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THEME 6: Application of Geoinformatics in Wetland Management

04

Applications of GIS and Remote Sensing for Mangrove Management in Uttara Kannada, Karnataka State

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The estuaries including mangrove habitats of most of the Indian west coast are much smaller compared to such along the east coast, with the overwhelming presence of Sundarbans and Orissa mangroves. The west coast estuaries, despite their high productivity and biodiversity, faced neglect regarding mangrove conservation and development programmes, probably on account their smallness. These estuarine regions, densely populated due to high productivity, are prone to rising human pressures causing greater mangrove fragmentation and losses. The lack of spatial quantitative maps on mangroves for the west coast has often crippled restoration programmes. In the Uttara Kannada district of Karnataka State, mangrove planting works in the small estuaries attempted during the recent years have raised high hopes of better ecology and higher biological production. Yet the local forest departments, which manage most mangrove areas, are to be equipped with spatial, quantified data on mangroves and potential area for mangrove planting. Using open source GIS software (QGIS) and remote sensing software (GRASS) and IRS imageries mangrove areas and potential areas available for planting in four river estuaries and some minor creeks in the Honavar Forest Division of Uttara Kannadawere mapped. Mangrove species associated with different salinity regimes are appropriately recommended for planting in suitable areas. Whereas *Rhizophora apiculata* and *Avicennia marina* are exclusive to high salinity (>15 ppt.) areas, *R. mucronata*, *Sonneratia alba* and *Excoecaria agallocha* are good for high to medium salinities (5-10 ppt) and *S. caseolaris*, a fairly large mangrove tree thrives in low salinity conditions (<5 ppt). The RS data using 2010 IRS p6 L4

MX 5M having resolution of 5 m, was useful in finding out distribution of only tree mangroves and not juveniles and shrubby forms, which need more higher resolution. The study of this nature, using GIS and remote sensing are handy tools for scientific planning and management of mangroves even at a micro-level. These tools are helpful in finding out alienation of potential mangrove areas for shrimp farming or other alternative uses. For instance in the Aghanashini estuary 2973 ha of intertidal areas have been diverted for shrimp farming, rice cultivation and salt production. The applicability of such modern techniques to micro-level mapping of mangroves, for depicting potential mangrove areas, assessing threats to mangroves through diversion of mangrove areas etc., for the relatively smaller west coast estuaries and creeks, is expected to pave way for increase in area under mangroves and improve the efficiency of mangrove management even at the village level.

Keywords: Coastal ecosystems, Mangroves, Estuaries

INTRODUCTION

Mangroves are unique trees and shrubs thriving along intertidal coastlines on soft saline sediments that are often anaerobic and sometimes acidic. Mangroves are well known for their adaptability, productivity and carbon sequestration. The estuaries including mangrove habitats of most of the Indian west coast are much smaller compared to such along the east coast, with the overwhelming presence of Sundarbans and Orissa mangroves. These estuarine regions, densely populated due to high productivity, are prone to rising human pressures causing greater mangrove fragmentation and losses. The lack of spatial quantitative maps on mangroves for the west coast has often crippled restoration programmes. In the Uttara Kannada district of Karnataka State, mangrove planting works in the small estuaries attempted during the recent years have raised high hopes of better ecology and higher biological production. Yet the local forest departments, which manage most mangrove areas, are to be equipped with spatial, quantified data on mangroves and potential area for mangrove planting. The aim of this paper is to depict accurately the current distribution of mangroves using GIS and remote sensing based maps, estuary-wise and creek-wise and forest administrative unit-wise and also estimating and showing on micro-level maps the potential area for mangrove planting in the Honavar forest division of Canara Circle.

MATERIALS AND METHODS

Study area

Honavar forest division is located between 74° 17' 31.83" to 74° 44' 56.52" east long. and 13° 55' 27.91" to 14° 41' 20.50" north lat. and extends over an area of 1409.42 sq.km, towards the coastal zone of Uttara Kannada, a hilly and heavily wooded district in central Western Ghats (Figure 1). There are four west flowing rivers in the district which merge with the Arabian Sea forming towards their mouths estuarine areas. There are also several small creeks also with mangroves. The estuary of Aghanashini River is the largest (5236 ha), followed by Sharavathi-Badgani (3415 ha), Gangavali (817 ha) and Venkatapur (219 ha).

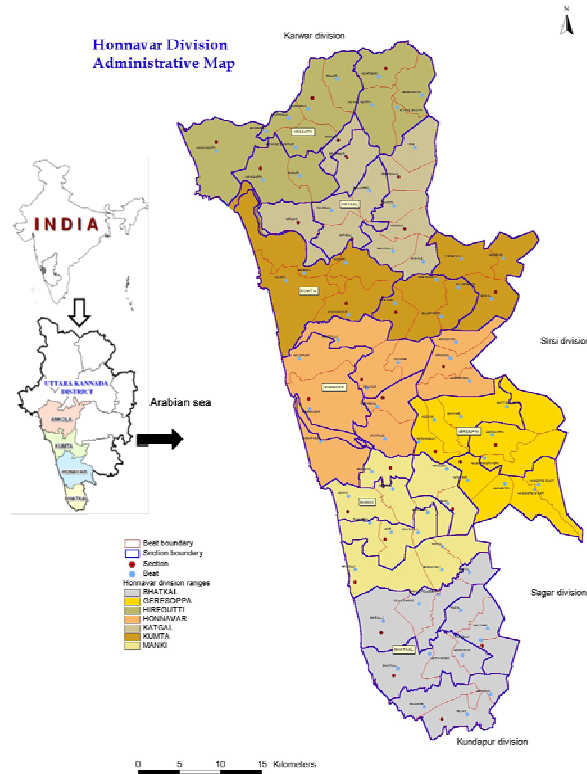
Method

Estuarine area with mangrove areas and potential areas available for planting in four river estuaries and several minor creeks in the Honavar Forest Division were digitized using open source GIS software (QGIS). Google Earth & Bing Earth Tile images were used for depicting the estuaries, mangrove areas and potential areas for planting. Mangrove areas were identified and mapped in the field using GPS readings and their areas estimated in ha. The mangrove areas and potential areas for planting are depicted on the administrative maps of the forest division to the smallest unit, the beat, for the convenience of the beat guard. The estuaries were gridded and sample surveys were made in selected grids for mangrove species composition and tree density. Estuarine water post monsoon salinity was measured and depicted on maps as high (>15 ppt), medium (5-15 ppt) and low (<5 ppt). Mangrove species composition in any specific grid was correlated to salinity status of the

grid. In general mangrove species of the study region were brought under three categories namely high, medium and low salinity mangroves. The GPS readings of mangrove tree species which covers minimum 5X5 meter canopy area were recorded and species-wise area under tree

mangrove distribution was estimated with the help of the RS data 2010 IRS p6 L4 MX 5M having resolution of 5 m, using remote sensing software (GRASS). Using images of estuaries during low tides and with the help of bathymetric maps areas suitable for mangrove planting was also estimated.

Figure 1 : Location of Study area



RESULTS & DISCUSSION

MANGROVE AREA ESTIMATES: ADMINISTRATIVE JURISDICTION-WISE

Bhatkal range: Venkatapur estuary (184.6 ha) of the range has some creeks also namely Bhatkal creek (45.43 ha), Belke creek (10 h), Jali creek (7.53 ha) etc. Mangroves are found mainly in Shirali beat of Shirali section, Bhatkal beat of Bhatkal section; and very little area Belke beat (Table 1 & Figures 2-3&4)

Honavar Range: Of the 3043 ha of Sharavathi – Badgani esturine complex, 2240 ha falls in Honavar Range. Mangroves occur in Kasarkod, Honavar and Haldipur beats of Honavar section, Aunsalli beat of Salkod section and Hadinbal and Jalvalli beats of Hadinbal section (Table 1 & Figures 2,5,6&7).

Kumta Range: Out of Aghanashini estuarie’s total waterspread area of 4,950 ha, 1,466 ha and 255 ha of Badagini estuary falls in the range, apart from Kumta creek (238 ha) and Dhareshwar creek (4 ha). Mangroves are found in Kumta, Manaki and Chandavar beats (Table 1 & Figures 2,8&9).

Katgal Range: About 1158 ha of Aghanashini is under this range. Mangroves occur in Mirjan and Katgal beats (Table 1 & Figure 2&10,).

Hiregutti Range: By far most area under mangroves in Honavar Forest Division is under this range which has parts of Gangavali and Aghanashini estuaries under it (Table 1 & Figures 2, 11&12).

Table. 1: Beat wise Area under Mangroves and potential area in Honavar Forest Division

RANGE	SECTION	BEAT	Beat Area (ha)	Mangrove area (ha)	Total area for planting (ha)	Rivers	Taluk
Bhatkal	Belke	Belke	2773	0.07	NA	Belke creek	Bhatkal
		Hadeen	2074	0.14	NA	Belke creek, Tannirmadi creek	Bhatkal
	Bhatkal	Bhatkal	4538	25.39	8.676	Venkatapur estuary	Bhatkal
	Shirali	Shirali	3931	10.79	14.089	Venkatapur estuary	Bhatkal
Manki	Mavalli	Mavalli	3738	3.35	NA	Mavalli creek	Bhatkal
	Manki	Manki	2648	0.62	0.467	Manki creek	Honavar
Honavar	Hadinbal	Hadinbal	2227	0.22	NA	Sharavathi estuary(Hadinbal river)	Honavar
		Jalvalli	2605	0.53	0.525	Sharavathi estuary(Hadinbal river)	Honavar
	Honavar	Haldipur	3232	13.53	26.13	Badgani estuary	Honavar, Kumta
		Honavar	5707	49.07	30.57	Sharavathi-Badgani esturine complex	Honavar
		Kasarkod	4507	54.48	99.43	Sharavathi estuary	Honavar
	Salkod	Aunsalli	2952	9.96	4.454	Badgani estuary	Honavar, Kumta
Kumta	Chandavar	Chandavar	3038	0.87	NA	Badgani estuary	Kumta, Honavar
		Kumta	4820	22.99	67.866	Badgani estuary, Kumta creek, Dhareshwar creek	Kumta, Honavar
	Manaki	5158	26.49	22.827	Aghanashini estuary	Kumta	
Katgal	Katgal	Katgal	2386	0.24	NA	Aghanashini estuary	Kumta
	Mirjan	Mirjan	3287	83.85	35.669	Aghanashini estuary	Kumta
Hiregutti	Gundubala	Kenkani-Shivapura	1926	3.93	1.402	Gangavali estuary	Ankola
		Moralli	1534	0.35	NA	Gangavali estuary	Ankola
	Hiregutti	Hiregutti	2756	21.94	157.69	Aghanashini estuary	Kumta
	Madangeri	Madangeri	7233	61.93	549.30	Gangavali estuary, Aghanashini estuary	Kumta, Ankola

Figure. 2: Beat-wise mangrove area vs number of patches

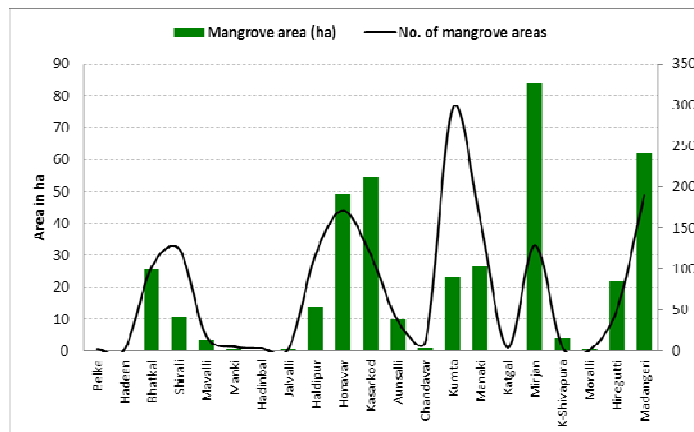


Figure. 3: Shirali beat

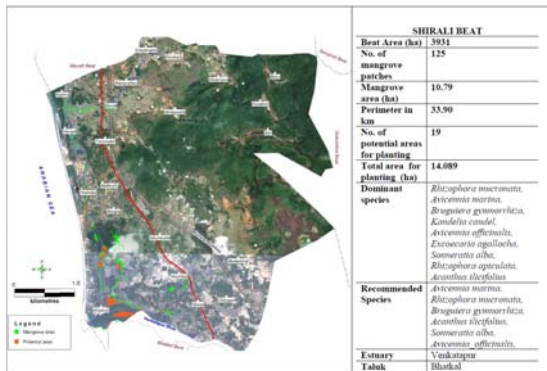


Figure. 4: Bhatkal beat

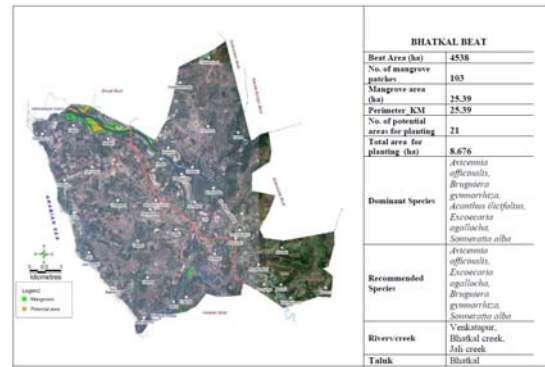


Figure.5: Kasarkod beat

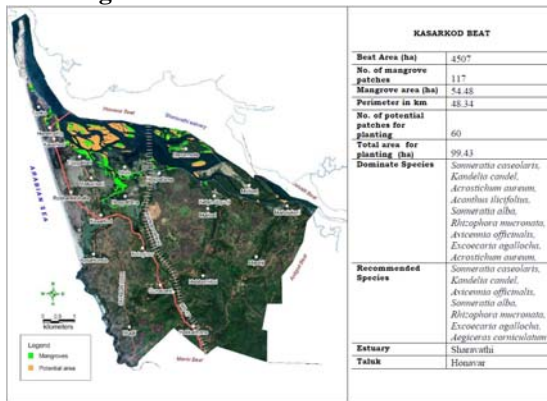


Figure. 6: Honavar beat

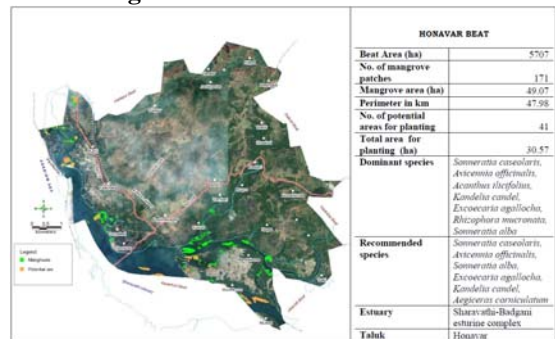


Figure.7: Haldipur beat

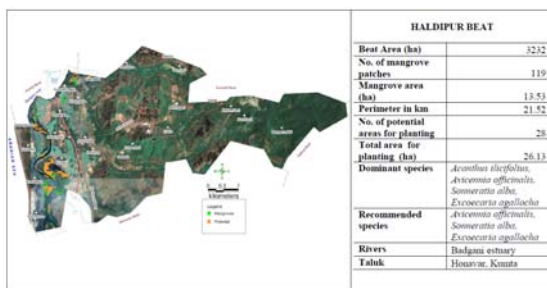


Figure.8: Manaki beat

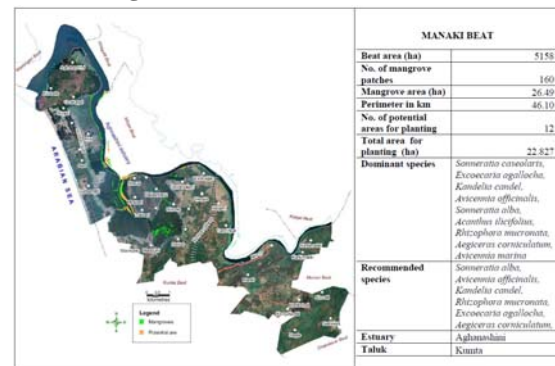


Figure.10: Mirjan beat



Figure. 9: Kumta beat

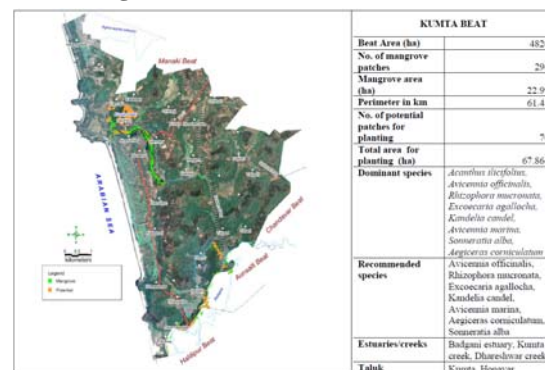


Figure.11: Madangeri beat

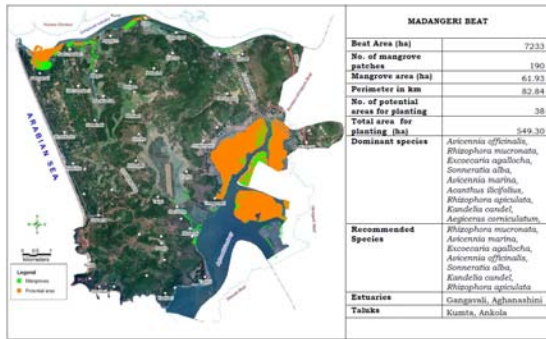
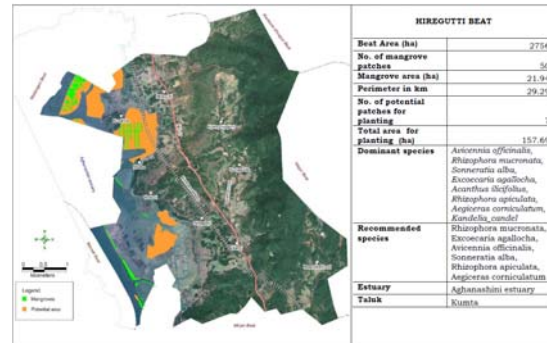


Figure. 12: Hiregutti beat



ESTUARY-WISE MANGROVE SITUATION

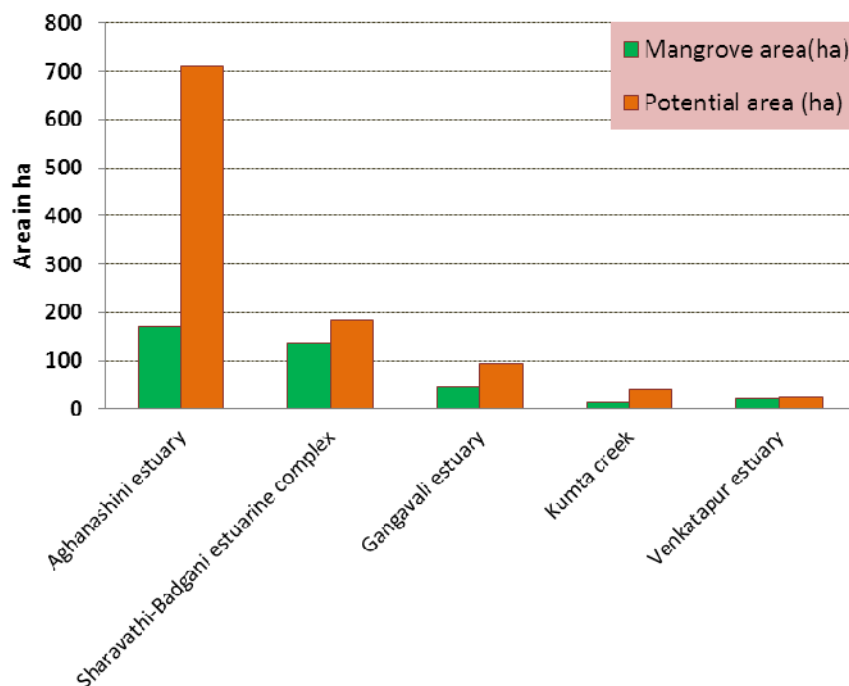
HONAVAR FOREST DIVISION: Among the estuaries Aghanashini topped the list with 169 ha

of mangroves and 711 ha of potential area for planting followed by Sharavathi-Badgani estuarine complex (136 ha and 184 ha respectively -**Table 2** & **Figure 13**) apart from t creeks to a lesser extent.

Table 2. Estuary and creek-wise details of mangrove area and potential area for planting

Sn	Estuary name	Mangrove area(ha)	Potential area (ha)	Total water spread Area (ha)
1	Gangavali estuary,	45.93	95.29	817.10
2	Aghanashini estuary	169.40	711.00	5236.00
3	Kumta creek	14.23	42.42	238.10
4	Dhadeshwar creek	1.43	2.57	4.02
5	Sharavathi-Badgani estuarine complex	136.20	184.40	3415.00
6	Apsarkonda creek	0.14	0.00	1.30
7	Manki creek	0.62	0.47	21.63
8	Mavalli creek	3.06	0.00	17.80
9	Murudeshwar creek	0.37	0.00	35.37
10	Venkatapur estuary	20.54	22.77	219.20
11	Jali creek	0.02	0.00	5.40
12	Bhatkal creek	1.69	0.00	53.22
13	Huvilmadi creek (Hadeen Creek)	0.10	0.00	13.71
14	Belke creek	0.12	0.00	5.97

Figure.13: Estuary -wise details of mangrove area vs. number of patches



GANGAVALI ESTUARY: The Gangavali or Bedti River, forming the northern boundary of Honavar Division (**Figure 14**), has 571 ha of estuary. The mangroves are more of fringing type in linear formations near borders. Some denser patches occur in Nadumaskeri, Agragon, Hadav, Joog, and Ulware. Dense mangroves, linear mangroves and sapling areas are also shown in the figure. Nadumaskeri has the largest area (18.57 ha) under mangroves and more potential area (17.24 ha) for planting (**Table 2**). Using IRS p6L4 MX5 M imagery the details of landscape/waterscape elements observed in the estuarine belt as a whole (total waterspread area) are given in the **Table 3 & Figure-15**.

AGHANASHINI ESTUARY: The estuary is 13 km long and 2 to 6 km broad. The expansive and shallow nature of the estuary and the presence of several mudflats make it ideal for mangroves. Details of village-wise area under mangroves and potential area for mangrove planting are shown in **Table 2**. Masurkurve 32 ha and Hiregutti with 23 ha have more area under mangroves. Hiregutti has 151 ha suitable area for planting followed by Madanageri with 128 ha. With almost 733 ha of potential areas for planting Aghanashini estuary

could be developed as one of the finest mangrove areas of Karnataka (**Figure-16**).

Using RS data from 2410 IRS p6L4 MX5 M estimates could be made of only three dominant tree mangroves namely *Avicennia officinalis*, *Rhizophora mucronata* and *Sonneratia alba* alongwith other landscape/waterscape elements (**Table 4** for details). The interpreted imagery is given in **Figure-17**

SHARAVATHI -BADGANI ESTUARINE COMPLEX: The Sharavathi River from the Western Ghats joins the sea at Honavar with an estuarine spread of 2695.8 ha, including the estuary of a smaller river Badgani, merging with former. River flows between richly wooded banks fringed with mangrove bushes. The execution of Lingankakki and Gersoppa dams for power generation resulted in dipping of salinity conditions to low levels (<0.5 ppt most of the year) resulting in the disappearance of most of high and medium salinity tolerant mangrove species from the estuary, leaving behind mostly low brackish water ones. Total area under mangroves in the Sharavathi part of estuary was about 54 ha and potential area for planting 124.7 ha. The Badgani estuary that merges with Sharavathi has higher

salinity but the mangroves are in small fragments (16.4 ha) and the potential area is only 55 ha (Table 2). Using remote sensing imagery from 2010 IRS p6L4 MX5 M area under tree mangrove species was estimated and along with other waterscape/landscape elements given in the Table 5 & Figure 18.

VENKTAPUR ESTUARY: Venktapur is a small west flowing river from the Western Ghats near Bhatkal town towards south-west of Uttara Kannada. (Figure 19). It has 21 ha of mangroves and 23 ha of potential area for planting (Table 2).

Venktapur estuary is the only estuary in the Division with the rare presence of *Bruguiera gymnorhiza*. Details from 2010 IRS p6L4 MX5 M imagery are given in Table 6 & Figure 20.

KUMTA CREEK: This is the only notable independent creek with mangroves in the division, others being smaller and dealt with as part of the estuaries with which they are linked. The Kumta is situated on its north bank. Details regarding mangrove areas and potential areas are given in **Table 2** and **Figure 21**

Figure 14. Gangavali estuary:mangrove areas and nature of bottom sediments

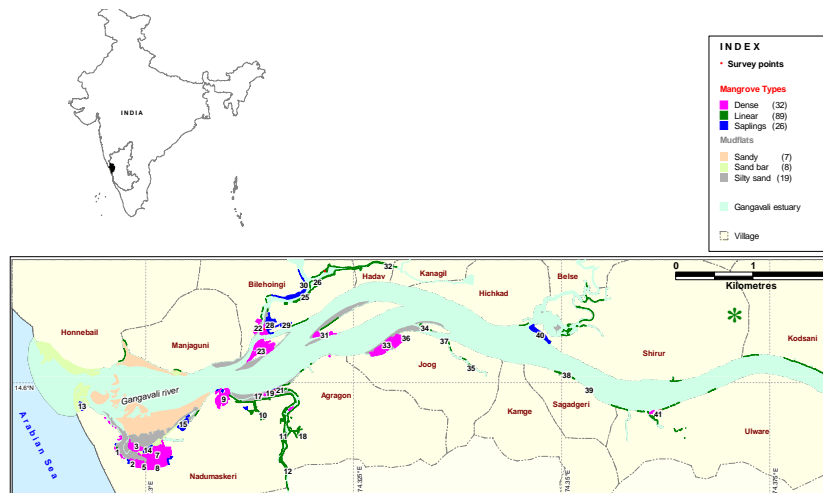


Table 3. Gangavali estuary: Area under tree mangroves (for 3 species) and other landscape/waterscape elements (based on 2010 IRS p6L4 MX5 M imagery)

Category LSE/WSE	Area in ha	%
<i>Rhizophora mucronata</i>	3.010	0.46
<i>Sonneratia alba</i>	1.903	0.29
<i>Avicennia officinalis</i>	2.088	0.32
Other vegetation	36.465	5.58
Open water	620.996	76.6
Estuarine fields	102.622	15.72
Plantations	6.693	1.03
Total area	817.1 ha	

Figure 15. Gangavali estuary: species-wise tree mangrove distribution and other landscape/waterscape elements (based on 2010 IRS p6L4 MX5 M imagery)

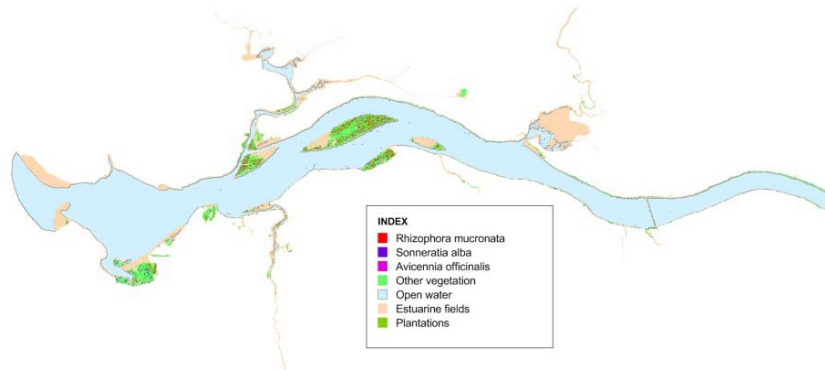


Figure 16. Aghanashini estuary: mangroves, salinity zones and potential area for planting

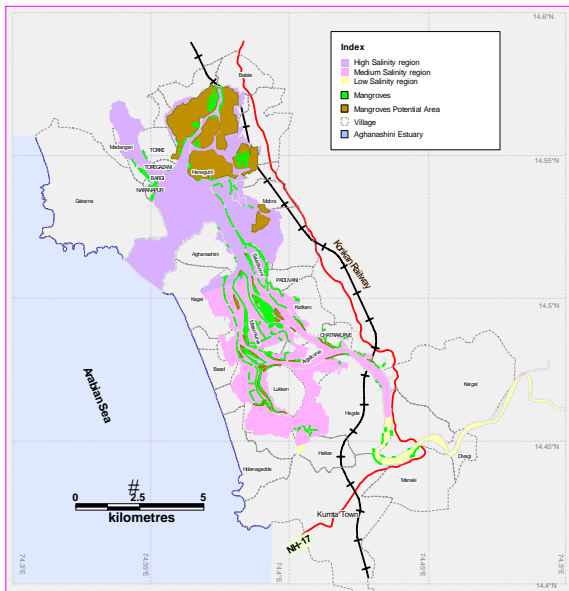


Figure 17. Aghanashini estuary: tree mangroves, other landscape/waterscape elements

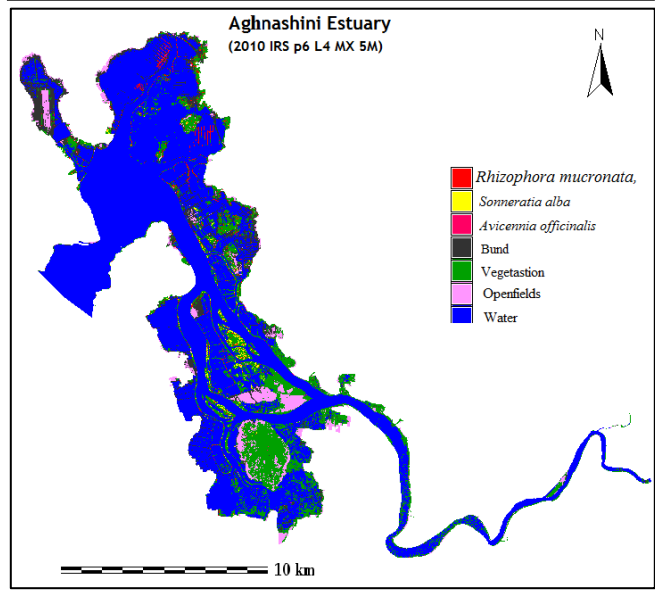


Table 4. Aghanashini estuary: area under individual tree mangroves (for 3 species only) and other landscape/waterscape elements as deciphered from 2410 IRS p6L4 MX5 M imagery

Category	HA	%
<i>Rhizophora mucronata</i>	74.27	1.42
<i>Sonneratia alba</i>	33.72	0.65
<i>Avicennia officinalis</i>	5.40	0.11
Vegetation	857.46	16.37
Water	3615.19	69.05
Open fields	259.13	4.94
Bund	390.83	7.46
Total area	5236.00	

Table 5. Sharavathi-Badgani estuarine complex: Area under tree mangroves and other waterscape/landscape elements (based on 2410 IRS p6L4 MX5 M imagery)

<i>Avicennia officinalis</i>	10.70	0.51
<i>Sonneratia alba</i>	23.00	0.67
<i>Kandelia candel</i>	6.81	0.20
<i>Rhizophora mucronata</i>	5.41	0.16
<i>Sonneratia caseolaris</i>	81.96	2.40
Plantations	219.65	6.44
Vegetation	515.21	15.08
Water	1334.90	39.08
Open space	1218.12	35.66
Total area	3415.75	

Figure 18. Sharavathi-Badgani estuarine complex: distribution of tree mangroves (4 species) and other landscape/waterscape elements

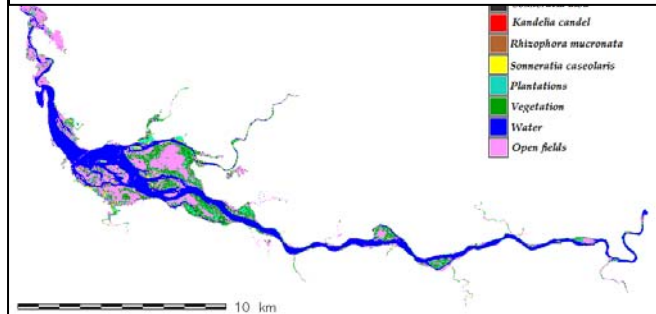


Figure 19. Venkatapur estuary: mangrove areas and potential areas

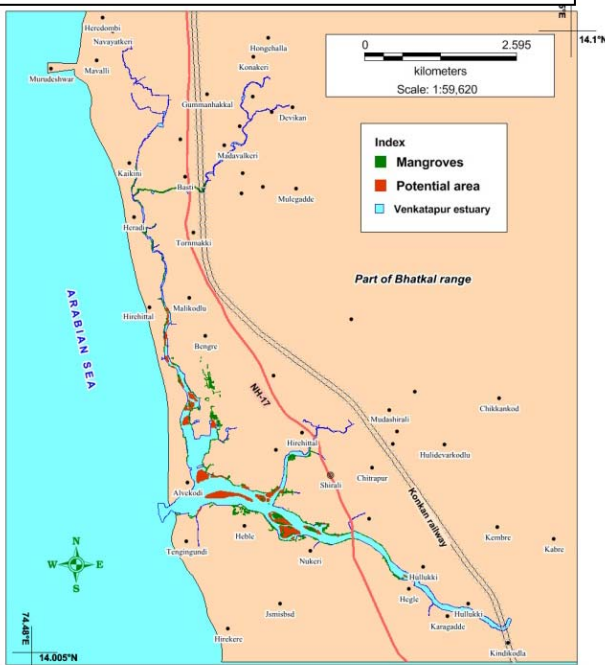


Figure 20. Venkatapur estuary: tree mangroves and other landscape/waterscape elements

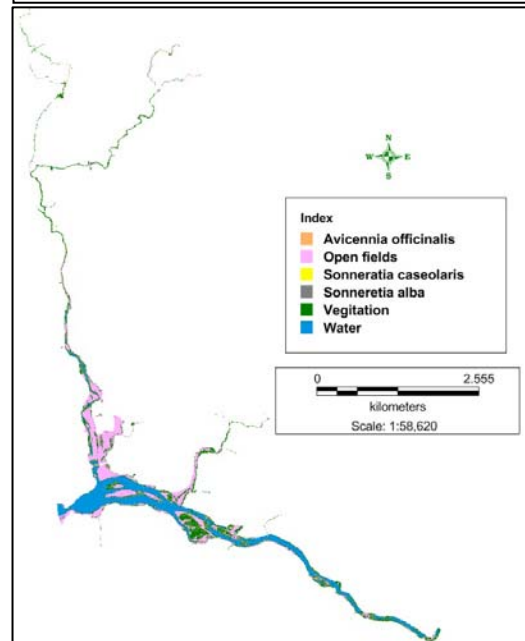


Table 6. Venkatapur estuary: area under tree mangroves (for 3 species only) and other landscape/waterscape elements (based on 2010 IRS p6L4 MX5 M imagery)

Category	HA	%
<i>Avicennia officinalis</i>	9.928	4.53
<i>Sonneratia caseolaris</i>	0.711	0.32
<i>Sonneratia alba</i>	5.636	2.57
Vegetation	56.545	25.81
Open fields	70.933	32.38
Water	75.336	34.39
Total area	219.089	

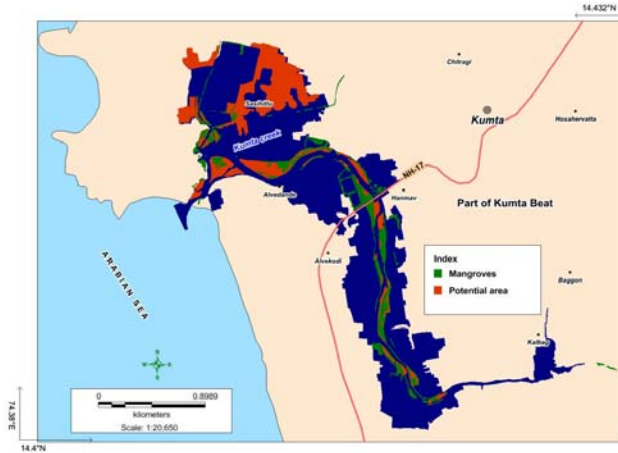


Figure 21. Kumta creek: mangroves and potential area for planting

CONCLUSIONS

Tropical estuaries are among the most productive ecosystems of the world. The west flowing rivers from the Western Ghats are relatively smaller compared to the east flowing ones. Their estuaries are naturally lesser in area, but nevertheless endowed with high productivity and species diversity. Area under mangroves is relatively smaller, and especially south-west Indian estuaries hardly merited any consideration for funding under mangrove planting schemes until last one decade or so. For instance, although Honavar Forest Division has 1407.67 sq.km of forests, mangroves cover 3.90 km only, according to our current estimate. Further 1019 ha of potential area for mangrove planting could be readily available as well. Moreover, if disused shrimp farms, in hundreds of ha area, are taken over by the State and restored with mangroves, on mutually agreeable terms with the farmers, that would be an achievement of enormous magnitude in coastal ecological protection and safeguarding of local livelihoods.

On the other hand various all India level surveys on mangroves hardly reported any mangrove areas from the State of Karnataka. Studies in Uttara Kannada estuaries show that despite their smaller sizes, collectively they produce hundreds of crore rupees worth fish, shrimps, edible bivalves, oysters etc. Mangroves play vital role in such productivity and in addition provide shelter and nursery grounds for many fishes. Over 120 bird species are reported from Uttara Kannada estuaries, particularly the ones with more mangroves. Mangrove soils are known to sequester much more carbon than tropical rain forests per unit area. Mangroves safeguard coastal zones from cyclonic damages, provide certain resistance to tsunamis and protect the shores from erosion. Yet in all India mangrove development programmes coastal Karnataka as such received only very little attention.

What is sorely lacking for the west coast estuaries is lack of any kind of detailed micro-level estuarine mapping to estimate mangrove areas and potential areas. If micro-level mangrove mapping is available high quality management systems can be implemented with better planning. Therefore, at the

behest of Honavar Forest Division in Uttara Kannada, the current study was made. Forest range-wise, and beat-wise, as well as estuary and creek-wise maps prepared depicting mangrove areas and potential areas for planting, in relation to salinity levels, will enable preparation of better projects in future for mangrove development. We recommend that such exercises be carried out for the entire west coast to gain a comprehensive picture of mangroves, including preparations of species-wise distribution maps enabling better conservation of this very vital coastal resource, meriting Coastal Regulation Zone I status, from any further fragmentation and dissolution.

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