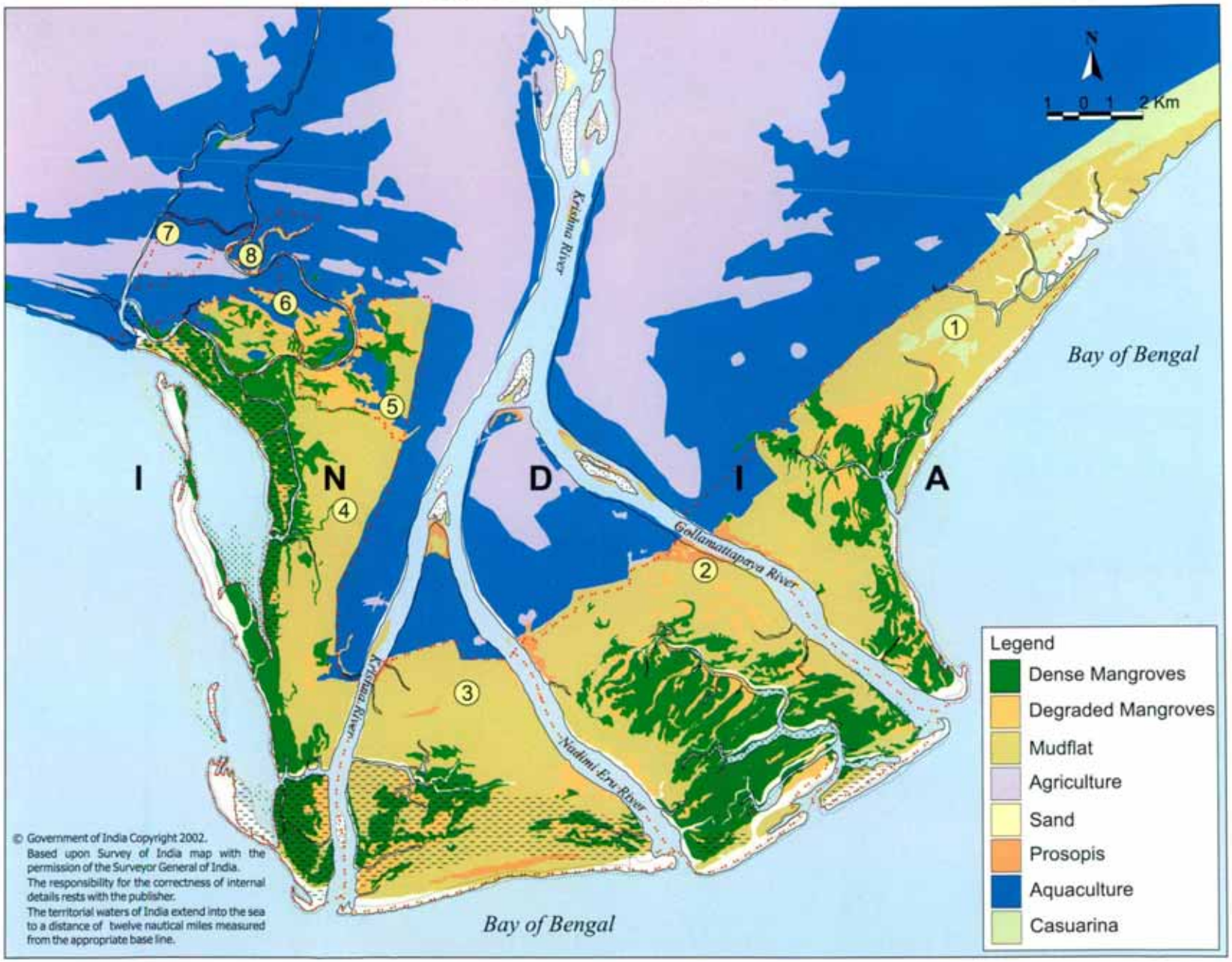
Aquaculture

Aquaculture is being practised both in revenue lands and forest areas. In some places, paddy fields have been converted to prawn farms; in other areas the same farms have been reconverted to paddy fields. It's mostly tiger prawns that are cultivated in the prawn farms.

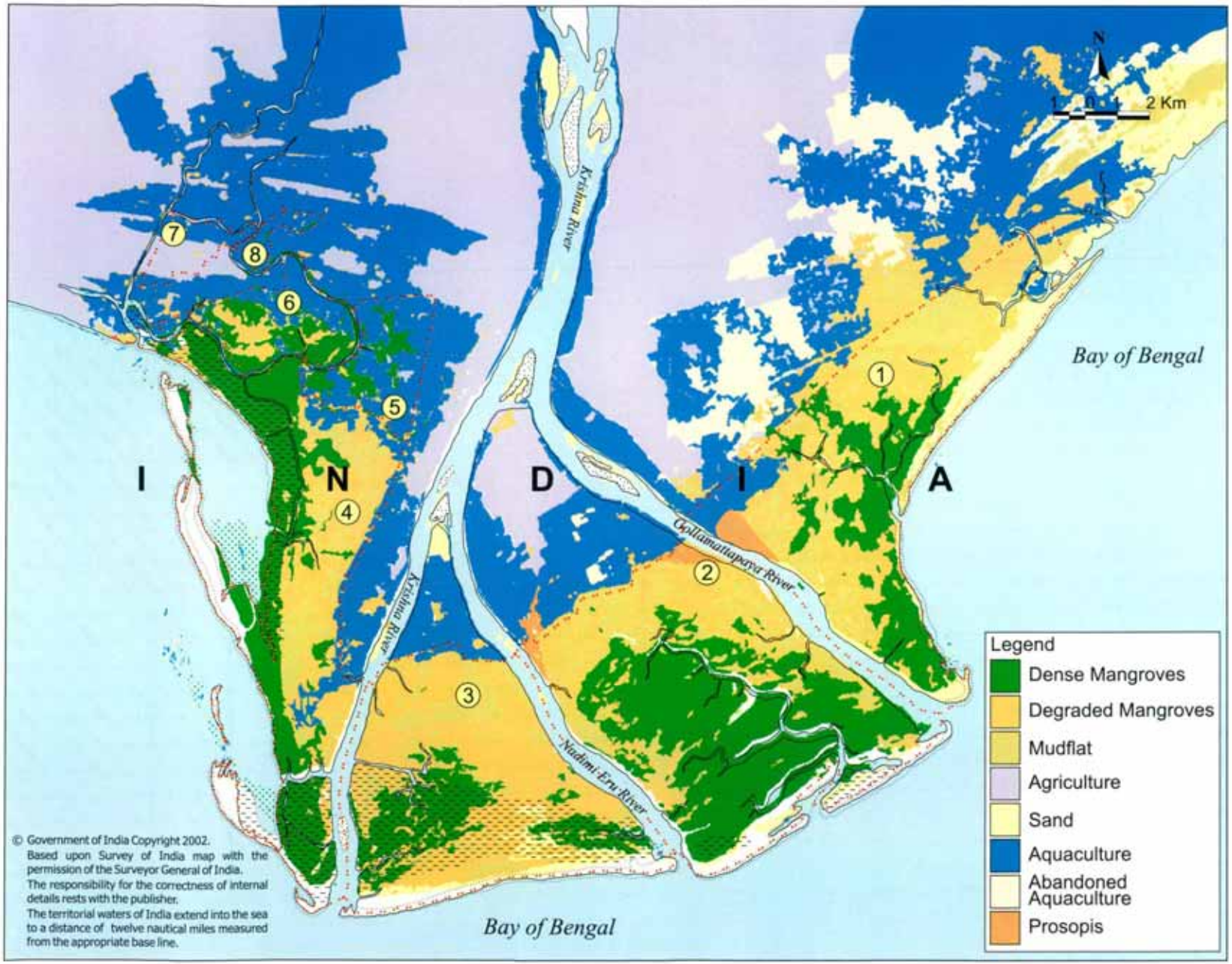
Map 4.17a Landuse Map - 1986



Map 4.17b Landuse Map - 1996



Map 4.17c Landuse Map - 2001



4.10. Dependency

Grazing

Cattle-grazing in mangrove areas inhibits mangrove growth and the establishment of young seedlings. The cattle gobble up young leaves of *Avicennia marina*, and this aborts or limits the growth of mangrove saplings in particular. According to the local community, cattle graze in the mangrove forest nearby because fodder isn't available (Map 4.18a and b).

Firewood

Coastal communities depend on mangroves for firewood, because of the proximity of the mangroves and the easy access to them. *Avicennia marina*, *A. officinalis* and *Aegiceras corniculatum* are the major species used for firewood.

House construction

Mangroves are tapped for house construction. The main species used are *Avicennia marina*, *A. officinalis*, *Exoecaria agallocha* and *Bruguiera cylindrica*. Following the 1977 cyclone, the Rashtria Swayam Sevak Sang (RSS), TATA, and Red Cross Society have constructed pucca houses in a few villages.

Figure 50. Mangrove wood used for fencing

Fishing

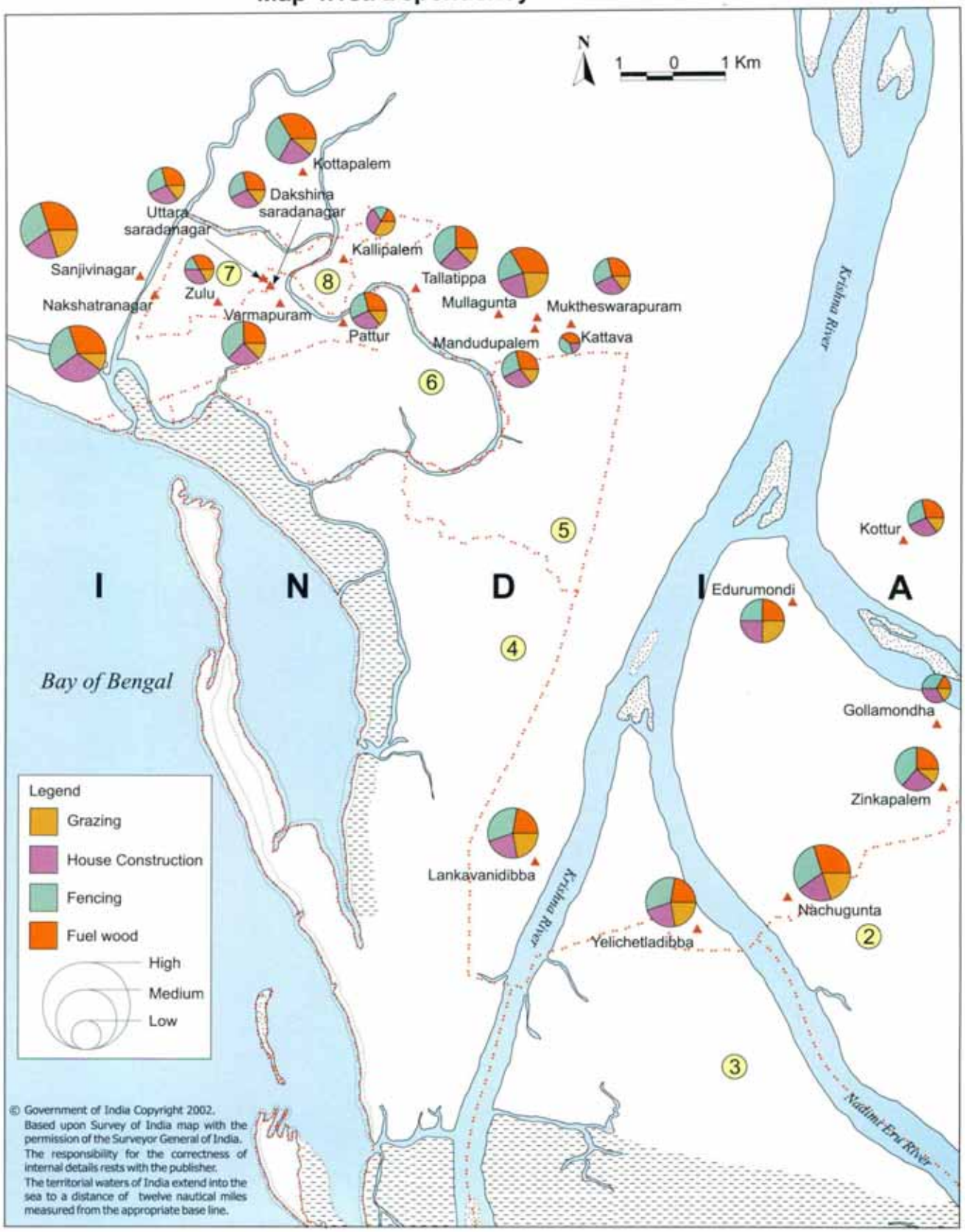
Fishing activities are noticed in all of the mangrove areas. Prawn seeds are collected for supply to aqua farms. Inevitably, a large number of juvenile fishes and prawns are also collected in the process – something that cannot but affect future fish production. Fishermen collect and market crabs, different varieties of eel fish (known locally as *Guddipamulu*, *Komiraya pamu*, *Kulimipamu* and *Semberipamu)* and shellfish.

Figure 51. Prawn seed collection using nets

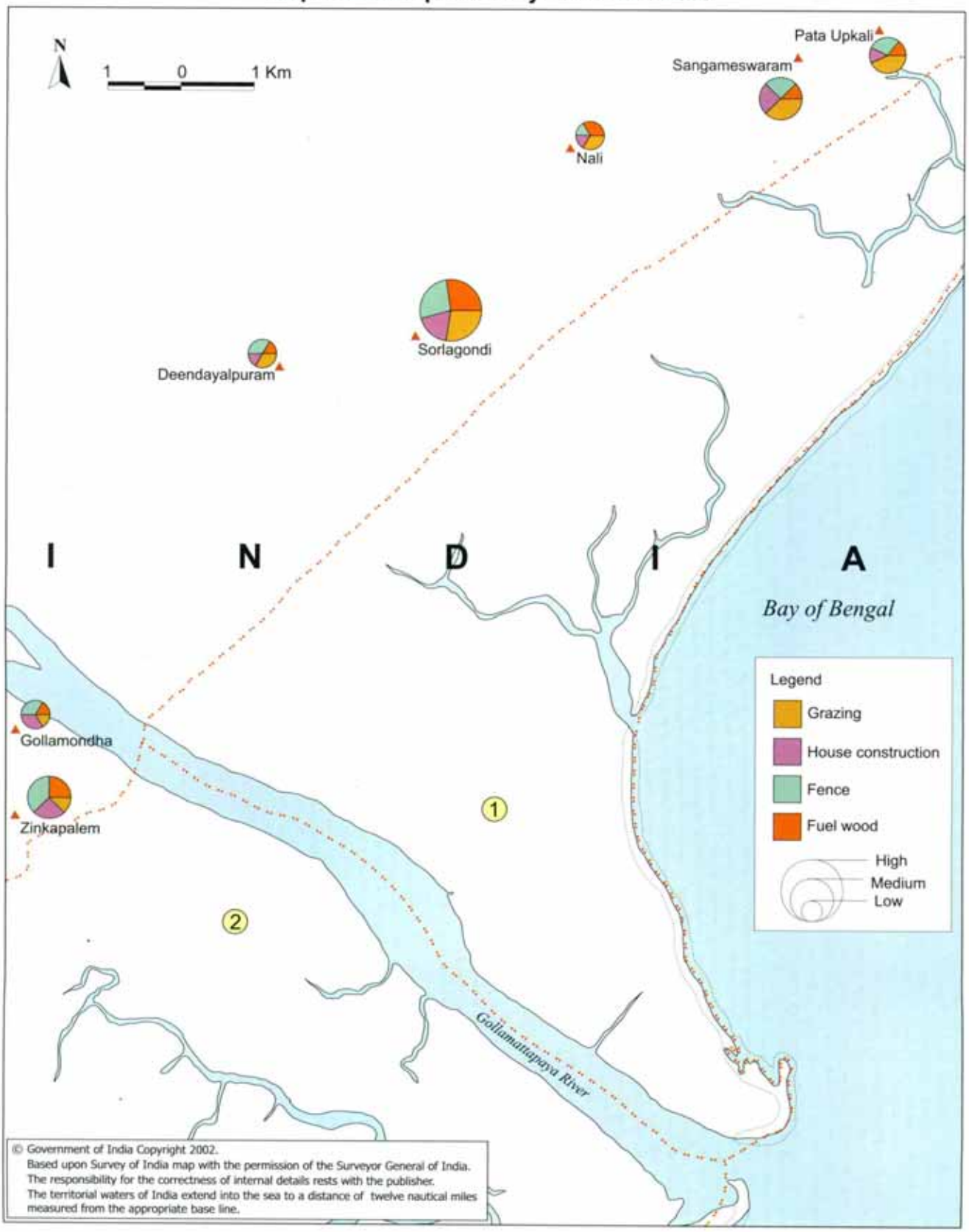
Figure 52. Crab collection

Figure 53. Prawn seed collection

Map 4.18a Dependency - Western Part



Map 4.18b Dependency - Eastern Part



4.11. Causes of degradation

The main causes of degradation of the Krishna mangroves are as follows:

a) *Changes in microtopography due to coupe-felling* : Extensive areas of healthy mangrove forest were coupe-felled in the past. Wherever coupe-felling was done, drastic changes occurred to the micro-topography because of the evaporation of soil water, the consequent stagnation of tidal water in the coupe-felled area, and the failure of natural regeneration in mangrove species.

b) *Changes in the biophysical condition due to cyclones*: The Krishna mangroves experienced two severe cyclonic storms during 1977 and 1990. Though the magnitude of the destruction could not be assessed, the storms caused extensive damage to mangroves through sand casting, making these areas unsuitable for mangrove vegetation.

Figure 54. Degraded area and coup felled area

c) *Progradation of shoreline*: Progradation (flat areas gradually tapering into the sea) of the Krishna coast shoreline has been rapid. Coupled with low tidal amplitude, this phenomenon hampers tidal flushing of the wetland in the upper portion of the mangroves. Result: mangrove wetlands in these areas have gradually got converted into terrestrial areas, no more suitable for mangrove plantation.

d) As explained earlier, the local community living in coastal areas particularly fishers, use the mangroves for firewood, fencing materials fodder, house construction and grazing.

e) *Conversion of mangrove wetlands into prawn farms*: Prawn farms are coming up on a large scale in the Krishna mangrove region. As mentioned earlier, even some part of the Reserve Forests has been converted into aquaculture farms.

f) *Reduction in fresh water flow*: The quantity of fresh water reaching the Krishna mangroves has got progressively reduced because of the diversion of fresh water in the upstream area. This also affects both the growth and the quality of mangrove wetlands.

Figure 55. Canal construction in degraded mangroves

4.12. Restoration and Redevelopment

The mangrove forest area is diminishing gradually, because of the reasons cited above. The project took up canal construction to restore degraded areas and expand the mangrove area. As much as 355 ha of degraded mangroves have been restored in the Krishna in this manner (Table 10). This activity also gave the local community – which provided labour for constructing the canals and planting the seedlings — much-needed income. Mangrove seedlings were raised in nursery beds in co-operation with mangrove villagers as per standard measurements and methods. All mangrove seedlings were raised to optimum height (to a pencil-thick 60 cms), then planted in the site when climatic and biophysical conditions were favourable. Seed beds were prepared during November and December, and seedlings planted in December and January. Training on nursery-raising and planting was imparted to members of the community and to village-level institutions in the respective demonstration villages.

Figure 56. Nursery (top) and canal construction (bottom) in Sorlagondi RF

Table 10 Details of restoration and Mangrove Management Units - Krishna

Demonstration village	Area restored (ha.)	Area under MMU (ha.)
Dheenadayalapuram	236	2000
Nali	5	
Zinkapalem	114	600
Total	**355**	**2600**

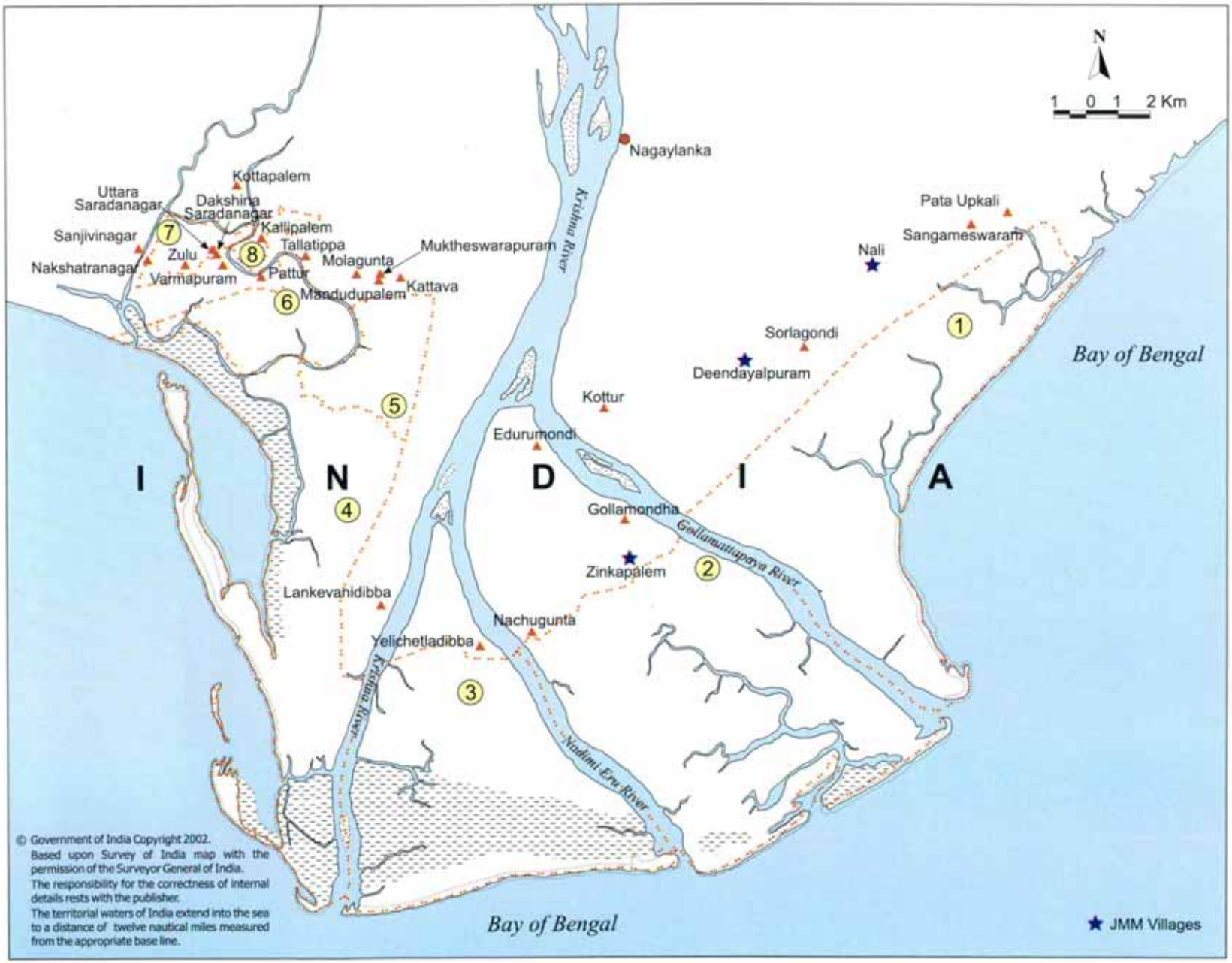
4.13. Joint Mangrove Management

Joint Mangrove Management – restoration and conservation of mangrove wetlands by the local community through village level institutions –has been demonstrated in three villages. Table 10. shows the area restored and the area under the protection and management of these villages.

The canal technique explained above has been followed for restoration. The villagers have been given alternatives to mangroves for fuel and fencing materials, to reduce dependence on mangroves. For example, gas, kerosene and smokeless stoves (which need less firewood than conventional stoves) have been distributed to women. Project staff have encouraged the villagers to use Prosopis and coconut and borassus palm refuse in place of firewood. Trees have been planted to provide fencing material for housing. Plantations of casuarina, bamboo, subabul and eucalyptus have been undertaken to meet the community's requirements for firewood and timber.

Figure 57. Restoration done in 1999

Map 4.19 Villages abutting Mangroves



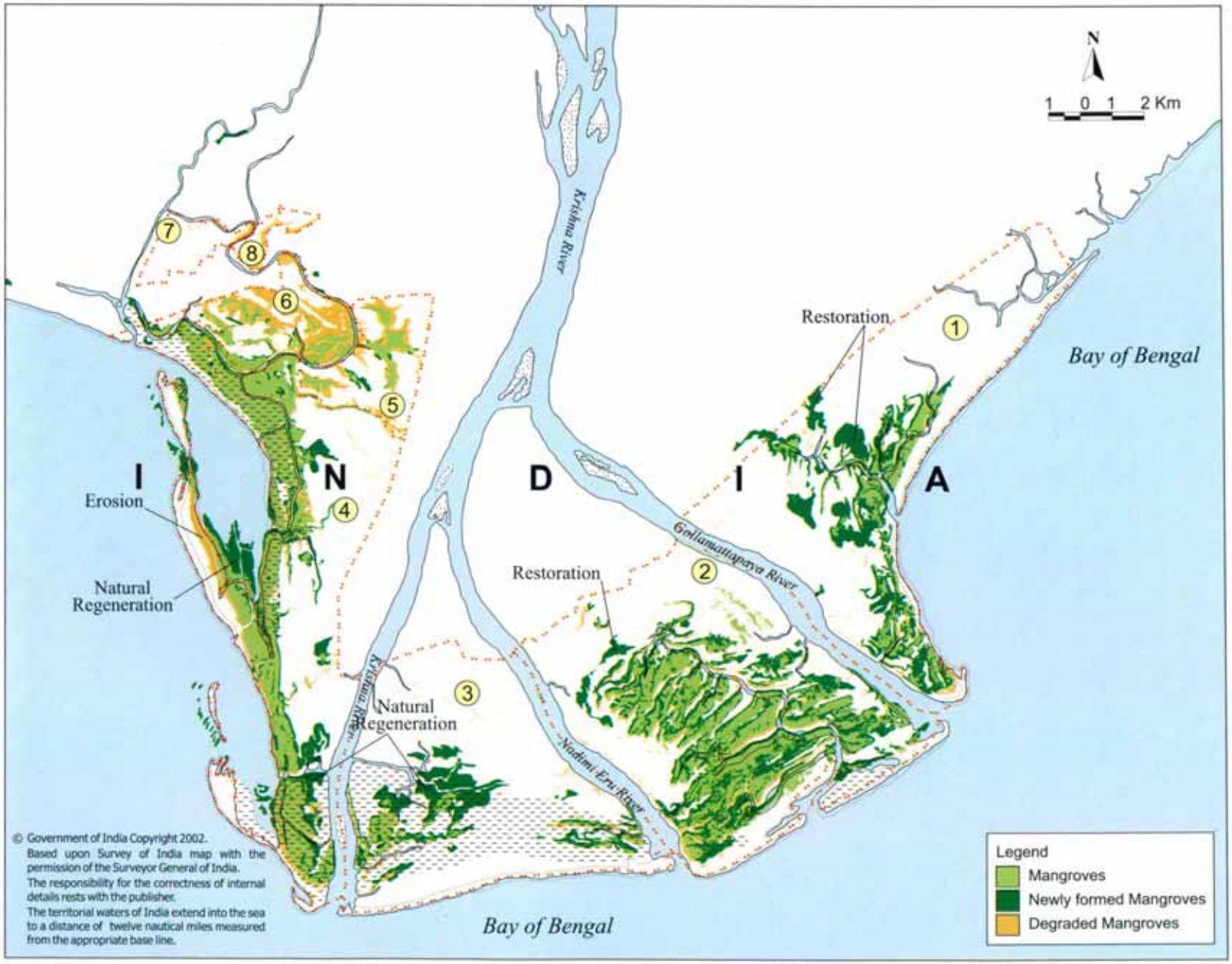
4.14. Changes in mangrove vegetation between 1986 and 1996

The mangrove vegetation underwent changes between 1986 and 1996. Data from the Landsat 5 Thematic Map (TM) and IRS 1C LISS III data were used to delineate the extent of mangroves in 1986 and 1996 respectively. Starting from the east, in Sorlagondi RF, mangrove vegetation has increased around the periphery of the core mangrove up to Lankivanidibba RF – about 3,039 ha. But considerable degradation of mangrove has occurred in the Mulagunta, Adavuladivi and Kottapalem RF Bit No.1. At the same time the shoreline has been found to be dynamic in the western part of the delta. The spit size is increasing; thus natural regeneration of about 300 ha of mangroves has been noticed on the sediments of the spit. The spit formation on the eastern part of the delta near Sorlagondi does not have much impact on mangrove vegetation during this period (Map 4.20).

Figure 58. Degradation due to hyper salinity

Figure 59. Large patch of degraded area - a common feature in Krishna wetland

Map 4.20 Changes in Vegetation between 1986 and 1996



4.15. Changes in mangrove vegetation between 1996 and 2001

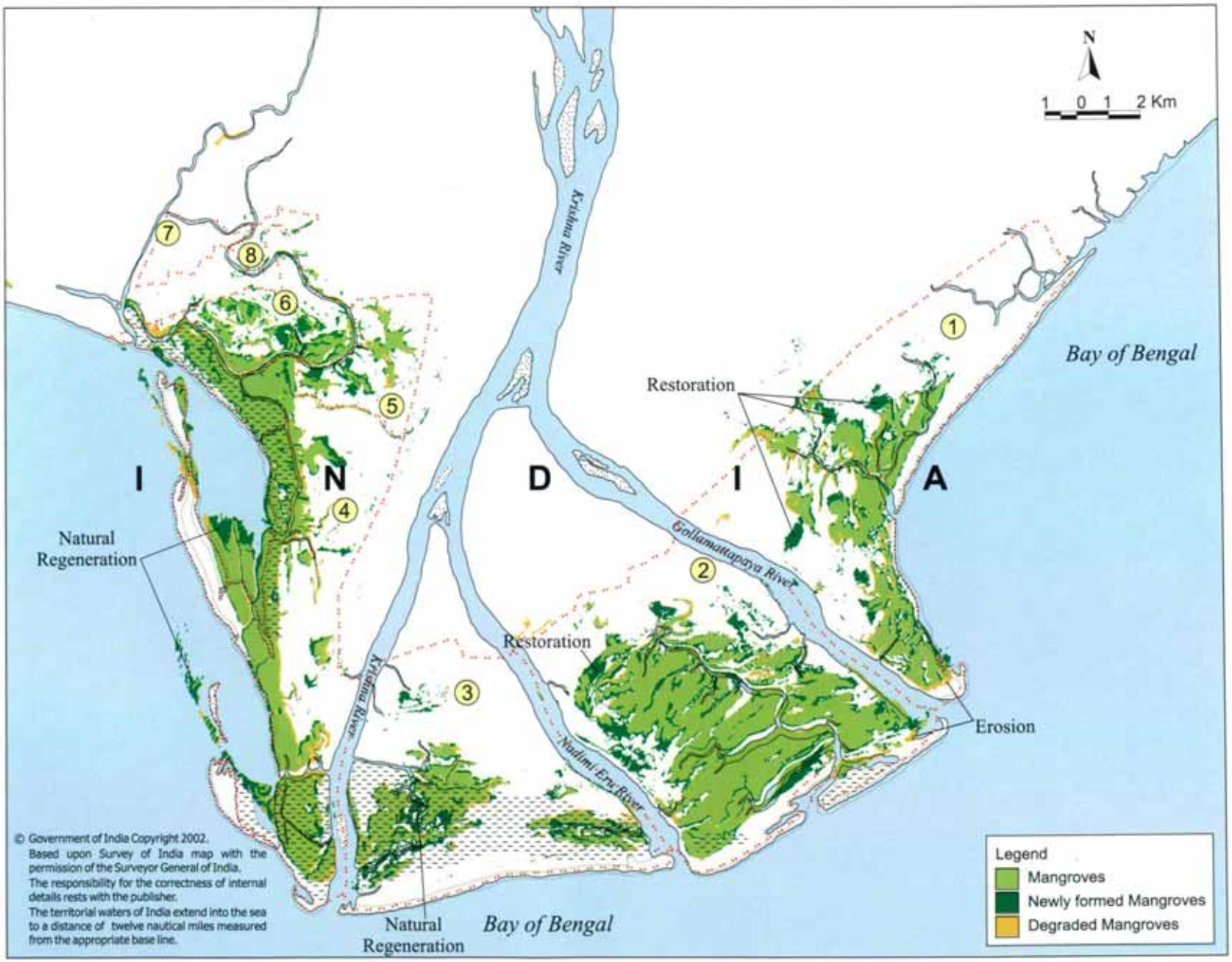
IRS 1D LISS III data of 2001 was used to delineate mangrove vegetation and associated wetland categories of the Krishna wetland. The total area under mangroves has increased noticeably between 1996 and 2001, mainly in the Sorlagondi RF and Yelichetladibba RF. The combined efforts of the Forest Department and MSSRF have improved mangrove restoration in the degraded area identified in 1986. Natural regeneration too has occurred along the shoreline of the western part of the delta. The new sediments of 1996 were seen in 2001 with naturally restored mangroves in the Lankivanidibba RF coast. Total mangrove vegetation area went up from 7,890 ha in 1996 to 9,512 ha in 2001 (Map 4.21).

Figure 60. Natural regeneration of Avicennia marina

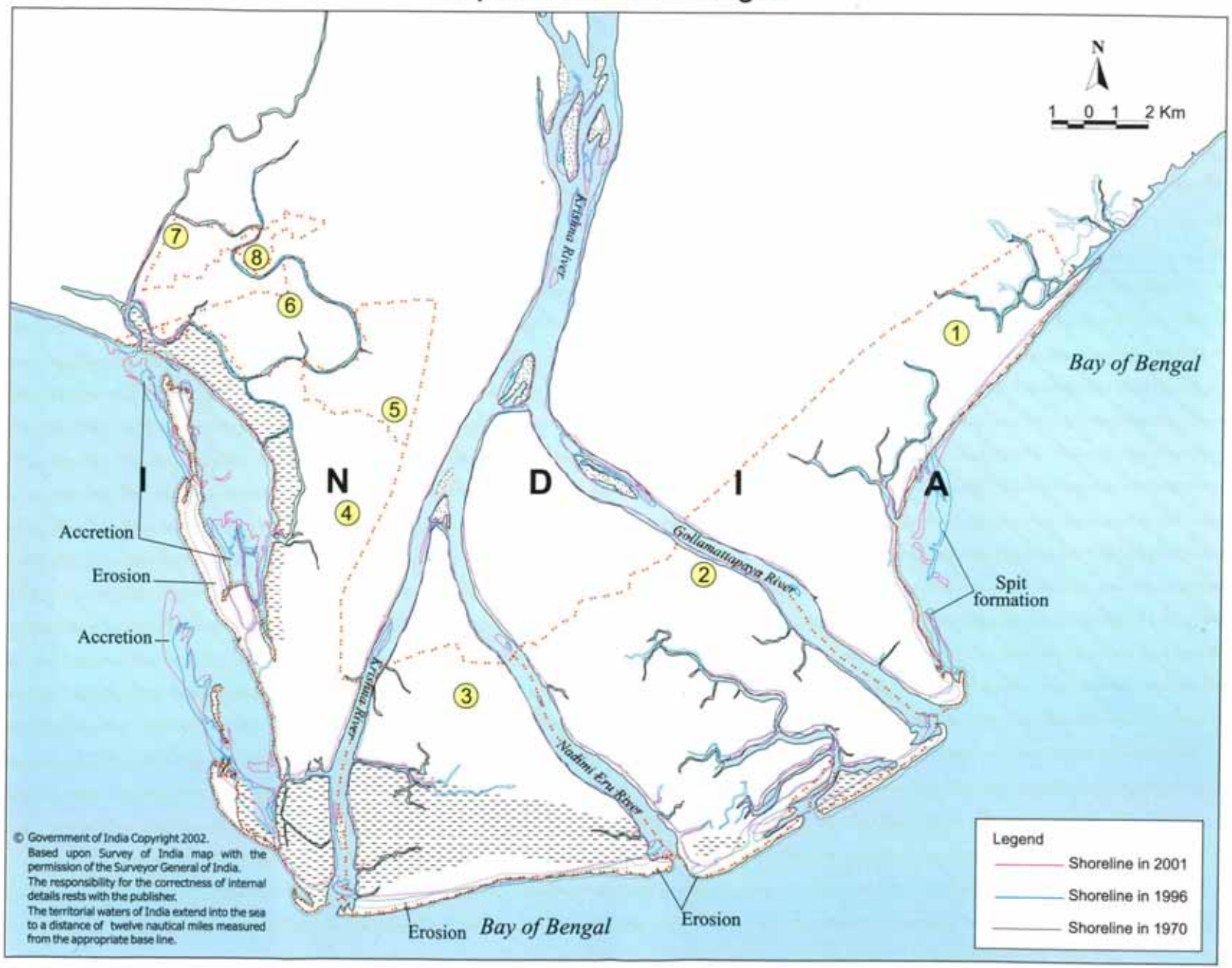
4.16. Shoreline changes

Like the Godavari coastline, the Krishna delta too has undergone many changes, starting from Sorlagondi in the east end to Nakshatranagar in the west end of the delta. Both erosion and accretion are noticed in the west and east coast of the delta, while considerable accretion has occurred in the southern part. The western part of the delta shows erosion and accretion of both land and mangrove vegetation. The sedimentation in this part – due mainly to discharge from Uppurevu and its distributor canals – has resulted in natural regeneration of mangrove vegetation. Sedimentation near Sorlagondi due to discharge from canal network in the delta has led to the formation of dynamic sand spit and lagoon. The coastline and its mangrove vegetation have eroded completely on account of wave action in the south-facing delta portion in Lankivanidibba RF, Yelichetladibba RF, Nachugunta RF and Sorlagondi RF (Map 4.22).

Map 4.21 Changes in Vegetation between 1996 and 2001



Map 4.22 Shoreline Changes



Chapter 5

Long-term Management

The species diversity and population density of each species relate directly to the spatial and temporal discharge of river water flow. It has been determined that the past management practice of clear felling by coupe contractors (without realizing that mangroves are not coppicing by nature) has led to blank formations and inhibited natural regeneration.

The dams constructed across the Godavari river at Dowleswaram and Alamatti Dam in Karnataka; as well as the Prakasham barrage at Vijayawada in Andhra Pradesh across the Krishna to increase cultivable areas – have reduced river water flow and consequently the nutrients that mangroves require. The natural regeneration of mangrove species and the establishment of saplings have been inhibited. This has in fact led to the gradual disappearance of some mangrove species. The loss of *Sonneratia apetela* from the mangroves of Pichavaram is an example. It happened because of the reduced flow of river water from 1950 till date.

Chronological data on salinity and tidal amplitude show that past mangrove species need to be restored and re-established through afforestation as a means of long-term management. The river mouths must be periodically cleared and sand bars removed to ensure free flow of river water into the sea. This can improve nutrient supply not only to the mangroves but also to the juveniles of fish that breed in the open sea and take shelter in the mangroves. Periodical monitoring of sandbar formation in the river mouth, coupled with monitoring of rainfall and water discharge from Dowleswaram and other barrages, could be very effective. These measures must be implemented with rigour. Dredging of the river mouth can be organized in co-operation with port authorities and local fishermen, as both will benefit from the resulting economic and ecological improvements.

Another important cause of degradation is the felling of mangroves by the poor to meet genuine basic needs. A mangrove protection policy should offer these people viable alternatives to mangroves for firewood, fencing, fodder and house construction. A sustainable method of mangrove harvesting should also be evolved. . Participatory patrolling by members of EDC/ VSS and the staff of the Forest Department, and strict and systematic vigilance, are essential for better mangrove management.

Figure 61. Awareness programme in Deenadayalpuram played by Mangrove club children

Figure 62. Awareness through wall paintings for mangrove conservation

Figure 63. PRA in Nali village

Figure 64. Preparation of LBA Microplan- Bhairavalanka

Figure 65. Supply of drinking water - Solving the village concerns through micro plan

Figure 66. Casuarina plantation as alternative for timber in Bhairavalanka

Figure 67. Training for alternative income through coir rope making

Figure 68. Alternatives for fencing - Jatropha being used as line fencing

Figure 69. Alternatives for timber - community plantation in Deenadayalpuram

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