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A Study on Factors Affecting Ground water and Its Impact on Livelihood

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Abstract: ***Water plays an important role for the survival of human lives. Groundwater which is invisible and it is considered as pure in nature. Groundwater is used for drinking, domestic, agriculture and livestock. The major factors affecting groundwater are climate variability and anthropogenic activities. This study is about the improvement of groundwater level in Nilakottai and Palani block in Dindigul district. There are 6.21 lakhs bore wells out of 39lakhs and 0.91lakhs open wells out of 12lakhs in Tamil Nadu. About 30% of total bore wells in dindigul district is located within the Nilakottai and Palani block. According to Central Ground Water Board survey on February 2008, In Dindigul district, there are 10 over exploited blocks, 2 critical blocks and 2 safe blocks. Government of Tamil Nadu has banned groundwater development for irrigation in the over exploited blocks of Tamil Nadu. So in this study, some improvement measures are to be taken in two critical blocks to avoid lowering of ground water level in those areas.***

In the selected blocks the groundwater potential maps has been created using observation well data, soil map through Remote Sensing and GIS techniques further the factors that are affecting the groundwater level were analyzed, the dependency of groundwater on agriculture and other livelihood options have also been critically discussed. From this study it is found that climate variability and groundwater dependency on agriculture are the major driving factors for groundwater declination. Based on the potential map the possible sites suitable for recharging groundwater are suggested. The possibilities of constructing farm ponds, percolation ponds, trench pits and other water harvesting structures in the selected blocks have also been suggested.

Keywords: Groundwater, livelihood, climate change, dindugal, agriculture

I. INTRODUCTION

Groundwater is the most important source of fresh water in many regions of the world. It is a form of water occupying all the voids within the geological stratum. Groundwater storage and recharge are fundamental components of hydrological system. They are result of water percolating through various layers of soils and rocks after atmospheric precipitation. The amount of percolation varies from place to place and it depends on rainfall characteristics of soils, rocks, nature of terrain, temperature and humidity. Hence availability of subsurface water will also vary from place to place. Groundwater depletion is a term often defined as a long term water level declines caused by sustained groundwater pumping. It is a key issue associated with groundwater use. Subsurface flow is equally important since about 30% of the world's fresh water resource exist in the form of groundwater. It forms a critical input for the sustenance of life and vegetation in arid zones. The availability of groundwater from an aquifer at a place depends upon the rates of withdrawal and replenishment. The aquifers are generally classified as confined aquifer, unconfined aquifer, perched aquifer.

II. NEED FOR THE STUDY

Agriculture, Drinking and Domestic needs of water are fully depend on the groundwater. They deep bore wells of depth 500-700 feet are used to extract the water. Due to increasing of many bore wells water available only after the 500feet, which implies that groundwater level goes down in that area. Due to the decrease of groundwater level, the agricultural productivity goes down and also affects the environmental condition. Though the study area had enough rainfall there is no proper management of groundwater system and there is no provision for recharging the groundwater, which causes the depletion of groundwater level.

III. STUDY AREA

Dindigul District was curved out of the Composite Madurai District and became a separate entity since 1985. It is located between 10° 05‟ to 10° 09‟ North latitude and 77° 30‟ to 78° 20‟ East longitude, and its Mean Sea Level is (+) 280.11m. It is bounded by Erode, Tirupur, Karur and Trichy districts on the North, by Sivaganga and Tiruchi District on the East, by Madurai district on the South and by Theni and Coimbatore Districts and Kerala State on the West. It is spread over an area of 6266.64 sq. km.

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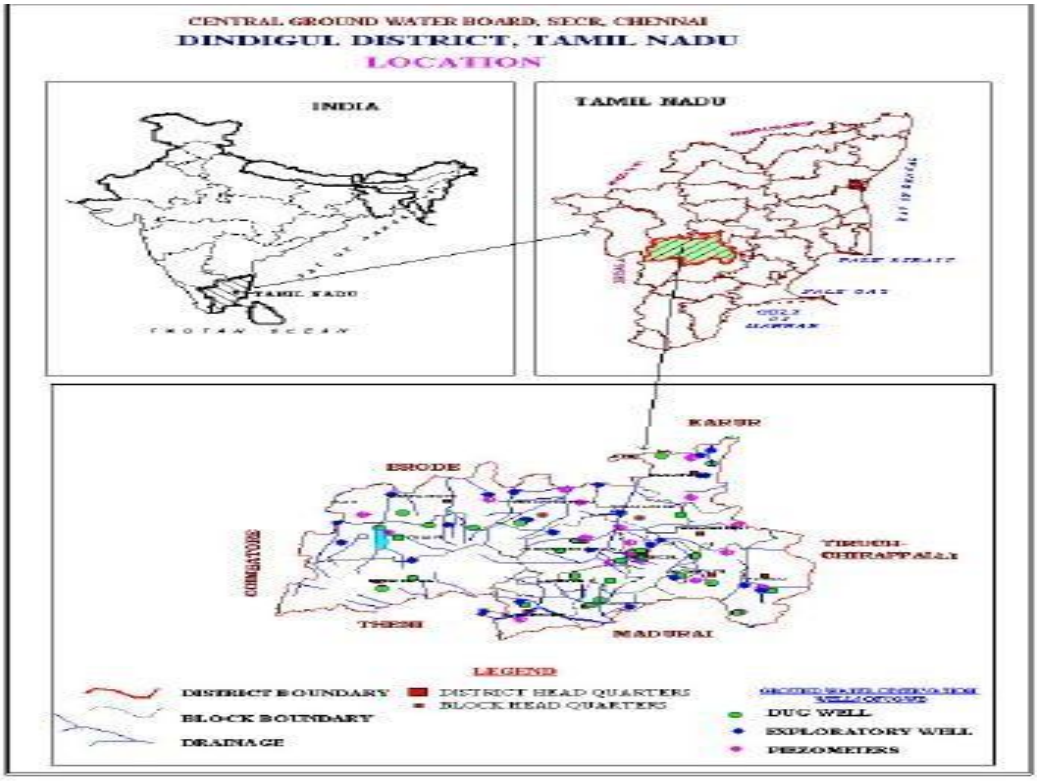

Fig. 1 Dindugal District (Nilakottai and Palani block)

A. Geomorphology and soil type

Differing resistances of the geological formation has given rise to various land forms. These are structural hills, residual hills, linear ridges and pediment terrains in the district. Structured hills are the major land forms in the district. The major part of Kodaikkanal and Palani hill occupies structural hills. Similarly, it is also found in parts Nilakottai, Natham, Vadamadurai, Oddanchatram and Gujiliamparai blocks. Shallow buried pediments and pediments are the results of denudational land forms and are encountered in major parts of the area. Flood plains of recent origin are found along the river courses. The coalescence of alluvial cones and fans, formed after composite slope boundary is bazada zones. These are found well developed in northern part of Palani Hills, southern part of Kodai hills and Natham hills. The valley fill sediments are found to occur in Oddanchatram, Reddiarchatram, Sanarpatti and Natham blocks and the southern slopes of Kodaikkanal hills. Red soils are prevalent in Palani, Natham and Oddanchatram, while Red sandy soils are prevalent in Nilakottai, Dindigul and Vedasandur. Black soils are found in all taluks except Kodiakanal.

B. Rainfall and Climate

The normal annual rainfall over the district varies from 700 mm to 1600 mm. It is minimum around Palani (709 mm) in the northwestern part and Vedasandur (732.4mm) in the northeastern part of the district. It gradually increases towards south and southwest and reaches a maximum around Kodaikanal (1606.8 mm).The district enjoys a tropical climate. The period from April to June is generally hot and dry. The weather is pleasant during the period from November to January. Usually mornings are more humid than afternoons. The relative humidity varies between 65% and 85% in the mornings while in the afternoon it varies between 40% and 70%. (District Groundwater Brochure, Dindugul District, Technical report, 2008).

C. Drainage

The important rivers in the basin are Shanmuganadhi, Nangangiar and Kodavanar. These rivers flow north and northeastward and join Amaravathi river which finally confluences with river Cauvery. They originate in the Palani hill range of Western Ghats and Sirumalai hills and they are ephemeral in nature.The southern part of the district falls under Vaigai Sub basin. The important rivers are Marudhanadhi, Manjalar and Vaigai River. They are also ephemeral in nature and receive flow during monsoon period only. The district follows a drainage pattern of sub-dendritic, dendritic, radial and parallel. Most of the streams are structurally controlled.

D. Nilakottai and Palani block

The geo-coordinate of the Nilakottai block is in 10.167 latitude and 77.852 longitude. Total area of the block is 249.78 km^2.Total population in the area is 124478. 28 villages come under the administrative control of Nilakottai Panchayat Union The geo-coordinate of the Palani block is in 10.46 latitude and 77.51 longitude. Total area of the block is 249.78 km^2. Total population in the area is 99024. 39 villages are comes under the administrative control of Palani Panchayat Union.

Fig. 2 Palani block map

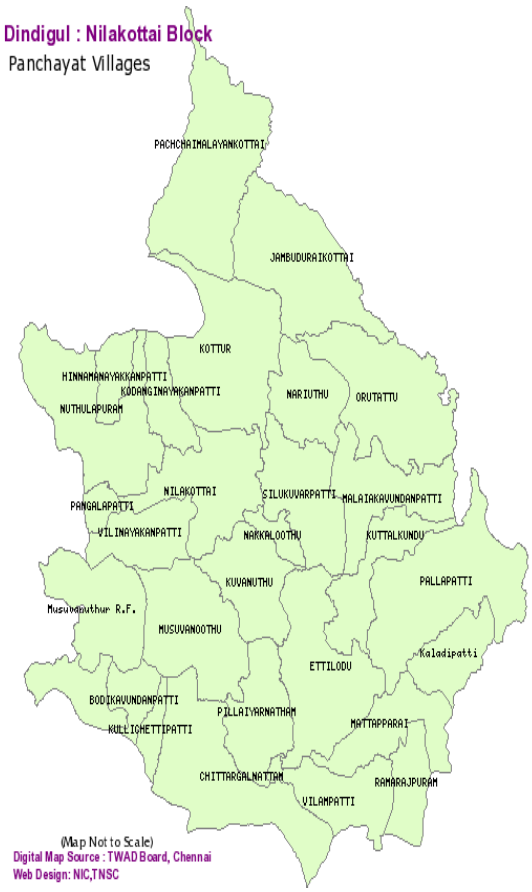

Fig. 3 Nilakottai block map

IV. METHODOLOGY

The methodology explained about the combination of Aster Dem, Land sat image with the secondary data such as soil, geology, geo morphology through weighted overlay analysis. The weighted overlay analysis can be made with the combination of elevation, drainage and slope. The secondary data such as soil, geology, rainfall, and groundwater level along with supervised classification of Land sat image. The groundwater potential zone map can be prepared through weighted overlay analysis. Based on the maps generated the possible sites to recharge the groundwater can be suggested.

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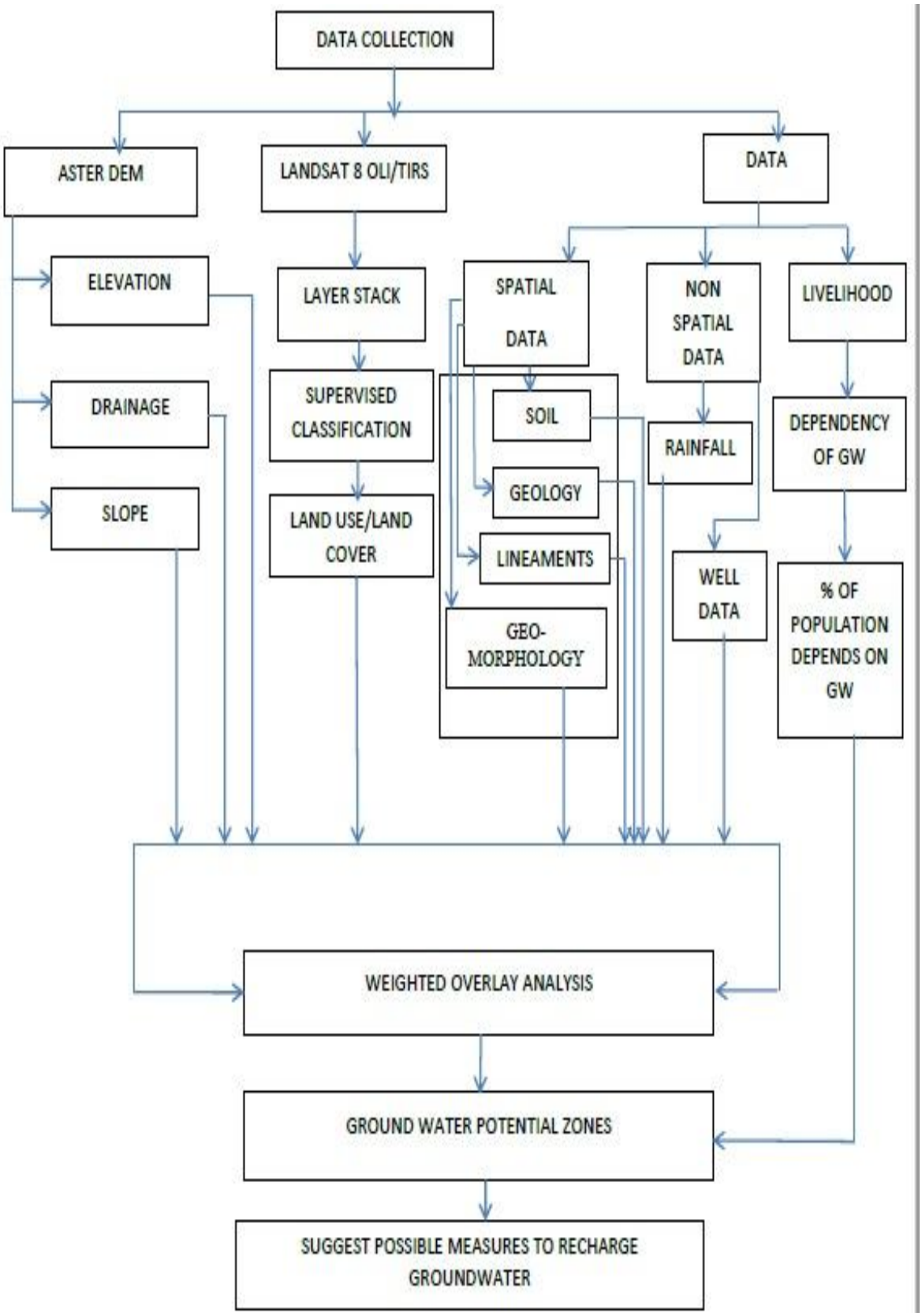

Fig. 4 Flowchart of Methodology

A. Softwares Used

For thematic map preparation software like ArcGIS are used since more accurate processing are achieved through these software. The description about each of these software are given below

1) *ArcGIS:* ESRI‟s ArcGIS is a Geographic Information System (GIS) for working with maps and geographic information. It is used for creating and using maps, compiling geographic data, analyzing mapped information, sharing and discovering geographic information, using maps and geographic information in a range of applications and managing geographic information in a database. The system provides an infrastructure for making maps and geographic information available throughout an organization, across a community, and openly on the Web.
2) *Stastistical Package for Social Studies (SPSS):* The statistical package for the social science is a widely used program for statistical analysis in package sciences, particularly in education and research. However, because of its potential, it is also widely used by market researchers, health- care researchers, survey organization, governments and most notably, data miners and big data professionals. Aside from statistical analysis, the software also features data management, which allows the user to do case selection, create derived data and perform file reshaping another feature is data documentation, which stores a metadata dictionary along with the data file.

B. Weighted Average Method

As mentioned in the methodology the selected parameter have been created using GIS. Totally 6 parameters have been considered for the study such as rainfall, slope, land use / land cover, geology, geomorphology and water level. The weightage given by the each parameters are Rainfall – 30%, Soil – 20%, Land use / land cover – 15%, Observation water level – 10%, Geomorphology – 15%, Slope – 10%. Then the tool „Weighted Overlay‟ in Overlay Toolset, which is built inside of Spatial Analyst Tools in Arc GIS, has been used to perform an overlay analysis. The weighted overlay tool, overlays several raster using a common measurement scale and weights each parameters according to its important. The result of overlay analysis has been classified into three classes as low, moderate, high in each block.

V. RESULTS AND DISCUSSIONS

Using the collected primary and secondary data, the variation of groundwater in the observation wells with respect to rainfall over the decade was interpreted. Maps such as land use/land classification, soil map, slope map and groundwater potential maps were generated using Arc GIS. Various inferences and interpretations were made based on the maps. Finally SPSS analysis was done to know the farmers perception in the selected blocks.

A. Roundwater Fluctuation In Palani Block

With the help of average rainfall and observation well data for four decades (1985-2015), a graph is plotted between the average rainfall and observation well level for Palani block in Dindigul district. From the figure 5.1 it is found that the well level increases with increase in the rainfall in the decades 1995 - 2005 and it falls when the rainfall decreases as in the decade 2005 – 2015, which shows that rainfall pattern is one of the factor which affecting the groundwater level.

Table 1
Rainfall Vs water level –Palani block

Year	Well level in m	Average rainfall in mm
1985	11.615	71.7
1995	8.025	76.32
2005	7.86	126.67
2015	10.653	55.568

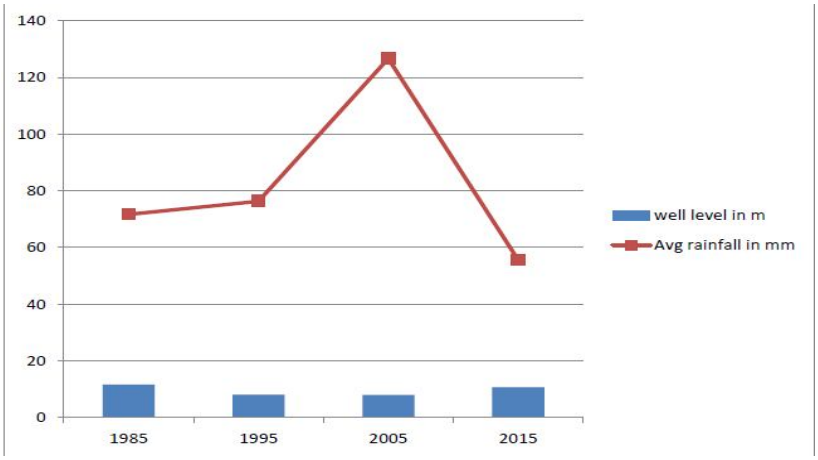

Fig. 5 Rainfall Vs water level –Palani block

B. Groundwater Fluctuation In Nilakottai Block

With the help of average rainfall and observation well data for four decades (1985-2015), a graph is plotted between the average rainfall and observation well level for Nilakottai block in Dindigul district. From the figure 5.2 it is found that the well level increases with increase in the rainfall in the decade 1995 - 2005 and it falls when the rainfall decreases as in the decade 2005 – 2015, which shows that rainfall pattern is one of the factor which affecting the groundwater level.

Table 2
Rainfall Vs water level – Nilakottai block

Year	Well level in m	Rainfall in mm
1985	9.467	49.1333
1995	8.45476	63.06667
2005	8.046667	90.87
2015	13.69395	38.19938

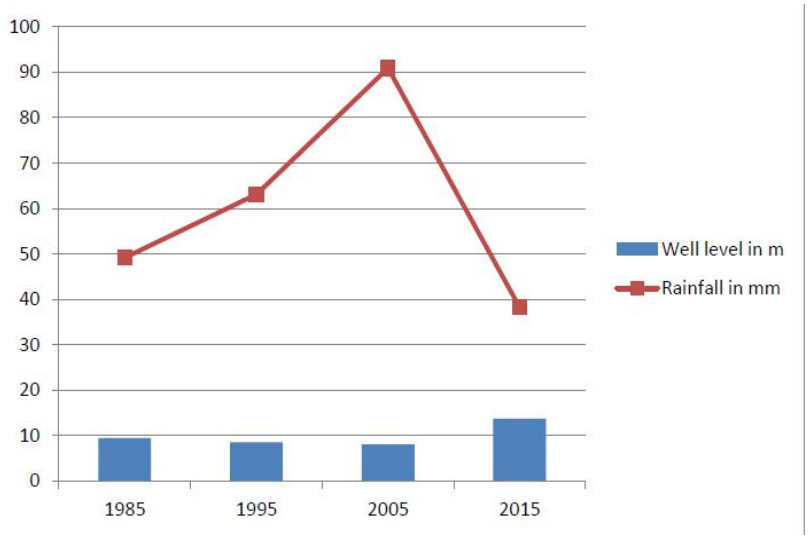

Fig. 6 Rainfall Vs water level –Nilakottai block

C. Comparison Between Nilakottai And Palani Block

The comparison between the selected blocks shows that Nilakottai block has more agricultural area (50%) than Palani block (38%). The water bodies available are more in Palani block (2.43%) than the Nilakottai block (1.46%). Thus the farmers in both the blocks mainly depend on groundwater for agriculture. During field visit it is observed that Palani block has more number of irrigation tanks which helps to irrigate some fields thus the dependency of groundwater on agriculture is comparatively low in Palani block than Nilakottai block. Thus the groundwater level is comparatively deeper in Nilakottai block than Palani block as given in the tables 1 & 2.

Table 3
Land cover/se in selected blocks

Classification	Area in % Nilakottai	Classification	Area in % Palani
Double/Tripple	40.045	Decious Forest	25.51
Decious Forest	33.41	Double/Tripple	25.39
Rabi Only	15.03	Rabi Only	11.09
Current Fallow	4.1	Current Fallow	8.29
Khariff Only	2.36	Water bodies	2.48
Scrup Land	1.68	Khariff Only	2.43
Water bodies	1.46	Scrup Land	1.62
Scrup / Degrated Forest	1.12	Scrup / Degrated Forest	1.33
Other Waste Land	0.61	Other Waste Land	1.05
Built-Up Land	0.16	Built-Up Land	0.598

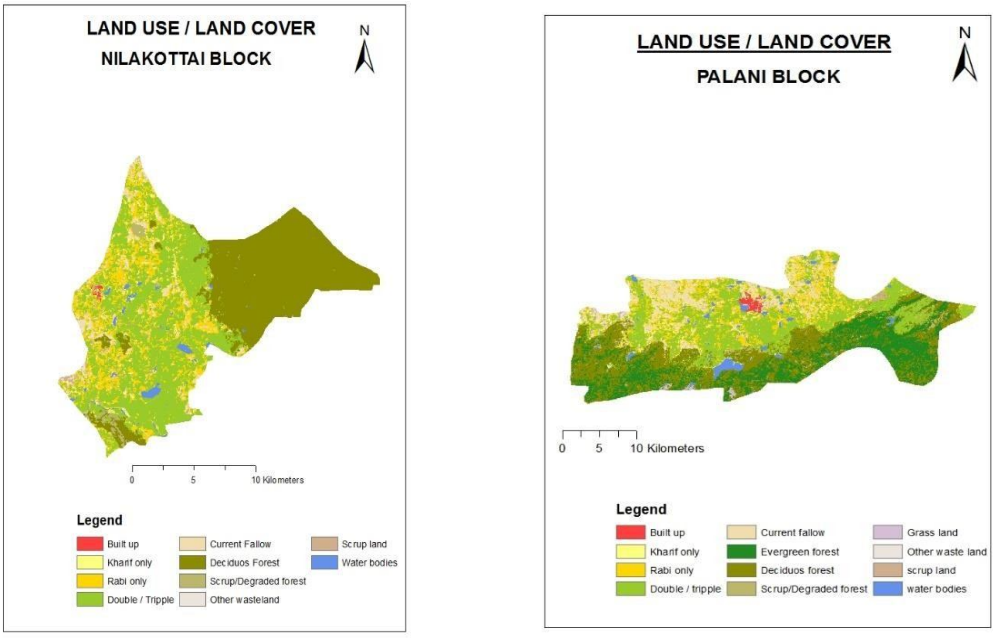

Fig . 7 Land Use / Land Cover Map of Nilakottai and Palani Block

D. Spatial Distribution Of Rainfall Over The Selected Blocks

The spatial distribution maps for Nilakottai block and Palani block was generated for the period 1985-2000 and 2000-2015. The change in rainfall pattern for each 15 year was studied for both the blocks. This map helps to critically analyse the effect of climate variability prevailing in the blocks and it also helps to study how these rainfall helps to increase the groundwater level and improves the potential of groundwater. Figure 7, 8 shows the rainfall pattern of Nilakottai and Palani block for the years 1985-2000, 2000-2015. The results are discussed below as follows.

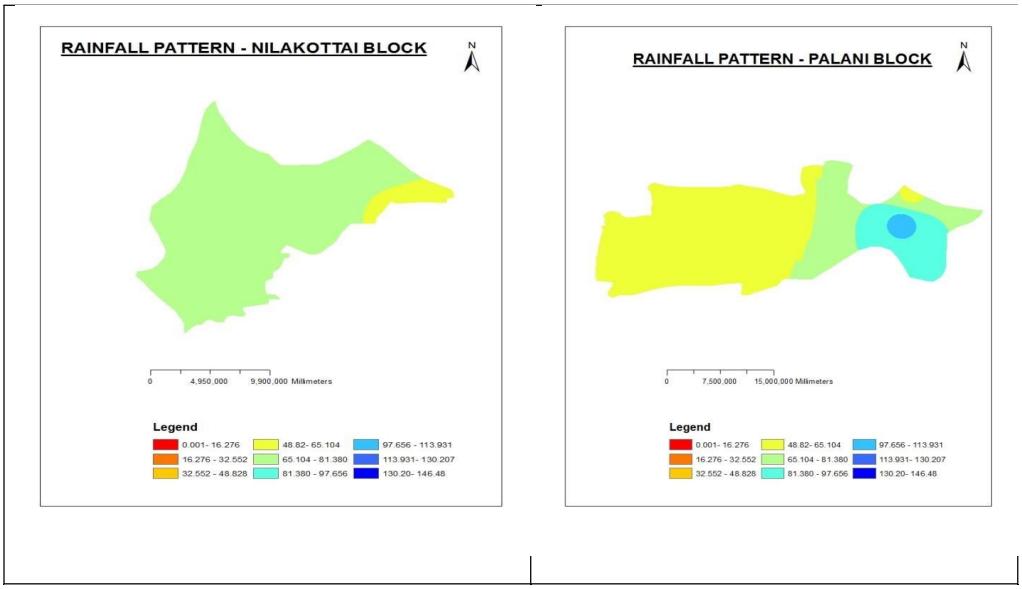

Fig .7 Spatial distribution of rainfall in the selected blocks for the period 1985-2000

From the figure 5.7 the maximum rainfall range of Nilakottai block lies between 65mm to 81mm and it has a lowest range of 42 mm to 65 mm. whereas Palani block has a highest range of 97mm to 113mm and lowest range of 48mto 65mm. from the year 1985-2000, Palani block received more rainfall when compared to Nilakottai rainfall.

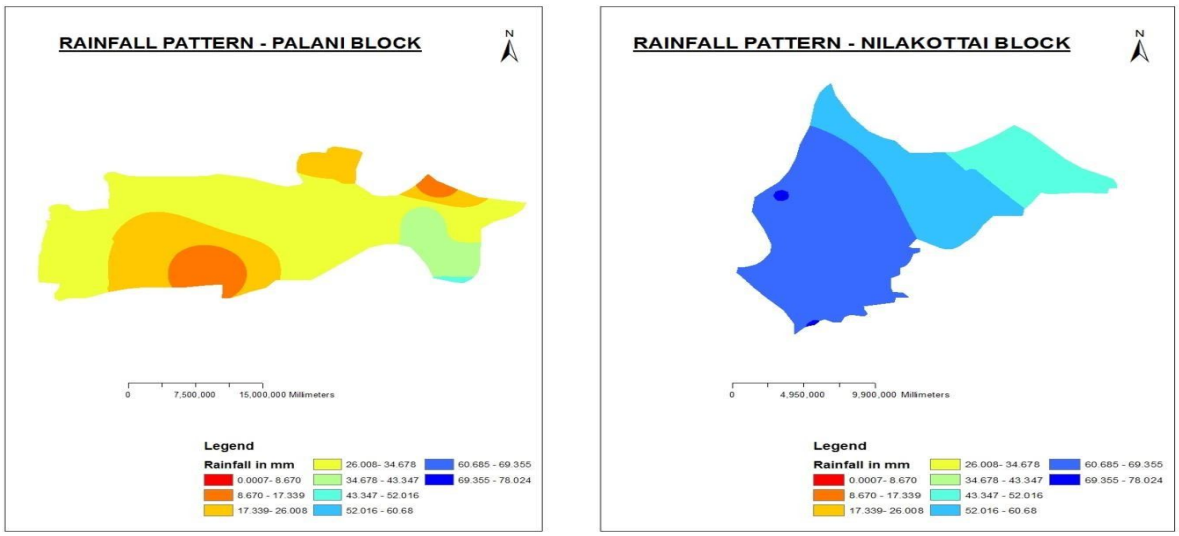

Fig.8 Spatial distribution of rainfall in the selected blocks for the Period 2000-15

From the figure 8 the maximum rainfall range of Nilakottai block lies between 69mm to 78mm and it has a lowest range of 43 mm to 52 mm. whereas Palani block has a highest range of 43mm to 52mm and lowest range of 8 mm to 16 mm. In the last 15 years the average rainfall pattern decreases for Palani block and slightly increases for Nilakottai block. This shows again climate variability prevailing in those blocks over the years.

E. Effect Of Rainfall And Groundwater Level In The Selected Blocks

The groundwater level increases as rainfall increases. From the generated rainfall distribution maps of Nilakottai and Palani block it is observed that Palani block has received more rainfall when compared to Nilakottai block during 1985-2000 (first 15 years) as given in the figure 7. From 2000-2015 (next 15 year) Nilakottai block has received more rainfall when compared to Palani block as given in the figure 8. This rainfall pattern clearly shows that there is a climate variability prevailing in the selected blocks.

F. Groundwater Potential Zone

As mentioned in the methodology the selected parameter have been created using GIS. Totally 6 parameters have been considered for the study such as rainfall, slope, land use / land cover, geology, geomorphology and water level. The weightage given for each parameters are Rainfall – 30%, Soil – 20%, Land use / land cover – 15%, Observation water level – 10%, Geomorphology – 15%, Slope – 10%.

The tool „Weighted Overlay" in Overlay Toolset, which is built inside of Spatial Analyst Tools in ArcGIS, has been used to perform an overlay analysis. The weighted overlay tool, overlays several raster using a common measurement scale and weights of each parameters according to its significance. The result of overlay analysis finds the groundwater potential zones for Nilakottai and Palani block. They are classified into three classes namely low, moderate and high in each block.

Figure 9 and 10 shows the groundwater potential maps of Nilakottai and Palani block respectively. Table 5 and 6 shows the area of potential zones of each class for each block.

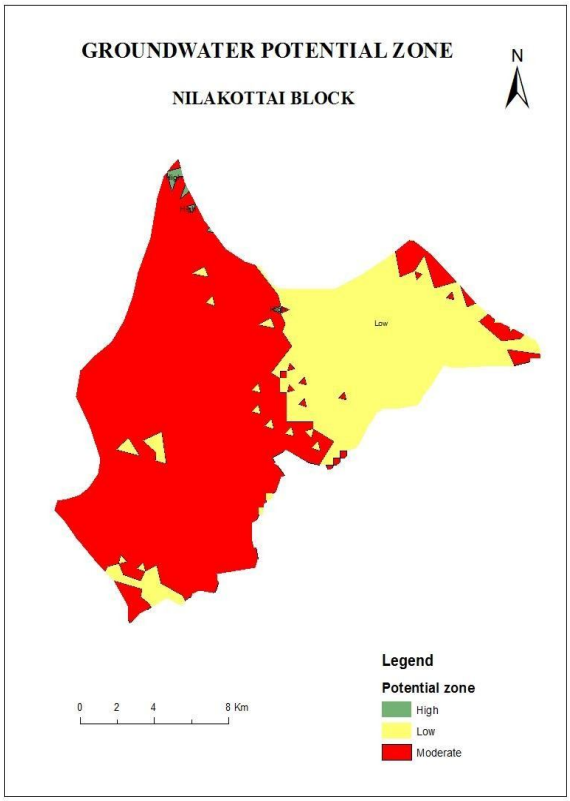

Fig .9 Groundwater Potential Zone Map of Nilakottai Block

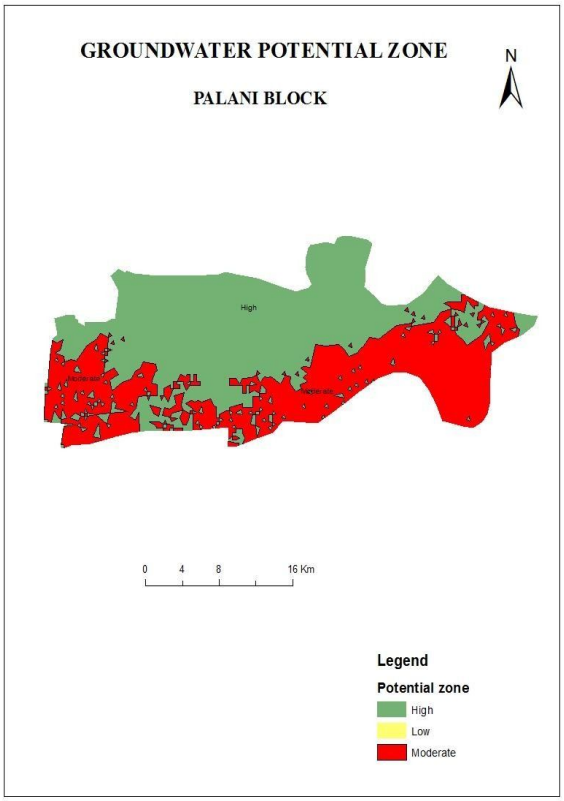

Fig .10 Groundwater Potential Zone Map of Palani Block

Table 4
Groundwater potential zones for Nilakottai and Palani block

Zone	Area in sq.km	Area in sq.km
	Nilakottai	Palani
High	0.8348	399.382
Moderate	174.4	272.696
Low	78.238	0
Total	253.47	672.078

From the figure 10, it can be observed Palani block has more area of high groundwater potential of 399.382 km^2 and moderate potential zone of 272.69 km^2. This is due to the fact that varying rainfall pattern over the years. There is a slight dependency of groundwater for agricultural and livestock purpose. The surface water bodies are available more in the Palani block. The more area of high potential zone is because of less dependency of groundwater on agriculture, more area of sandy soil which infiltrates water. When comparing the geology and groundwater potential map, the regions of sandy soil has moderate and high zones.

G. Spss Analysis

After carried out the questionnaire survey, the responses are entered in SPSS software and it was analyzed. From the analyses certain graphs are generated to understand agricultural practices of the farmers in the selected study area. Land holding size of farmers, depth of well, climate variability graphs is generated and they are discussed below. In which Climate variability Vs Age group graph is discussed here since it is more relevant to the work.

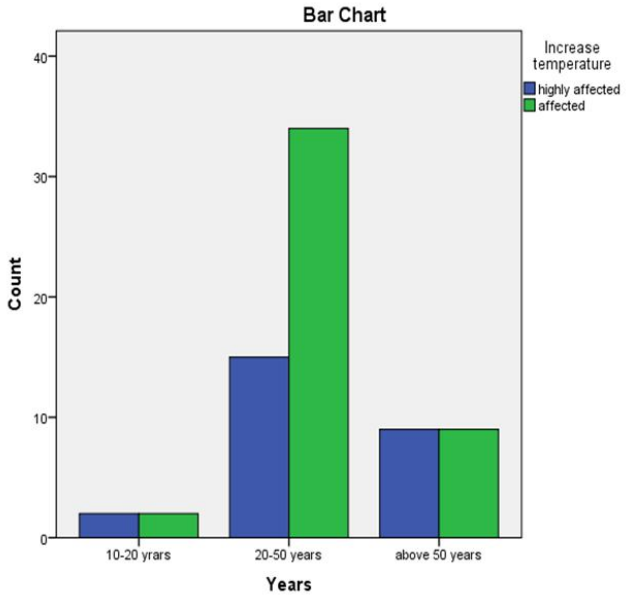

Fig .11 Climate variability for different age groups

Climate variability Vs different age groups, the graph shows that the age group between 20-50 years are highly affected due to climate variability. The age group of above 50 years are not experiencing more climate variability. Rainfall and temperature are the main climatic components affecting agriculture. Finally, the responses of each sample were entered in SPSS and a chi-square test was made. Almost all the people are depending on groundwater either in open well or bore well for agriculture. The major crop identified here is paddy. The test result shows that climate variability (decrease in rainfall, increase in temperature) uneven distribution of rainfall induces the groundwater declination. The groundwater declination affects to sustain agriculture in the selected blocks. Thus climate variability is one of the factor alters the groundwater level. The null hypothesis tested in SPSS

"Climate variability is the factor alters groundwater level" is accepted at level of significance 0.95.

VI. CONCLUSIONS

From the results obtained from questionnaire survey and GIS techniques, major conclusions were made as Climate variability, agriculture needs are the major factors influencing the fluctuation of groundwater level in the study area. The selected blocks have more area of agricultural area which is the dominating sector in utilizing groundwater Areas which have more sandy soil are capable of recharging groundwater. Most of the farmers experiencing climate change and diversified their crops from paddy to flower, maize and cotton. Alternate source of water for irrigation helps to curtail the dependency of groundwater and keep the status as safe. In case of Palani block, there are several irrigation tanks available thus pond recharge shafts in water spread area helps to recharge the wells located in the command area. The water bodies are available more in Palani block compared to Nilakottai block thus recharge shafts, construction of check dams and gabbion structures are the best techniques to recharge the groundwater and the surrounding wells. In case of Nilakottai block, more number of wells are available hence construction of dug wells is the most appropriate technique in this block. The annual average rainfall is changing, hence construction of farm ponds, percolation ponds, recharge pits helps to store and recharge this small amount of receiving rainfall.

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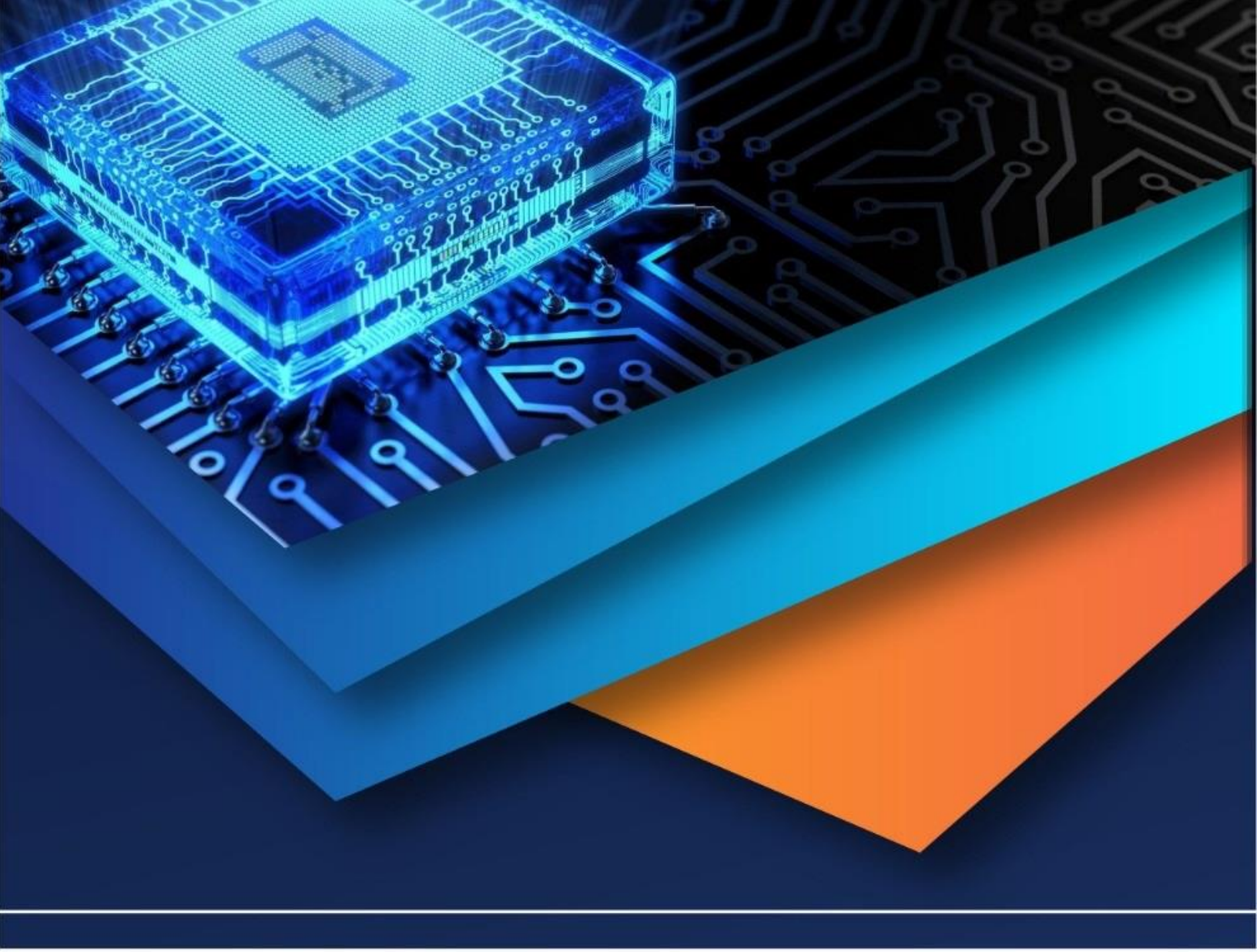

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