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GROUNDWATER RECHARGE STUDIES IN HANUR WATERSHED, KOLLEGAL TALUK, CHAMARAJANAGAR DISTRICT, KARNATAKA STATE, INDIA, USING REMOTE SENSING ANDGIS

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ABSTRACT

Changes in groundwater storage involve various recharge and discharge processes. Major recharge sources are rainfall, recharge from rivers, tanks, irrigation fields, ponds, wetlands, etc. Similarly, discharge processes include evapotranspiration, pumping, base flow to rivers, etc. Groundwater resource estimation studies in Hanur Watershed of Kollegal Taluk, Chamarajanagar District, are the drought-prone area, the average rainy days are 49 (as per Chamarajanagar district glance book 2017-18). The Hanur watershed area receives an average annual rainfall of 571.56 mm. (2001-2018). Groundwater is the major source of drinking and irrigation purposes in present study area. The increasing population and agricultural growing demands of threatens the sustainability of water resources. The recharge of groundwater mainly depends on geology formation, soils, geomorphology, and slope of the study area maps are prepared for using IRS-1C and 1D PAN+LISS III (the Year2005 with the resolution of 26 meters) were overlaid on Survey of India (SOI) toposheets on1:50,000 scale constructed through visual interpretation and using Arc Map (V 10.21) and Erdas Imagine 9.2 software. Hence, the groundwater estimation of resources and status in groundwater development in Hanur Watershed is carried out utilizing the Remote Sensing and GIS techniques & Coupled with fieldwork. The groundwater resources were evaluated based on the Groundwater Resource Estimation Committee (GEC) norms of 1997.

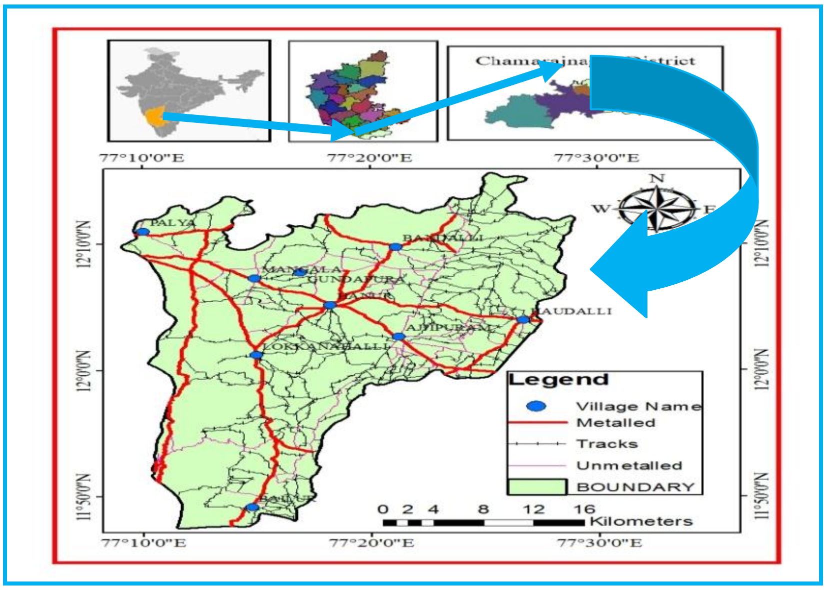
KEYWORDS: Groundwater resource, GEC-1997, GIS, Remote sensing, Hanur watershed.

1. INTRODUCTION

Water balance techniques have been extensively used to make quantitative estimates of water resources and the impact of man's activities on the hydrologic cycle (Kumar, 1996). The study of water balance in a groundwater basin forms a basis for the rational use, control, and redistribution of groundwater resources in time and space (Kumar and Kamal, 1992). Groundwater recharge is the annual volume of water, which enters into the saturated zone. The major source of recharge is the precipitation, which may penetrate the soil directly to the groundwater or may enter into surface water bodies like streams, lakes, reservoirs, etc. It is a replenishable but finite resource. Excessive withdrawal of groundwater may lead to depletion of groundwater storage which is likely to have serious social, economical, and environmental consequences. Therefore precise estimation of groundwater resources is essential for planning its optimum and judicious development and management.

2. Study area

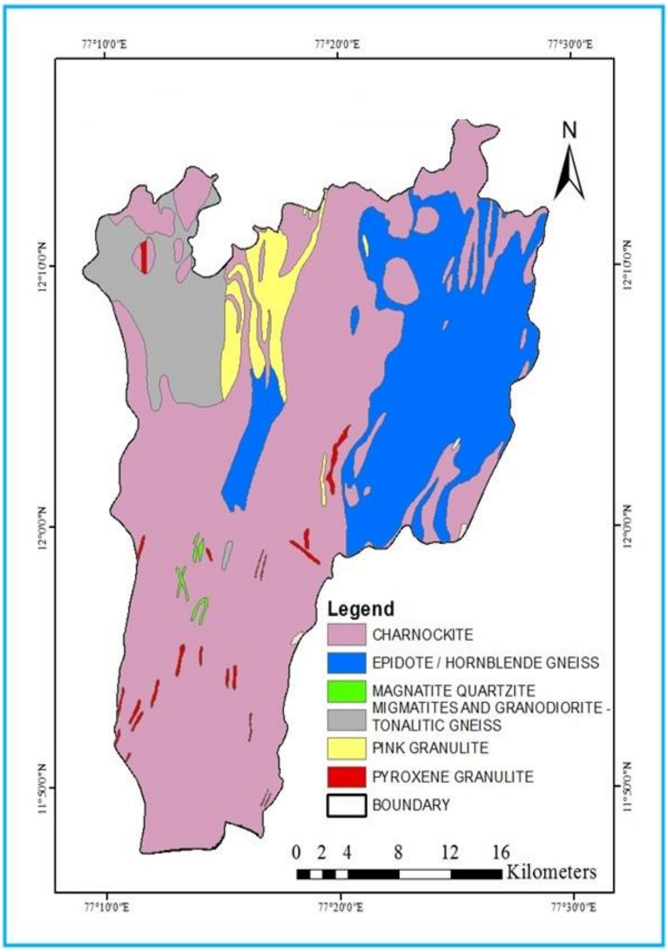
The Hanur watershed comprises southernmost part of Chamarajanagar district of Kollegal taluk, it lies between 77^0 5^1 to 77^0 30^1 East longitude 11^0 45^1 to 12^0 15^1 North latitude with the geographical area extent of 1026 sq km covering 115 villages coming under Survey of India (SOI) toposheets numbers are **57H/4, 57H/7, 57H/8, 58E/1, and 58E/5**.The nearest airport is Bangalore, which is 150 km it is well connected by road network to other important places**. (Map.1)**.



Map. 1: Location Map of the study area.

3. Hydrogeology of the Study area

Hanur watershed is a hard rock terrain comprising peninsular gneiss, Charnockite, and the limited extent of alluvium restricted mainly to sides of river courses. Among these, charnockite is the widespread formation in the study area. **(Map.2)** Crystalline rocks have no primary porosity. Hence, the water-bearing and yielding properties are primarily due to the development of secondary porosities like weathering, joints, fractures, and fissures. The thickness of the weathered zone generally from 5.00 m to 35.0m (Groundwater Information Booklet Chamarajanagar District, 2012). Groundwater occurs under phreatic (unconfined/water table) conditions in the weathered zone and alluvium. The alluvium forms a good shallow aquifer system along with the river courses. Groundwater occurs under semi-confined to confined conditions in fractured crystalline gneisses and charnockites. Groundwater exploration has proved the existence of potential fractured aquifers below the weathered zone at various depths down to 165 mbgl.



Map. 2: Geology map of the study area.

4. Concept of groundwater balance

Water balance techniques have been extensively used to make quantitative estimates of water resources and the impact of human activities on the hydrologic cycle. The study of water balance is defined as the systematic presentation of data on the supply and use of water within a geographic region for a specified period. With the water balance approach, it is possible to evaluate individual contribution of water sources in the system over different time, periods and to establish the degree of variation in water regime due to changes in components of the system. The basic concept of water balance is

Input to the system - Outflow from the system = Change in storage of the system

5. Methodology

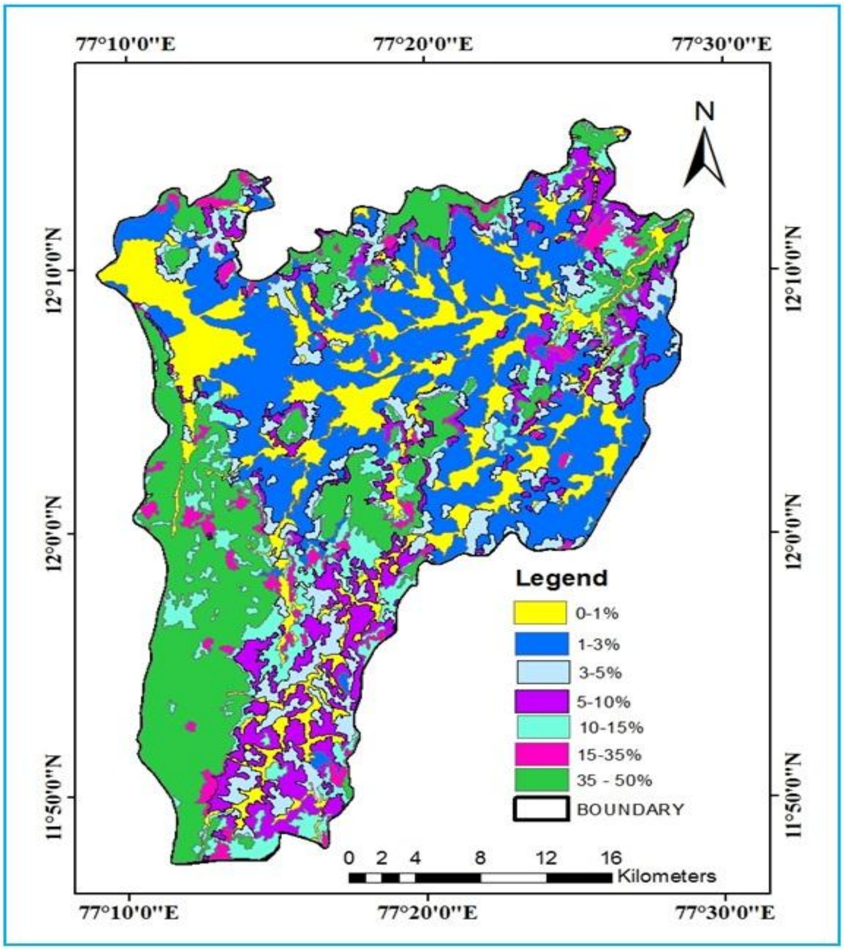
GEC-97 Methodology has been adopted in the present study to assess the groundwater balance

6. RESULTS AND DISCUSSIONS

The stage of groundwater development for the selected study area is assessed by estimating the various recharge and discharge components. The present study extensively used the Groundwater resources Estimation Committee norms and procedures.

7. Unit of Assessment

Hanur watershed area taken as the basic unit for groundwater recharges assessment. The total area of the watershed has an extent of 1026 km^2 Out of the total geographic area, the hilly terrain which is having slope more than 20%, is identified and excluded from the groundwater recharge assessment as these areas are not likely to contribute the groundwater recharge **(Map.3).** The Slope map of the study area depicts this situation. A significant portion of the SW side and hilltops in the other portions of the study area are identified as high runoff areas and are not worthy enough to consider for groundwater recharge estimation. The norms recommended by GEC 1997, specific yield value of 3 %, and rainfall infiltration factor of 12 % for weathered granite and gneiss formation is taken for recharge calculation.



Map 3: Slope Map of the study area.

8. Groundwater Level Fluctuations.

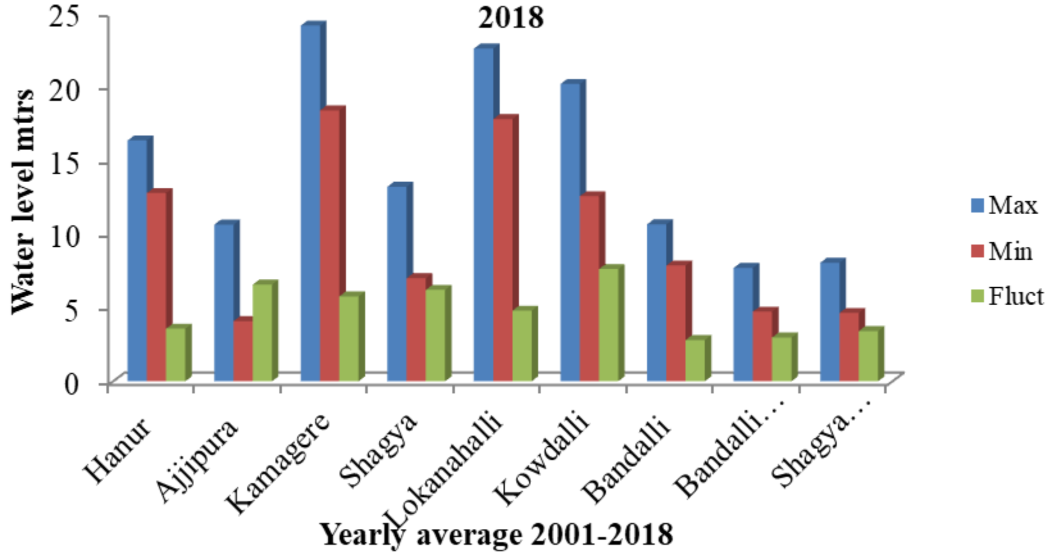
Water levels in aquifers reflect a dynamic balance between groundwater recharge, storage, and discharge. If recharge exceeds discharge, the volume of water in storage will increase and water levels will rise; if discharge exceeds recharge, the volume of water in storage will decrease and water levels will fall. Because recharge and discharge are not distributed uniformly in space and time, ground-water levels are continuously rising or falling to adjust to the resulting imbalances. Water levels in wells reflect these changes and provide the principal means of tracking changes in groundwater storage over time. Water-level measurements also provide insight into the physical properties that control aquifer recharge, storage, and discharge since these factors affect the timing and intensity of responses to hydrologic stresses such as precipitation or pumping.

Monthly Water level Data have been collected from the Department of Mines and Geology Chamarajanagar district from 2001 to 2018 The average Groundwater level fluctuation is 4.69 mbgl **(Table .1)** There are 9 observatory wells in the study area. These wells are monitored every month in the year; the average water level fluctuation is highest in Kowdalli village and lowest in Bandalli village.

Table 1: Average Annual Groundwater Level Fluctuation in Hanur Watershed 2001-2018.

Village Name	Year	Max	Min	Fluct
Hanur	2001-2018	16.345	12.8	3.5
Ajjipura	2001-2018	10.64	4	6.64
Kamagere	2001-2018	14.2	9.65	4.55
Shagya	2001-2018	13.28	7	6.28
Lokkanahalli	2001-2018	22.6	17.8	4.79
Kowdalli	2001-2018	19.83	12.48	7.35
Bandalli	2001-2018	10.65	7.86	2.8
Bandalli (Dug well)	2001-2018	7.7	4.73	2.97
Shagya (Dug well)	2001-2018	8.04	4.63	3.41
				4.69

Fig .1 Hanur Watershed Average Water level data in mtrs 2001-2018

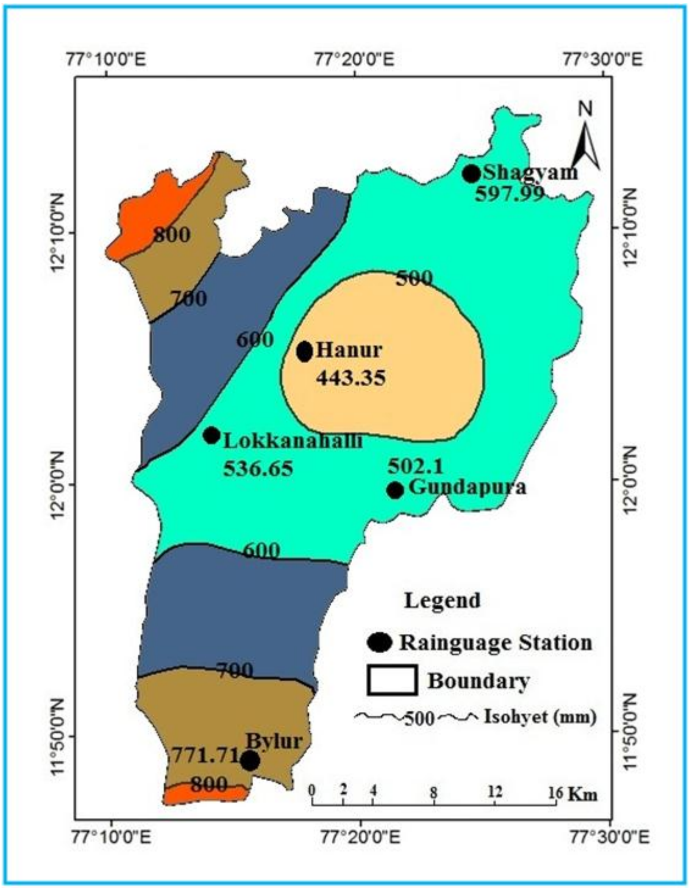


9. Groundwater recharge components

a) Recharge from rainfall (Rrf)

Precipitation is a major source of groundwater recharge in hard rock terrain. The five influencing rain gauge stations for the study area are, Bylur, Lokkanahalli, Shagyam, Hanur, and Gundapura. The average annual highest rainfall is noticed in Bylur (777.71mm from 2001-2018) the total area of the watershed has been calculated through digitization using Arc Map. The area for the assessment of recharge is estimated by deducting the hilly area from the total area (slope >20%). The weighted average infiltration factor is assessed by considering the infiltration factor as per the GEC methodology for hard rock 0.12. The total area of Hanur watershed covers 1026 Km^2, less hilly terrain slope more than 20% is 235.4 km^2 the annual average rainfall of the study area from 2001 to 2018 is 571.56mm. **(Map.4)**

Groundwater recharge from rainfall = Watershed area x RFI x Annual average rainfall
= 790.6 x 0.12 x 0. 57156 = **54.23 M. Cu. M**



Map. 4: Rainfall map of the study area.

b) Recharge from water bodies (Rt)

The GEC (1997) has recommended that based on the average area of the water spread, the recharge from storage tanks and ponds may be taken as 1.4 mm per day for the period in which the water bodies have water. The area of the water spread has been calculated using land use/ land cover map of the study area. During the monsoon seasons, water will be available approximately 120 days and during the non-monsoon seasons; water will be available for 90 days (January-March).The total water available days are 210. The water spread area in Hanur watershed is 5.47 sq km based on this assumption; recharge from water bodies has been calculated as follows.

Rt = Water spread area x No of days water available x seepage factor

Rt = 5.47 sq km x 210 days x 1.4 mm per day

Rt = 5.47x210x0.14

= 160.818 million cubic meters

c) Recharge from field irrigation

The process of re-entry of a part of the water used for irrigation is called the return flow. Percolation from the applied irrigation water was derived both from the surface water and groundwater sources. The main crops in the study area are paddy, jowar, Bajra, Ragi, pulses, oilseeds, cotton, and sugarcane, etc. The total irrigated lands in Hanur watershed is 31,142 hectares in the year 2017-2018 (as per Chamarajanagar district glance 2017-2018). The total water requirement is 91.99 M.cu m and the total groundwater return recharge is 11.18 M cu. m **(Table.2).**

Table 2: Crop duty and Groundwater recharge in Hanur Watershed 2017-2018 in Hecters.

Sl No.	Description	Paddy	Khariff Season	Rabi Season	Summer Season	Perennial Sugarcane
1	Extent in Hectares	1200	23837	4490	760	855
2	Water requirement in mts (per Hectare)	1.2	0.21	0.29	0.56	1.2
3	Total water requirement in mts (per Hectare)	1440	5005.77	1302.1	425.6	1026
4	% of recharge considered	40 % (Range of depth to water table below ground level 10 to 25 mtrs as per GEC Norms 2009 page no 215)	5%	5%	5%	20%
5	Ground water recharge in hectare meter	576	250.29	65.1	21.28	205.2

10. Groundwater Draft or Discharge

The groundwater draft is the quantity of groundwater withdrawn artificially or naturally from the aquifers, during a certain period. The outflow from the system is considered mainly through the groundwater draft. This is mainly through pumping from a number of bore wells for the purpose of agricultural, domestic, and industrial use. The annual draft for irrigation purposes is estimated based on the total number of bore wells and the average annual unit draft. The unit draft is calculated based on the amount of water pumped from wells, the number of pumping hours, and the total number of pumping days in a year. The unit draft of different types of wells is 1.7 ham for bore well with pumpset, 0.90 ham for dug well with pumpset, and 1.98 ham for dug cum bore well with pumpset (GWREC 1997 page no 212 appendix 3.1). The wells data is collected from the department of economics and statistics Chamarajanagar district, there are 6222 bore wells, 2570 dug cum bore wells present in the study area. 30% of the total annual draft is considered as a groundwater draft during the monsoon period and the remaining 70% is considered as a groundwater draft during the Non-monsoon period. By using the above estimation the annual gross draft is estimated as the annual gross draft from bore well is 105.75 M.cu. M and 50.86 M cu. m from dug cum bore well with pumpset.

11. Groundwater balance

It is the most important factor to determine the dynamic groundwater reserve of the study area for future development. The basic hydrological principle states that a balance must exist among the quantity of water supplied to the watershed (recharge) and the amount leaving from the watershed (discharge) and the change in groundwater storage (Karanth, 1987). The groundwater balance is computed as follows:

Groundwater balance = (Net recharge) - (Net discharge/ draft)

= (54.23 +160.818+11.18) – (105.75+50.86)

= (226.228)-(156.61) = 69.618 M. cu. m

12. Stage of Groundwater Development

The level of groundwater development in an area is computed as the ratio of the net yearly draft to the total utilizable groundwater resource for irrigation (GWS No. 286). It can be expressed as

Level of Groundwater Development= Net Yearly Draft / Utilizable Resource for Irrigation x 100

In the present study groundwater resource estimation committee's methodology -1997 was followed for evaluating the groundwater recharge assessment in the study area. Recharge from Rainfall (Rrf) and recharge from water bodies (Rt) based on crop duty and unit draft methods are used for groundwater recharge assessment of the Hanur watershed. The total geographical area of the watershed is 1026 sq km out of which, slope more than 20% 235.4

The groundwater recharge from rainfall by rainfall infiltration factor is also adopted. In this method, the rainfall infiltration factor is considered as 12 % and recharge from water bodies' seepage factor is considered as 1.4 mm per day as per GWREC 1997. The average period of rainfall is 18 years i.e. from 2001 to 2018 is considered for 5 rain gauge stations average annual rainfall is 571.66 mm. By using the above method, an attempt has been made to categorize the areas of the watersheds into four categories namely, safe, (<70%) semi-critical, (70%- 90%) critical (90% - 100%) and overexploited (>100%) areas, as per the groundwater recharge estimation studies in Hanur watershed overall recharge is 226.228 M. cu. m and groundwater draft 156.61 M. cu. m the balance is 69.618 M. cu. m the stage of groundwater utilization percentage is 69.22% the Hanur watershed fall into safe categories.

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