Assessment of Fluctuation of Ground Water Potentiality over Land use pattern change, A Geomatical approach.

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Abstract

Digital image processing technique in assessment of land use pattern change-over reveals the various results of its impacts & consequences over resource environment that indirectly indicates the human intervention, collateral damage of the living conditions, thus it is necessary to be identify the environmental changes ,which has the indirect effects mainly over the groundwater potential zones. Land use/ land cover mapping is essential component where in other parameters are integrated on the requirement basis to drive various developmental index for ground water resource. Land-use and land-cover classification assessed for a total area of about 3554.9 Km² in the parts of Tiruvallur & Kancheepuram districts of Tamilnadu - India from the LANDSAT series for the periods 1991, 2000 & 2006 respectively..

The resultant changeover is analysed that defines the radical change of the land use pattern. This Changeover distribution lead to the consequences over the ground water recharge potentiality in the study area that is been inferred through the analysis using weightage assessment. Changes in the Land use refers to natural vegetation, water bodies, rock/soil, artificial cover etc., are noticed that leads to the adequate effect on the potentiality of the ground water recharge condition, which is clearly evidenced by the fluctuations in the water level data for the mentioned years. Study area covers from 80 ^{0}0'N-13 ^{0}30'E to 80 ^{0}1'N-12 ^{0}14'E and the Urbanization in the study area also the main component for the decline of the potentiality of the ground water in the study area, meant for the exploitation in an non-equilibrium state, that has the impact of saline water intrusion . A Numerical approach for estimating these consequences through the calculation of statistical enumeration for Normalized Building Index (NDBI), Normalized Vegetation Index (NDVI) that are Used to find the root cause for the fluctuations over the Ground water potentiality proved through the assessments via geomatic technique for the Groundwater potentiality changes in the concerned intervals of time period with respect to landuse pattern change.

1.Introduction

Groundwater potentiality in the developing city area will be in the fluctuating manner, created due to the over exploration because of the demands created by the population explosion. So monitoring the groundwater potential in these types of areas will result in assessing various conditions of the potentiality index .Assessment can be evaluated with the help of landuse pattern change over a periodical time through the calibration of **GPI.**

Landuse pattern-Understanding the landuse and land cover refers to the usage of the land for various purposes like domestic, industrial, builtup lands, etc., will reveal about the GPI indirectly.

Urban development-Vigorous growth of the population and industrial development leads to the decrease of agriculture landschanged to be urbanised. It also leads to the indirect depletion and pollution of the aquifers.

1.1. Importance of the theme

Ground water is a major resource for all living things in the world. Conservation must be enhanced for the life of the resource because every individual depends on it. So, the assessments must be done for evaluate the condition of its potentiality .Since the importance of groundwater for the existence of human society cannot be overemphasized. Groundwater is the major source of drinking water in both urban and rural. Besides, it is an important source of water for the agricultural and the industrial sector.

2.StudyArea

Study area covers from $80^{0}0'$N-$13^{0}30'$E to $80^{0}1'$N-$12^{0}14'$E about 3559.9km^2 in parts of Tiruvallur & Kancheepuram districts of Tamilnadu, India. It covers from the north eastern coast of Tamilnadu which has the condition of tsunami prone zone , storm surge areas , urbanisation & increasing population growth , long linear beach with coastal features , salty pulicat lake , rivers like coovam, adayar, palar and the Buckingham canal & Madras harbour. Moreover being it lies in coastal associated zone, it is vulnerable for coastal hazards.

2.1 Data's used

- ✓ Landsat TM (1991) , ETM (2000) , ETM + (2006)

2.2 Software's used for the study

- ✓ Arc-gis 9.3.1 , Envi- 4.7 , Ms-office

3.Methodology

Temporal datasets of Landsat TM(1991), ETM (2000) , ETM + (2006) are analysed using the digital image processing technique results in the classification of the features in broad level in phase I . Detailed analysis for classification of the image using gis for the precise assessment of the land use changes in phase II. Finally the groundwater potentiality indexes in concerned years are calculated using the formula of GPI and estimating the changes with GPI.

4. The study involves 3 phases

1. DIP – Digital Image Processing for the classification of the landuse pattern involves two main parameter calculations NDBI & NDWI
2. Visual interpretation carried out for the landuse classification for the precise assessment.
3. GPI-Groundwater Potentiality Index calculated for the entire study area with temporal data assessments for the fluctuation in the potentiality of the groundwater with respect to landuse changes.

4.1.Phase I -*DIP*

Image Classification technique works on the principal of classifying the pixels based on the given training sets or systemic classification using the reflectance and radiance character .Two main classification methods are ***Supervised*** and ***Unsupervised*** *classification.*

4.1.1. NDBI - Normalised Differential Building Index

Building Index calculated using the formula

$NDBI = \frac{MIR-NIR}{MIR+MIR}$, **which** is in the Range of **-1 to 1.***(Figure-1)*

4.1.2.NDVI

Normalised Differential Vegetation Index calculated using the formula

$NDVI = \frac{NIR-R}{NIR+R}$, which is inthe Rangeof **-1 to 1**.*(Figure-2)*

These classification results were analysed for Positive value which defines the Building and Vegetation Index values & Negative value defines the other objects

Table 1.Percentage of Parameters

	NDVI		NDBI	
	Total %	**Others %**	**Total %**	**Others %**
1991	58.65	41.34	54.82	45.17
2000	40.48	59.51	66.73	33.27
2006	33.03	66.96	71.82	28.18

4.1.3 Result of Image classification

Vegetation % decreases with respect to the increasing % of the builtup lands shows the landuse pattern changes in a manner that has an indirect effect on the surface runoff deviation gets decreased leads to the infiltration less capability on the geosystem terrain which has to be studied detail to ensure the impacts over the GPI.

4.2 Phase II

Visual interpretation and conventional survey carried out for the landuse classification for the precise assessment of the change in the landuse and

Landover pattern in the study area. For the good assessment we have taken the Landsat data in various periods 1991,2000,2006 for the temporal analysis of landuse/landcover deformations with respect to the groundwater potentiality index.*(Figure-3&Table-2)*

4.3 Phase III :

GPI-Groundwater Potentiality Index calculated for the entire study area with temporal data assessments for the fluctuation in the potentiality

$$GPI = [\alpha * L] + [\beta * G] + [\gamma * S] + [\delta * SL] + [\mathcal{E} * P]$$

α – coefficient of SRD of L,
β- Coefficient of SRD of G,
γ - Coefficient of SRD of S,
δ- Coefficient of SRD of SL,
Ɛ- Coefficient of SRD of P.

Where, these coefficients are termed as surface runoff deviations calculated using the efficiency of the infiltration for the type of geosystem terrains. SRD – surface runoff deviation.

L = LANDUSE, G = LITHOLOGY, S = SOIL,SL = SLOPE, P = RAINFALL

These coefficients represent the surface runoff deviations for the geosystem gradients, calculated by the product of surface runoff coefficients with infiltration efficiency of the geosystem gradients.

5. Calculation of Coefficients

SRD = Difference between standard deviation of the favourable area with unfavourable area / total mean of the area

α - SRD * weight & rank of L
β - SRD * weight & rank of G
γ- SRD * weight & rank of S
δ - SRD * weight & rank of SL

Since for the coefficient of rainfall, we have only the rainfall data for one station, we calibrated for the entire study area by the average annual rainfall by the following method

E / R= Rainfall coefficient. Where, E- standard deviation of the 5 year pre & post annual rainfall with concerned year (1991, 2000, 2006),
R- Rainfall of the concerned year

Difference between Pre & Post E/R gives the rainfall coefficient for the concerned years 1991, 2000 and 2006.

GPI – applying the above mentioned formula which gives us the ground water potentiality index for the particular year data.

6. Conclusion

Graph-1 shows that the decreasing level of the GPI in the favourable geosystem terrain which is the consequence of landuse pattern change in the study area,that influences over the GPIi.e.continuous downward of the favourable regions from 1991 to 2006(*Figure-5&Table-4*). These results were supported by the drastic increase in the urbanisation and over exploitation regions reported by the CGWB in 2011. Thus these assessments give us a thought provoking idea about the Ground Water conditions fluctuated with respect to the landuse /land cover changes mainly by the urbanisation, over exploitation of Groundwater, and some other factors contributing indirectly. Remote sensing and Digital Image Processing plays a vital role in prediction and assessments of certain serious issues posed to the environment .

6.1 Consequences &Impacts of the analysed Result

Water scarcity will be promoted if the same condition prevails as the GPI unfavourable area succeeds and GPI favourable conditions deceeds.

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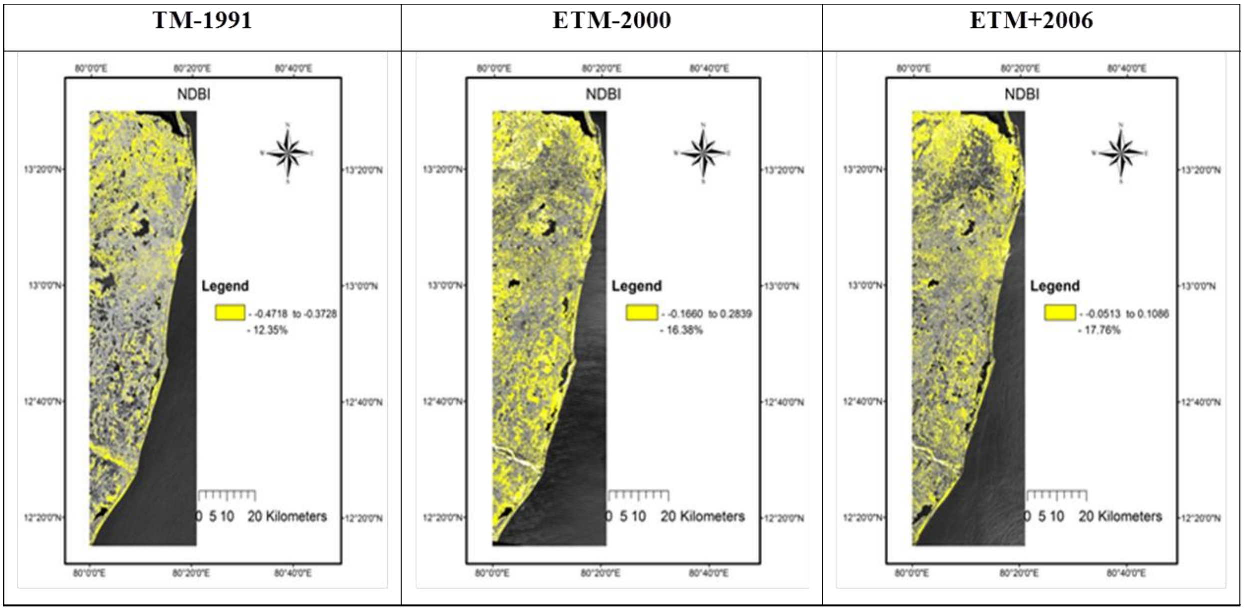


Figure 1.NDBI spatial output

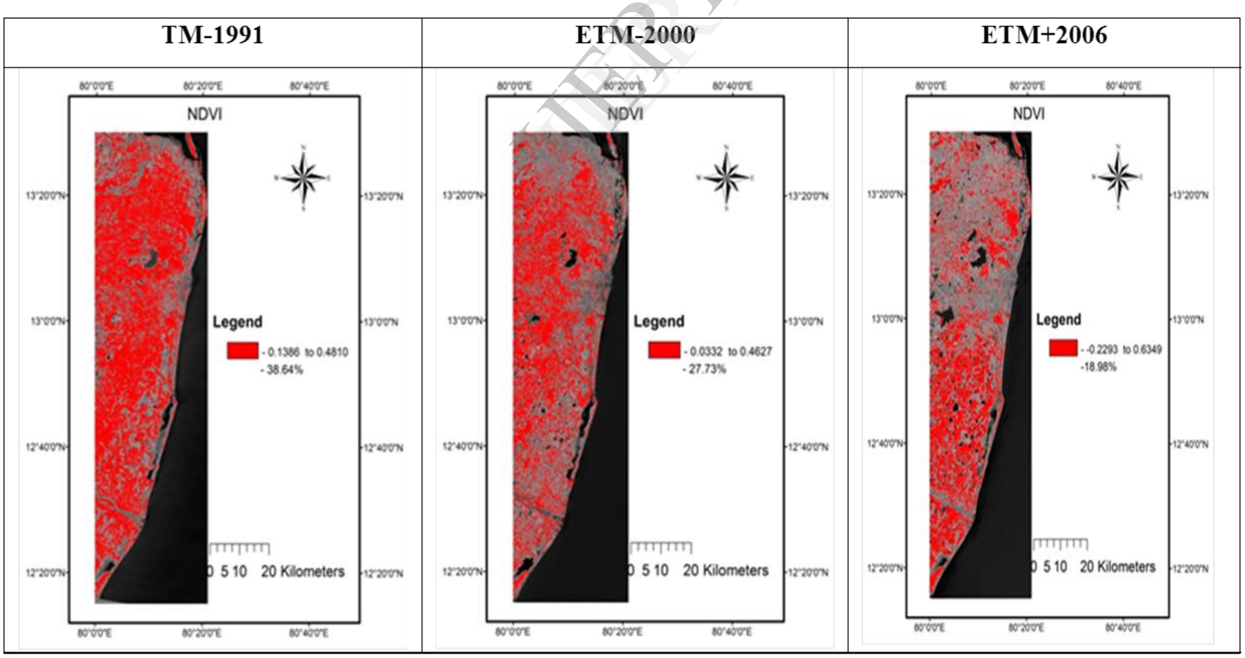


Figure 2.NVBI spatial output

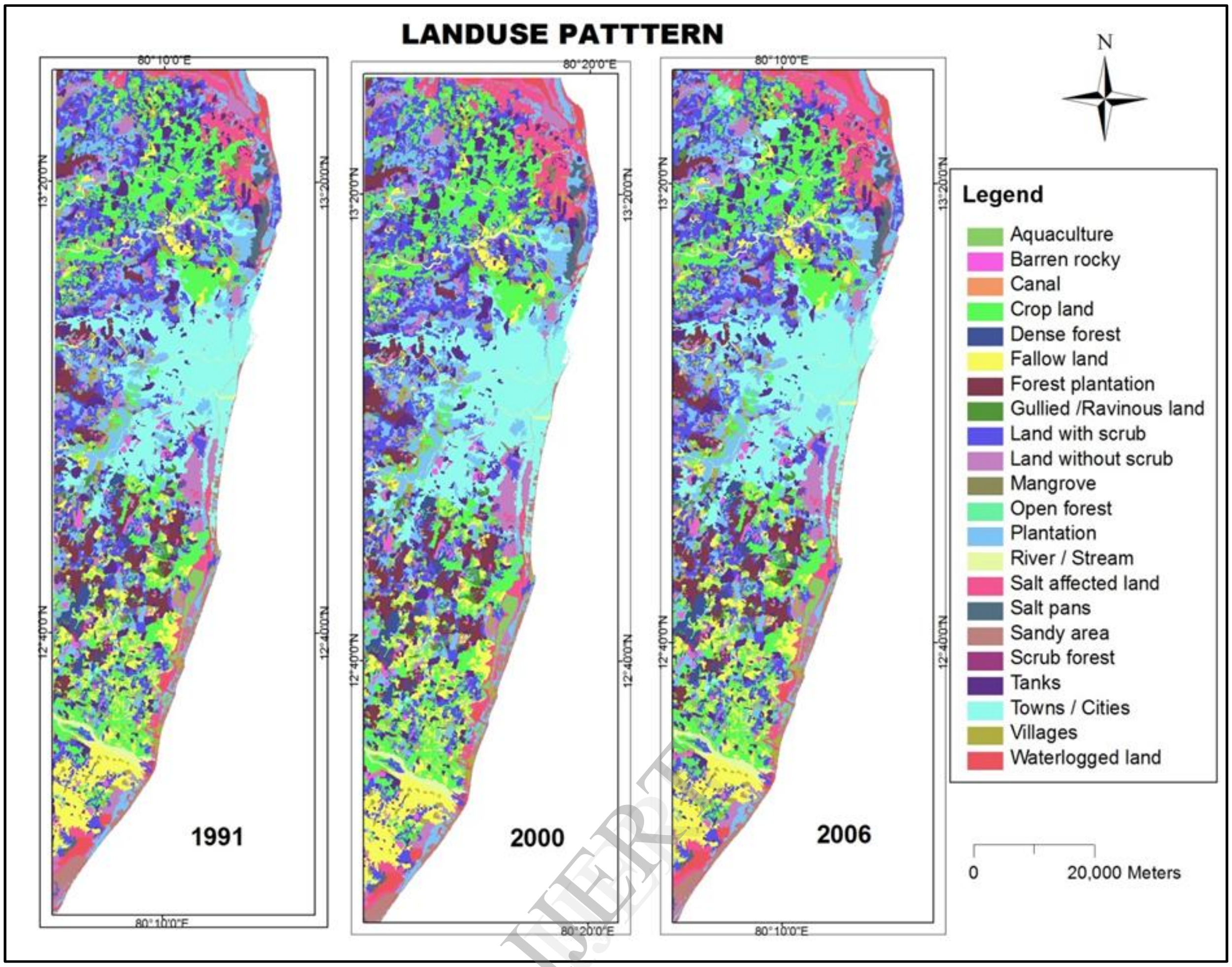


Figure 3.Landuse Pattern Variation

Table 2.Statistical output of Landuse/Landover variation

S.NO	LANDUSE & LANDCOVER	AREA - 1991 SQ.KM	AREA - 2000 SQ.KM	AREA - 2006 SQ.KM
1	Crop land	631.04	624.87	615.49
2	Dense forest	38.93	38.93	38.93
3	Fallow land	269.67	269.67	269.03
4	Forest plantation	154.58	154.58	154.58
5	Land with scrub	549.67	543.50	522.07
6	Land without scrub	196.46	195.21	177.47
7	Plantation	447.81	441.34	435.35
8	Salt affected land	135.28	158.09	178.09
9	Scrub forest	9.93	9.93	9.93
10	Towns / Cities	449.50	457.63	492.08
11	Waterlogged land	58.84	59.12	59.12

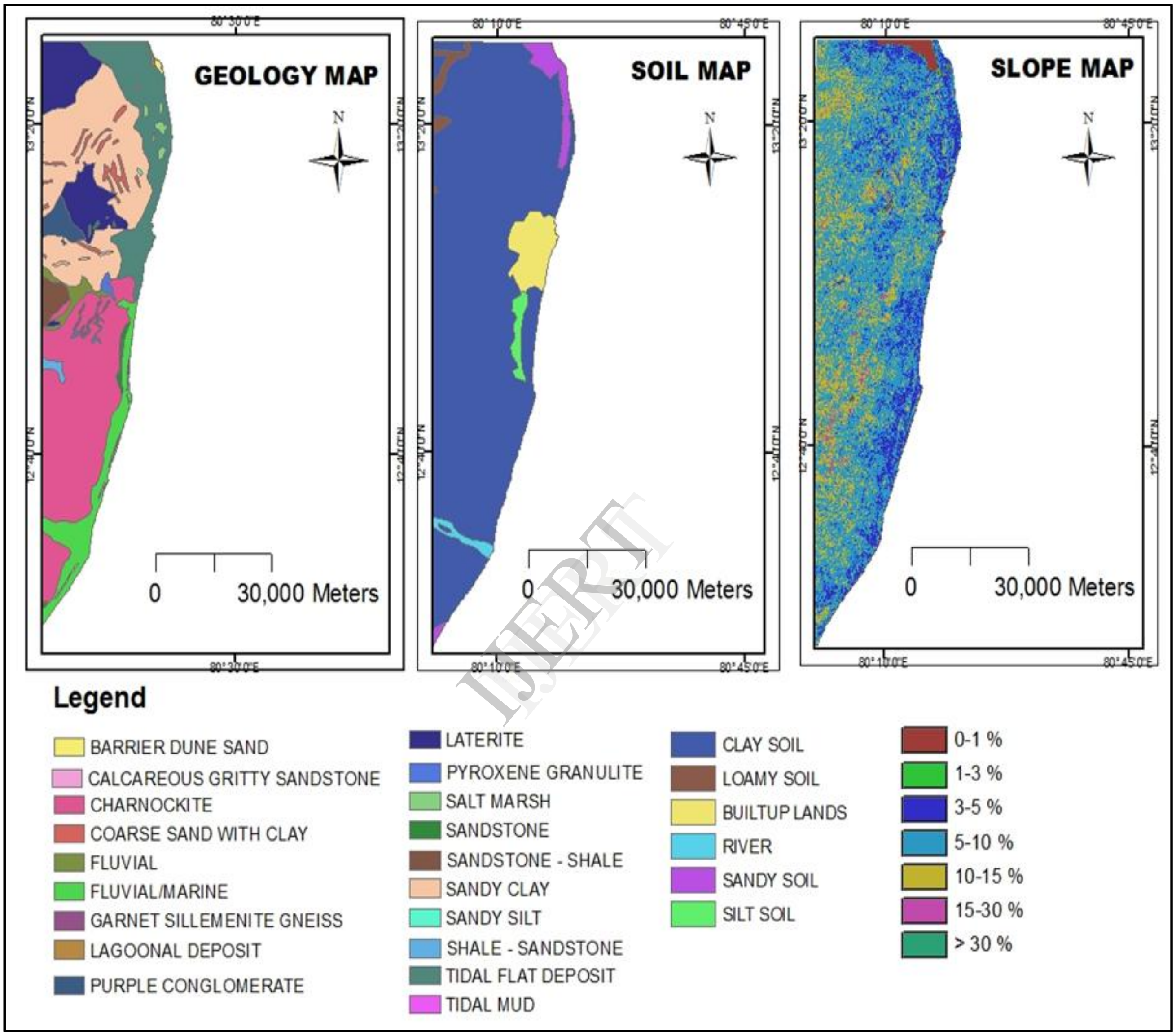


Figure 4.Thematic layers of Geology, Soil, and Slope

Table3.Weight and Rank assigning according to their properties for GPI

LANDUSE & LANDCOVER			
FAVORABLE ZONES	**WEIGHT & RANK**	**UNFAVOURABLE ZONES**	**WEIGHT & RANK**
Crop land-CL	20	Towns / Cities-TC	2
Plantation-PL	19	Salt affected land-SAL	6
Land with scrub-LWS	18	Waterlogged land-WL	7
Land without scrub-LWOS	17		
Dense forest-DF	16		
Forest Plantation-FP	13		
Fallow Land-FL	12		
GEOLOGY (SOI)			
Barrier sand dune	19	Charnockite	1
Sandstone	18	Purple conglomerate	2
Coarse sand with clay	17	Pyroxene granulite	3
Sandstone-Shale	16	Salt marsh	4
Calcareous gritty sandstone	15	Lagoonal deposit	5
Garnet Sillemnite Gneiss	14	Tidal flat deposit	6
Sandy clay	13	Tidal mud	7
Laterite	12	Sandy silt	8
Shale sandstone	11	Fluvial marine	9
Fluvial	10		
SOIL			
Sandy soil	6	Buitup lands	1
Loamy Soil	5	Silt soil	2
		Clay soil	3
SLOPE (IMSD Classification)			
0-1 %	7	10-15 %	3
1-3 %	6	15-30 %	2
3-5 %	5	>30 %1	1
5-10 %	4		

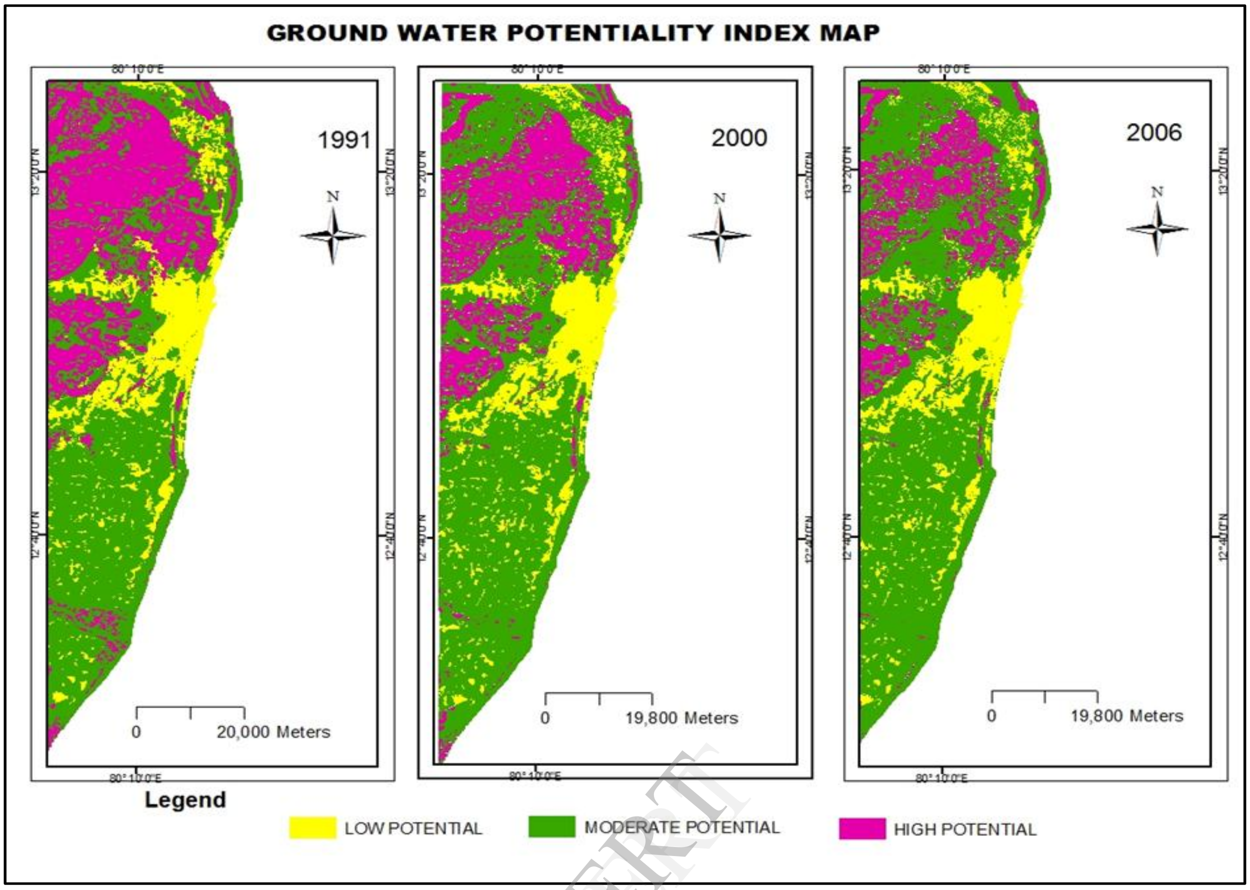
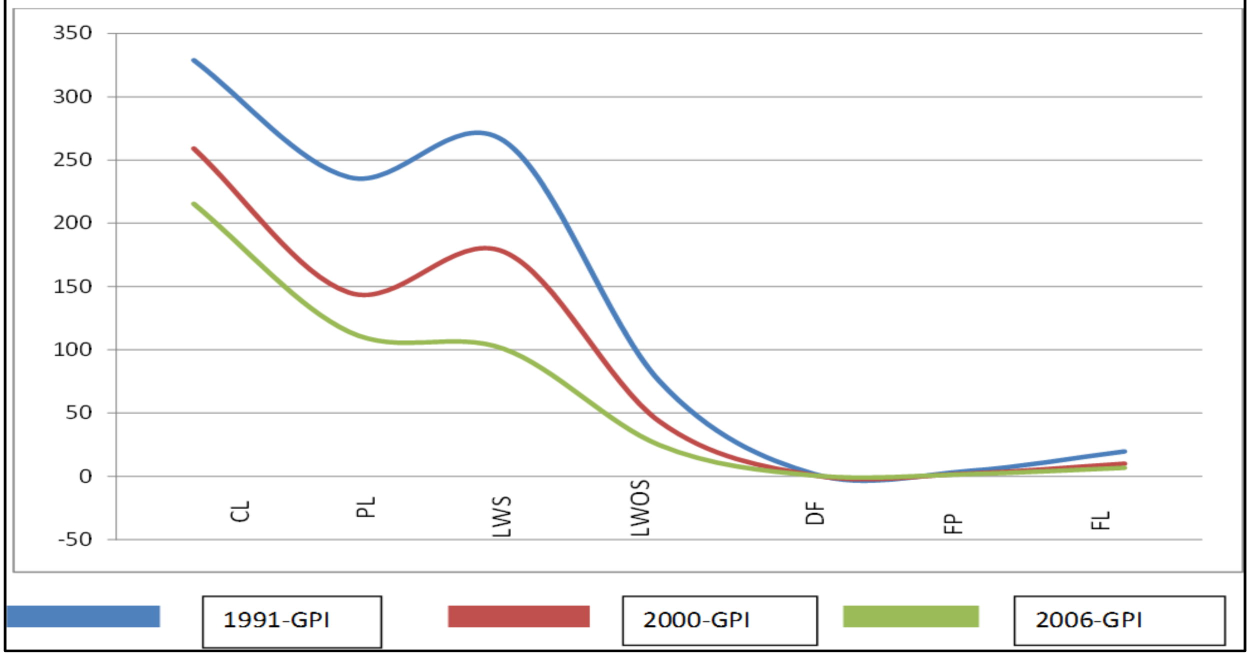


Figure 5.GPI output in various years

Table 4.GPI Potential Zone variation

FEATURES	1991 GPI-AREA	2000 GPI-AREA	2006 GPI-AREA
FAVOURABLE REGION			
Crop Land	328.94	259.12	215.39
Plantation	236.43	145.25	114.28
Land With Scrub	265.15	177.45	100.73
Land Without Scrub	75.48	43.53	24.77
Dense Forest	1.82	0.77	0.62
Forest Plantation	4.30	2.25	1.78
Fallow Land	19.65	9.96	6.73
UNFAVOURABLE REGION			
Towns & Cities	449.50	457.63	492.08
Salt Affected Land	135.28	158.09	178.09
Water Logged Lands	58.84	59.12	59.72

Graph-1: **Degradation of GPI** – Favourable region



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