Prioritisation of Sub-Basins and Delineation of Suitable Zones for Artificial Groundwater Recharge of Nakrekal basin, Nalgonda district, Telangana state, India, using GIS and Remote Sensing tools

K. M. Ganesh, M. Jagapathi Raju, D. S. V. Prasad

Abstract: Evaluation of availability of groundwater, its present use and balance assets for subsequent usage are the main elements of sustainable development and management of ground water assets. To meet of the requirement of the population family and industrial needs had the demand of water resources is sustainly expanding to keep up the food security. Based on the results obtained by the analysis in the study, the tentative sites for construction of recharge structures such as percolation tanks, check dams, farm ponds, and the de-siltation of tanks have also been suggested. But the field investigation is inevitable before implementing any water-harvesting program. Further, the groundwater resource estimation has to be taken up at the regular intervals to know the net balance available for future use. The sub-basin wise groundwater resource estimation has also been carried out to prioritise the sub-basins for taking up the artificial recharge structures. Further, based on the suitable zones for artificial groundwater recharge and the prioritisation of the sub-basins, few sites have been tentatively located for taking up artificial recharge structures. Various thematic sheets have been produced based on "Groundwater Estimation Committee-1997 method and assessed the groundwater resource and groundwater balance. The layers generated from the satellite data (IRS ID LISS III) and from the field data have been used for the index overlay operations for delineation of Groundwater prospective zones as well as for delineating the suitable zones for artificial groundwater recharge structures.

Index Terms: Groundwater resource, groundwater balance, Artificial groundwater recharge

I. INTRODUCTION

The dependability of groundwater is very much increasing day by day and was already high on account of unreliable water supplies from the surface water reservoirs due to vagaries of monsoon.

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Further, in general 85% of the total rainfall is confined to south-west monsoon i.e. between June and September.

Much of the 4000 billion cu.m of the rain in the country falls in just 100 hrs out of the 8760 hrs in a year. Under such erratic rainfall conditions, the natural recharge to the groundwater becomes highly erratic.

At this juncture, the artificial recharge to groundwater is vital and needs the attention of the Government and the awareness of the common man [1].

The artificial recharge is to augment the natural infiltration of rainwater or surface run-off into the underground formation by artificial methods .

Wherever the demand of groundwater is more than its availability, augmentation of the resource is required by construction of percolation tanks, check dams and other type of recharge structures.

Though the augmentation of the resource is possible at many places, the prioritisation of the zones is essential.

Further, the identification of suitable zones with favourable hydrogeological conditions is a primary requisite to implement the construction of artificial recharge structures.

In the hilly and undulating terrain consisting various size of watershed to storage the water along the various water system of the existing water resources are not alignment to meet the demand but there is excess runoff which need to be harnessed for creating surface and sub-surface storage[2].

During the present study, the sub-basins have been prioritised for augmenting the groundwater recharge based on the stage of groundwater development for taking up the artificial recharge.

Further, an attempt has been made suggest the tentative sites for putting up different types of artificial recharge structures after delineating the favourable zones for artificial recharge.

A. Location

The Nalgonda district is one of the drought prone districts of Telangana and frequently being afflicted by famines. The study area, Nakrekal basin is a part of this district and falls in the Survey of India toposheet no's 56 0/8 and 56 0/12. It lies between the north latitudes of of $17^{0}00'00''$ to 17^{0} 15' 07" and Eastern longitudes of 79^{0} 16'28" to 79^{0} 34'15", and covers an area of about

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409 sq.km. Fig.1 depicts the location map of the area. The present study is intended to use the remote sensing data, G.I.S. technology and spatial modelling techniques, in the Nakrekal basin [3].

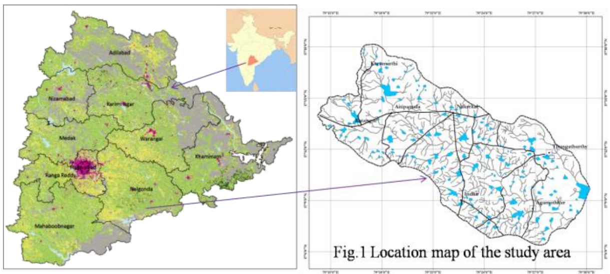

Fig.1 Location map of the study area

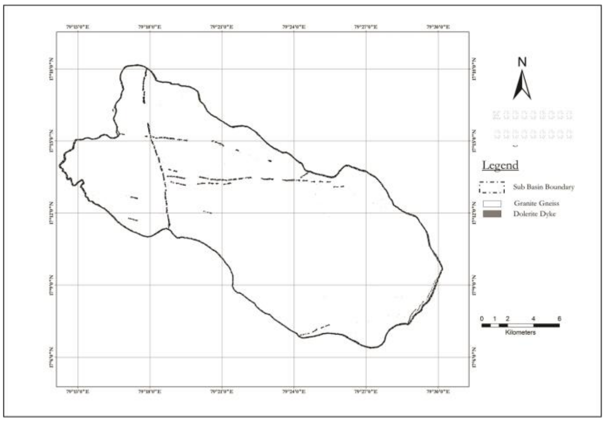

Fig.2 Geology of the study area

II. GEOLOGY OF THE STUDY AREA

In the area, biotite rich grey granites, pink granites, porphyritic granites and migmatitic granite gneisses are the common rock types and are referred in literature as the Peninsular gneisses. The migmatitic gneisses composed of feldspar, quartz, biotite and minor amounts of magnetite usually enclose biotite rich xenolith which shows considerable effects of interaction in the marginal zones. Veins of quartz, pegmatite, aplite and epidote are prevalent, and cut across all the granite rocks. Dolerite dykes, extending in length as much as 30 to 40 km. Cut across the rocks. Fig. 2 shows the geology area [4].

The younger intrusive rocks (dykes) consist of fine-grained dolerite and shows the ophitic and at few places porphyritic texture. These dykes appear as boulder strewn linear ridges due to their characteristic resistance to weathering and act as groundwater barriers. These dykes are mainly trending north-south and north-west –south-east. One major dyke trending north-south traverses through the northwestern part of the study area. Another major dyke trending northeast-southwest traverses through the southeastern boundary of the basin. Some of the dykes in the study area are concealed in nature. The secondary porosity and permeability resulting from structural discontinuities like faults, joints and fractures are the main sources of the movement and the occurrence of the groundwater in hard rock areas. In groundwater movement and introduce an element of directional variation in hydraulic conductance act as conduits of the structurally weak planes.

III. MATERIALS AND METHODS

A. Prioritization of sub-basins for artificial groundwater recharge

The sub-basin wise groundwater resource estimation is made as per rainfall infiltration method and water table fluctuation method. Based on the results obtained through the sub-basin wise estimation, the entire Nakrekal basin has been sub-divided into ten sub-basins and the stage of groundwater development has been estimated. It is noticed that one sub-basin is falling under critical category, five sub-basins are under the 'semi-critical' stage and the remaining four sub-basins are falling under 'safe' category [5]. The Fig. 3 depicts the sub-basin wise stage of groundwater development.

These sub-basins have been prioritised into 3 categories based on stage of groundwater development (GWD) – (i) High priority (GWD - > 80%) (ii) Medium priority (GWD – 70-80%) and (iii) Low priority (GWD- < 70%).

Based on this categorisation, two sub-basins are categorised as high priority, four sub-basins are categorised as Medium priority and the remaining four sub-basins are categorised as Low priority.

B. Delineation of Suitable zones for Artificial groundwater Recharge Method

The suitable zones for taking up the artificial recharge structures such as percolation tanks, check dams and farm ponds' have been delineated by integrating the following thematic layers..

- Hydrogeomorphology
- Lineaments
- Depth to geo-electrical basement
- Depth to water table
- Thickness of weathered zone
- Land use / Land cover
- Drainage frequency
- Soils

For joining the several maps an index overlay method was taken during the present investigation. In each input map were allot various scores in this model of the map classes occurred. The average score is then defined by

$$\bar{S} = \frac{\sum_{i}^{n} S_{ij}W_i}{\sum_{i}^{n} W_i}$$

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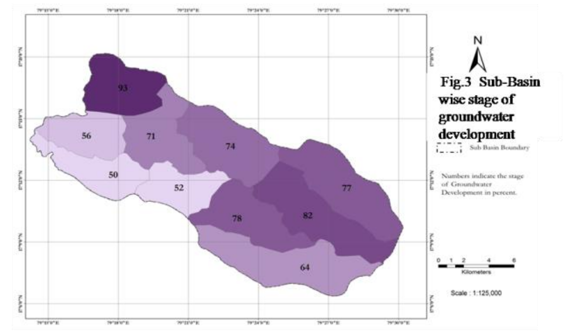

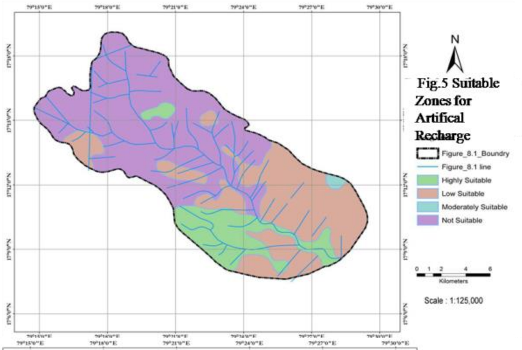

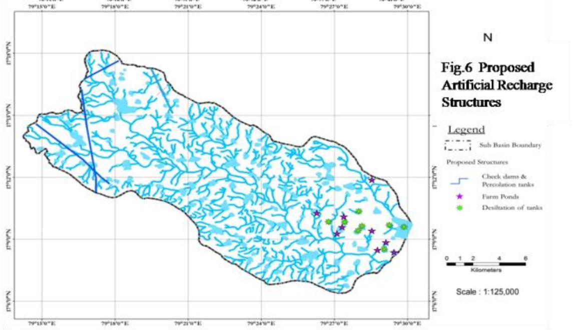

Where S is the weighted score for an area object (polygon, pixel) Wi is the weighted score for the i-th output map Sij is the score for the j-th class of the i-th map. The weights have been assigned to the each input map as shown in the Table 1.

Table 1 Weights assigned to the input maps.

S.NO.	Input map	Weight
1	Hydrogeomorphology	8
2	Lineaments-Confirmed	9
3	Lineaments-Inferred	7
4	Lineaments Intersection-Confirmed	9
5	Lineaments Intersection-Inferred	7
6	Depth to geo-electrical basement	7
7	Depth to water level	5
8	Thickness of weathered zone	3
9	Land use/ land cover	3
10	Drainage frequency	2
11	soils	1

Further the map classes in each input map have been assigned the scores based on their importance in augmenting the recharge to the groundwater. The Fig. 4A,B,C,D and Fig.4E,F,G,H are showing the thematic layers of the area**.**

The scores assigned to the map classes of each input map are shown in the Tables 2 to 9.

Table 2 Scores of the Hydrogeomorphic units.

S.NO.	Map class	Weight
1	Shallow valley fill	10
2	Moderately weathered Pediplain	9
3	Shallow weathered Pediplain	8
4	Shallow Buried Pediplain	4
5	Others (Inselbergs, Pediments, Linear ridges etc.)	0

Table 3 Scores of the Lineament buffers.

S.NO.	Input map	Weight
1	Lineaments-confirmed	9
2	Lineaments-inferred	7
3	Lineaments Intersection-Confirmed	9
4	Lineaments Intersection-Inferred	7

Table 4 Scores of the Geo-electrical basement depth.

S.NO.	Map class	Range	Score
1	Shallow	< 15	2
2	Low	15-25	3
3	Medium	25-35	5
4	Deep	35-45	7
5	Very deep	>45	8

Table 5 Scores of the Depth to water table.

S.NO.	Map class	Range	Score
1	Shallow	< 10	4
2	Low	10-12	6
3	Medium	12-14	8
4	Deep	>14	10

Table 6 Scores of the Thickness of weathered zone.

S.NO.	Map class	Range	Score
1	Shallow	< 10	4
2	Low	10-12	6
3	Medium	12-15	8
4	Deep	>15	10

Table 7 Scores of the Land use / Land cover.

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O.	class	ore
1	Irrigated areas	4
2	Open scrub	3
3	Settlements	2
4	Stony waste	0
5	Water bodies	0

Table 8 Scores of the Drainage frequency.

S.NO.	Map class	Score
1	<2	2
2	2-4	4
3	4-6	8
4	>6	12

Table 9 Scores of the Soil map.

S.NO.	Map class	Score
1	Sandy soil	4
2	Red soil	4
3	Alkaline	3
4	Black soil	2

IV. RESULTS AND DISCUSSION

By integrating the thematic layers mentioned above, the map showing the suitable zones for taking up the artificial recharge structures has been generated, which is presented in the Fig. 5 . The map thus obtained is classified into four zones as below

- Highly suitable zones
- Moderately suitable zones
- Low suitable zones
- Not suitable zones

These zones may be well thought of, along with the prioritised sub-basins for taking up the different artificial recharge structures.

Highly Suitable zone

These zones are mainly associated with the valley fill zones, deep water table areas, and deeply weathered and fractured zones.

These zones have high porosity and permeability developed because of the fracturing and deformation.

These zones are very suitable for constructing the percolation tanks and check dams.

The depth to the geo-electrical basement is also providing the information about the sub-surface weathering and the fracturing.

Moderately suitable zone

This zone is existed in the moderately weathered pediplains and some part of shallow weathered pediplains, and along the minor lineaments, where the porosity and permeability are developed because of the weathering and at places due to fractured zones.

The construction of check dams and at few places where the fractures traverse, this zone is suitable for percolation tanks.

Low Suitable zone

This zone is found in the shallow weathered and buried pediplains where the rate of infiltration and porosity are very low.

This zone is not suitable to take-up the massive scale artificial structures. However, some of the artificial recharge structures such as farm ponds can be taken up in these zones. Keeping in view, the stage of groundwater development, some farm ponds and de-siltation of the existing tanks have been recommended in this zone.

Not Suitable zone

The zone is confined to the part of shallow weathered pediplains, inselbergs, and pediment inselberg complexes.

These zones are lack of either primary or secondary porosity. Hence, this zone is not suitable for any kind of new artificial recharge structures.

However, the existing tanks may be de-silted, which can help in supplementing the recharge to groundwater in these zones to some extent.

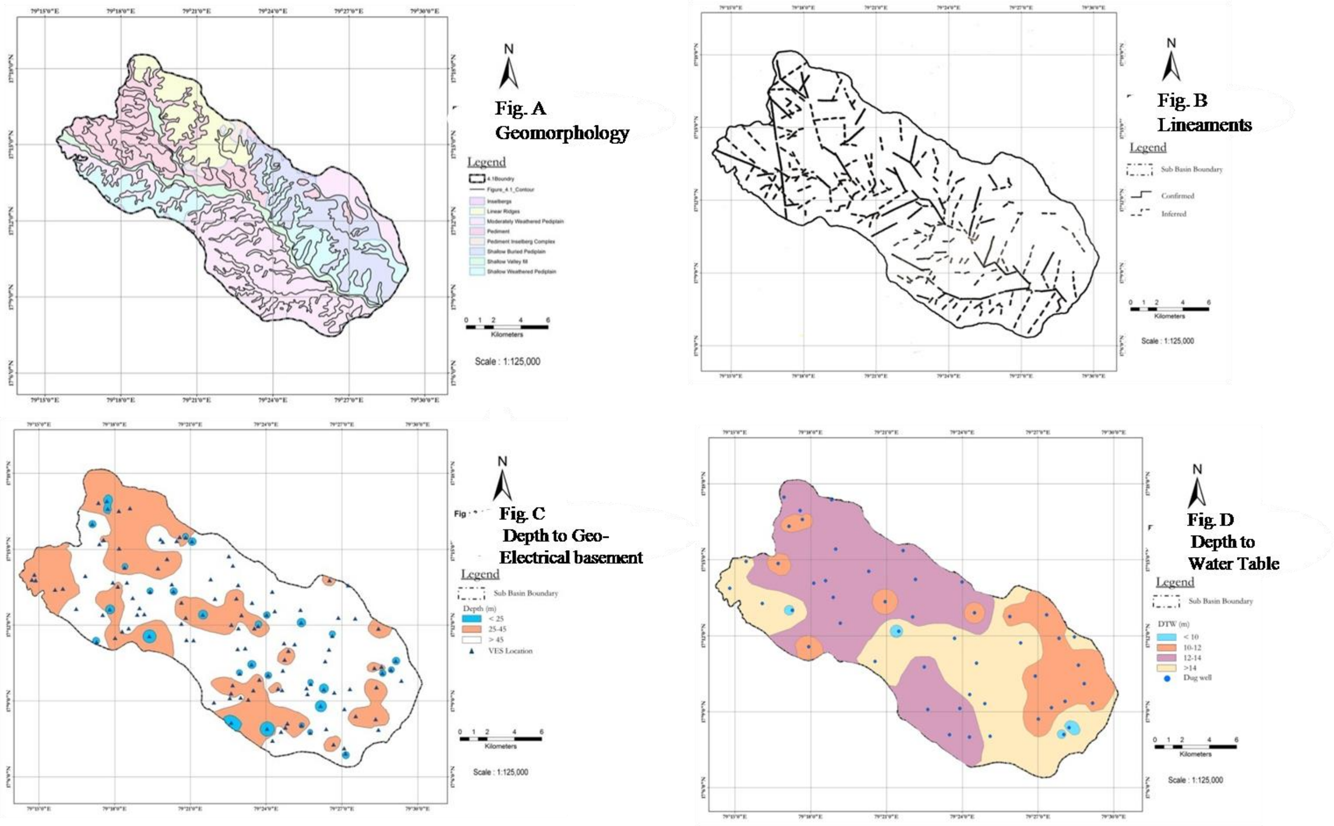

Fig. 4A,B,C.D. Thematic layers

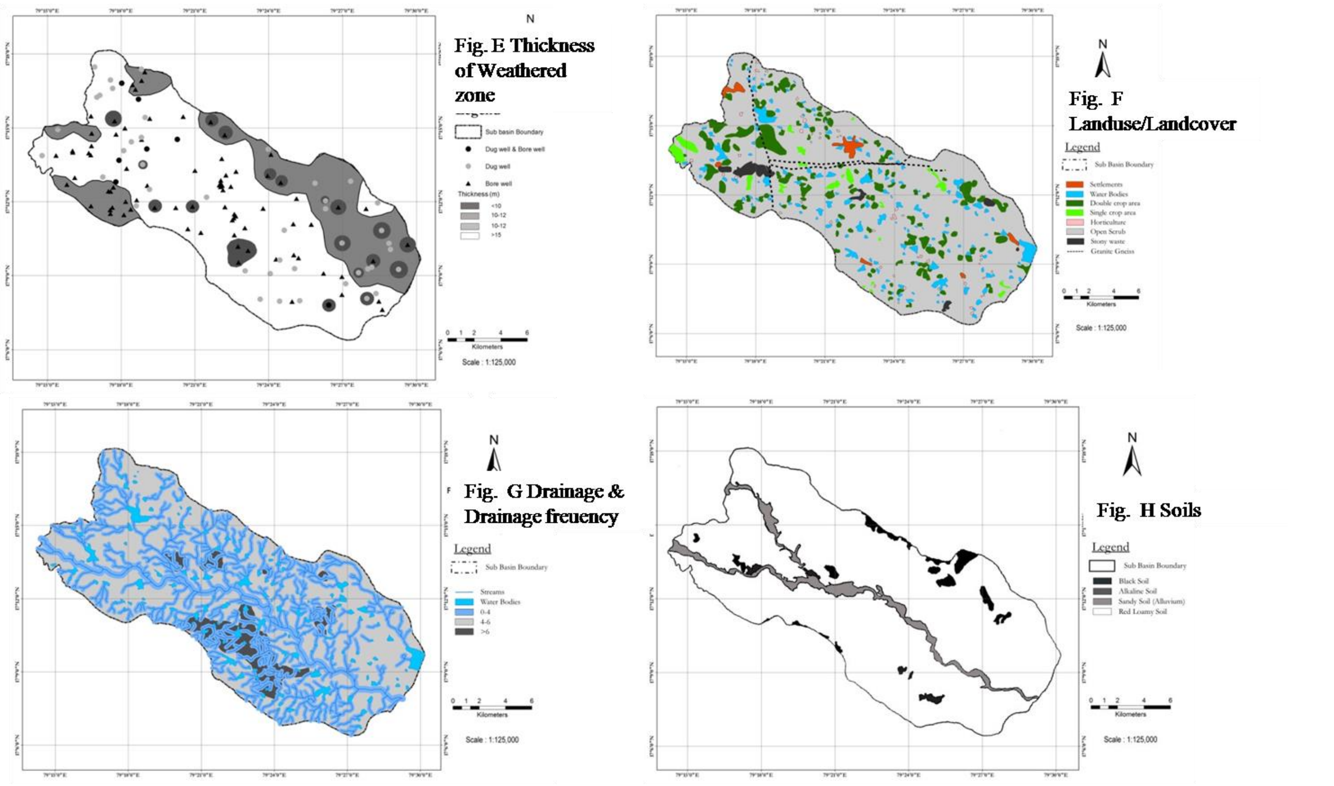

Fig. 4 E,F,G,H Thematic layers

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V. CONCLUSIONS

The suitable sites for putting up different types of recharge structures (percolation tanks,check dams, farm ponds and desiltation of tanks) have been suggested considering the points of

- Presence of suitable zone for artificial groundwater recharge
- Drainage and catchment area
- Presence of cultivated land
- Locations of habitations
- Presence of silted-up tanks/water bodies

The sites proposed for different types of artificial groundwater recharge structures are shown in the Fig. 6.

The prioritised zones are also shown in these maps, which will help the planners for judiciously deciding upon putting the recharge structures on priority.

It is important to note that the sites selected are tentative and the detailed field investigations are inevitable before implementing the structures.

The research area has been classified as Potable and Non-potable by integrating the three parameter maps. Further the causative parameter(s) responsible for non-potability of the groundwater has also been determined. As far as the Prioritisation of Sub-Basins for Groundwater Recharge is concerned the sub-basins have been prioritised based on the stage of groundwater development and on the long-term trend of depth to water table. Two sub-basins have been prioritised as high, four sub-basins as medium and the remaining four sub-basins as low priority. The Delineation of suitable zones and Identification of sites for Artificial Recharge to ground water research carried to understand the research area has been classified as Highly suitable, Moderately suitable, Low suitable and not suitable zones, based on its suitability for artificial recharge and few sites have also been identified for taking up artificial recharge structures.

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