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Spatio -Temporal change study on Wetlands of Krishna delta using Remote Sensing Techniques

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ABSTRACT
An attempt has been made to map and record the land use / land cover changes with reference to wetland in and around the Krishna delta region over a period of 17 years (1983 – 2000) based on interpretation of digital remote sensing data. On-screen visual interpretation was carried out on IRS - 1A (LISS I) and 1C (LISS III) digital imageries for the years 1990 and 2000 respectively coupled with field observations. Comparison of the SOI toposheet (1983) and IRS imageries resulted changes due to natural and man made activities in the study area over period of 17 years. Tremendous change has been observed in mangroves, mudflats, sandy area and plantations. The area under mangroves was decreased from 22,500 ha in 1983 to 9633 ha in 2000. Mudflats were decreased from 8700 ha to 6300 ha. About 39 % increase in plantation and 43.15% increase in sandy area has been observed from 1983 to 2000. It is concluded that most of wetlands mudflats, mangroves and agriculture land were converted to aquaculture (35,000 ha) which was not existing in 1983. This change in delta lead to the deposition of sand/silt and polluted water to the lower reaches result in mangrove degradation and sand deposition. . This paper presents the role of remote sensing studies in assessing the land use changes in unapproachable wetlands in the Krishna river delta.

INTRODUCATION

Wetland represents a specific ecosystem found in the inter tidal zone along the tropical and subtropical coastal areas and are often located near estuary and deltas. According to Forest Survey of India (FSI 2005) 4, 44,800 ha of mangrove wetlands, nearly 2, 75,800 ha is present along the coast. Mangrove wetlands of east coast are larger and high in diversity because of larger delta created by east flowing rivers and gentle slope of the coast (Selvan 2003). This rich ecosystem has been undergoing serious alterations largely induced by human activities in the coastal zone of the rivers Krishna and Godavari. Continuous and efficient retrieval of the reliable information from the wetlands is therefore necessary for conservation of the precious ecosystem (Baidya & Chodhury 1986 and Selvam et al., 2002).

Coastal wetland environments such as lagoons and mangrove swamps are very fragile, but important as it is harboring a variety of flora and fauna (Alongi, Boto & Robertson 1992). Hence, their existence is essential for coastal stability and well being of coastal communities. The environmental setting of this multi use ecosystem is governed by physical forces such as geomorphology of the coast, climate, tidal, amplitude and duration, and quantity of fresh water inflow (Thom 1984). By virtue of its geographical extent and climate, India supports a rich diversity of inland and coastal wetland habitats (Wetlands of India., 1994). India's 7,500 km coast line has numerous lagoons, estuaries and mangrove swamps (Mangroves in India 1994). The Krishna delta region along the east coast region of India is the one of the densely populated and highly resourceful area of the country in terms of agriculture, industry, fish production, etc. The wetlands play an important role in protecting the coastal environments (Woodraff 1992) and also in tsunami, flood control, coastal erosion and help in ground water recharge ability, besides sustenance of flora and fauna (Swaminathan 1994; IUCN 2005 and Jayshree Venkatesan 2007).

Among the marine ecosystems, mangroves constitute the second most important ecosystem in productivity and sustained tertiary yield after the coral reefs (Qasim & Wafar 1990). At the ecosystem level mangroves serve as nursery, feeding and swamping grounds for commercial fishes and shell fishes, provide detritus for the coastal ecosystem, reduce the velocity of wind, coastal erosion, and flood water flow velocity. This also helps in sediment filtration, nutrient retention, pollution removal; bio-chemical process such as production of methane, nitrous oxide, and carbon dioxide as well as the fixation of carbon and nitrogen.

The recent spurt in human activities like commercial aquaculture activity has completely transformed the coastal wetlands into aquaculture and encroachments for other activities. About 40% of exiting mangrove forests has been depleted in India by human interference (agriculture, aquaculture, irrigation, industry and fuel wood extraction), which has resulted in increased erosion and decline in fishery resources. (Krishnamurthy, Choudhury & Untawale 1987 and Upadhyay, Rajiv Ranjan & Singh 2002).

Presently, the wetland ecosystem is fast disappearing in the coastal belt especially in Krishna delta. Hence, an attempt has been made to map and record the land use / land cover changes with reference to wetland in and around the Krishna delta region using remote sensing.

The modern techniques like remote sensing and GIS are the excellent tools for mapping the dynamic coastal wetland environments and provide accurate information to understand the nature and extent of environmental changes due to human activities (Ramachandran et al., 1998). Satellite remote sensing data is an useful source to get information regarding wetlands as it provides timely and synoptic coverage of the area, complementing the field verification, which are difficult to carryout conventionally especially in wetland areas.

Study area

The study area is a part of Krishna Delta covering an aerial extent of 1020 sq km. It covers between the 80° 50' 00″ to 81° 25' 00″ E longitude and 15°70' 00″ to 16° 25' 00″ N. latitude (Fig.1). The Krishna delta is the seaward extended land mass created by alluvial deposits of the river. Geomorphologically, the Krishna delta comprises bays, tidal creeks, extensive tidal mudflats, splits, and sand bars. The first distributary Hamsaladeevi, branches off and meets sea near Machileepatnam. Two distributaries, namely Gollamuttapaya and Nadimeru branches out 30 km downstream from Hamsaladeevi distributary (Varadarajulu et al., 1985). Mangroves are abundant in three islands located between Gollamuttapaya, Naduneru and the Krishna River. The general climate of the area is tropical monsoonal with average annual rainfall of 1076 mm, out of which 64% occurs during southwest monsoon season.

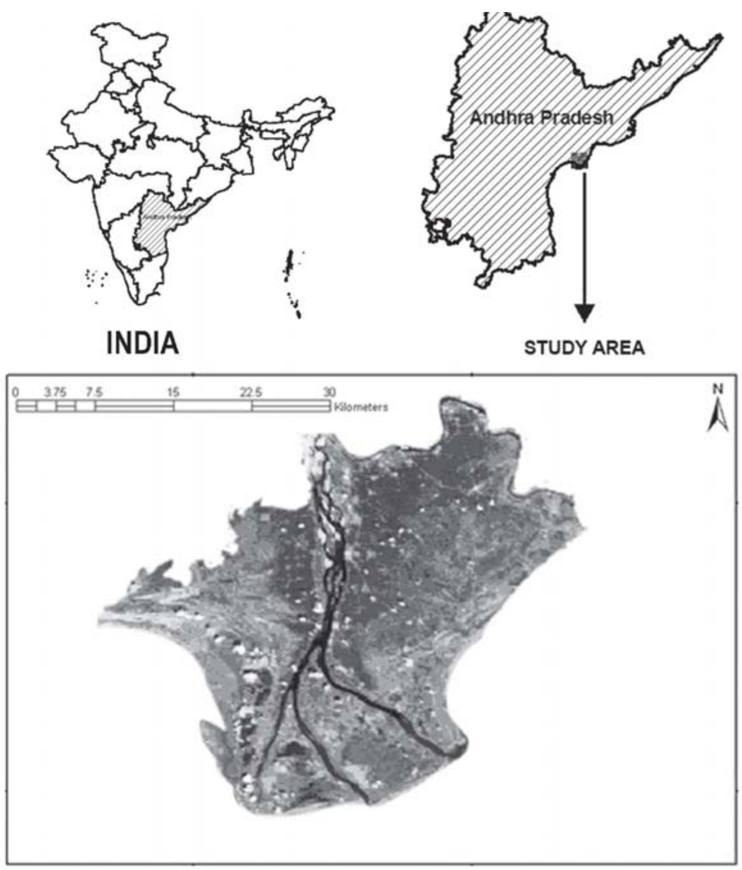

Figure 1. Location of the study area.

Methodology

Pre-processing is carried out for satellite data acquired from IRS 1A/LISS- I image (72m of spatial resolution) of 21st January 1990 (Path 23/Row 57) and IRS 1C / LISS- III image (23m of spatial resolution) of 23rd October 2000 (Path 102/Row 62).

Image data are treated with various image enhancement techniques, which are described briefly below, for enhancing the ground features for better interpretability and analysis. Initial understanding of the image data is obtained by displaying the satellite data on an interactive display monitor with a three-band composite called false color composite (FCC).

Image enhancement

Image enhancement is a technique to improve the apparent distinction between the features in the satellite image to increase the visual interpretability. As the satellite image obtained has less contrast, to make the image bright and sharp, contrast stretching image enhancement technique is applied to increase the brightness of the original input image. By examining the image histogram, the minimum and maximum brightness values in the image are determined. Then the histogram equalization, a non-linear contrast enhancement technique is implemented by redistributing the image pixel value into output dynamic range such that the frequency of occurrence of gray value range is almost the same throughout the image. Histogram equalization provides the greatest contrast enhancement to the most populated brightness values in the image, there by bringing the features into sharp focus. Later the image is further improved by using Filter Sharpener, which nullifies the effect of high frequency noise present in the input image and produces a smooth image LUT (Look up Table) and the image looks interpretable so that even small features like settlements are also be seen very clearly.

On-screen digitization was carried out to identify the land use /land cover classes using ERDAS IMAGINE 9.1. Primarily land use/land cover features were mapped from the SOI toposheet of the year 1983 (Fig.2). Various land use / land cover features, such as mangroves, mudflats, agriculture, coastal plantation, built up land, sandy area etc. were interpreted from imageries of IRS -1A (Fig.3) & IRS-1C (Fig.4) coupled with field observations. Wetland classification was carried out based on the classification proposed by Space Applications Centre, Ahmadabad (Table.1).

RESULTS AND DISCUSSION

The dynamic nature of the various land use categories in the study area are evident from change detection analysis and is shown in Table 2. The table shows the detailed results on how the land has been increased / decreased in each category between the years 1983-1990 and 1990-2000 respectively. Comparison of the results obtained from IRS imageries of 1A and 1C resulted changes during 10 years period due to natural and man made activities in the study area. The relative changes in wetland ecosystem are shown in Fig.5.

Table 1. Classification system followed for wetland mapping

Level I	Level II	Level III
Non Vegetated Wetland	Mud flat	High-tide flats
	Sand	Beach
Vegetated Wetland	Mangroves	Dense
		Less dense
		Degraded
Others	Forest plantation	Interior
	Beach plantation	Coastal
	Agriculture lands	Presently cropping
		Current fallow

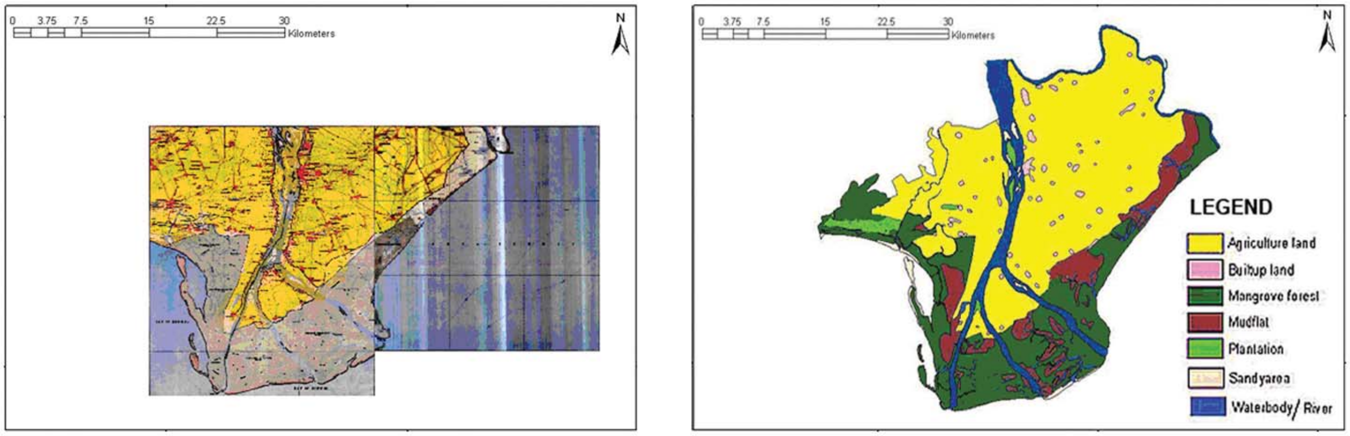

Figure 2. Topo sheet (1983) of the study area and landuse categories

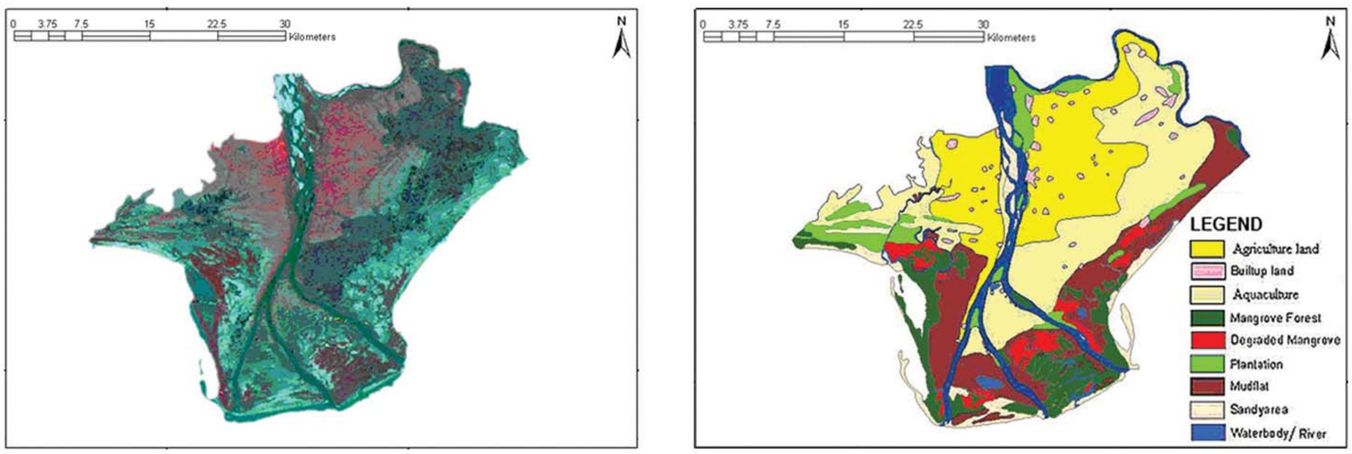

Figure 3. Digital False Color Composite of IRS 1A (1990) and landuse/landcover map

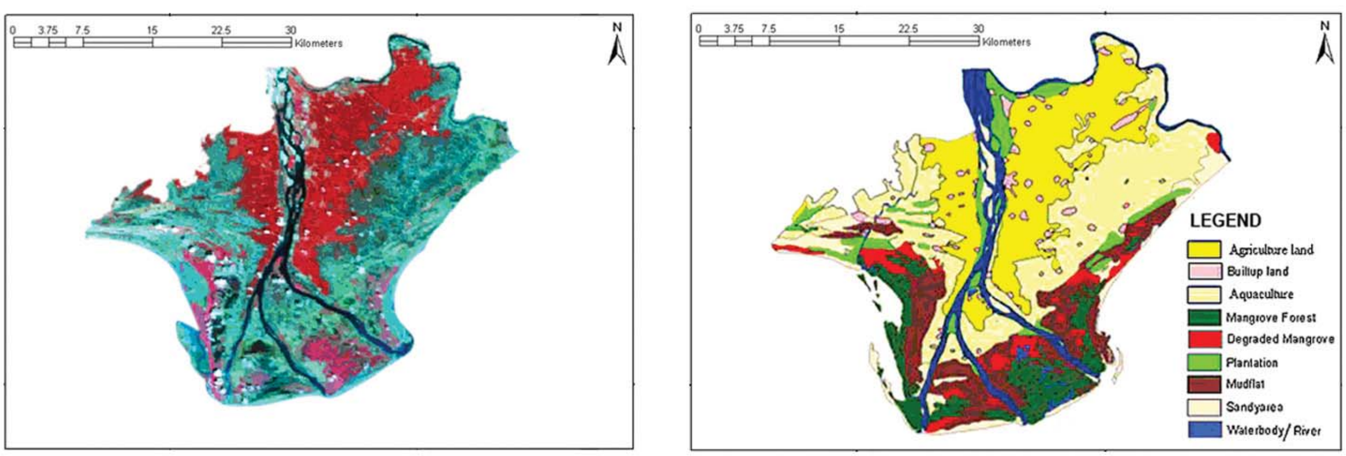

Figure 4 . Digital False Color Composite of IRS 1C (2000) and landuse/landcover map

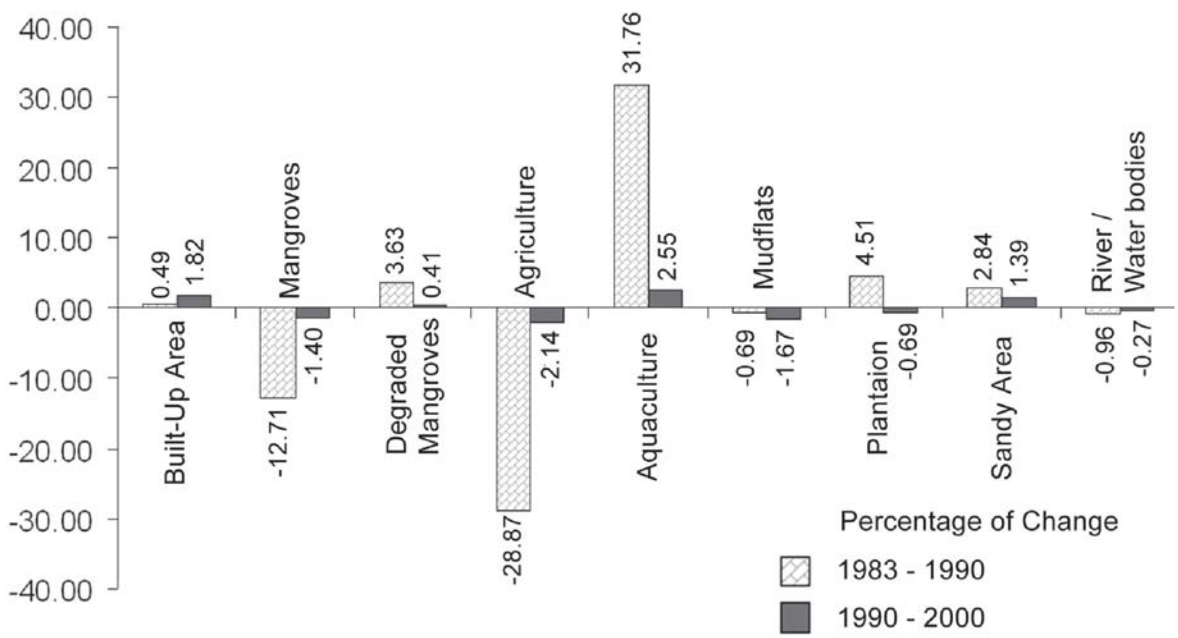

Figure 5. Landuse change from 1983-2000

Built up area

Mostly human settlements come under this category. These are easily descrambled on the satellite imagery based on their light tone and linear pattern .The change in built up area has estimated at 1650 ha in the year 1983, 2147 ha in 1990 and 4000 ha in 2000. Built up area is increased by 1853 ha during 10 years period.

Agriculture

This land use class occupies a major portion of the study area. This is because of well-developed irrigation facility, fertile nature of the soil and favourable climatic conditions in the delta. Paddy is the principle crop grown in both seasons in the area. The harvested portions of the agriculture land are also included in this class. These areas devoid of vegetation with greyish tinge with regular patterns can easily be demarcated from the satellite imagery. Field observation and enquiries revealed that paddy is the dominated crop in these parts. The total geographic area under this land use in the year 1990 shows 25,100 ha and it comes to 22,922 ha in the year 2000. It was 54,550 ha in 1983 from SOI map.

Aquaculture

The land use type is most dominated in the study area. These are easily identified on the satellite imagery based on their light tone and appearance in linear pattern with rectangle or square shaped tanks spread over a considerable extent. It is 32,400 ha in 1990 and further increased to 35,000 ha as per 2000 imagery. There was no aquaculture in 1983.

Mangrove

Mangroves mainly present where the sea and fresh water mix. Most of the mangrove forest ecosystems that occur in the intertidal zone along tropical and sub tropical coastal lines. Most of the mangrove wetland is present towards southern part of study area. In satellite imagery they appear in dark red in color, medium texture with smooth pattern. Toposheet (1983) reveals that there is 22,500 ha area is occupied by mangrove forest. As per the status report of FSI, it is only 9300 ha during the year 2003. Remote sensing studies have indicated that it is only 9,533 ha in 1990 and 8100 ha in 2000 from LISS-III data. Maximum deforestation of mangroves occurred during 1983 to 1990 period. But there is marginal restoration in mangrove forest as per the FSI (2005) report.

Degraded Mangrove

These are the mangroves of earlier time. These are easily identified in satellite imagery coupled with field observations and previous records. In the satellite image these patches are identified by greyish colour,

Table 2. Areas of different categories & percentage change between 1983 and 2000

S.NO	Landuse/landcover Features	Area(Ha)			Percentage of total area			%Change (1983-1990)	%Change (1990-2000)
		1983	1990	2000	1983	1990	2000		
1	Built upland	1650	2147	4000	1.62	2.1	3.92	0.49	1.82
2	Mangroves	22500	9533	8100	22.06	9.35	7.94	-12.71	-1.40
3	Degraded Mangrove	-	3700	4115	-	3.63	4.03	3.63	0.41
4	Agriculture	54550	25100	22922	53.48	24.61	22.47	-28.87	-2.14
5	Aquaculture	-	32400	35000	-	31.76	34.31	31.76	2.55
6	Mudflats	8700	8000	6300	8.53	7.84	6.18	-0.69	-1.67
7	Plantation	1400	6000	5300	1.37	5.88	5.2	4.51	-0.69
8	Sandy area	2600	5500	6915	2.55	5.39	6.78	2.84	1.39
9	River/Water bodies	10600	9620	9348	10.4	9.43	9.16	-0.96	-0.27
	Total	**102000**	**102000**	**102000**	**100**	**100**	**100**		

coarse texture and rough pattern. This land use covers an area of 3,700 ha in 1990 and 4,115 ha in 2000. About 415 ha have been increased during a period of 10 years due to polluted waters and silt depositions from aquaculture activity which was sever during 1990 to 2000.

Mudflats

The saturated land portion covered with a thin film of water occasionally or permanently and is liable to tidal inundation is considered as mudflats. These areas can be seen in the portions closer to the coast where the tidal channels /creeks influence is more. However, based on the tonal characteristics in the satellite imagery coupled with field checks, such as their monotonously level ground, presence of occasional tidal inlets appears in dark greyish color, medium texture and slightly rough pattern. About 3,700 ha of area of mud flats decreased during 10 year period. The change is probably due to aquaculture activity.

Plantation

In the satellite image the linear patches with dark brownish red color and coarse texture are the casuarina plantations and dark brownish pink color are the banana plantation. The area that comes under the region within 1 to 3 km land ward from the present shoreline is the belt of consolidated coastal sands, which is suitable for plantation crops like casuarina, cashew etc. Near the river course, banana plantation and some other cash crops are also noticed. The area under plantation was 1,400 ha in 1983, 6,000 ha in 1990 and 5300 ha in 2000.

Sandy area

The areas fully covered by sandy wastes come under this category. These areas composed of coarse to fine sand completely devoid of vegetation. The sandy areas are the present beaches along the shoreline. The sandy area includes breach, beach ridges, sand dunes and sand bars. The sandy areas are easily identified on the satellite imagery based on their whitish tone, fine texture and smooth pattern. On the ground, however, most of these areas do not exhibit any relief as they are either removed by subsequent fluvial erosion or as of late, more or less plain due to the human activities. Towards the coast, the beach ridges are somewhat prominent and are vegetated. It was 2,600 ha in 1983 and it rose to 5,500 ha (1990) and further increased to 6,915 ha (2000).

CONCLUSIONS

The study analysed the wetlands, such as vegetated wetland like mangroves and non vegetated wetland (Mudflat) which are decreasing at a rapid scale in the Krishna river delta as evident from the study of toposheet (1983), remote sensing data sets from 1990 and 2000. Tremendous decrease in the aerial extent of mangroves, mudflats, sandy area and plantations has been observed. As per FSI reports there was a marginal increase in mangroves of this area a by 2003. Remote sensing studies revealed that 14,400 ha of mangrove forest and 29,450 ha of agriculture land are transformed into aquaculture, built up land, plantations and sandy area. Increase in degraded mangroves is due to the polluted waters from the aquaculture. Mangrove wetlands are marshy in nature and intersected by a number of tidal creeks and channels, which makes regular and direct monitoring of mangrove conservation more difficult. Careful study of changes in coastal environmental conditions forms cornerstone for coastal management and leads to sustainable utilisation of coastal resources. The results in this study clearly demonstrate the use of satellite based mapping and monitoring of coastal ecosystems, where the conventional study and approach is difficult and incorrect. The increase of urban settlements and unprecedented increase in aquaculture indicates the extent of anthropogenic disturbance in the Krishna river delta.

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