

Study on impact of land use and land cover change on ground water quality

Mohamed Shanavaz¹, Akbar Basha² and
Dr. N.Ramesh³

^{1,2} Assistant Professor, Department of Civil engineering, B.S.Abdur Rahman university
Vandalur, Chennai, Tamil Nadu - 600048, India

³ Environmental Engineer, Department of Science and Technology & Environment,
Government of Puducherry, Puducherry - 605 001.

Abstract

This study shows the land use and land cover change (LU/LC) of the Puducherry district from 1993 to 2008. The landsat TM (1993) and landsat 8 (2008) satellite imagery was utilized for change detection and urban sprawl. The spatial analysis and distribution of ground water quality was assessed for the period of 1993 and 2008. The results discuss the cause of changes in the ground water quality and salt intrusion in the coastal aquifers.

Keywords: LU/LC change, ground water quality, change detection, urbanization

1. Introduction

Change detection is very generic concept which applies in medical imaging, forest or vegetation inspection, flood monitoring and predominantly for land use and land cover analysis [1]

LU/LC is a phenomenon occurring in this world because of urbanization and anthropogenic invasions. The land cover change indicates the land surface cover changes in and around the urban areas which replaces the vegetation cover. Whereas, Land use change refers to the change occurring due to human made constructions, urbanization, irrigation, real estate and other actions[2].

Urban sprawl is an important problem in developing countries like China and India. The impact of urban sprawl on environment is innumerable such as carbon di-oxide emissions, air pollution, surface water quality and ground water quality deterioration. Urban

sprawl has created a threat on natural resources and environment[3].

The expansion of city creates a significant change in underground water quality due to huge exploitation of ground water. The change in LU/LC has a significant contribution in ground water contamination.

Remote sensing technology helps in identifying the changes occurred within the region by comparing the satellite imagery. Spatial interpolation and spatial variation maps produced using Geographic Information Systems (GIS) provide a graphic view on the water quality variation along the coastal region of puducherry district[4].

The LU/LC cover change and assessment of its impact on ground water quality provides a significant indications of the trend of ground water quality deterioration and salt water intrusion along coastal region of Puducherry district.

Puducherry is located between 11°46' and 12°30' of northern latitude and between 79°36' and 79°53' of eastern longitude. Pondicherry is situated between Marakkanam and cuddalore. Pondicherry Union territory consists of four districts namely Pondicherry (PO), Karaikal (KA), Mahe (MA) and Yanam (YA).

2. Methodology

2.1 Study Area

Puducherry district (PO) is taken as the study area along the coastal region with fifteen locations for

water sampling through bore holes. The study area and site locations also include Tamil Nadu regions extending approximately 18 kilometers on both the sides of Pondicherry town.

2.2 Data Source

Sequential images captured from a region may be used to detect changes [1]. The Landsat Thematic Mapper (TM) of 1993 and Landsat 8 imagery of 2008 was utilized to measure the changes occurred in fifteen years. The reason to consider these two dated satellite imagery for analysis is to compare the water samples from bore holes obtained from fourteen sites during 1993 and in the year 2008.

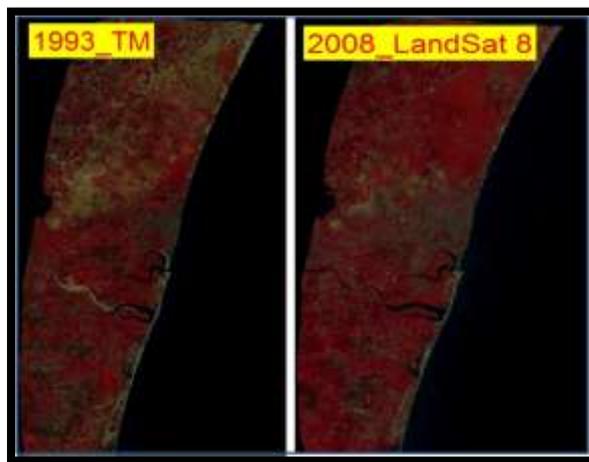


Figure 2.1 LandSat TM and LandsatS 8 imagery.

2.3 Supervised Classification

The region of interest was classified into six classes such as Urban area, Ocean, River, vegetation cover, Barren land and miscellaneous (No data).

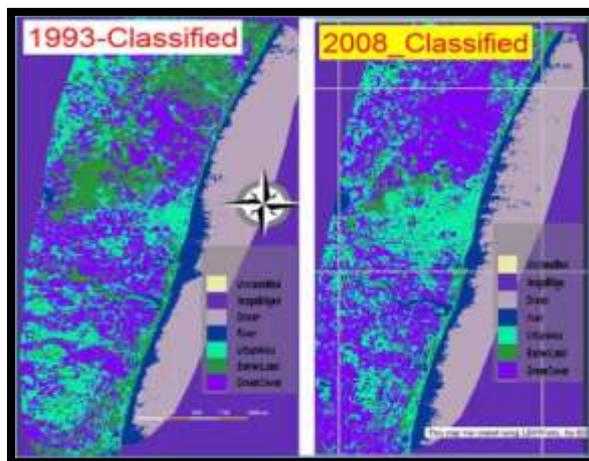


Figure 2.2 Classified map of ROI

2.4 Land use / Land Cover change

The classified map of 1993 and 2008 provides the statistics of changes occurred in terms of area square Kilometers. The area covered by Vegetation and trees, Barren land and urban area are extracted to assess the impact of LU/LC change on ground water quality.

S. No	Classified Land	1993TM (in Sq.Km)	2008 (in Sq.Km)
1	Urban Area	100.864	107.942
2	Vegetation Cover	113.713	175.645
3	Barren Land	79.010	25.207

Table2.1 Classified Area and statistics

The above classification indicates the changes in urban area. The significant and interesting fact was that the Vegetation cover has increased and Barren land area has reduced as cultivation has happened in over a period of fifteen years. The landsat imagery by visual interpretation illustrates the same phenomenon derived through statistics using ArcGIS software.

2.4 Ground water quality distribution map

The water sampling from bore holes were collected from fifteen stations in 1993 and 2008. The tabulation below shows the concentration of Chloride, Alkalinity, Total Dissolves Solids (TDS) and salt intrusion (SI) are observed from lab titrations.

S.NO	LOCATION	TDS	ALKALINITY (ppm)	CHLORIDE (ppm)	SALT INTRUSION
1	Kanagachettikulam	291	46.67	35	0.75
2	Periya Kalapet	336	40.67	58	1.43
3	Periya Mudaliyarcha	837	50	31	0.62
4	Kottakuppam	610	83.33	244.33	2.93
5	Kuruchikuppam	714	209	244	1.17
6	Pondicherry town	446	163.33	134.7	0.82
7	Thengaithitu	598	200	151	0.76
8	Veerampattinam	640	243.33	134.67	0.55
9	Andiarpalayam	617	203.33	123.67	0.61
10	Pannithittu	1410	173.33	512.33	2.96
11	Eachankadu	1535	186.67	607.33	3.25
12	Kirumampakkam	2559	193.33	1514.67	7.83
13	Pillayarkuppam	1755	165	987.56	5.99
14	Manapet	2559	193.33	335.67	1.74
15	Pudukuppam	1240	213.33	451.67	2.12

Table 2.1 Ground water quality in 1993

S.NO	LOCATION	TDS	ALKALINITY (ppm)	CHLORIDE (ppm)	SALT INTRUSION
1	Kanagachettikulam	494	78.84	110.7	1.40
2	Periya Kalapet	230	39.42	67.7	1.72
3	Periya Mudaliyarcha	385	87.6	90.5	1.03
4	Kottakuppam	977	48.18	284.44	5.90
5	Kuruchikuppam	800	151.4	335.9	2.22
6	Pondicherry town	1120	481	373	0.78
7	Thengaithitu	596	274	224	0.82
8	Veerampattinam	472	185.6	86.21	0.46
9	Andiarpalayam	1069	365.1	241.4	0.66
10	Pannithitu	401	161.3	61.7	0.38
11	Eachankadu	748	168.9	199.7	1.18
12	Kirumampakkam	336	163.2	60.8	0.37
13	Pillayarkuppam	1242	263	443.8	1.69
14	Manapet	920	178.6	211.5	1.18
15	Pudukuppam	597	124.8	158.8	1.27

Table 2.2 Ground water quality in 2008

2.5 Spatial distribution using GIS

The Chloride, Total dissolved solids, Alkalinity and salt intrusion concentration were interpolated to create a surface for visual interpretation and for analysing the cause and effect relationship because of LU/LC change.

3. Results and Discussion

3.1 LU/LC change

The LU/LC change analysis shown from the satellite remote sensing and image processing analysis shows the following changes occurred between 1993 and 2008.

1. The barren land area has surprisingly reduced from nearly 80 Sq.Km to 25 Sq.Km. The barren land has been converted to Green cover with vegetation and trees. This is evident from ground validation from Auroville region. The Auroville region was Barren land during 1990's and now it has been renowned to be man made forest.
2. Urbanization has happened which has expanded from nearly 101 Sq.Km area to 107 Sq.Km.
3. Green surface cover because of vegetation and tree cover has increased from 133 Sq.Km to 178 Sq.Km. The variation and increase in green cover is due to transformation of land in Auroville. This is quite evident and visually interpreted from Landsat 1993 and Landsat 8 imagery.

3.2 Ground water quality mapping

From Total alkalinity map, The alkalinity is within the permissible limits of 600mg/L as Calcium Carbonate but the variation in concentration level has increased from 1993 to 2008. The total alkalinity is increasing from Thengaithittu, Veerampattinam and Andiarpalayam from the year 1993 towards North and North-East along Kuruchikuppam.

From the chloride concentration spatial distribution map. In 1993, Pillayarkuppam and Kirumampakkam sites exceeded the permissible limit of chloride of 100mg/L. This was due to industrialization at the outskirts of the city. The measures were taken by the government to reduce the chloride concentration level by shutting down the chemical industries. The 2003 map shows that the two places from nearly 1300 mg/l reduced to 100 mg/L.

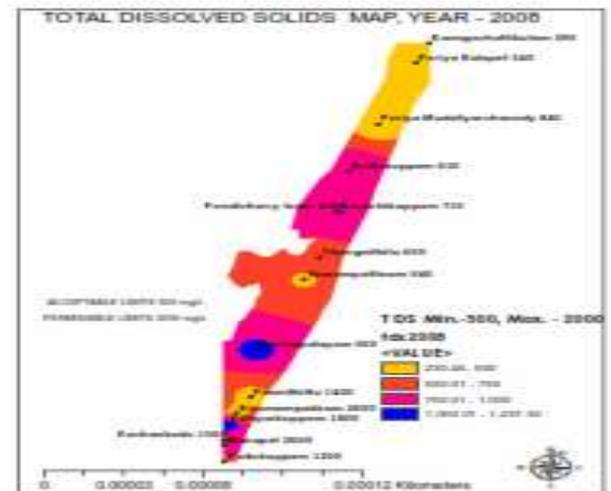
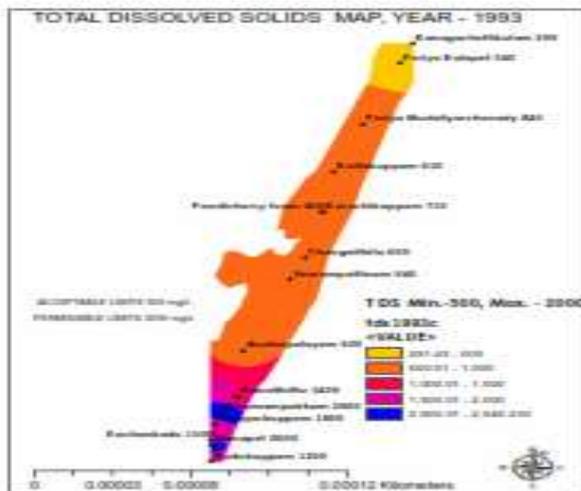
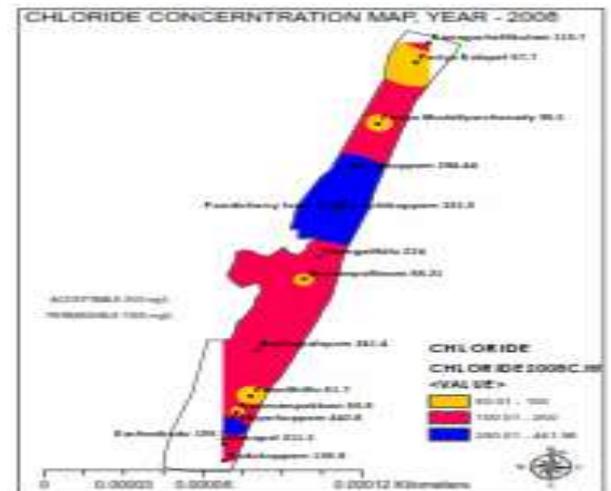
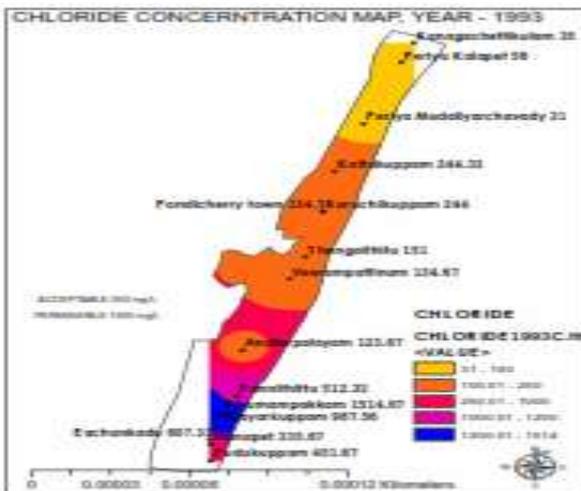
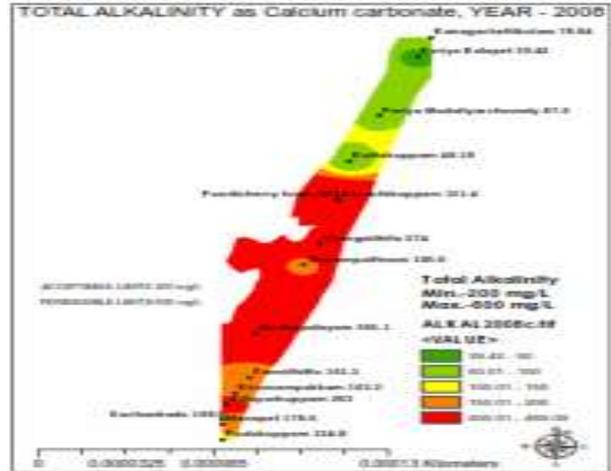
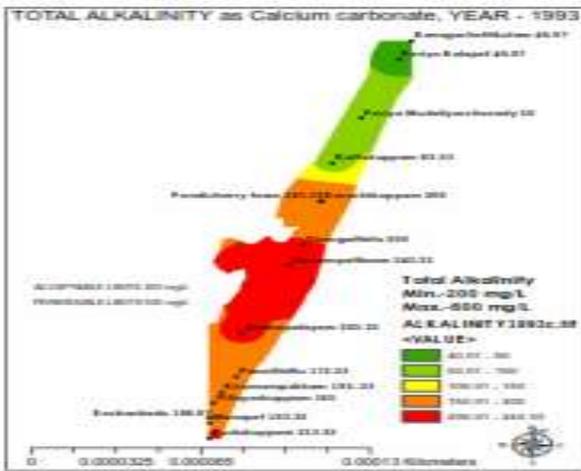
From Total Dissolved Solids (TDS) maps. Kirumampakkam and manapet exceeded the permissible limits of TDS, which is 2000mg/L. The remedial measures has given response in reduction in concentration levels of TDS in this two regions to fall below 2000 mg/L.

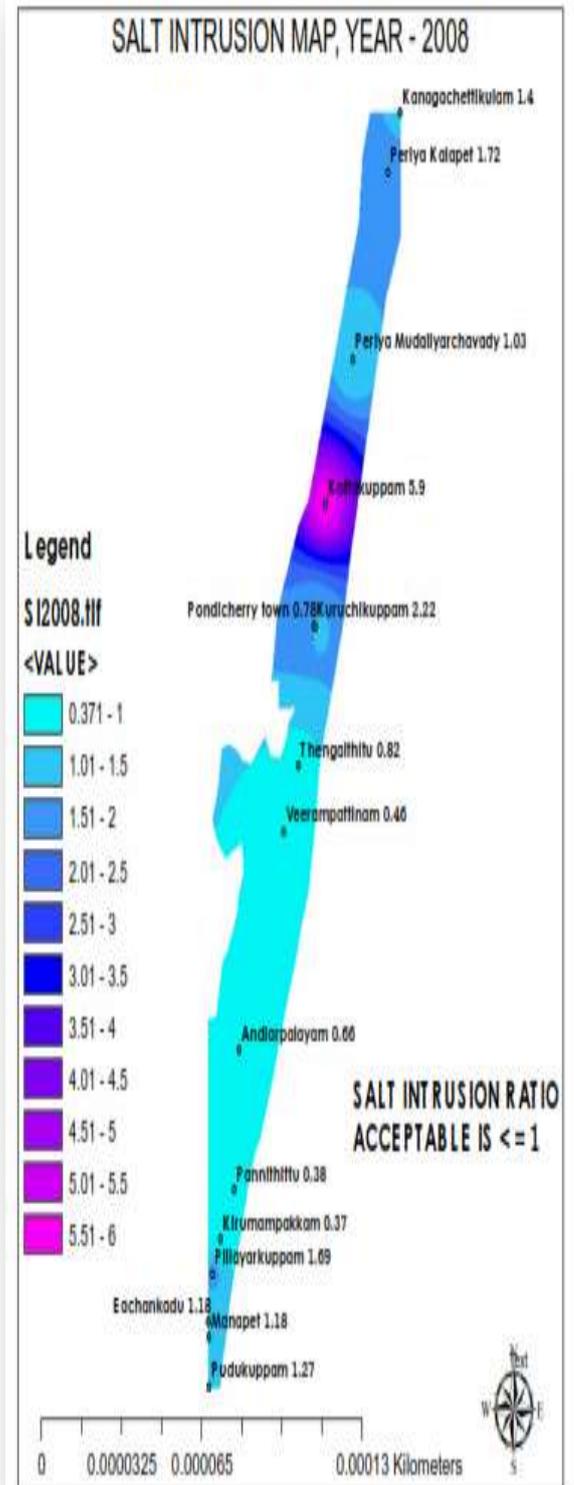
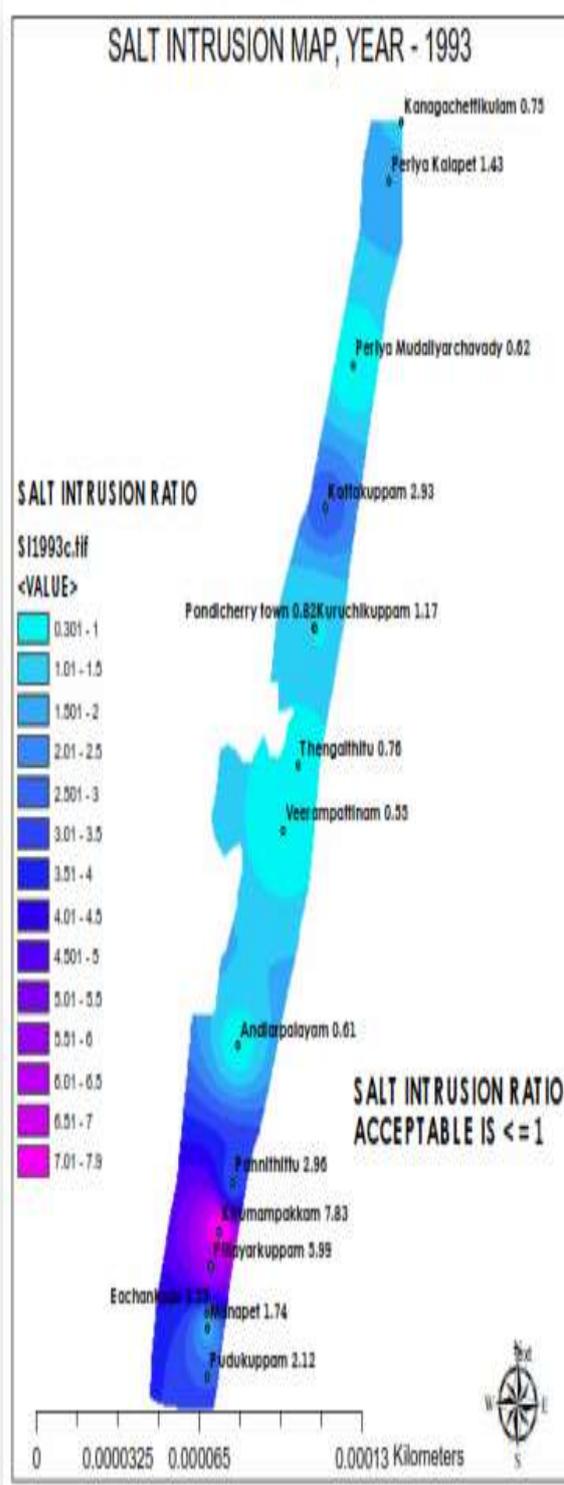
3.3 Salt intrusion map

Salt water intrusion is the process where sea water enters the coastal aquifers [6]. Due to huge exploitation of ground water from aquifers, The salt water intrusion takes place where more volume and rapid exploitation occurs. This study shows that the locations like Kirumampakkam and Pillayarkuppam had alarming signals of salt water intruding in the empty space of aquifers in 1993. The regulations paved a way to decrease the salt intrusion in those regions later in 2008.

6. Conclusions

The study on the impact of change in LU/LC on ground water quality was analyzed. The ground verification and analysis suggests that there is a significant impact on the ground water quality. Integrating remote sensing satellite imagery, Geographic Information systems (GIS) and field data (ground water sampling) suggests that further quantitative analysis has to be done on identifying the impacts of LU/LC change on Temperature, water quality, air quality, thermal comfort and Human health.





Acknowledgments

The contribution and support of Department of science and technology (DST) and pollution control board of Puducherry is appreciable. The free availability of Landsat legacy of National Aeronautics and Space Administration (NASA) satellite imagery is a boon for researchers without which miniscale research projects could not occur. The classification was done with Leo Works, ESA.

References

- [1] Murat ilsever, Cem Unsalan, 2012 : Two dimensional change detection methods, Remote sensing applications, Springer, ISSN 2191 - 5768. Page No. 2 (2012).
- [2] Mausel, Lu,D., Brondizio, Moran, E. 2004 : Change detection techniques, International journal of remote sensing, 25 (12), 2365 -2401.
- [3] Sudhira.H.S, Ramachandra.T.V, Jagadish.K.S, 2004 : Urban sprawl : metrics, dynamics and modelling using GIS, International journal of applied earth observation and Geo Information 5, 29-39.
- [4] Weng.Q.A. A remote sensing GIS evaluation of urban expansion and its impact on surface temperature in the Zhujiang Delta, China. International Journal of remote sensing 2001; 22: 1999 - 2014.
- [5] Bureau of Indian standards. 2012 : Indian standard - Drinking water specifications.
- [6] Pilgrim.L, Geo.P, 2015 : Salt water intrusion in coastal aquifers, Amec Foster wheeler Frederiction, NB.