View metadata, citation and similar papers at core.ac.uk
brought to you by CORE
provided by NOPR

Indian Journal of Geo Marine Sciences
Vol. 48 (08), August 2019, pp. 1205-1209

Evaluation of coastal aquaculture ponds using remote sensing and GIS

K. Nagamani[1*] & Yasodharan Suresh[2]

[1]Centre for Remote Sensing & Geoinformatics, Sathyabama Institute of Science and Technology, Chennai , Tamil Nadu, India

[2]Department of Geography, Tourism and Travel Management, Madras Christian College, Chennai , Tamil Nadu, India

[*][E-mail: nagamaniloganathan@gmail.com]

Coastal aquaculture is one of the fast growing food production sectors worldwide, contributing to more than half of the total volume of aquatic foods for human consumption, and offering great potential for global food security. Remote sensing and GIS technologies contribute to the mapping and monitoring of changes in aquaculture providing essential information for coastal management applications. The present study investigates the growth and expansion of aquaculture and its spatiotemporal dynamics in Nagapattinam district (from Vedaranyam to Vettar River) over the last decade. Multitemporal IRS 1C and IRS P6 remote sensing data were analyzed for detecting and assessing land use and land cover (LULC) change in the Nagapattinam area (Tamil Nadu). Visual interpretations have been made with the help of field surveys, primary data collected on field, and secondary data from government departments. LULC maps were prepared to identify changes in aquaculture areas. The classified area for aquaculture in Nagapattinam is 4.02 km^2 in 2006 and 9.80 km^2 in 2016. Similarly, the salt pan areaincreased from 0.53 km^2 to 1.53 km^2 in 2016. The coastal wetlands and marshy lands were used for aquaculture and salt pan activities during 2006 to 2016, providing a livelihood for the people in that area. The study will assist to identify change dynamics in environmental sustainability in the context of livelihood option/development activities.

[**Keywords**: Pond aquaculture; Salt pan; Dynamics; Remote sensing; GIS]

Introduction

Aquaculture is growing more rapidly than any other segment of the animal farming industry[1]. In India, the annual fisheries and aquaculture production increased from 0.75 million tonnes in 1950-1951 to 9.6 million tonnes in 2013-2014[2]. Expansion of aquaculture is due to potentially high commercial returns and the ability to produce export earnings. The coastal belt of Nagapattinam is one such locale where aquaculture activity is expanding owing to the availability of land and water resources which are conductive for aquaculture development. These locations cannot be utilized for agriculture. Remote sensing has emerged as the most suitable tool for quantitatively measuring land-cover changes at the landscape scale[3]. Satellite images provide a synoptic coverage of the earth's surface in spatial and temporal scale and help us to understand how the changes have happened in various parts of the environment including coastal waters[4,5]. An integrated Geographical Information System (GIS) and remote sensing technique deals with the spatiotemporal information of land use and land cover (LULC) features that are well recognized for decision making in the scientific realm[6,7]. GIS and remote sensing combines the multiple spatial datasets, such as maps, aerial photographs, and satellite images for preparing the quantitative, qualitative, and descriptive geo-databases for periodical changes of the LULC features[8]. More recently, the status of GIS, remote sensing, and mapping applications in aquaculture was reviewed from an ecosystem and management perspective[9]. Most of the existing LULC patterns replicate the interaction of human action with the environment, and because their magnitude and location can be heterogeneous, remote sensing techniques can be used for multitemporal monitoring, revealing the changes in the land cover and supplying important information on land-cover dynamics[10].

The present study has been carried out in Nagapattinam coast (from Vedaranyam Canal to Vellar River) of Tamil Nadu to ascertain the changes in LULC from 2006 to 2016 along with the growth and development of aquafarming practices.

Methodology

Study area

Nagapattinam is located between 10° 40' 00", N 79° 45' 00" E and 10° 55' 00"N 79° 55' 00"E (Fig. 1). The total study area covers 71.71 sq. km.

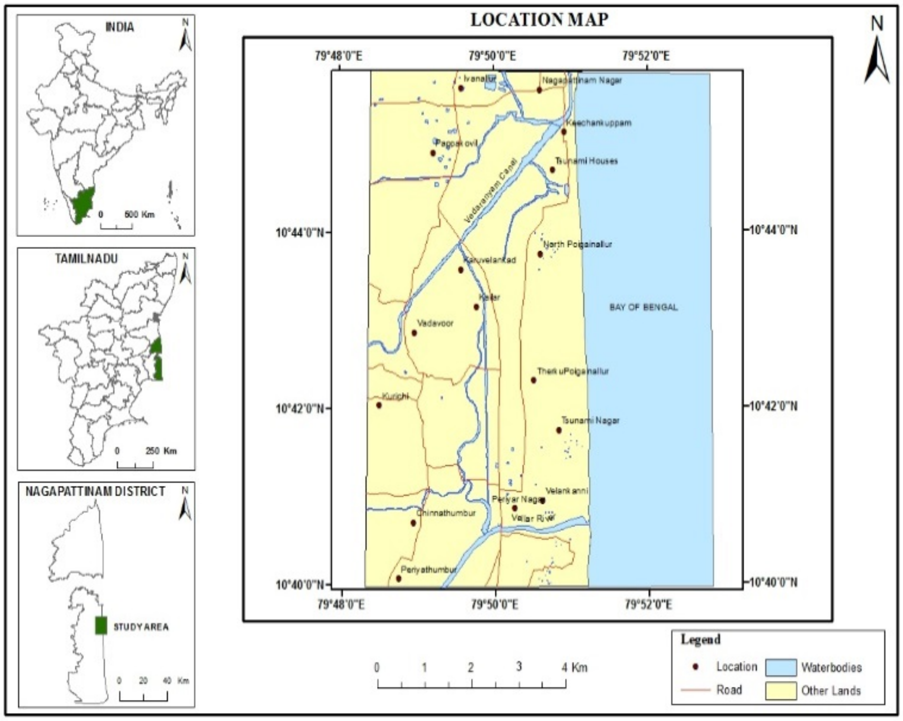

Fig. 1 — Location map

Data utilized

In this study, satellite images from IRS 1C of 2006 and IRS P6-LISS IV of 2016 were used to observe changes in the spatial extent and distribution of aquaculture ponds. ArcGIS 10.2.1 and ERDAS Imagine 2014 were used for spatial analysis.

Analysis

IRS 1C and IRS P6 satellite data of the study area were used and the detailed methodology adopted in this research is shown in Figure 2. Decadal changes could be assessed as data of January 27, 2006 and February 7, 2016 were available to delineate aquaculture farms, their spatial extent and distribution along with other major land use classes. IRS 1C and IRS P6 images were collected from National Remote Sensing Centre (NRSC), Hyderabad. The IRS 1C image of 2006 has a spatial resolution of 70.5 m and the IRS P6 LISS IV pan merged has a spatial resolution of 5 m. All the satellite images were used for Universal Transverse Mercator (UTM) projection in zone 44N. Topographic sheets sheet no. 58N/14 for the year 1970 in the scale 1:50000 were used to prepare the base map. ArcGIS 10.2.1 was used to display and geo-reference the satellite images. In visual interpretation, the image was classified into different categories which helped generate LULC maps and generate a set of points randomly; this was then validated in field using Global Positioning System (GPS).

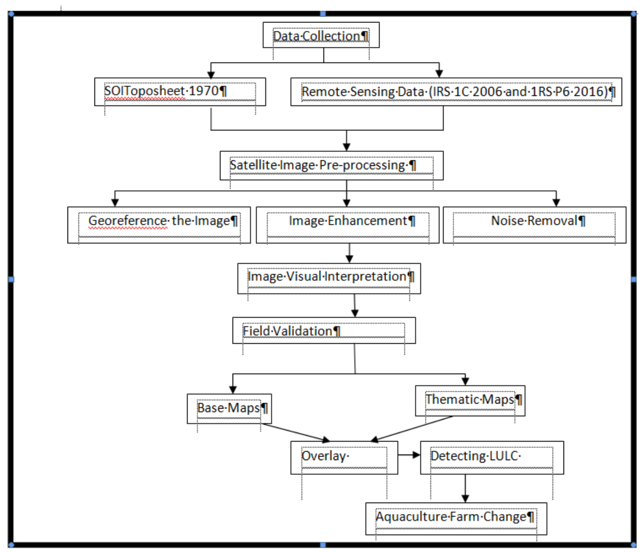

Fig. 2 — Methodology flowchart

Results and Discussion

The major land use classes were identified from the false color composite (FCC) created through visual interpretation keys, such as color, texure, shape, and tone through standard methods. Aquaculture farms were recognizable as diverse shades of pink or blue color surrounded by square or rectangular-shaped bunds, salt pan by white color, and waterbodies are black in color. Two classified maps pertaining to 2006 (Fig. 3) and 2016 (Fig. 4) were prepared and compared to compute the change in percentage of each class (Fig. 5 and Table 1). The results of the pre-field and post-field interpretations were cross-checked in the field using GPS. The results are arranged in the form of a matrix. Ground truth authentication of the classified LULC features

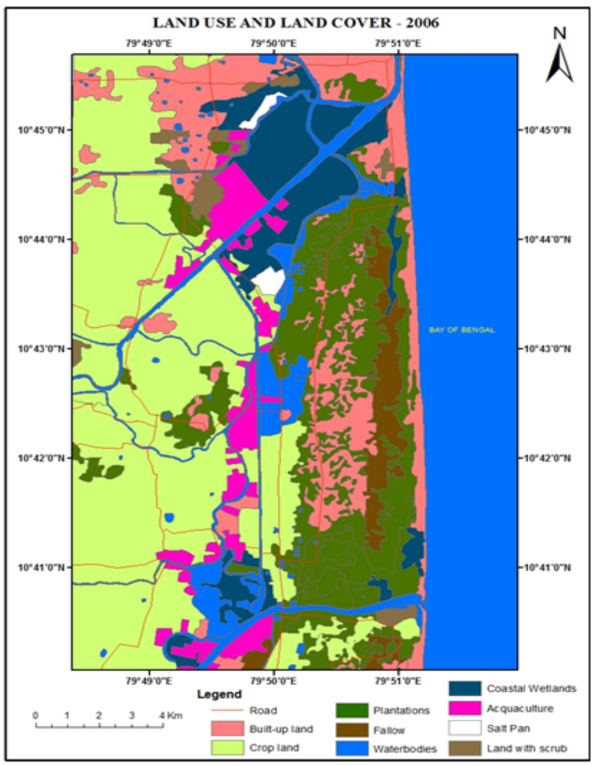

Fig. 3 — Land use and land cover – 2006

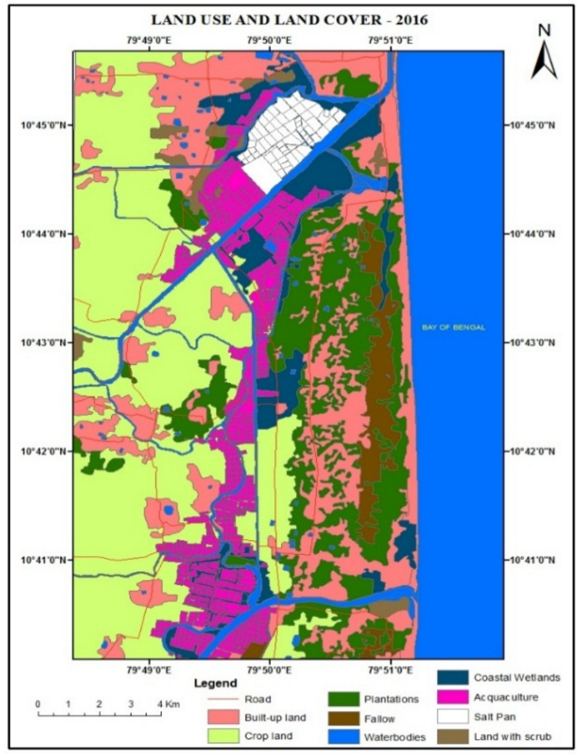

Fig. 4 — Land use and land cover – 2016

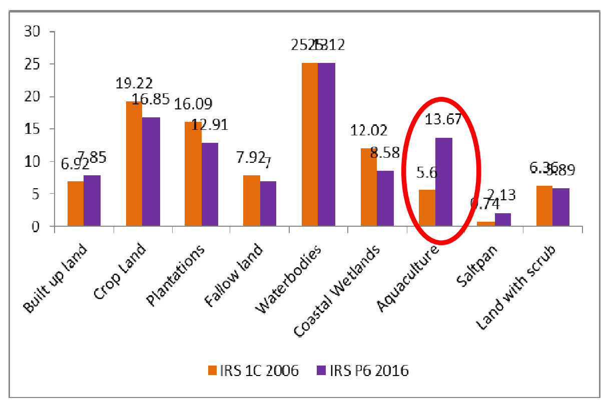

Fig. 5 — Land use and land cover 2006 and 2016

Table 1 — Area and percentage of change in different coastal land use and land cover features in the study area during 2006–2016

Sl. No.	Classification	Area in Sq. Km. 2006	%	Area in Sq. Km. 2016	%
1	Built- upland	04.96	6.92	05.63	7.85
2	Crop land	13.78	19.22	12.08	16.85
3	Plantations	11.54	16.09	09.26	12.91
4	Fallow land	05.68	7.92	05.02	7.00
5	Water bodies	18.02	25.13	18.01	25.12
6	Coastal wetlands	08.62	12.02	06.15	8.58
7	Aquaculture	04.02	5.60	09.80	13.67
8	Saltpan	00.53	0.74	01.53	2.13
9	Land with scrub	04.56	6.36	04.23	5.89
	Total	71.71	100	71.71	100

Table 2 — Accuracy error matrix (IRS P6- 2016)

Verified in Image

Verified in Ground Verified in Ground

Land use	B	CL	PT	FL	WB	CW	AQ	SP	LS	Row Total	PA%	EO%
B	15		1							16	94	6.3
CL		25							1	26	96	3.9
PT			10	1						11	91	9.1
FL				10					1	11	91	9.1
WB					15		1			16	94	6.3
CW			1			17				18	94	5.6
AQ			1				20	1		22	91	9.1
SP							1	10		11	91	9.1
LS				1				1	10	12	83	16.7
Column Total	15	25	13	12	15	17	22	12	12	143		
UA %	100	100	77	83	100	100	91	83	83			
EC %	0	0	23.1	16.7	0	0	9.1	16.7	16.7			

performed using 143 samples reveals that the accuracy of the classified features is 92.3% (Table 2). This specifies adequate precision of the classified LULC features for change studies.

A broad distribution of aquaculture category during 2006 and 2016 shows that the extent of aquafarms, increased from 4.02 km^2 to 9.8 km^2 (Figs 3 and 4). The aquaculture area increased from 5.60% to 13.67% of the total geographical area between 2006 and 2016 (Fig. 6). Vedaranyam canal and Cauvery tributaries such as the Uppanar and Vellar rivers are suitable land for brackish water aquaculture and many small-scale aquaculture farms are operating around this area. It is also observed that a few aquaculture farms have been developed close to the seashore.

Expansion of aquaculture could be mainly due to introduction of the species *Penaeus vannamei,* in 2009. According to the MPEDA report, the introduction of *P. vannamei* through specific pathogen-free (SPF) stock in 2009 opened up a new vista in Indian aquaculture and more and more farmers took to aquafarming. On an all India level too, more areas were added for aquaculture and the seafood exports from India crossing 1 million tonnes for the first time, with the export earnings crossed $ 4.5 billion during 2013-2014[11,13].

The study area experienced an appreciable increase in salt pan area as well: From 0.53 km^2 (0.74%) to 1.53 km^2 (2.13%). There has been a radical increase in the human population in the last decade and this is reflected by the increase in

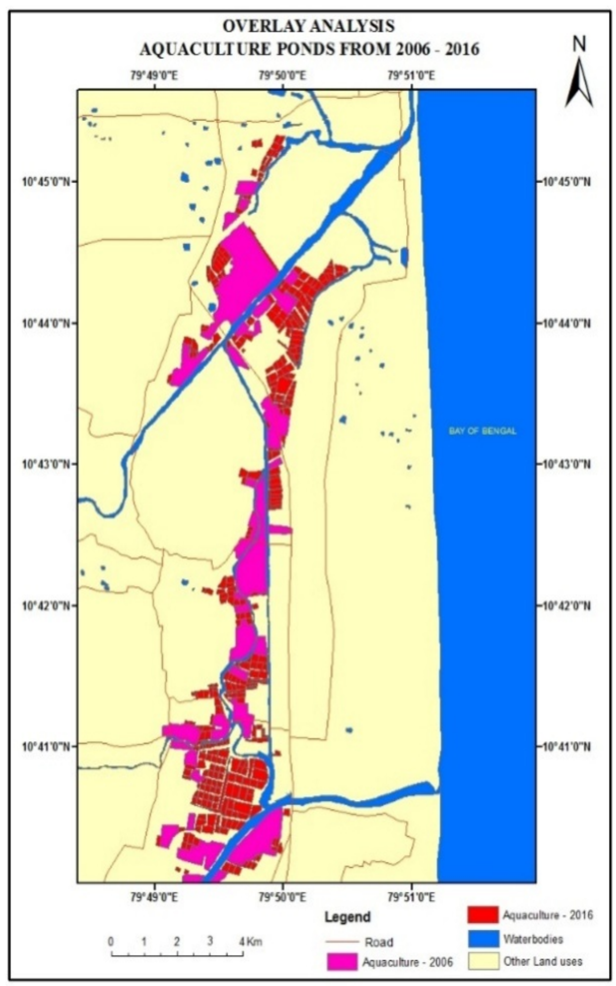

Fig. 6 — Aquaculture change dynamics 2006 and 2016

settlement area between 2006 and 2016. The decrease in wetlands with shrubs/grass may have been due to rapid urbanization and industrialization along the coastline. These anthropogenic activities had limited the entering of high tides and backwaters on to the main land, and this is the main reason for the decrease in wetlands along the coast. Most of the wetlands have been converted to fallow lands because of non-availability of tidal water/backwater and moisture. As satellite images offer in sequence the spatial distribution of different LULC classes, it is possible to expand this kind of database with accurate, up-to-date land/sea information and carry out periodic assessments of the resource use pattern.

The optimum and sustainable use of natural resources for aquaculture can lead to economic gains, although if badly planned and managed, this can also lead to short- and long-term economic loss[14].[14] The graphical analysis of LULC maps shows changes in LULC classes between 2006 and 2016, with marked changes observed in three classes, namely, plantations, coastal wetlands, and aquaculture, whereas the remaining classes displayed negligible changes (Figs 5 and 6). The rapid growth of aquaculture and the market demand are beneficial for overall economic growth of the area, as the net profit from shrimp farming is much higher. With the development of aquaculture activities, there is an additional need to preserve the environment without affecting the livelihood of the people. For this, the guidelines of the Coastal Aquaculture Authority need to be followed, so that the quality of groundwater, land, and soil in the coastal areas can be maintained.

Conclusion

Satellite remote sensing based spatiotemporal pattern of mapping shows the expansion of aquaculture farms in Nagapattinam (Tamil Nadu) during 2006-2016. This study also demonstrated that high-resolution images coupled with GPS-based field survey can be very useful for extracting detailed information about the earth's surface and for estimating the LULC changes.

References

1 Hein, L., Impact of shrimp farming on mangroves along the east coast of India, *Unasylva*, 51(2000):48-54.

2 Dhinagaran, V., *District Groundwater Brochure*, Technical Report Series, Regional Director, CGWB, Chennai, (2008).

3 International Food Policy Research Institute (IFPRI), 2014–2015 , Global food policy report http://www.ifpri.org/sites/default/files/gfpr/2015/index.html.

4 Misra, A., Murali, R.M., Vethamony, P., Assessment of the land use and land cover/land cover (LU/LC) and mangrove changes along the Mandovi–Zuari estuarine complex of Goa, India, *Arab. J. Geosci*., 8(1)(2013): 267-279.

5 Phillips, M.J., Kwei Lin, C., Beveridge, M.C.M., Shrimp culture and the environment; lessons from the World's most rapidly expanding warmwater aquaculture sector. In: *Environment and aquaculture in developing countries*, (edited by R.S.V. Pullin., H. Roesnthal and J.L., Maclean), *ICLARM Conference Proceedings*, 31, ICLARM, Manila, Philippines and CSIRO, Cronulla, Australia (1993): 171-197.

6 Misra, A., Balaji, R., Decadal changes in the land use and land cover/land cover and shoreline along the coastal districts of southern Gujarat, India. *Environmental Monitoring and Assessment*. (2015), 187(7):461. https://doi.org/10.1007/s10661-015-4684-2.

7 Singh, A., Digital change detection techniques using remotely sensed data, *Int. J. Remote Sens.,* 10(1989). pp. 989 – 1003.

8 Kaliraj, S., Chandrasekar, N., Spectral recognition techniques and MLC of IRS P6 LISS III image for coastal landforms extraction along South West Coast of Tamilnadu, India, *Bonfring Int. J. Adv. Image Processing*., 2(3)(2012): 1-7.

9 Kapetsky, J.M., Aguilar-Manjarrez, J., Spatial perspectives on open ocean aquaculture potential in the US eastern exclusive economic zones,. in: *Proceedings of the Fourth International Symposium on GIS/Spatial analyses in Fishery and Aquatic Sciences*, August 25–29, 2008, (Universidade Santa Úrsula, Rio de Janeiro, Brazil) 2010, pp. 235-254.

10 FAO. 2014, National Aquaculture Sector Overview India, Ministry of Agriculture, Department of Animal Husbandry, Dairying and Fisheries. 2014, p.1.

11 R Rekha, P.N., Ambasankar, K., Stanline, S., Sethuraman, K., Dayal, J.S., Panigrahi, A. and Vasagam, K.P.K., Design and development of an automatic feeder for Penaeus vannamei culture. *Indian J. Fish.,* 64(Special Issue): 40, (2017): 83-88. DOI: 10.21077/ijf.2017.64.Special-issue.76209-12.

12 Rekha, P.N., Gangadharan, R., Ravichandran, P., Dharshini, S., Clarke, W., Pillai, S.M., Panigrahi, A., Ponniah, A.G., Land-use/land-cover change dynamics and groundwater quality in and around shrimp farming area in coastal watershed, Cuddalore District, Tamil Nadu, India, *Curr. Sci.*, 113(9)(2017): 1763-1770, doi: 10.18520/cs/v113/i09/1763-1770.

13 Rekha, P.N., Gangadharan, R., Dharshini, S., Clarke, W. Ramanathan, G., Debrol Vimala, D., Panigrahi, A., Gopal, C., Digital database on shrimp farming in coastal watershed of Cuddalore District, Tamil Nadu, *Indian J. Fish.,* 64(Special issue)(2017): 39-45.

14 Philips, M.J., Aquaculture and the Environment—Striking a balance, *Proceedings Infofish-Aquatech'94 Conference* (1995), Aquaculture towards the 21st Century, Colombo, Sri Lanka, 1995, pp. 29-31.