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Environmental Impact Assessment of Thamirabarani River Basin, Tamil Nadu using Remote Sensing and GIS Techniques

P. Mohana[1*], K. Nagamani[1], S. Muthusamy[2] and P. M. Velmurugan[3]

[1]Centre for Remote Sensing, Sathyabama Institute of Science and Technology, Chennai - 600119, Tamil Nadu, India; mohanaperumal@yahoo.com, nagamaniloganathan@gmail.com
[2]V. O. Chidambaram College, Tuticorin - 628008, Tamil Nadu, India; muthusamy.geo@gmail.com
[3]Centre for Earth and Atmospheric Sciences, Sathyabama Institute of Science and Technology, Chennai - 600119, Tamil Nadu, India; velapmv@gmail.com,

Abstract

Objective: To assess the landuse and landcover along with rainfall, to monitor the changes in waste and degraded lands, and to assess the water quality parameters mainly on TDS and Chloride and its impact in environ and to take the necessary action. **Methods/Statistical Analysis:** Land use/Land cover map, geology, geomorphology, drainage and waste lands maps were prepared using IRS P6 satellite Imagery. Rainfall details of 30 years were collected in the meteorological department and water quality samples were collected in control wells for pre monsoon and post monsoon season and using interpolation technique and overlay analysis, assessed the water quality and landcover changes. **Findings:** Using this analysis, the study clearly indicates that wasteland extent is increasing year by year due to the various water quality and rainfall changes. Micro level planning of water source and quality will increase the good environment. And identified the favorable sited for augment ground and surface waters bodies. **Applications/Improvements:** Suggestion to convert the wasteland into productive lands and sustainable developmental activity like construction of check dams, rehabilitation of tanks & canals, rainwater harvesting structures, and waste water recycling.

Keywords: Environmental Impacts, Remote Sensing, Water Quality, Waste Land, GIS

1. Introduction

During the urbanization process, most of the natural features are getting modified; mainly the green-covers are replaced by impervious surfaces like buildings, pavements and roads etc[1,2]. These in turn reduce the available green-cover services, namely air quality amelioration, micro-climate amelioration and the hydrological process regulation, which degrade the air quality, water quality and micro-climate. It ultimately affects the "environmental characteristics", i.e. ability to keep up the health and wealth of the people. . Information on land use and land cover is required in many aspects in land use planning and development, as a prerequisite for monitoring changes in environmental due to water quality[3].

To improve the status of the environ, water quality study is must because in this study area "Tamirabarani River Basin" 55% of the total geographical area is covered by waste lands. So, Detection of land use changes, by using modern remote sensing techniques[4,5] and water quality variations are helpful in environmental impact assessment.

1.1 Tamirabarani Basin – Description

The Tamirabarani river basin is one of the 17 river basins of Tamil Nadu and located in Tirunelveli and Thoothukudi districts. It is a perennial source of water supply for irrigation, drinking purposes and power generation. The irrigation system of this basin is centuries old and well developed with its own ayacut system.

**Author for correspondence*

Tamiraparaniriver originates from Agastiyarmalai on the Western Ghats, at an altitude of about 2000 m, with its number of tributaries (ie) Servalar, Manimuthar, Gatananadhi, Pachaiyar and Chittar forming a well defined, compact drainage basin and flows towards north-east initially and towards east in the middle and at the end confluences with Bay of Bengal near Pazhaya Kaayal[6].

This basin area has varied climatic conditions influenced by Southwest and Northeast monsoons. The sand carried by the river contains copper and hence the name 'Tamiraparani' which in Tamil means bearer of copper.

1.2 Administrative Boundary

The geographical area of the basin is about 5665 sq. km which lies in the revenue districts of Tirunelveli and Thoothukudi in Southern Tamil Nadu. The total extent of the basin area is covered within the administrative boundaries of Sankarankoil, Tenkasi, Shenkottai, Ambasamudram, Tirunelveli and Nanguneritaluks of Tirunelveli district and Kovilpatti, Thoothukudi, Srivaikundam and Tiruchendur taluks of Thoothukudi district as shown in Figure 1.

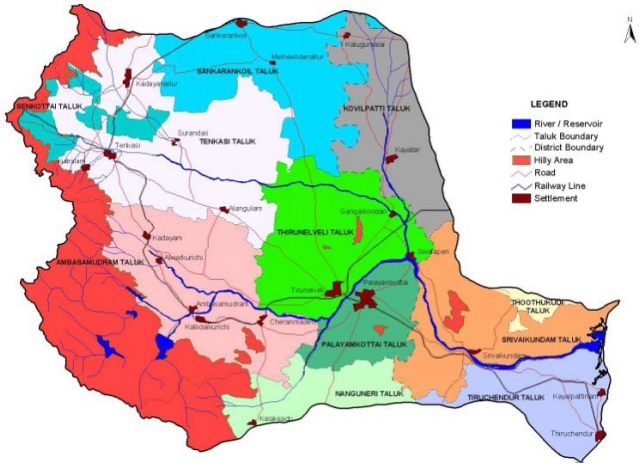

Figure 1. Administrative boundary of Thamirabarani River Basin.

The basin area is bounded on the north by Vaippar river basin and on the south by Nambiyar river basin. The ridge of the Western Ghats viz., Kerala - Tamil Nadu border forms the western boundary of the basin while the Gulf of Mannar forms the Eastern boundary of the basin. The length of basin is about 120 km and its width varies from 20 to 85 km. Tirunelveli and Palayamkottai, the major urban centers are located almost at the center of the basin. Shenkottai, Tenkasi, Thoothukudi, Kovilpatti, Kad ayam, Ambasamudrum, Cheranmadevi, Srivaikundam and Tiruchendur are the other important urban centers in the river basin.The average annual rainfall varies in the basin from 639 mm (Cheranmadevi) to 1200 mm (Sivas ailam) in Ambasamudram taluk of Tirunelveli district[6].

2. Methodology

2.1 Data Collection, Base Map and Various Thematic Maps Preparation

The available Survey of India Toposheets of scale 1:50,000 will be used for base map preparation. Satellite image mosaic map was prepared by digital image processing techniques using ERDAS imagine software. Two full scenes of LISS IV (January and August 2014) IRS-P6 data were used for generating satellite mosaic of the basin. Based on this, different thematic layers like drainage map, geomorphology map, geology map, land use and land cover map, slope map, soil map, waste land map have been generated by visual and computer interpretations.

Rainfall and water quality data were collected from IMD and through field collection were interpreted in the GIS environment and prepared the various thematic layers like TDS, chloride and ground water maps.

2.2 GIS Analysis

After the preparation of various thematic layers in ARC GIS software and required overlay analysis were carried out toidentify the various areas where we have to take necessary steps to reclaim the good environ and suggest the various developmental plans[7].

2.3 Drainage Map

Tamiraparani is a perennial river which flows through Tirunelveli and Thoothukudi districts. This basin consists of hills and ridges in the western part, undulating lands and gently sloping lands in the middle part and plains and sand dunes in the eastern coast. Tamiraparani River traverses about 120 km through 2 districts as shown in Figure 2. Its tributaries in the Ghats are Peyar, Vellar, Karaiyar and Pambar. The main tributaries are Servalar, Manimuthar, Gatananadhi, Pachaiyar and Chittar. Chittar has large drainage area. Gundar, Karuppanadhi, Hanumanadhi and Uppodai are the tributaries of Chittar. Ramanadhi is a trib-

utary of Gatananadhi. There are 7 sub basins. 9 reservoirs have been formed in the basin and the total water spread area is 48,769 ha. 880 system tanks and 613 non system tanks are available in the basin for irrigation.

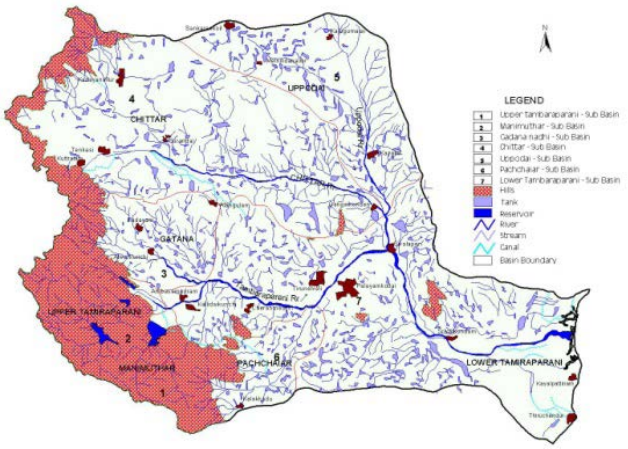

Figure 2. Drainage map of the study area.

2.4 Geology Map

Geology of Tamirabarani basin comprises of crystalline rocks of Archaean age on the western portion and sedimentary formation of Tertiary and Quaternary ages on the eastern coastal area. Nearly 90% of the basin area is covered by the crystalline rocks such as metamorphosed rocks (gneisses and charnockites). A sedimentary formation of Tertiary age consists of calcareous tufa sandstones and shell limestones. Quaternary formations are laterite, kankar, shell limestone, alluvium, theri sands and silts shown in Figure 3. The windblown red sanddunes of Sawyerpuramtheri and Kudiraimozhitheri occur in the northeastern and southeastern part of the basin respectively.

2.5 Soil Map

Soil is one of the natural resources which have the most direct impact on agricultural development. In an agrarian State like Tamil Nadu, it becomes necessary to take steps for its proper conservation and management. Soil survey identifies nature of soils, their extent and physico chemical characteristics etc. In the soil map, different soil types are shown withdifferent soil unit numbers. The soil unit numbers are related with different types of soil categories as shown below. The soilcategories foundin this river basin is Entisol, Inceptisol, Vertisol and Alfisol as shown in Figure 4.

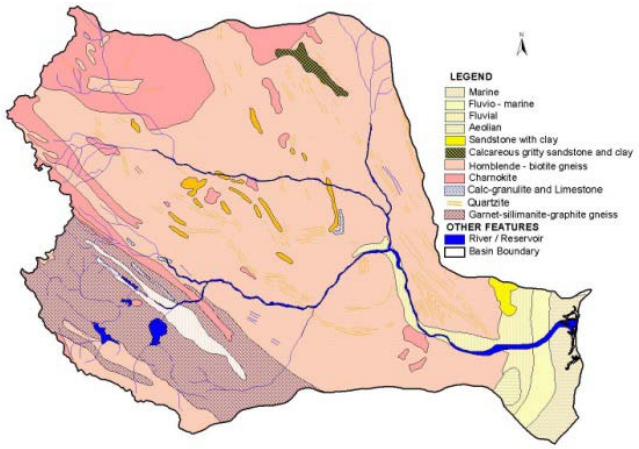

Figure 3. Geology map of the study area.

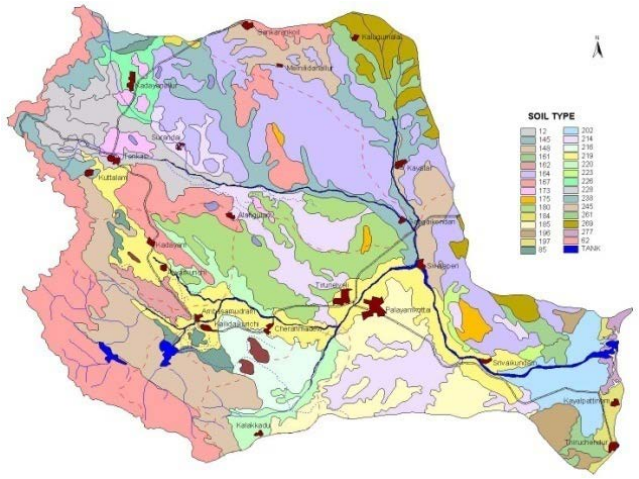

Figure 4. Soil map of the study area.

2.6 Geomorphology Map

Geomorphology exercises a significant control over the groundwater region, relief, slope, and depth of weathering, thickness of deposition, nature of the deposited materials and the assemblage of different landforms. LISS IV FCC imagery of IRS-P6 was studied in detail to get inferences in relation to geomorphologic conditions of the river basin. This study brings out the four major exogenous landforms, 1. Denudational, 2. Fluvial, 3. Aeolian and 4. Coastal are shown in Figure 5. Bazada, old river courses and lineament intersection zones are very good groundwater potential zones. Flood plain, valley fill, palaeo channels, buried pediments, deep pediments and lineaments are good potential zones. Buried pediments - shallow & moderate, sanddunes and interdunal depressions are moderate potential zones.

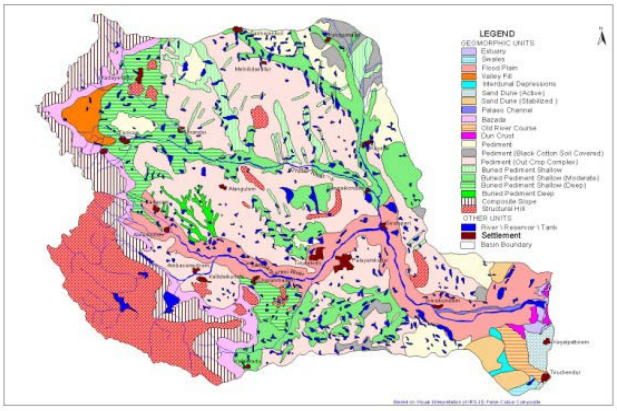

Figure 5. Geomorphology map of the study area.

2.7 Land use Map

Land use map of Tamirabarani basin was prepared using the IRS P6 LISS IV data of August 2014. Landuse categories of second level were delineated from the remote sensing data showing the detailed landuse classification[8] like built-up land, cropland, wasteland, forestland and water bodies as shown in Figure 6. Built-up land refers to settlements. Agricultural lands are primarily lands put into use for production of food and commercial purposes. Cropland is covered by paddy, sugarcane and betel veins, etc. Forestland is covered by dense, medium dense and deciduous forest. Scrubs and shrubs are covering plains and hills. Water bodies include reservoirs, lakes, tanks, ponds, rivers, streams and canals.

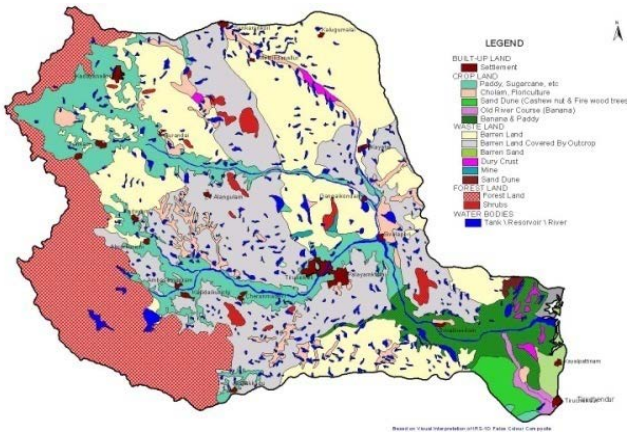

Figure 6. Landuse map of the study area.

2.8 Waste Land Map

Wasteland is described as degraded land/ currently underutilized/deteriorating for lack of appropriate water and soil management on account of natural causes that can be brought under vegetative cover with reasonable effort. Wasteland can result from inherent/ imposed disabilities by its location, environment, chemical and physical properties of the soil, financial or management constraints. Wasteland in this basin has been studied using the IRS P6 imagery for adopting the norms of Technical Task Force Group, NRSA, Department of Space, Hyderabad and is categorized into barren land, barren land covered by outcrop, alkalinity/salinity area and sand dunes. Wasteland covers an area of about 3274 km2 (55%) in this basin refer Figure 7.

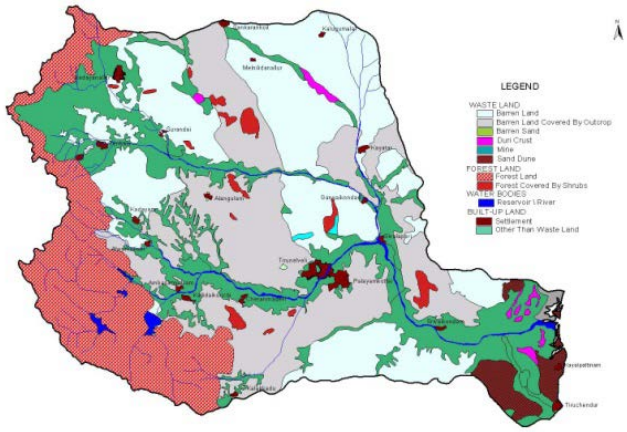

Figure 7. Waste land map of the study area.

2.9 Rainfall Contour Map

The average annual rainfall (1996 to 2015) varies in the basin from 639 mm (Cheranmadevi) to 1200 mm (Sivasailam) in Ambasamudram taluk of Tirunelveli district. The average annual rainfall is high on upper reaches of Tamiraparani and Manimuthar rivers in the Western Ghats. In plains, the average annual rainfall ranges from 700 mm to 1000 mm. Low rainfall pockets with less than 700 mm rainfall is observed around Sankarankoil, Kayathar, Cheranmadevi, Srivaikundam, Tirunelveli and Palayamkottai.

The Southwest monsoon rainfall is very high ranging from 1195 mm to 1500 mm in Valayar, Sivasailam, Oothu and Agasthiyarmalai, and is very low ranging from 26 mm to 88 mm in Thiruchendur, Tirunelveli, Srivaikundam, Sankarankoil, Palayamkottai, Nanguneri and Cheranmadevi. In other locations the rainfall varies from 159 mm to 734 mm. The Eastern part except coastal area and the north western part of Western Ghats, experiences 100 mm to 200 mm rainfall as shown in Figure 8.

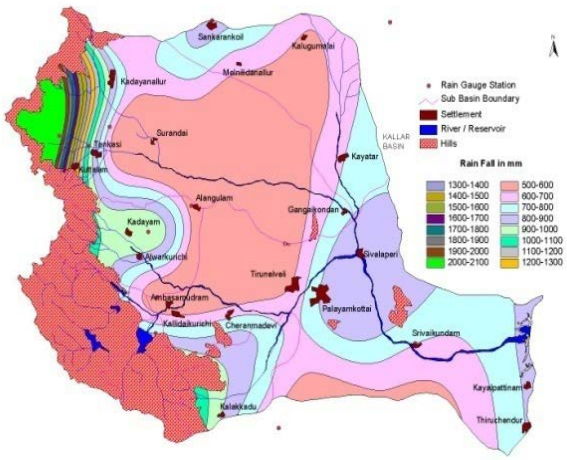

Figure 8. Rainfall contour map.

The northeast monsoon rainfall is predominant in the western parts of the basin in the eastern slope of Western Ghats. Maximum rainfall is observed in Sivasailam, Oothu, Valayar, Manjolai and Agasthiyarmalai. It ranges from 850 mm to1350 mm. Minimum rainfall is observed in Karuppanadhi, Kayathar, Sankarankoil, Cheranmadevi, Kadayanallur, Srivaikundam, Tirunelveli, Kovilpatti and Palayamkottai ranging from 325 mm to 500 mm. In other areas it ranges from 550 mm to 900 mm.

2.10 Water Quality Map

2.10.1 Total Dissolved Solids Map (2010 Pre Monsoon)

Water quality samples were collected from the control wells present in the river basin and analyzed the entire parameters. But in this study mainly focuses on TDS and Chloride. The total amount of dissolved chemical species in water is called total dissolved solidsas shown in Figure 9. As per B.I.S classification good quality water has less than 500 mg/lit of TDS, moderate quality water between 500 and 2000 mg/lit and poor quality above 2000mg/lit. The amount of dissolved solids in water is expressed as salinity. 1pre monsoon groundwater quality TDS map reveals that the area adjoining hills and forests in northwest and southwest have good quality water. In coastal area, east of Srivaikuntam and north of Kayalpattinam have good quality. Quality of water is poor near Palayamkottai, Kovilpatti and west of Kayathar where TDS value is more than 2000 mg/lit. In the rest of the area the quality is moderate.

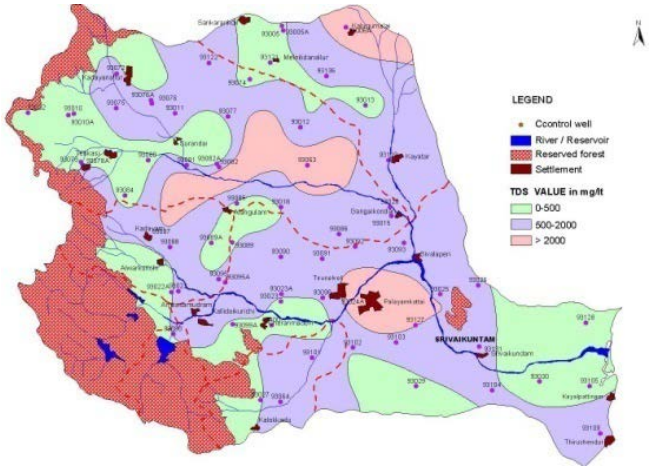

Figure 9. TDS map – 2010 pre monsoon.

2.10.2 Total Dissolved Solids Map (2014 Pre Monsoon)

2014 pre monsoon water quality TDS map reveals that most of the area is dominated by good and moderate quality of water. The minimum value of TDS is 215 mg/lit at Sankarankoil. The maximum value of TDS is 2327mg/lit at Tiruchendur, where the presence of salts in groundwater is extremely high. In the coastal area, due to seawater intrusion, the salinity has increased. Apart from coastal area, Thidiyur, Kulayaneri also have higher amount of TDS. This may be due to disposal of solid wastes and sewage. Comparing 2010 and 2014 pre monsoon TDS maps, it is seen that, areas adjoining hills and forest in west, which had good quality of water in 2010 has only moderate quality in 2014. In central portion of the basin, the TDS value has decreased considerably indicating the improvement in the quality of water shown in Figure 10.

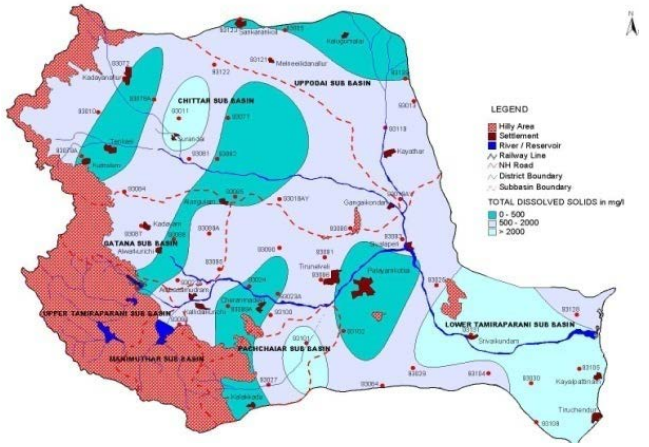

Figure 10. TDS map – 2014 pre monsoon.

2.10.3 Chloride Map (2010 Pre Monsoon)

Chloride is a major dissolved constituent of water. The most common chloride in natural water is sodium chloride. Chlorides found often in water include chlorides of calcium, magnesium and iron. As per B.I.S classification, the chloride content in groundwater having less than 250 mg/lit is good, 250 to 1000 mg/lit is moderate and more than 1000 mg/lit indicates poor quality. Areas adjoining hills and forest have good quality water. In the east, along coast and in North, groundwater quality is poor. Also at Palayamkottai, and west of Kayathar the quality is poor in certain pockets. In other regions the quality of water is moderate as shown in Figure 11.

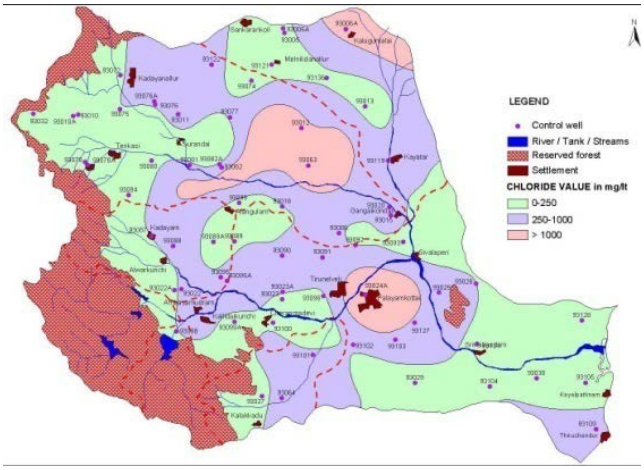

Figure 11. Chloride map – 2010 pre monsoon.

2.10.4 Chloride Map (2014 Pre Monsoon)

Chloride 2014 water quality map indicates good and moderate groundwater quality in central, north and western parts of the basin. The quality of water is poor in the coastal area due to seawater intrusion. In two pockets viz one north of Surandai and another east of Kayathar the quality of water is poor due to soil factors. Comparing both the maps, it is observed that in the coastal area, water quality has become saline due to seawater intrusion. Generally, the quality of groundwater has marked improvement in the basin which may be due to rainfall factor in Figure 12.

2.11 Overlay Analysis

Integration of all the Thematic maps was done in a GIS environment for subsequent overlay analysis. It shows that the waste lands areas are mostly high chloride content areas and high TDS value areas. To improve the status of eco-degradation in the study areas developmental plans have to be decided.

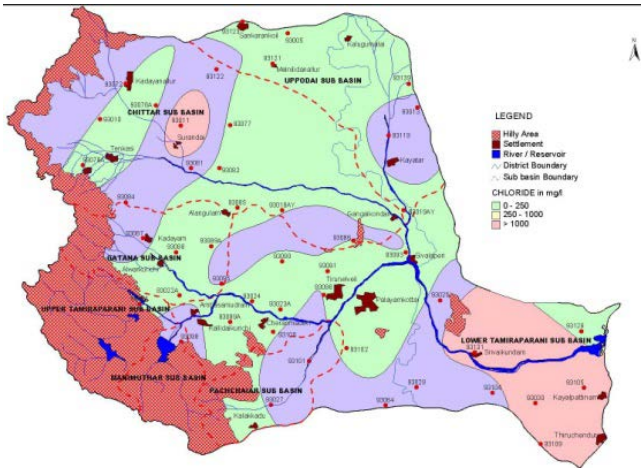

Figure 12. Chloride map – 2014 pre monsoon.

3. Results and Discussion

Analysis of temporal layers Land use/Land cover of Tamiraparani basin in 2010 and 2014 years reveals that degradation of land and water is due to the shortage in irrigation and water supply and changes in ground water quality. .

The study clearly indicates that waste land extent is increasing year by year due to the above facts. Unless some remedial measures undertaken the situation will become worse hence, the waste lands have to be converted has productive lands by providing water supply to the lands[9]. By overlaying and superimposing geomorphological and lineament intersection maps on the waste lands maps, favorable sites will be selected for augmenting water supply for irrigation. For prioritizing the irrigation tanks to be Modernized and detailed sane geomorphological and lineament intersection map will be superimposed on tank layer map. So that suitable tanks will be selected. This will help to increase the surface water potential and ground water conditions.

4. Conclusion

The study is centered on Tamirabarani river basin to manage and reclaim the good groundwater potential zones and suggested various developmental plans like construction of Check dams, Reservoirs, formation of new tanks, Rehabilitation of tanks and canals, Rainwater harvesting structures, Percolation ponds, Waste water recycling,

Domestic sewage treatment & reuse, Reclamation of red category industrial effluents and Control weeds growth. Wasteland development also helps various crops and some forest plantation for improvement and ultimately the status of agriculturist. This type of study will also be adopted for other sub basins to improve the overall environmental characteristics.

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