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Environmental Impacts Assessment of Brackish Water Aquaculture Activity in Nagapattinam Region, South East coast of India

Rajesh J*, Lakshumanan C, Govindaraj V and Karthick P

Centre for Remote Sensing, Bharathidasan University, Tiruchirappalli, Tamil Nadu, India

Abstract

Coastal Land use Change has become an important component in current strategies for managing coastal resources and monitoring its environmental changes. This study examines the Landuse conversion and improper aquaculture activities in the coastal region of Nagapattinam SE coast of India. The brackish water aquaculture practices started very extensively since year 2000 onwards where fertile agriculture land, Mudflat areas, swampy land have been converted for the aquaculture ponds. Using temporal satellite data of Landsat ETM+PAN 1999, IRS P6 LISS IV 2007, Lands at OLI 2014 the changes that have been estimated. The results indicate that, the agricultural activity has been on the decrease these years. In addition, the data also suggest that the agricultural lands are decreasing due to increasing brackish water aquaculture activities, mud land, swampy land and waterlogged areas have been converted during last decade. Water quality index indicating in terms of index numbers, offers a useful representation of overall quality of water for public or for any intended use as well as in the pollution abatement programmes and in water quality management. Water quality index was calculated based on the basis of various physical chemical parameters like pH, Electrical conductivity, total dissolved solids, nitrate, calcium, sulfate, magnesium, fluoride, total hardness, sodium, chloride, carbonate and bicarbonate. Groundwater quality results clearly indicate that almost entire PWD selected Controlled well of Nagapattinam Taluk groundwater unsuitable for drinking purpose. It is also observed that the pollution load is relatively pre monsoon season. Average values for the seasons are taken into account the study area slightly alkaline. Chloride is the most important parameter in assessing the water quality. Since 2002 (19.49-excellent water quality) Tirumarugal only suitable for drinking purpose and other areas not suitable for the Period of (1998-2007). Result shows the change that has been occurred during 15 years of period mud land and swampy land, waterlogged areas totally converted to aquaculture activities.

Keywords: Remote sensing and GIS; Landuse/landcover changes; Aquaculture status; Physical groundwater quality; Nagapattinam

Introduction

Landuse/Landcover changes have become an important component in current strategies for managing natural resources and monitoring environmental changes. The advancement in the concept of the vegetation and health of the world's forest, grassland and agricultural resources has become a major priority. Although the term land use and land cover is often used interchangeably, their actual meanings are quite distinct. Land cover refers to the surface cover on the ground, whether vegetation, urban infrastructure, water, bare soil or other. Mapping land cover is essential for global monitoring studies, resource management, and planning activities [1-3]. Identification of land cover establishes the baseline from which the change detection can be performed, and provides the ground cover information for baseline thematic maps. Landuse applications involve both baseline mapping and subsequent monitoring and develop strategies to balance conservation, conflicting purposes, and developmental pressures. Issues substantial land use studies removal or disturbance of productive land, urban encroachment, and depletion of forests.

To assess the land use and land cover changes in Nagapattinam Taluk, since the growing population pressure on land and increasing land degradation have required not only the collection and mapping of land use data but also updating and monitoring of information on land use for effective planning and management land for agriculture, Aquaculture, forestry, pasture, industry, settlements etc. The aim of this study is to assess the impact of brackish water aquaculture activities, improper conversion and to suggest measures to preserve and manage the coastal environment in a sustainable manner.

Study Area Description

Nagapattinam Taluk is a coastal region of Tamil Nadu, 326 Km, from south of Chennai, lies between Northern Latitude 10.46"16' and 79.50"50' Eastern Longitude. A District is known for its Rich Religious Heritage and Communal Harmony. Total population is 282784 as per 2011 census and male population is around 139917 and female population is 142867. Number of house hold in this taluk is 70683. The area receives rainfall under the influence of both southwest and northeast monsoon. A good part of the precipitation occurs as during very intensive storms resulting mainly from cyclones generated in the Bay of Bengal especially during the northeast monsoon. The rainfall pattern in the district shows interesting features. Annual precipitation, which is 1500 mm in Vedaranyam, the southeast corner of the Taluk, rapidly decreases to about 1100 mm towards the west of the district [4]. The area enjoys humid and tropical climate with hot summers, significant to mild winters and moderate to heavy rainfall. The temperatures various from 40.6 to 19.3°C with sharp fall in night temperatures during monsoon period. The relative humidity ranges from 70-77% and it is high during the period from during October to November (Figure 1).

***Corresponding author:** Rajesh J, Centre for Remote Sensing, Bharathidasan University, Tiruchirappalli, Tamil Nadu, India, Tel: 9751693758; E-mail: rajeshgeomtech@gmail.com

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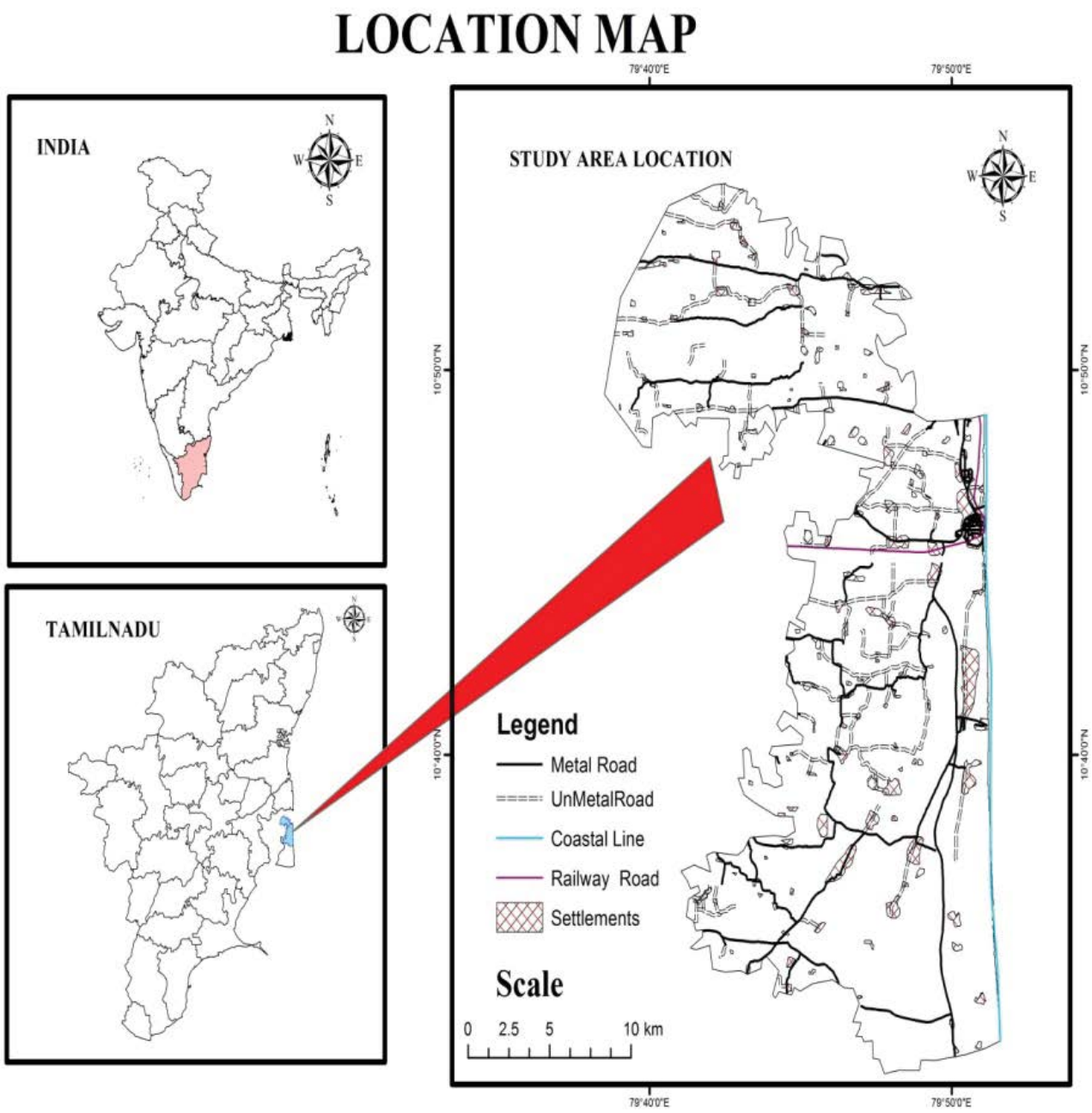

Figure 1: Study area Location map.

Methodology

Land use/ landcover maps were prepared by visual interpretation method using temporal satellite data, and LANDSAT ETM+PAN 1999, LISS IV data for the year, 2007, and LANDSAT OLI 2014. Aquaculture zone maps were prepared using Land sat ETM+PAN 1999, LISS III data for the year, 2007, and LANDSAT OLI 2014. The Satellite data were visually interpreted and coupled with field checks, the maps were finalized. Then the various land use and land cover features were digitized. Include settlement, cropland, fallow land, plantation and sand with salt affected land, water bodies, land with scrub and land without scrub.

Land Use/Land Cover Changes during 1999, 2007, 2014

A broad classification of different types of vegetation and land use patterns was done and 13 different classes were identified (Figures 2-5). The land use features like plantations, water bodies, mud lands, aquaculture, croplands, Fallow Lands, Sand Area, Water Logged Area, Land with Scrub, Land without Scrub, Settlements were identified from the satellite imagery (Tables 1 and 2). The Analysis shows that the aquaculture lands have been increased from 8.31 sq.km in 1999, 14.96 sq.km in 2007, 17.63 sq.km in 2014 (Figure 5). The plantation cover has also Decreased from 23.60 sq.km in 2003, 22.73 sq.km in

Classes	Area in sq.km			Area in (%)			Changes in (%)	
	1999	2007	2014	1999	2007	2014	1999-2007	2007-2014
Crop Land	338.17	324.37	300.91	65.70	59.26	56.45	6.43	2.81
Fallow Land	31.25	36.39	43.91	4.40	4.81	5.74	-0.41	-0.93
Settlements	25.78	36.61	48.46	3.80	5.08	6.72	-1.29	-1.64
Water bodies	17.46	16.72	11.26	2.56	2.55	1.67	0.01	0.88
Land With Scrub	20.90	25.59	39.27	3.28	3.84	5.94	-0.56	-2.09
Land Without Scrub	22.81	28.65	14.40	3.71	4.47	2.31	-0.77	2.16
Aquaculture	8.31	14.96	17.07	1.40	2.45	2.81	-1.04	-0.36
Swampy Land	3.43	6.62	9.94	0.59	1.11	1.68	-0.52	-0.57
Mud Flat Land	2.60	4.94	3.94	0.45	0.84	0.68	-0.39	0.16
Salt Affected Land	4.94	8.22	10.83	0.85	1.40	1.88	-0.55	-0.47
Water Logged Area	14.40	18.27	7.72	2.51	3.17	1.36	-0.65	1.80
Sand Area	1.83	2.53	4.15	0.33	0.45	0.74	-0.13	-0.29
Plantation	23.60	22.74	21.18	4.24	4.09	3.82	0.15	0.27

Table 1: Landuse / Land cover changes during 1999 to 2014.

Features	Area in sq km			Area in (%)			Changes in (%)	
	1999	2007	2014	1999	2007	2014	1999-2007	2007-2014
Aquaculture	8.31	14.96	17.64	1.57	2.83	3.33	-1.26	-0.51
other land use	520.73	514.29	511.40	49.60	49.28	49.15	0.32	0.13
Total	529.04	529.25	529.04	100.00	100.00	100.00	0.00	0.00

Table 2: Aquaculture Distribution Changes during 2003, 2007 and 2014.

2007, and 21.17 sq.km in 2014. The crop lands has been decreased from 338.17 sq km in 2003, 324.37 sq.km in 2007, 300.91 sq.km in 2014. The Swampy land has been increased when compared to 1999 from 3.43 sq.km, 2007- 6.62 sq.km to 9.94 sq.km in 2014. The mud land has been increased from 2.60 sq.km in 1999, compared 4.94 sq.km in 2007, after its decreased 3.93 sq.km in 2014. The water cover has also been reduced when compared from 16.72 sq.km in 1999, 17.46 sq.km in 2007, 11.26 sq.km in 2014, the land left Fallow has also been increased from 1999-31.25 sq.km 2007-36.39 sq.km, 2014 -43.91 sq.km. The settlements cover has been increased when compared to 1999-25.78 sq.km, 2007-36.61 sq.km, and 2014-48.46 sq.km. Sand Area has been increased when compared to 1999-1.83 sq.km, 2007-2.53 sq.km, and 2014- 4.15 sq.km. Land with Scrub has been increased when compared to 1999-20.90 sq.km, 2007-25.59 sq.km, and 2014-39.27 sq.km. Land Without Scrub Decreased from when compared to 1999-22.81 sq.km 2007-28.65 sq.km and 2014- 14.40 sq.km. Water logged area has been Decreased from when compared to 1999 -14.40 sq.km, 2007-18.27 sq.km, and 2014-7.72 sq.km. Salt Affected Land has been increased from when compared to 1999-4.94 sq.km, 2007-8.22 sq.km, and 2014-10.83 sq.km. There was a significant increased in Salt-Affected land areas, plantation, cropland is decreased was due to the construction activity of the land use areas a significant restoration of a major restoration of, a large restoration, a great restoration of, an important scrub forest areas occurred due to human activities (Figure 2).

Aquaculture Distribution during 1999, 2007 and 2014

Aquaculture is a commercial activity that can affect water quality, biodiversity through the introduction of exotic animals, parasites, and diseases, land use, groundwater resources; and economic and social attributes. Effects of aquaculture facilities on natural habitats can be found in conversion of upland and wetland areas to ponds and impoundments, and in the creation of infrastructure required to grow target species [5,6]. The analysis shows that the features like crop lands, Water bodies, and mud land have been decreased when comparing from 1999, 2007, to 2014 (Table 3). A broad distribution of land use patterns included the Aquaculture Ponds were identified. Aquaculture pond covers total area of about 529.04 sq.km and the dominant Land use categories are Aquaculture pond 1999-8.31 sq.km and other land use 520.73 sq.km, 2007-14.96 sq.km and other land use 512.29 sq.km, 2014-17.63 sq.km and others 511.40 sq.km (Figures 6 and 7).

Rainfall and Temperature

The area receives under rainfall under the influence of both southwest and northeast monsoon. A good part of the precipitation occurs during very severe storms resulting mainly from cyclones caused in the Bay of Bengal especially during the northeast monsoon. The Taluk receives rainfall almost throughout the year. Rainfall data (period 1983, 1988, 2002.) shows the normal annual rainfall of the Taluk is 1230 mm. The rainfall pattern in the district shows interesting features. Annual precipitation, which is 1500 mm in Vedaranyam, the southeast corner of the Taluk, rapidly decreases to about 1100 mm towards the west of the district. The area enjoys humid and tropical climate with hot summers, significant to mild winters and moderate to heavy rainfall. The temperatures various from 40.6 to 19.3°C with sharp fall in night temperatures during the monsoon period. The relative humidity ranges from 70/77% and it is high during the period from during October to November (Figure 8).

Groundwater Quality

Ground water quality is a crucial concerned for mankind. Because it is directly associated with human health welfare. The quality of groundwater important to drinking and irrigation purpose. In the coastal region natural process like saline water intrusion, wind-driven sea spray and marine aerosols to degrade the groundwater quality. John [7] has used the geographical information system (GIS) to represent and understand the spatial variation of different geochemical elements in Panvel Basin, Maharashtra, India.

Ground water quality parameters were studied and level of contamination due to Industry, saltpan, sea water intrusion, agriculture, brackish water aquaculture and municipal sewage water on the east coast. Over the period of 1998, 2003 and 2007, groundwater data were collected from ground water department, PWD, Chennai and prepared the spatial distribution of water quality index map using Geographical information system (GIS) (Tables 4-6; Figures 9-12).

Electrical conductivity

Electrical conductivity (EC) is the most important parameter in determining the suitability of water for drinking water and irrigation

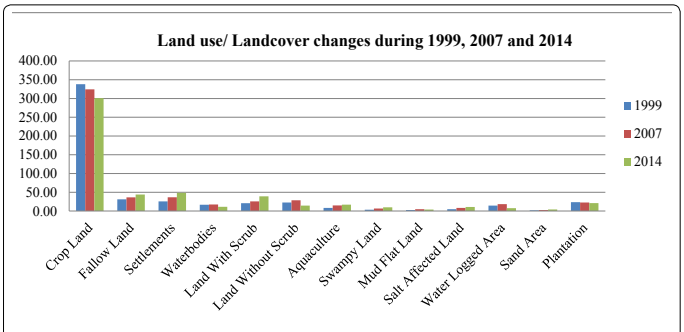

Figure 2: Landuse/Land Cover changes during (1999, 2007 and 2014).

		Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
Rainfall	1983	-	-	-	-	63.6	71.2	124	111.4	155.4	99.8	141.6	1016
Temperature	1983	25.819	27.899	29.2	30.8	32.27	32.11	31.211	30.1	29.36	28.96	27.189	25.86
Rainfall	1988	-	-	-	71.8	-	18.8	179.4	79.8	20.8	85.2	420.6	53
Temperature	1988	24.512	26.177	29.065	30.465	33.365	32.665	30.311	29.312	28.912	28.524	25.023	24.635
Rainfall	2002	56.4	266	-	-	48.6	54	68.4	15.4	116	208.6	384	112.6
Temperature	2002	25.4	25.5	28.465	30.953	33.453	31.912	32.012	30.288	30.576	27.912	25.623	24.523

Table 3: Distribution of Rainfall and Temperature (1983, 1988, 2002).

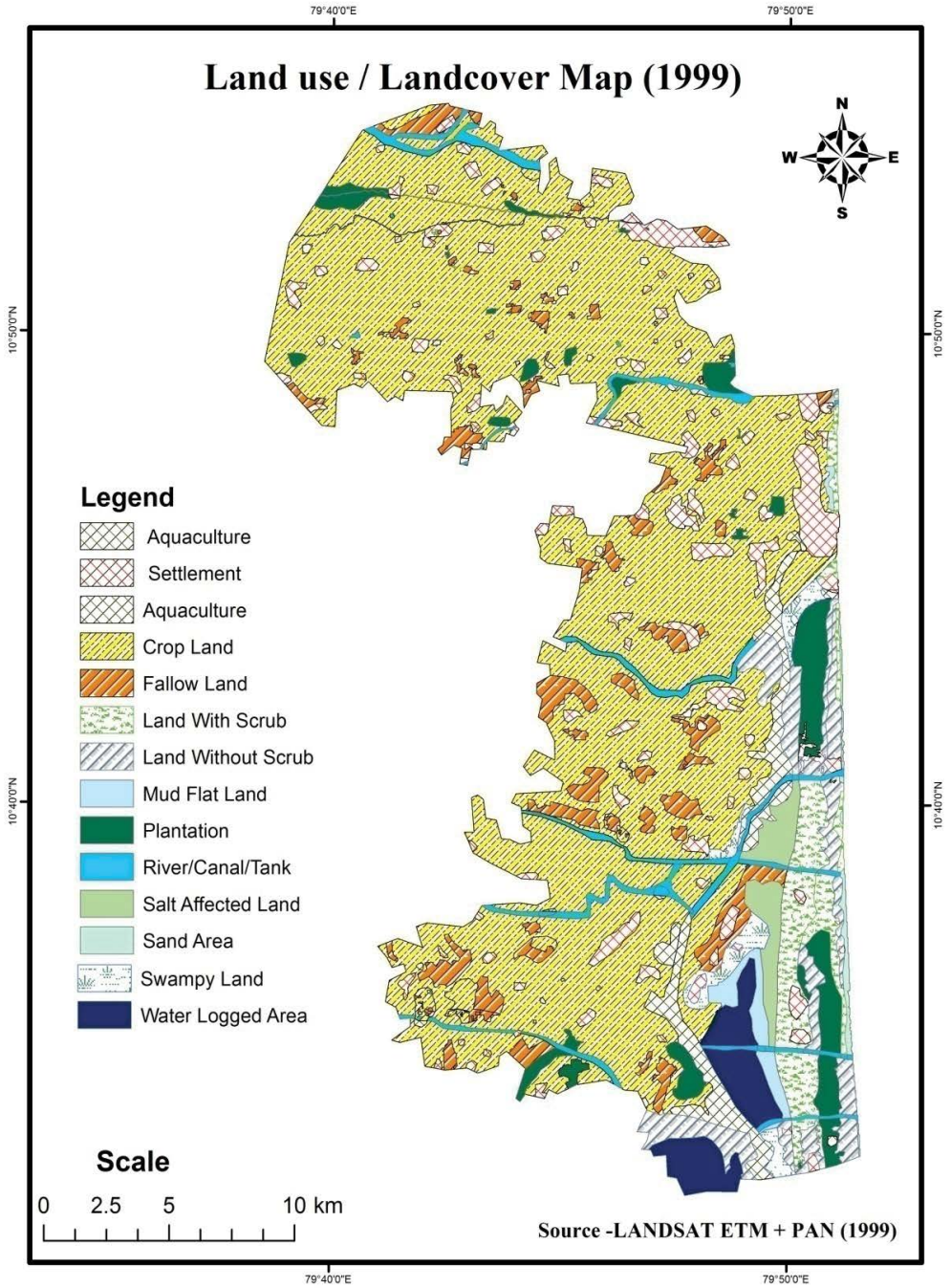

Figure 3: Landuse/Landcover changes during 1999.

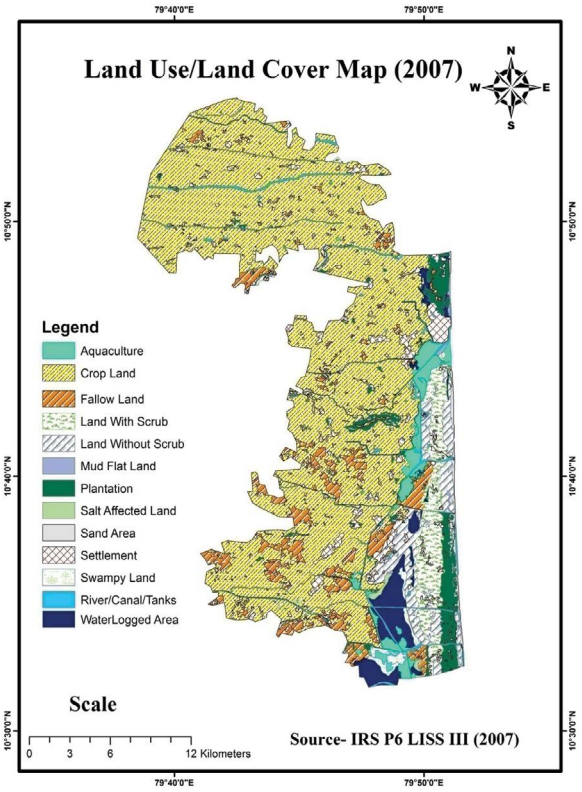

Figure 4: Landuse/Landcover changes during 2007.

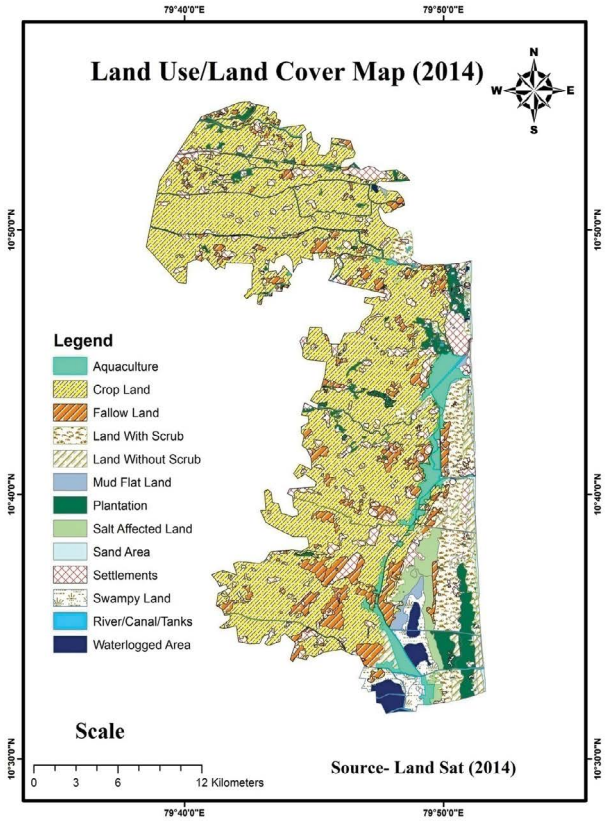

Figure 5: Landuse/Landcover changes during 2014.

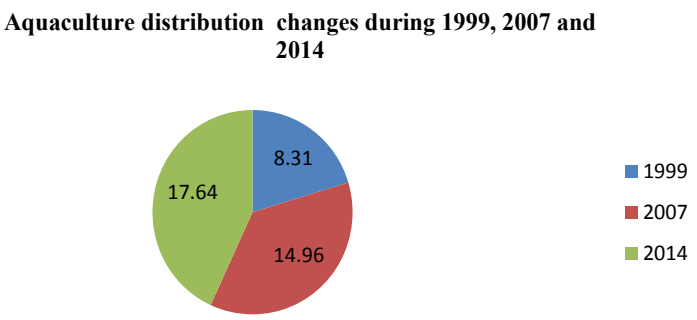

Figure 6: Aquaculture Status during (1999, 2007, 2014).

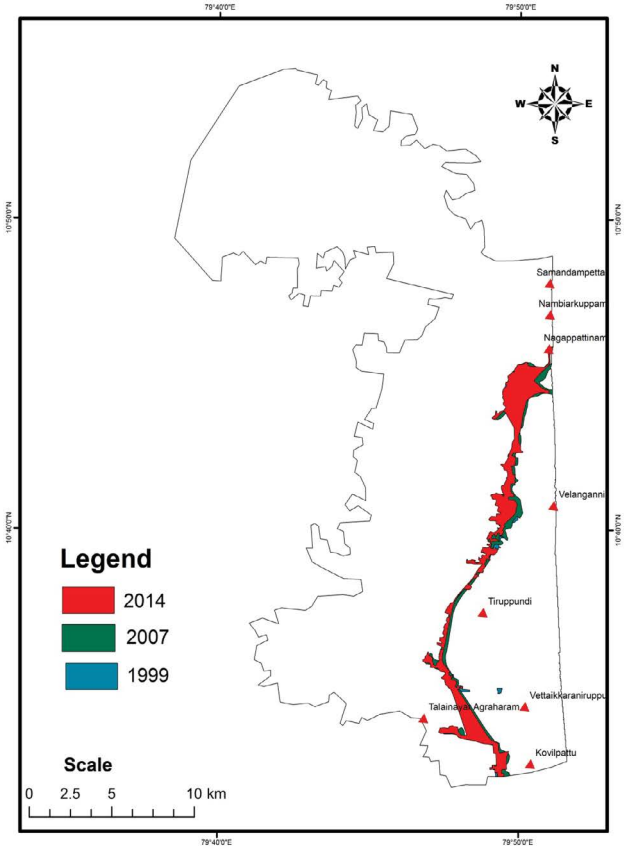

Figure 7: Aquaculture pond distribution during 1999, 2007 and 2014.

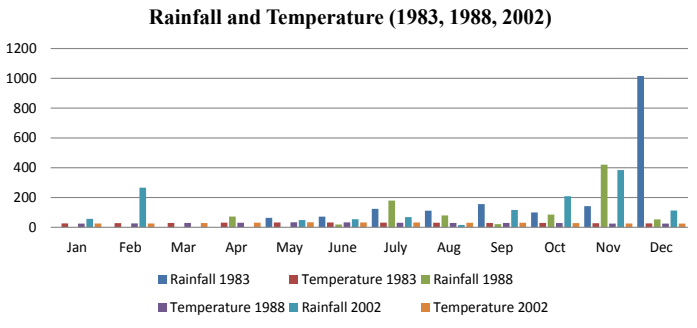

Figure 8: Distribution of Rainfall and Temperature.

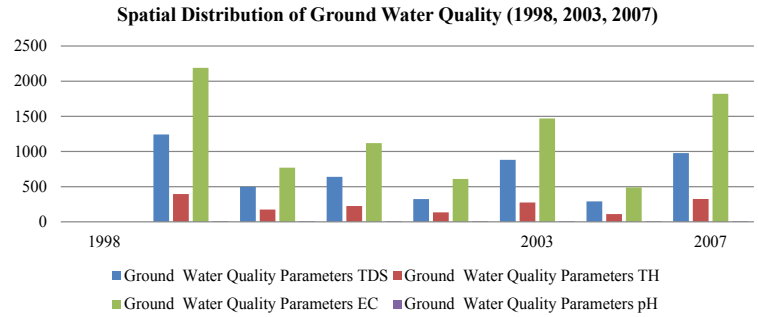

Figure 9: Spatial Distribution of Ground Water Quality (1998, 2003, 2007).

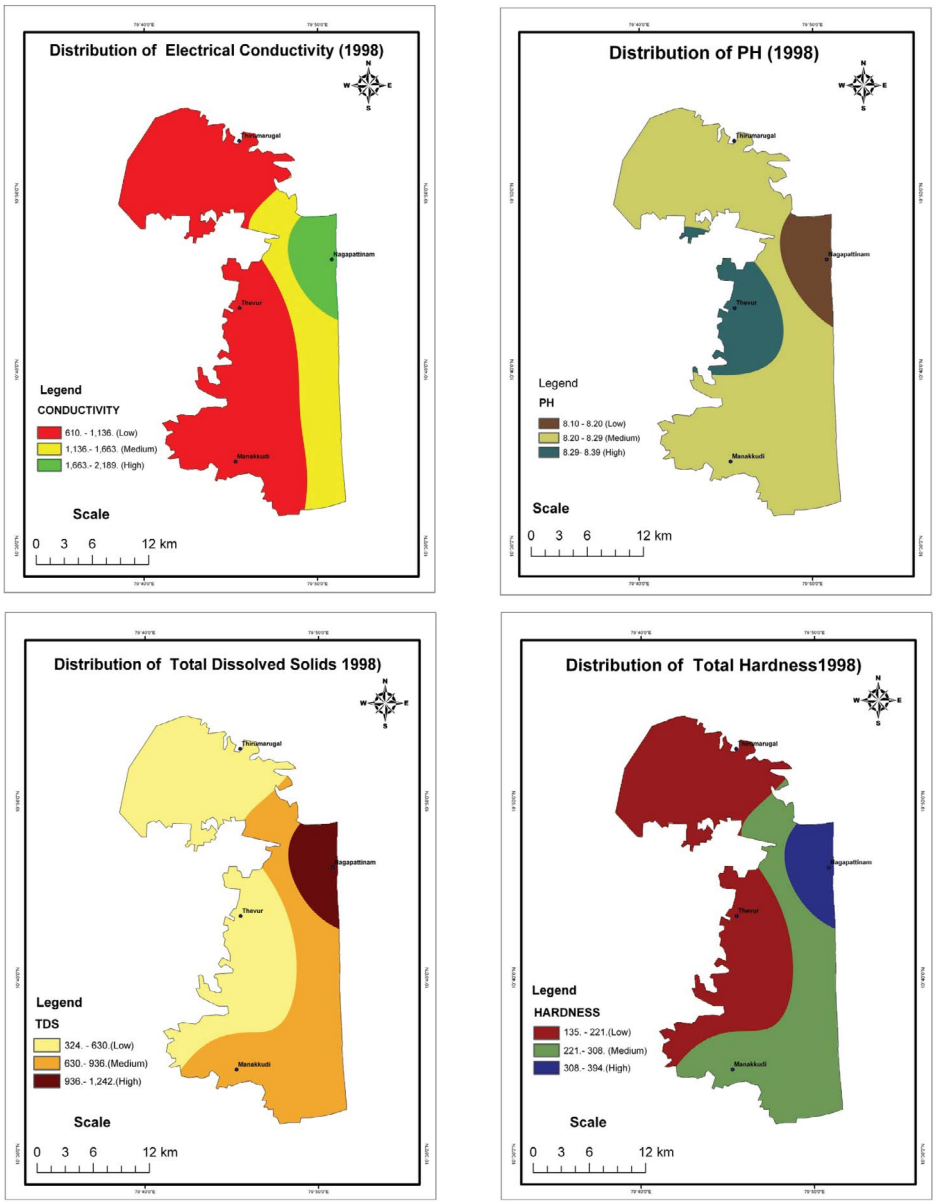

Figure 10: Spatial distribution of (1998) EC, pH, TDS, TH.

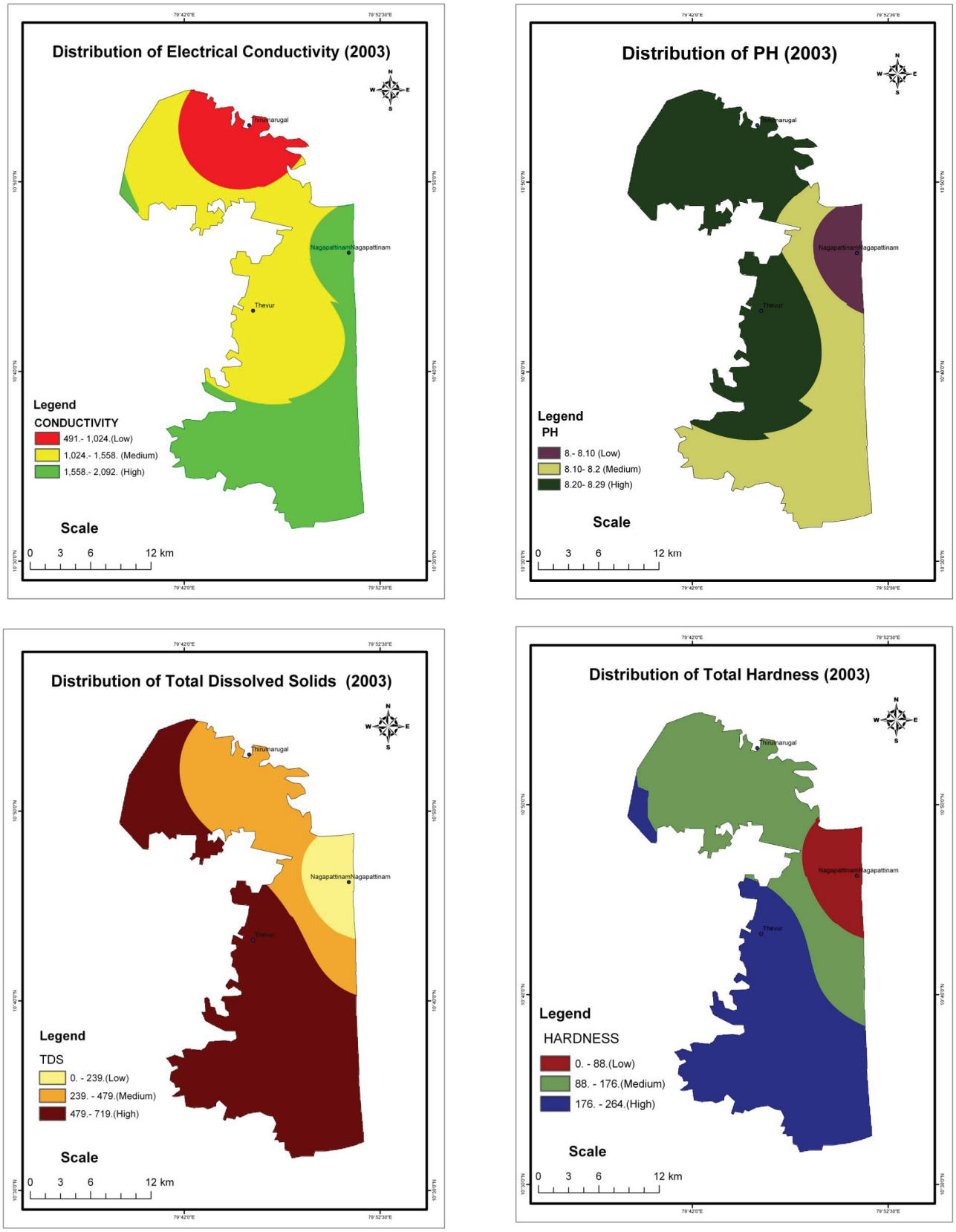

Figure 11: Spatial distribution of (2003) EC, pH, TDS, TH.

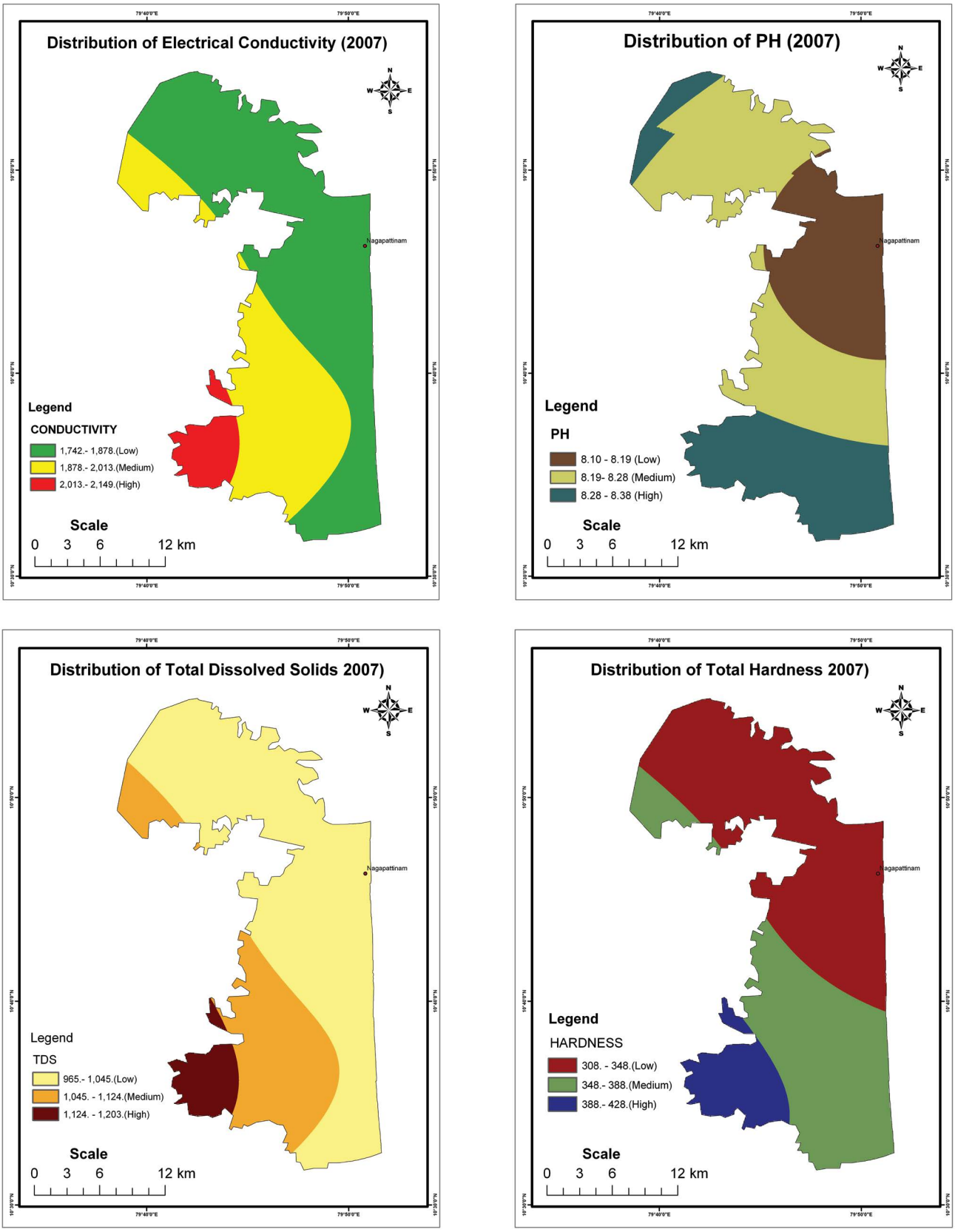

Figure 12: Spatial distribution of EC, PH, TDS, TH (2007).

S No	Parameters	Standard Values (s_n)	Recommended Agency	Unit Weight
1	P^H	6.5-8.5	ICMR/ BIS	0.2190
2	EC	300	ICMR	0.371
3	Total dissolved Solids	500	ICMR/ BIS	0.0037
4	Total Alkalinity	120	ICMR	0.0155
5	Total Hardness	300	ICMR/ BIS	0.0062
6	Total suspended soils	500	WHO	0.0037
7	Calcium	75	ICMR/ BIS	0.025
8	Magnesium	30	ICMR/ BIS	0.061
9	Chloride	250	ICMR	0.0074
10	Nitrate	45	ICMR/ BIS	0.0412
11	Sulphate	150	ICMR/ BIS	0.01236
12	Dissolved Oxygen	5.00	ICMR/ BIS	0.3723
13	Biological oxygen demand	5.00	ICMR	0.3723

Table 4: Drinking Water standards recommending Agencies and Unit weights (All value except pH and Electrical Conductivity are in mg/L).

	Water Quality Status
0-25	Excellent Water quality
26-50	Good Water quality
51-75	Poor Water quality
76-100	Very Poor Water quality
>100	Unsuitable for drinking

Table 5: Water quality Index (WQI) and status of water quality.

Location	Year	Ground Water Quality Parameters			
		TDS (Mg/L)	TH (Mg/L)	EC (µS/cm)	pH
Nagapattinam	1998	1243	395	2190	8.1
Tirumarugal		498	175	770	8.3
Manakudi		640	225	1120	8.2
Thevur		324	135	610	8.4
Nagapattinam	2003	882	275	1470	8.2
Tirumarugal		291	110	490	8.3
Nagapattinam	2007	977	325	1820	8.1

Table 6: Ground Water Quality Parameters.

use. EC in water is due to ionization of dissolved inorganic solids and becomes a measure of total dissolved solids. It is used as a primary index to select the suitability of water for all purposes [8-10]. In this area EC values in ground water ranged from minimum 360 µS/cm to maximum 7200 µS/cm. The EC reached 490 to 7130 µS/cm in the year of 1998 and 2007 respectively. The higher value of EC from (2004) Tirumarugal suggests the enrichment of salt due to evaporation effect. Like pH, EC is also higher Nagapattinam, Tirumarugal, because of additional leaching from sand dunes, municipal wastes and intense agricultural activities compared to other areas [11,12].

pH

The pH of 90% of the water sample was within the desirable limit of 6.5-8.5 given by WHO/BIS standard and most of the samples were slightly alkaline in nature. In this study pH of water samples from Nagapattinam Taluk varied from 7.2 to 8.6. Over a period of 10 years, the Groundwater data were used for spatial distribution the pH was classified in three classes such as low (<6.5), medium (6.5-8.5) and high (>8.5). Nagapattinam areas are coming under high pH (>8.6). An increase of pH in the post-monsoon suggests that dissolution has been enhanced due to high interaction between soil and rainwater [13,14].

Total dissolved solids (TDS)

TDS is mostly due to dissolve ionic matter and bear a relationship with the electrical conductivity of water. The acceptable value of TDS in groundwater 500 mg/L. In the present study, TDS values varied between 291 and 4375 mg/l indicating excess input of ionic matter into groundwater samples, even though local geological settings (Saltpan, Aquaculture and sea water interruption), soil characteristics, and even lithology of the study area may also be contributed to total dissolved solids content in groundwater. In general, TDS increased from rainy to winter and summer seasons. There was a sudden rise in the TDS value (>4375 mg/l) at Tirumarugal, which receive the sewage directly. The domestic sewage which had very high TDS made the water more contamination particularly during summer and winter seasons [15].

Total hardness

Total Hardness is due to the presence of divalent metallic cations like calcium, magnesium, strontium, ferrous and manganese ions. Hardness is determined as $CaCO_3$ mg /l. Mainly Total Hardness due to Calcium, Magnesium, Iron and strontium concentration in water. Though hardness is not harmful to health, but suspected for chances of heart disease. In the study area the total hardness values ranging from minimum of 135 mg/l and the maximum of 590 mg/l. The value of total hardness in Nagapattinam, Thevur, Tirumarugal, Manakudi were above the tolerance limit for drinking water and irrigation purpose during the year 1998-1999, 2001-2004 and 2005-2007. In the year of 1998, all the area showed within the permissible range [16]. There was a sudden rise in the Total Hardness value (>590 mg/l) at Tirumarugal.

Conclusion

The result of Land use/ landcover and Aquaculture area changes clearly revealed in the trend of Land use and Land cover in Nagapattinam Taluk. It also shows that the cropland areas decreasing when compared to 1999, 2007 and 2014 and in the reverse the barren land areas are increasing which is not a good sign. It also gives us a view on the water bodies that has been decreased when compare with 1999, 2007, and 2014 maps. Thus the study has exposed the satellite data the unique capability to detect the changes in Landuse and land covers mostly accurate. Land use changes such as Mudflat areas and brackish water Creek entirely converted to as aquaculture ponds, swampy land and Salt Affected areas. With this data this has been found that the Agriculture lands are decreasing at the cost of haphazard to assessment growth of during 2014 Aquaculture activity found increased when compared to 1999 and 2007 during the past. These will affect the ground water quality, land and soil quality of the coastal areas.

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