A Geo-spatial analysis of Ground Water Zonation in Dindigul Panchayat Union, Tamil Nadu, India

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Abstract: **In the recent years, ground water prospecting and targeting has become an important task because of increased demand for water resource and also due to their constant depletion. Vagaries of monsoon and indiscriminate exploitation of ground water often result in the declining trend of ground water levels.**

Remote sensing has become an important and effective tool in providing an up-to-date data related to geographical studies. Recently extensive use of satellite remote sensing has made it easier to define the spatial distribution of different ground water prospect classes on the basis of geomorphology and other associated factors. Remote sensing data provides useful information about spatial variations in surface features, as the concept of remote sensing is a reality based powerful aiding tool. Hence in the present study remote sensing data and geographic information system technique have been used to study the ground water zonation in Dindigul Panchayat Union, Tamil Nadu, India.

***Index Terms*: Ground water resources, Recharge zonation, Favourable zones.**

I. INTRODUCTION

Ground water is one of the most valuable natural resources, which supports human health, economic development and ecologicaldiversity.In India, demand of groundwater resources continuously increases with the advent of industrialization and population expansions. In this context, demarcating groundwater potential zone is essential to locate high groundwater potential areas for future consumptive use. Hence in the present study, remote sensing data and geographic information system technique have been used to study the ground water zonation in Dindigul Panchayat Union, Tamil Nadu, India.

II. REVIEW OF LITERATURE

Earlier studies regarding ground water recharge and identification of ground water potential zones have been reviewed for an understanding of the need of such analysis.

Devendra Sharma and Jugran, D.K. (1992) in their study have demarcated the hydro morphological units to establish the area of surface runoff and areas of ground water recharge by interpreting IRS 1B LISS II (1992) data in Pinjaur-Morni-Kala area, Ambala district, Haryana and Sirmur district, Himachal Pradesh [1].

Liaqat, A.K. Rao and Mohammed Asif, (1994) have attempted to delineate the ground water prospect zone in Rajgarh district, Madhya Pradesh by interpreting Landsat 5 TM FCC (1993) imagery. On the basis of the hydrogeomorphology map, it has been noticed that the ground water prospects were poor in highly dissected plateau, residual hill and structural hills, in the study area [2].

Pradeep, K. Jain. (1998) in his study has interpreted IRS LISS II data of 1998 to prepare the ground water prospect map in Upper Urmil river basin, Chhatarpur district, Central India. By interpreting hydromorphogeological and lineament map, the ground water prospect map was generated. The author has concluded that the hydromorphogeological units such as older alluvial plain, flood plain and deeply buried pediplain are the prospective zones for ground water [3].

Ramalingam, M and Shantha Kumar, A.R. (2000) have made an attempt to delineate the areas favourable for recharge possibilities at regional scale for Tamil Nadu. Various thematic maps such as geomorphology, geology, soil, slope, landuse, drainage, drainage density, lineament density and ground water fluctuations were prepared using IRS 1C LISS III, 2000 data and critically discussed. Ranks and weights were assigned to each theme by considering its importance. Using Arc/Info, the themes were integrated and the areas suitable for artificial recharge have been identified. Many recharge structures such as check dams, percolation ponds, recharge pits, subsurface dykes and contour trench were suggested based on the field conditions in Tamil Nadu [5].

Jagadeeshwara Rao, P and Hari Krishna, P. (2004) used IRS 1B LISS II of 1992 and IRS 1D LISS III of 1999 to generate the ground water potential zones in PeddaGedda watershed of Andhra Pradesh. The results prove that the deep weathered zones such as pediplain moderate and pediplain deep have delineated as good ground water potential zones in the study area [6].

Biswajeet Pradhan (2009) identified ground water potential zonation for basaltic watersheds using satellite remote sensing data and GIS techniques at the Bharangi River basin, Thane district, Maharashtra, India using Satty's Analytical Hierarchal Process model with the aid of GIS tools and remote sensing data like IRS 1B LISS III and LANDSAT TM. The digital elevation model (DEM) was created from the topographic database and the contour lines and elevation data clouds were interpolated using triangulated irregular networks (TIN), and finally variedground water potential zones for hard rock basaltic basin are demarcated [7].

Suganthi. S, Elango.L, and Subramanian,S.K. (2013) have delineated the ground water potential zones and its relation to the Ground water level in the coastal part of the Arani and Koratalai River Basin, Southern India, using Remote Sensing and Geographic Information System techniques. The ground water potential map, derived by assigning appropriate weightage to different thematic maps, prepared from Linear Imaging Self-Scanning Sensor III (IRS-1D LISS III) satellite imagery, was added to the final ground water potential map. The derived ground water potential map was overlaid with the ground water level and location of well fields for validation. The map prepared will help in systematic and proper development of ground water resources to meet the growing water requirements of the study area[8].

DemekeSewnet, Hasan Raja Naqvi and A. S. Mohammed Abdul Athick (2016) identified Ground water Potential (GWP) zones in theSede River Watershed of the Blue Nile Basin using an integrated remote sensing and GIStechniques and Satty's Analytical Hierarchy Process (AHP). The thematic layers wereintegrated using weighted overlay analysis method to delineate GWP map of the study area.Normalized Differentiate Water Index (NDWI) results showsthe positive value less than 0.09 which highlights no existence of water and finally extracted pixels (>0.20) of NDMI and resulted ground water potentialsites have been validated by existing borehole data[9].

Raju Thapa, Srimanta Gupta, ShirshenduGuin and Harjeet Kaur (2017) delineated the ground water potential zones in Birbhum district, West Bengal, using various thematic layers viz. geology, geomorphology, soil type, elevation, lineament and fault density, slope, drainage density, land use/land cover, soil texture which are digitized and transformed into raster data in ArcGIS 10.3 as input factors. The multi-influencing factor (MIF) technique is employed where ranks andweights are assigned to each factor and finally ground water potential zones are classified into four categories namely low, medium, high and very high zone[10].

Biswajit Das, Subodh Chandra Pal, Sadhan Malik and Rabin Chakrabortty (2018) have delineated the ground water potential zones of Puruliya district, West Bengal using the integrated RS-GIS and analytical hierarchy (AHP) techniques. All the themes and their features have been assigned weights according to their relative importance and their normalized weights were calculated after the hierarchical ranking by pair-wise comparison matrix of AHP. Ground water potential map has been prepared through weighted overlay model in GIS environment after integrating all the thematic layers. The entire district has been classified into three different ground water potential zones—high, moderate, and low[11].

P. Arulbalaji, D. Padmalal and K. Sreelash (2019) delineated the ground water potential of a small tropical river basin located in the western side of the Western Ghats in India. A combination of geographical information system and analytical hierarchical process techniques (AHP) was used in the present study. A total of 12 thematic layers such as Geology, Geomorphology, Land Use/Land Cover, Lineament density, Drainage density, Rainfall, Soil, Slope, Roughness, Topographic Wetness Index, Topographic Position Index and Curvature were prepared and studied for ground water potential zone demarcation. Weights assigned to each class in all the thematic maps are based on their characteristics and water potential capacity through AHP method[12].

As per the study undertaken by the Department of Rural Development, Government of Tamil Nadu and Tamil Nadu Water Supply and Drainage Board (1998-99), Ground Water Prospectives - A profile of Dindigul district, Tamil Nadu, 1999, and State Ground and Surface Water Resources Data Centre, (2000) [4] the Ground Water Recharge and Balance Potential is assessed for all the panchayat unions in Dindigul District, Tamil Nadu. The study states that, out of 14 blocks in the district, 2 blocks come under 'dark' category where the ground water draft is between 85-100 percent to its annual recharge, 4 blocks remaining 'grey' where the level of ground water development is between 65-85 percent and the remaining blocks where the development is lesser than 65 percent are grouped as 'white' area blocks. The study suggests that immediate steps have to be taken in the grey regions of Dindigul district, to arrest the declining ground water levels. It is important to note that Dindigul Panchayat Union, the study area, comes under the grey area.

Hence in the present study, an attempt is made

1. To identify the favourable zones for recharge and
2. To delineate areas of different capabilities such as high, moderate, less and poor by integrating different thematic layers using Arc/GIS software to recommend suitable methods for recharge depending upon the terrain conditions, landforms, availability of water and soil conditions etc…

III. Study Area

Dindigul panchayat union is situated in Dindigul district, Tamil Nadu (Figure 1). It lies between 10°14'45" and 10°31'00" North latitudes and 77°45' and 78°4'30" East longitudes covering the Survey of India (SOI) topographic map 58 F/14, F/15, F/16 and 58 J/3 extending over an area of 409.70Sq.Kms. The area consists of 18 administrative units i.e., village panchayats namely Adiyanuthu, Agaram, Alakkuvarpatti, Ammakulathupatti, Anaipatti, Balakrishnapuram, Chettinaickanpatti, Kovilur, Kurumbapatti, Mullipadi, Pallapatti, Periyakottai, Silapadi, Sirumalai, Thadikombu, Thamaraipadi, Thottanuthu and Vellodu. Among these, Sirumalai village panchayat is a hilly area located in the southern part of the study area (Figure 2).

Fig 1 STUDY AREA LOCATION MAP

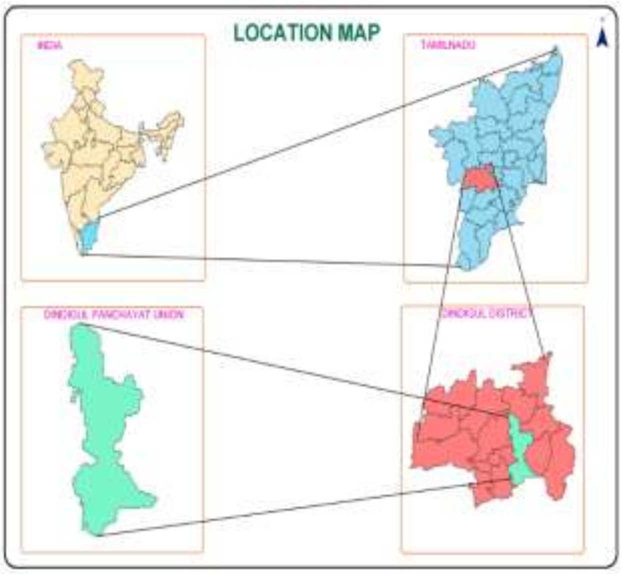
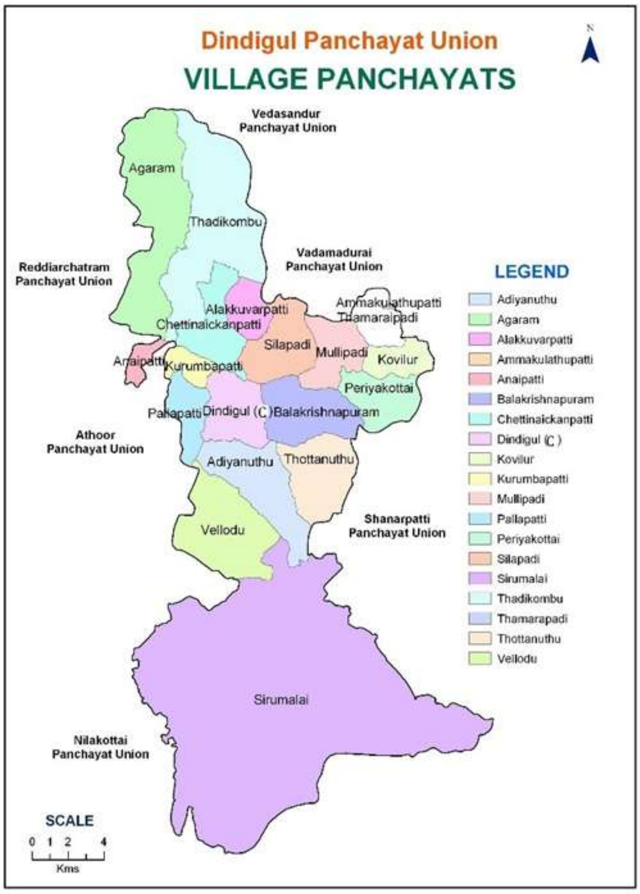


Fig 2 DINDIGUL PANCHAYAT UNION – VILLAGE PANCHAYATS



IV. DATA PRODUCTS

a. Collection of hydrological / hydrogeological and allied data from various agencies,
b. Analyzing water level data,
c. Study of rainfall pattern,
d. Analysis of satellite data Landsat 8(2017) for the preparation of following thematic maps

i) Geology,
ii) Geomorphology,

iii) Physiographic Soil,
iv) Lineament and
v) Land use,

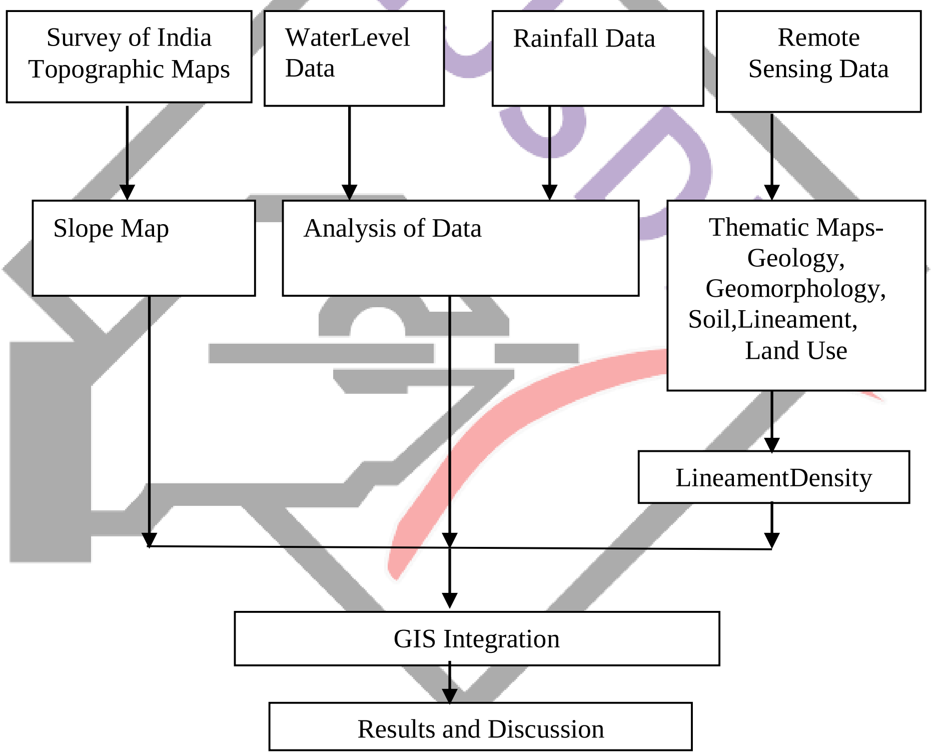
e. Slope map is prepared from the Survey of India topographic maps,
f. In addition to the above thematic maps the following maps were also derived.
i) Lineament density map,
ii) Depth to weathered zone map,
iii) Run-off polygons,
iv) Water level fluctuation contour map and
v) Drainage density map.

V. METHODOLOGY

Dindigul Panchayat Union is underlaid by hard crystalline formations of Archaean age in which the occurrence and behaviour of ground water is controlled by topography, climate and subsurface geological conditions. The landforms of Dindigul Panchayat Union are also quite varying which control the occurrence and movement of ground water. Hence systematic and scientific approach is adopted to delineate different zones of recharge and to pinpoint suitable sites and structures in the area. The methodology followed to identify the ground water zonation in the study area is shown in Flow Chart 1.

FLOW CHART 1

METHODOLOGY FOR ASSESSING GROUND WATER QUALITY – RECHARGE ZONATION



VI. ANALYSIS OF DATA

All the above thematic maps were digitized using Arc/GIS software. Then the above thematic maps were reclassified into four groups and they are assigned ranks from 1 to 4. The rank 1 is considered as the most favourable zone for recharge and rank 4 is considered as the least favourable zone for recharge. The ranks are assigned for each theme and all the thematic maps are reclassified into 4 ranks each (Report on identification of recharge areas using RS and GIS in Tamil Nadu, Sponsored by Department of Rural Development, Government of Tamil Nadu Water Supply and Drainage Board, Chennai, 1998-99).

Basically, matrix is derived from the weightages given to each parameter. Matrix values are nothing but a parameter value that is assigned based on the important criteria. This includes firstly the behavior of the parameter with respect to the objectives of the study and secondly how this behavior changes with respect to particular area, in this case the Dindigul panchayat union.

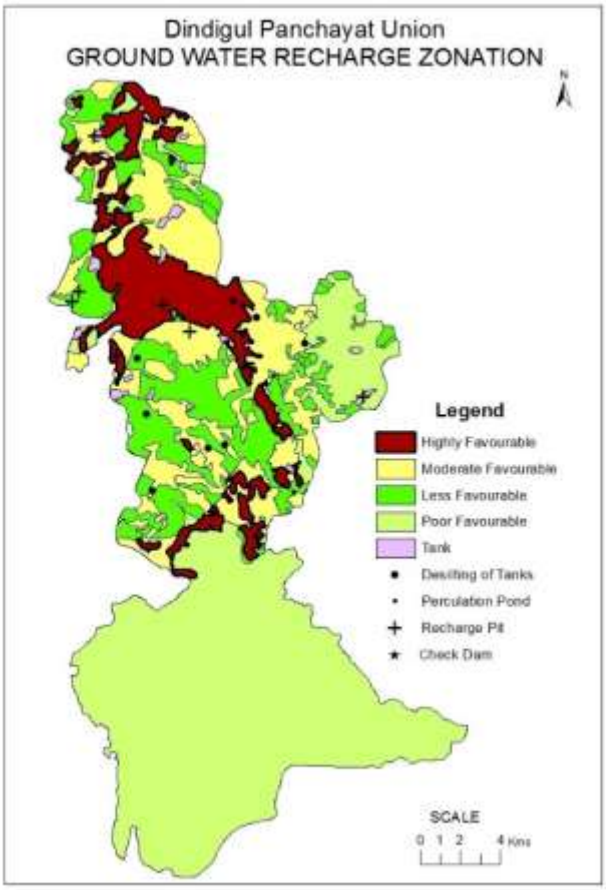
In the hard rock domains of the study area, factors like geomorphic units, water level fluctuation, lineament density, slope, runoff potential, soil characteristics, drainage density, and depth to weathered zone were considered as important factors influencing the ground water recharge. (Report on identification of recharge areas using RS and GIS in Tamil Nadu, Sponsored by Department of Rural Development, Government of Tamil Nadu Water Supply and Drainage Board, Chennai, 1998-99).

The above said thematic maps were integrated by giving weightages for different themes using GIS packages and Dindigul panchayat union was classified into different zones of recharge.

VII. INTEGRATION

By integrating various thematic layers, the study area has been classified into various recharge zones such as Highly favourable recharge zone, Moderately favourable recharge zone, Less favourable recharge zone, and Poor favourable recharge zone (Figure 3).

FIG 3: GROUND WATER RECHARGE ZONATION IN DINDIGUL PANCHAYAT UNION



The following table 1 shows the area covered by each Zonation Class in Dindigul Panchayat union.

TABLE 1

AREA COVERED BY GROUND WATER RECHARGE ZONATION CLASS IN DINDIGUL PANCHAYAT UNION

Recharge Zonation Class	***Area (Sq.Kms)***
Highly favourable zone	48.53
Moderately favourable zone	76.44
Less favourable zone	71.40
Poor favourable zone	213.33

From the above table, it could be observed that the area under poor ground water recharge class has covered 213.33 Sq.Kms (52.06 percent) followed by moderate (76.44 Sq.Kms;18.66 percent) and less favourable (71.40 Sq.Kms;17.43 percent) classes. The area under high ground water recharge class covers only 48.53 Sq.Kms (11.85 percent).

VIII.RESULTS AND RECOMMENDATIONS

Hornblende-biotite gneisses occupy major parts of Dindigul Panchayat Union. Kodaganar drains the major part of the study area with its tributaries. Ground water occurs generally under water table conditions in the weathered, jointed and fractured zones in the study area. Semi confining conditions of ground water occur along the lineament zones with the deep-seated fault zones.

In order to delineate different zones of recharge like high, moderate, less and poor, thematic maps on geology, geomorphology, soil and landuse drawn using the satellite data and the derived maps such as water quality, water level fluctuations, thickness of weathered zone, runoff potential and drainage density were integrated using Arc/MAP software. Field checks were carried out in all the village panchayats to check the zonation map and to select suitable sites for constructing recharge structures.

In the first stage, sites that are not having sufficient ground water potential were considered for artificial recharge activities. In the second stage, based on various parameters listed above, suitable recharge structures were proposed.

The following are the recommendations suggested through this study in Dindigul panchayat union. The favourable locations for the following recommendations are also clearly pointed out in Figure 3.

1. It is recommended to construct check dams in Adiyanuthuand Vellodu village panchayats.
2. Percolation Ponds are recommended in Vellodu village panchayat in the study area.
3. Desilting of tanks is recommended in Vellodu, Adiyanuthu, Silapadi, Mullipadi, Kurumbapatti, Pallapatti and Thottanuthu village panchayats.
4. Recharge pits are recommended wherever possible. Thickness of clay layers present in the area makes recharge difficult in Agaram, Periakottai and Chettinaickanpatti village panchayats in the study area.

IX.Suggestions for Sustainable Management of Ground Water Resources

The ground water resources of the study area could be maintained by adopting the measures suggested below.

1. Regulation in the utilization of ground water by enacting Legislation

Large-scale ground water exploitation is planned by a number of government agencies and private concerns for the following reasons.

1. To maximize agricultural production,
2. For providing drinking water supply to urban and rural areas and
3. Providing water supply for municipal and industrial sectors.

But, while executing schemes for ground water development, ground water discipline is not observed by most of the agriculturists. Such haphazard development of ground water will create a lot of socio-economic problems and may also cause permanent damage to ground water aquifers. Hence, it is very essential that ground water legislation is enacted expeditiously to regulate the development of ground water.

2. Artificial recharge to augment ground water resources

Artificial recharge schemes are to be proposed for

1. Reducing the adverse conditions of over exploitation of ground water,
2. Improving the conservation techniques and
3. Popularizing the storage techniques.

Construction of percolation ponds or check dams in the elevated terrains will help to minimize the natural flow of water either through rainfall or through the seasonal rivers and this in turn will benefit the surrounding areas by recharging the ground water.

3. Arresting further deterioration of ground water in the study area

Immediate steps have to be taken in grey area regions to arrest any further deterioration in the study area. But in the absence of ground water legislation it is very difficult to regulate ground water development in such critical areas. Further energization of wells in grey area regions has to be stopped to safeguard the existing ground water structures.

4. Popularizing micro-irrigation scheme

As ground water is becoming a scarce commodity, it has to be judiciously used by adopting water conservation techniques like sprinkler and drip irrigation systems. For this purpose, institutional finance has to be provided with attractive subsidy. Horticultural crops like coconut, mango, sapota, tamarind etc., can be developed advantageously by adopting these techniques and short-term crops like groundnut and vegetables can also be cultivated. Hence, these new techniques have to be popularized among the farmers.

5. Implementation of widespread rainwater harvesting methods

The method getting most popularized now is rainwater harvesting technique. By adopting this method, there is a possibility of addition of rainwater to the ground water source. Central Ground Water Board, an apex organization of ground water survey and exploration, has undertaken various schemes of artificial recharge in the country. The additional recharge through this technique has potential to substantially enhance the ground water resources already under stress.

X.CONCLUSION

From the above study made on the ground water recharge zonation in Dindigul panchayat union, it could be observed thatthepoor class has covered a larger area of 213.33 Sq.Kms (52.06 percent). To overcome this situation, favourable locations are recommended in certain areas of the study area. Added to this, suggestions for sustainable management for ground water resources in Dindigul panchayat union are also listed. These could help to preserve the existing ground water resources in the study area.

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