

Change detection studies in and around Kolleru Lake using high resolution data

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Abstract

Kolleru is one of the largest freshwater lake situated in Krishna and West Godavari districts of Andhra Pradesh state, India, having an area of 198.92 sq. km. Agriculture was practiced on the lake surrounding areas. During the aqua boom in late eighties and early nineties, the lake underwent phenomenal changes leading to disastrous ecological changes and irreparable damages. If this trend continues the lake may soon disappear. In the present study, an attempt has been made to estimate the area under fish pond culture within the lake area using high resolution data from satellites. The changes that are occurred during the last ten years in Kolleru lake area have been studied. The digital base map covering the lake and surroundings with the administrative boundaries have been prepared. The satellite data from Landsat and IRS have been analysed and classified, after geometric rectification of the images. The area under fish culture in the lake in each mandal has been estimated and presented. It is found that more than 65% of the lake area has been encroached for conversion into fish ponds by 1999. The detailed discussion on the causative factors due to encroachment into the lake area for conversion to fish ponds have been presented. The various action plans to restore the lake area is also discussed in detail.

1. Introduction

Aquaculture is the domestication and rearing of aquatic animals and plants. It is related to agricultural development and fisheries management, both initially the domains of biological scientists. The social scientific perspective into aquacultural projects was found inevitable in technology transfer and resource management. After technology was designed, or a new management regime was conceptualized, economists were asked for feasibility studies and economic impact statements. It is realized the importance of other types of social scientific analysis, due to failures in technology transfer and resistance to the regulation of natural resources. Economics is still the most heavily represented social science in the field of aquaculture and constitutes an integral part of any aquaculture venture, whether subsistence or commercially oriented.

There are three areas in which aquaculture can make a significant contribution: rural development (Grover, et al., 1980; Liao, 1988; Mitchell et al., 1986), generation of export revenue (Mitchell et al., 1986; Rahman, et al., 1985; South Carolina Sea Grant, 1989) and replenishment of wild stocks of commercially and recreationally important aquatic species (Amend, 1989; MaccKenzie, 1977; McCay, 1989).

The increasing population and declining fish stocks for capture, aquaculture has forced to look for innovative ways to secure an inexpensive source of protein for both the rural and urban poor. Because of the ar-

ray of production systems available, aquaculture provides a mechanism to increase protein consumption in Third World countries. Even very poor farmer can supplement his or her family's protein requirement through a backyard pond using a species that requires no feed and little care, provided adequate water, proper soils, and a source of post larvae are available. Landless rural poor and displaced fishermen can grow fish in cages or net enclosures in lakes, estuaries, and bays, because many aquaculture systems rely on either communally controlled or open-access waters (Brass, et al., 1987; Nakamura and Trauth-Thomas, 1986; Santaella, 1989).

Tropical brackish water and saltwater aquaculture have contributed to the destruction of mangrove forests and salt marshes, because they have been cleared for use as ponds. The ecological importance of mangroves and salt marshes is now well established. They are habitat for various animal species, they retard coastal erosion, and they are the spawning grounds for various finfish, crustaceans, and mollusks. The role of these coastal resources in the subsistence of the rural poor, as resources of firewood, food, and building material has been identified. Fishermen also depend on mangroves, which provide nursery and breeding habitat and important to the fishery. The conversion of mangrove stands into shrimp and milkfish ponds renders a valuable economic resource useless to these two social groups as well as causing ecological degradation. In this instance, the decline in species diversity is directly

related to the decline in occupational diversity and the resultant social displacement.

Extensive aquaculture practices are being carried out which can be violent from the mushrooming growth of shrimp farms in an un-ruled manner, leaving in the wake of evident protest from environmentalists and social activists demanding the closure of these farms. Lack of knowledge on scientific management of aquaculture farming ends in outburst of viral diseases, incurring heavy losses is quite evident in recent past. Hence the holistic coastal aquaculture development can be sustainable and yield high production by judicious planning of the farms, ensuring supply of quality food, aeration of pond water, daily water exchange and high level of management efficiency.

In the 1960s, India made headlines with its Green Revolution, by producing more than double of its wheat production from 1965 to 1972, using high-yielding varieties and improved technology. Today, India is pushing ahead with a Blue Revolution, in rapid increase of its fish production in small ponds and water bodies. This is a boon to small farmers, the nation's nutrition and its gross domestic product.

The Indian fisheries sector, which 50 years ago produced only 6,00,000 tones of fish, today produces 5 million tones, including 2.6 million tones from freshwater aquaculture. Although the yield from marine fisheries has stagnated at 2.4 million tones per year, freshwater aquaculture is growing at a healthy 6 percent a year. The Indian market can absorb an estimated 4.5 million tones of freshwater fish. While it is true that India is known as a vegetarian culture, in fact 55 percent of Indians are non-vegetarian. The Indian present annual per capita consumption of fish is 8 kilos per person, while the global average is 12 kilos. So there is lot of room for inland fresh water aquaculture to grow by availing all the freshwater bodies in the country.

Kolleru is one of the largest freshwater lake situated in Krishna and West Godavari districts of Andhra Pradesh state, India. The lake has a water spread area of 135 sq. km (The Hindu, 5 May 1996). The water comes from a huge catchment area of 4,760 sq. km. The water fed to the lake by three major streams namely Budameru, Tammileru and Rammileru along with 15 major channels and 16 drains carrying inflow of 0.65 to 1.10 lakh cusecs. According to some studies, the maximum inflow was once estimated at 2 lakh cusecs. The sole outlet into the Bay of Bengal is the Upputeru drain with a capacity of 15,000 to 20,000 cusecs.

The lake is surrounded by 8 revenue mandals of the two districts. More than 2 lakh people reside in 148

villages situated in the vicinity of the lake, of which one fourth of population is of the traditional fishermen community called 'vaddees'. Agriculture was practiced on a lake area and its surroundings and is prone to frequent floods. With the advent of aqua boom, the lake has seen a phenomenal development of pond aquaculture. Through aquaculture farms in and around Kolleru Lake, the fish production has increased from 6,000-7,000 tonnes in 1980 to 50,000-60,000 tonnes by 1985-86. If this trend continues lake may soon disappear.

Keeping in view of the importance of the Kolleru Lake, in this paper an attempt has been made to map and monitor the aquaculture development in the lake for the past decade using high-resolution data from Landsat and IRS sensors. The detailed methodology and the results are presented.

2. Materials and Methods

The study area (Fig. 1) is covered in four old revenue tehsils, namely Eluru, Tadepalli Gudem, Bheemavaram of West Godavari district and Kaikalur of Krishna district, Andhra Pradesh, India. The revenue tehsils were later restructured in to revenue mandals during 1955. The revenue tehsil (administrative) maps on 1:63,360 or 1 inch = 1 mile scale were obtained from Central Survey Office of Andhra Pradesh. The administrative maps containing village boundaries, transport network, canals, etc., surveyed during 1929 and updated during August 1953 were digitally scanned. The digitally scanned maps are projected with the standard referencing scheme. The projection considered here is the polyconic and the spheroid taken is Everest with the same Everest datum. The geometric rectification of these maps was done using standard procedure available in image analysis package. The mosaics of the geo-referenced maps were done to prepare the final base of the lake and its surroundings, covering the eight newly structured revenue mandals.

The multi date digital data of Landsat 5 - TM of November 23, 1989 and December 07, 1994 of 142 path and row 051, IRS 1B - LISS II of December 23, 1992 of path 23 and row 57, IRS 1C - PAN & LISS III of May 10, 1996 of path 103 row 61 and IRS 1D - LISS III of March 12, 1999 of path 103 row 61 was selected

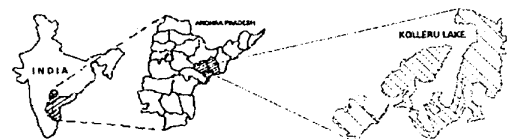


Fig. 1. Study area.

Table 1. Characteristics of different satellite sensors used in the present study.

Satellite Characteristics	Landsat	IRS 1A/1B	IRS 1C/1D	
	TM	LISS-II	LISS-III	PAN
Wave lengths in micro meters	0.45-0.52 0.52-0.60 0.63-0.69 0.76-0.90 75.75-75.75 10.5-12.50 2.08-2.35	0.45-0.52 0.52-0.59 0.62-0.68 0.77-0.86	0.52-0.59 0.62-0.68 0.77-0.86 1.55-1.70*	0.50-0.75
Spatial Resolution in meters	30 x 30	36 x 36	23.5 x 23.5	5.8 x 5.8
Scene coverage in kilo meters	185 x 185	148 x 148	140 x 140	70 x 70
Repetitivity in days	16	22		341 orbits/24 days

* Spatial Resolution is 70.5 x 70.5 meters and scene coverage is 148 x 148 km.

for the present study covering the Kolleru lake and surroundings. A brief description of the satellite sensors are provided in Table 1. Field visit was made to collect the ground truth for verification and for preparation of accurate map. These data sets are geometrically rectified to the geo-referenced study area base map using standard image to image tie-up procedure. The standard data enhancement techniques, like linear stretch, contrast enhancement, etc., and RGB-IHS-RGB data fusion for PAN and LISS III data merging were used for better representation of output product. The FCC of 1989 and its interpreted maps through onscreen digitization (visual image interpretation) along with 1999 are presented in Figs. 2 (a), 2(b) and 3(a), 3(b) respectively. The images and maps of the other years are not presented due to limitation in length of the paper.

3. Results and Discussion

The Kolleru Lake ($16^{\circ} 33'54.52''N$ and $16^{\circ} 45'33.86''N$, $81^{\circ} 05'07.52''E$ and $81^{\circ} 21'02.84''E$) is shown in Fig. 1. The lake area was reported (30th Au-

gust, 1996, Indian Express) as much as 954 sq. km. And in some other report it was mentioned that the area was 135 sq. km (The Hindu, 5 May 1996). On the other hand, the lake area was computed as 178.92 sq. km., from the digitally scanned tehsil administrative maps obtained from Central Survey Office of Andhra Pradesh. These maps surveyed during 1929 were updated during August 1953. In case of Indian Express report, there may be a print mistake, since the area of the government land (lake) was given as 40,604 acres in the same report. Hence the lake area was considered as 178.92 sq. km for the present study. Out of the 178.92 sq. km, an area of 56.6 sq. km is in Krishna district and 122.32 sq. km in West Godavari district. Fig. 2a, shows the False Colour Composite (FCC) of Landsat 5, Thematic Mapper (TM) bands 7, 5 and 4 covering the lake area on 23rd November, 1989. The bands 4, 5 and 7 were selected since the geological features are very clear in these bands. The image shown in Fig. 2(a) was visually interpreted through on screen digitization using ERDAS imagine 8.3 and is presented in Fig. 2(b). In Fig. 2(b), various classes like fish ponds, paddy fields, weeds, fallow lands, lake

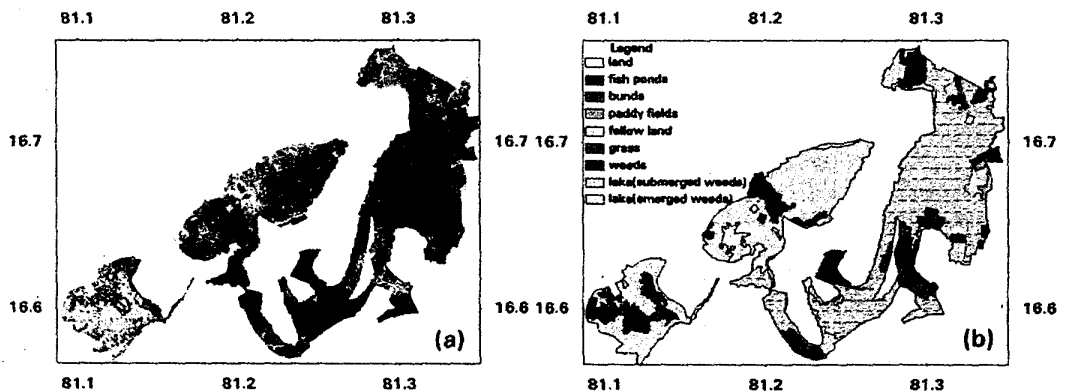


Fig. 2 (a). False colour composite of LS-TM (bands 7, 5, 4) covering Kolleru lake dated 23 November, 1989, (b) Interpreted map.

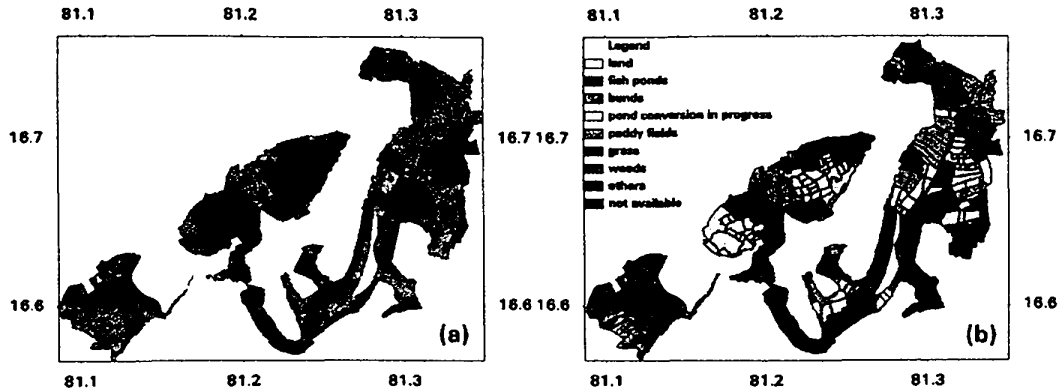


Fig. 3 (a). False colour composite of IRS-1D/LISS-III (3.2,1) covering Kolleru lake dated 12 March, 1999, (b) Interpreted map.

with submerged and emerged weeds, bunds, etc., It can be seen from the Fig. 2(b), that 86.56% of the lake (i.e. 155 sq. km) is covered with weeds and water logged area with submerged and emerged weeds. An area of 7.3 sq. km is under paddy cultivation including fallow lands. Fish pond culture is practiced in 8.25 sq. km. Grass is covered in an area of 5.37 sq. km and 3.16 sq. km area is covered under bunds. Fig. 3(a) shows the FCC (bands 3,2,1) of IRS-1D/LISS-III covering the lake area on 12th March, 1999. The visually interpreted map from Fig. 3(a) is illustrated in Fig. 3(b). It is seen from the map that an area of 49.55 sq. km is covered under weeds. The grass is occupied in an area of 12.56 sq. km. An area of 34.20 sq. km is under fish ponds and also an equal amount of area (33 sq. km) is under construction of fish ponds. An area of 24.55 sq. km is under paddy cultivation. Considerable amount of the lake area (22.24 sq. km) is under bunds. Nearly 3.0 sq. km area is covered under other categories. Surprisingly 63.67% of the lake area is practiced under fish pond and paddy cultivation. It is very clearly seen from the Figs. 2(b) and 3(b) that fish pond cultured area in the lake has been increased from 8.25 sq. km (825 ha or 2,062.5 acres) during 1989 to 67.17 sq. km (6717 ha or 16,792.5 acres) during 1999. Similarly for the past decade, paddy cultivated area has been increased from 7.27 sq. km (727 ha or 1,817.5 acres) to 22.24 sq. km (2,224 ha or 5,560 acres). Accordingly the bunding area increased from 7.27 sq. km to 24.55 sq. km. It was reported in 1996 that an extent of 8,104 acres is covered by fish tanks and 6,763 acres covered by wet paddy cultivation. It is seen presently that the fish ponds are varying from small (2.5 hectares) to big (80 hectares, natural pond) in area. Kolleru Lake, the biggest fresh water body in Asia, produces an amount of nearly 20,000 tonnes of fish from 6,717 ha of fish ponds. The fish produced in the lake will provide an amount Rs. 50 Crores per annum. On the other hand the introduction of aquaculture can disrupt the

traditional patterns of land. In the present case, the biggest fresh water body having ecological importance and sanctuary for migratory birds will disappear in the near future. In the Kolleru lake area there is no potable water in 50 villages due to conversion of lake into artificial fish ponds. The inflows into the lake from various rivers and streams were deliberately blocked as also the outflow through the Upputeru drain resulting in drying up a major portion of the lake for easy conversion of the lake into artificial fish ponds. The deliberate blockages leading to disastrous consequence of floods in the lake and its surrounding, which is more so happened during the recent floods in 2000. The Remote Sensing Technology, which can provide direct and strong proof on the encroachments, in the absence of proper information.

4. Conclusions

1. There is a phenomenal development of pond aquaculture in the lake area in the past decade and also significant increase in fish production with an average of 2000-3000 kg/ha. The pond culture activities in and around the lake help rural poor of the area.
2. On the other hand, the fresh water aquaculture in the lake has contributed to the destruction of the Kolleru lake, because the lake has been occupied for use as a pond aquaculture and wet paddy cultivation and is leading to the disappearance of ecologically important lake and sanctuary for migratory birds in very near future.
3. The deliberate blockage of water inflow into the lake from various rivers and streams and also the outflow through Upputeru drain for pond aquaculture and wet paddy cultivation leading to disastrous consequences of floods in and around the Kolleru lake during cyclones and very active southwest monsoon seasons.

4. The high-resolution data from satellites will be useful in mapping and monitoring of the Lake from time to time and can provide direct and strong proof on the encroachments, in the absence of proper information by conventional means.

Finally it is suggested that the removal of fish ponds in the lake and construction of a regulator at Upputeru to arrest the outflow to restore the original Kolleru lake.

Acknowledgements

The authors are extremely thankful to Dr. D.P. Rao, Director, NRSA for his keen interest and encouragement. We thank Sri. Tilak Thota, JRF, INCOIS for his help.

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