Monitoring shrimp farming development from the space: a RS and GIS approach in Kandleru creek area, Andhra Pradesh, India

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Introduction

Andhra Pradesh contributes more than half of country's shrimp production in India. Shrimp farming had been started to expand in Kandleru creek area since 1987/88. Availability of vast tracts of saline lands coupled with abundant quantity of wild seeds and strong export demand for shrimp were initially responsible for attracting the entrepreneurs towards shrimp farming. As a consequent hundreds of hectares of lands were brought under this venture. But the expansion was not smooth which left depletion of natural resources around the creek and environmental degradation of creek water quality. The industry is facing regular disease problem since 1994. Therefore the area once found as most ideally suited for shrimp culture has later been questioned its viability or sustainability. A considerable management and planning need for further development (expansion and/or intensification) of this venture is utmost important.

GIS and Remote Sensing methods have been used as successful planning and management tools. Remote Sensing data have been proven useful in assessing the natural resources and in monitoring the changes (Ratanasermpong et al., 1995). Remote Sensing technique is also a useful source of information as it provides timely and complete coverage of the study area, complementing field surveys of higher information content (Satyanarayana et al., 2001). GIS that can be considered as a database management system (allows users to store, retrieve and manipulate data) (Burrough, 1986) has an important role in planning process where land use changes as well as the existing pattern are intensive (Salam and Ross, 1999). High-resolution Remote Sensing data and GIS help in integrating multiparamter spatial information for generating locale-specific plan (Kasturirangan, 1995). The present work has mainly focused on the application of Geographical Information System complemented with Remote Sensing techniques to monitor shrimp farming development in Kandleru creek area.

Shrimp farming in Kandleru creek area

Kandleru creek (lies between latitude 14°10'-14°18'N and longitude 79°57'-80°09'E), which is situated south of Nellore (a coastal district in Andhra Pradesh) town and flows from west

to east, has been identified as high potential area for large-scale expansion of marine shrimp farming. After a joint survey from DOF and MPEDA that had identified 13,000 ha area suitable for shrimp farming development in the district and 50% of these areas are in either sides of the creek, the shrimp farming activity in Kandleru area boosted up very fast (Anon, 2001). According to Marine Products Export Development Authority (MPEDA) in 2001 there were 475 shrimp-farmers involved in farming activities with an area of 2,577 ha (Figure 1). There are other 1,000 ha area that is occasionally under shrimp farming.

Figure 1: Shrimp ponds along the Kanldleru creek, small pump used for water inlet into the ponds.

Beside this rapid expansion that coincided with natural resources degradation (conversion of mangrove and agriculture land into shrimp farms) in the study area (Shivkumar et al., 2001), there is also serious concern of significant deterioration of creek water quality due to shrimp farming that appears to be the serious shrimp health problems faced by the farmers. Since all these shrimp farms receiving and discharging water into the creek, the viral pathogen spread over the entire creek and affected the entire population in the farms (Anon, 2001).

Application of RS and GIS based Change Detection Method (CDM)

Remotely sensed digital data sets acquired by Indian Remote Sensing Satellite (sensor LISS-II, LISS-III and PAN) in 1988 and 2001 (Table 1), topographic maps (1:50,000 scale, prepared by Survey of India) and published information regarding landuse/land cover practices were used as data basis for CDM method. Geographical Positioning System (GPS) was used to establish a number of Ground Control Points (GCPs) during an intensive field visit conducted on February 2002.

Table 1: IRS (Indian Remote Sensing Satellite) data used for the study

Satellite / sensor	Data type		Date of pass
	Wavelength (μm)	Spatial resolution (m)	
IRS 1A LISS II	0.45 - 0.52 (B1) 0.52 - 0.59 (B2) 0.62 - 0.68 (B3) 0.77 - 0.86 (B4)	36.25	17 October 1988
IRS 1C LISS III	0.52 - 0.59 (B2) 0.62 - 0.68 (B3) 0.77 - 0.86 (B4) 1.55 - 1.70 (B5)	23.5	20 February 2001
IRS 1C PAN	0.50 - 0.75	5.6	20 February 2001

The geometric correction and registration of three images were done using 15 ground control points (GCPs) in each image. Linear polynomial equation was used to implement the corrections. Georeferencing of satellite imagery was carried out using digitized topographic

map. Nearest neighbor interpolation method was used for resampling the satellite image. Image fusion techniques (PCA and RGB/HIS) were applied to obtain high spatial and spectral resolution from low spatial-multispectral images and high spatial panchromatic images. It was useful to identify the shrimp farms from vegetation and other land uses for its capability to enhance the specific shapes and extract spectral reflectance of shrimp farms (Figure 2). Band ratio (Red Band/Near Infrared Band) technique was carried out to differentiate water from other land use classes, which has helped to find and locate active shrimp farms.

Figure 2: Data Fused Image of Kandleru creek area derived from IRS 1C LISS-III (23.5m) and IRS 1C PAN (5.8m), (RGB/IHS). The rectangle shape water bodies with dykes along the creek are shrimp

Several classifiers were applied to extract maximum environmental information for creating database in GIS. Creek map was digitized from 1.50,000 scale topographic map. Other information layers such as villages, roads, canals, islands, and swamps were also used as GIS layers (Figure 3). Finally, the analysis was carried out in Arcview GIS. Increasing shrimp farms, decreasing natural resources and changing others land use patterns were identified, located and evaluated at two different dates of data acquisition.

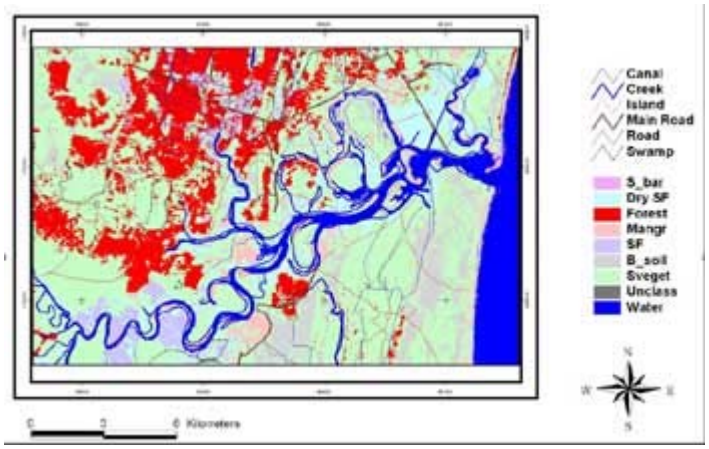

Figure 3: Land use or land cover map of Kandleru creek area in 2001

Results and discussions

The present study encompasses an area of 256.64 km^2 that covers the major part of Kandleru creek area where the dramatic changes of landuse or land cover can be found along with mushrooming of shrimp farms. Digital interpretation of all those data have identified 9 major landuse or land cover types in the study area (Table 2, Figure 2). The shrimp farms have been presented in two classes corresponding to active shrimp farms and

dry shrimp farms according to the differences in spectral characteristics revealed during the classification technique.

Table 2: The landuse classes selected or discerned from the satellite data used.

(SF) Active shrimp farms or shrimp farms with water	**(Sveget)** Small vegetation (grass field and agriculture field)
(Dry SF) Harvested shrimp farms without water or drying of shrimp farms during pond preparation	**(B_soil)** Barren soil (basically without vegetation)
(S_bar) Sand bar created in the creek mouth	**(Mangr)** Mangrove Forest
(WtrB) Water bodies (creek, reservoirs other than active shrimp ponds)	**(Unclass)** Unclassified lands
(Forest) Terrestrial forest other than mangroves, agriculture fields and grasslands	

The spatial location as well as the mushrooming of shrimp farms captured by LISS-III and PAN data revealed some interesting observations. During 1988 to 2001 new shrimp farming areas along the Kandleru creek have been increased 82%. About 50% of these new shrimp farms have been identified in small vegetation and agriculture area. Other 34% were identified in areas, which were mangrove in 1988. The study also revealed that mangroves along the Kandleru creek have been deteriorated 72% by different land use activities. About 22% mangroves were encroached by shrimp farming whereas 50% mangroves were cleared and converted into small vegetation and agricultural lands. A total of 1218 ha new shrimp farming area in 2001 has been derived from areas, which were previously small vegetation and agriculture lands in 1988 (Table 3, Figure 4). Whereas 835 ha new shrimp farming area has been derived from mangrove area. Disturbed mangrove forest and regular patches of shrimp farms are abundant in all along the creek. The landuse or lands cover classes with distributed area derived in 1988 and 2001 are presented in Table 3.

Table 3: Individual landuse class with encompassing area (ha) identified through processing and interpretation of LISS-II (1988) and LISS-III (2001) images.

Land use classes	Total area (ha)	
	LISS-II (1988)	LISS-III (2001)
SF	539.57	936.04
Dry SF	-	2017.92
S_bar	22.8	24.98
WB	3230.14	2582.48
Forest	4928.98	4371.48
Sveget	11194.81	12067.31
B_soil	1853.09	2604.20
Mangr	3708.88	1046.84
Unclass	186.01	13.03

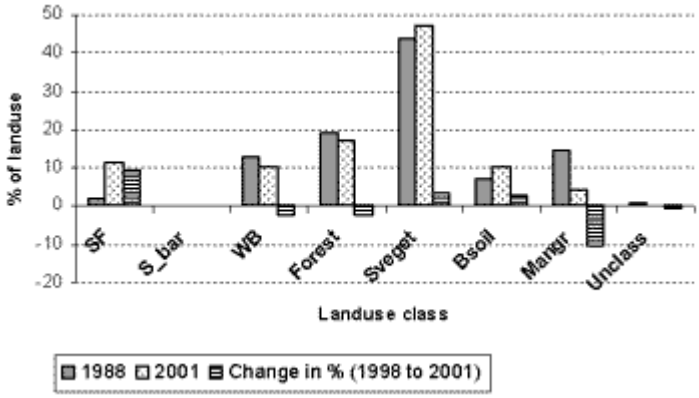

Figure 4: The percentage (%) of different landuse classes with changes in 13 years (1988 to 2001)

The total landuse or land cover data suggest that shrimp aquaculture area has been increased 9.41% during 13 years (Table 3). In 2001 there are 2954 ha of shrimp farming area that was only 540 ha in 1988 (Figure 5).

Conclusion

This study verified the development of shrimp farming area noticed from 1988 to 2001 using LISS-II, LISS-III and PAN image interpretation. Detailed investigation was found to be useful in identifying landuse changes occurred in this time frame. The mushrooming of shrimp farms has been developed by clearing mangroves in many places around the creek. However, the major conversion had happened from small vegetation and agriculture lands into shrimp farms than conversion of mangrove into shrimp farms.

Selection of multi-date satellite images taken at different season reduced or eliminated the difficulty faced to identify dried shrimp ponds while they were seen as barren lands on the day of satellite pass in 2001. Water logged paddy fields and shrimp ponds almost appear similar and are difficult to distinguish. Image fusion and band ratio techniques were proven useful to identify and locate the shrimp farms.

The results of this study revealed an uncontrolled and unplanned growth of shrimp farms in the study area. It may help to boost the economy of rural people but some environmental problems, which are already apparent, must be addressed for sustainable growth of the shrimp industry. Environment database developed in this study is being used for locating suitable site for shrimp farms development and finding carrying capacity of the creek.

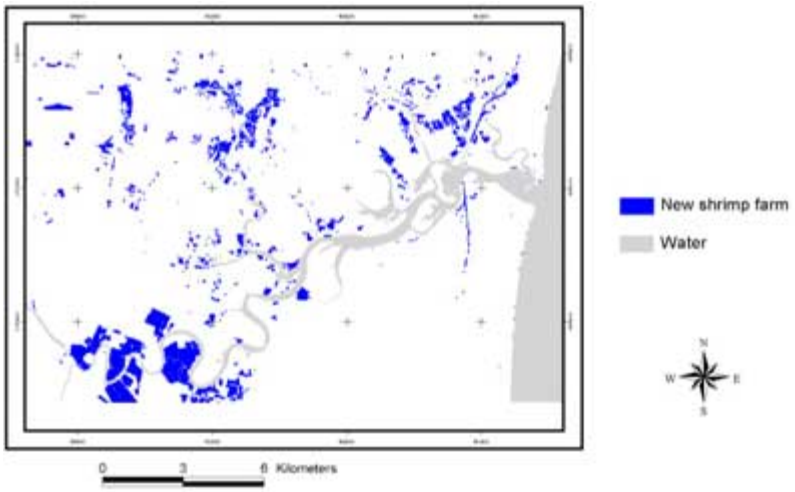

Figure 5: The encroachment of new shrimp farming area from other landuses in Kandleru creek area during 1988 to 2001.

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