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Effect of Artificial Recharge Structure on UnconfinedAquifer in Basalt Land Form: A Case Study

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ABSTRACT

Groundwater storage of an area depends on the factors such as topography, geology, intensityof rainfall, number of rainy days and nature and thickness of soil cover. Hard rock poses unusual problems due to marked variation in hydraulic characteristics. This poses uncertain issues about the aquifer sustainability, so conservation of ground water is essential, which can be achieved by artificial recharge to ground water table. In situ tests were conducted for determination of hydraulic properties and yield characteristics of open wells. The study revealed the fact that, groundwater availability is quite appreciable in the middle and western portion of the sub watershed whereas, northern portions of the sub watershed need proper strategies for conservation, to meet future demands. Hence, artificial recharge for the open wells is essential in such conditions. Hence, in the current study, an attempt is made towards the assessment of the effect of check dams constructed on small streams and rivers in hard rock landscape with a semi-arid climate. For this purpose, along with field tests, SWAT and HYDRUS – 1D model were used. It is noted that there is increase in water levels recorded after construction of the recharge structures. The characteristics of soil and thickness of the weathered zone had a significant impact on recharge. Construction of recharge structures at the sub- watershed level is useful in the development of ground water potential.

Key Words: *Check Dam , Double Ring Infilterometer, Ground water, Gulp Permeameter,HYDRUS-1D Model,, Recharge Percentage, Recharge Structure, SWAT model,, Unconfined aquifer.*

1 Introduction

Groundwater storage of an area depends on the factors such as topography, geology, intensity of rainfall, number of rainy days and nature and thickness of soil cover. Quantitative estimate of recharge to aquifers and storage to aquifers information is needed. In the current scenario, the groundwater has increased in India, (According to UN Water Resources Utilization Report 2010), because of which, over exploitation, over dependency on ground water, the depletion, has increased. So, number of bore wells and open wells are drying up or has become dysfunctional. In the year 2014, 13000 bore were declared dysfunctional according to the bore well census, conducted by department of minor irrigation, government of Karnataka. There were 14 lakh bore wells in Karnataka state (Based on the bore well census, 2019, conducted by Department of Minor Irrigation, Government of Karnataka, India). This quantity is increasing by 30 % annually. Hence, it is evident that, there is increasing dependency on ground water and also, the replenishment is essential to retain the aquifer (unconfined or deep aquifers) sustainability, to satisfy the demand for adequately. Further, recharge to the aquifer in hard rock landscape is a challenging task, since , there is heterogeneity in the aquifer geometry and complexity in the hydro-geological processes. Natural recharge, in these aquifers is dependent on rainfall. Drop in rainfall, also results in drop in recharge rate to the aquifers. So,artificial means for recharge to the aquifers is essential, particularly in hard rock aquifers. A water harvesting structure is constructed across a stream , or drainage or in the zones with good recharge potential. This recharge structure, stores runoff and transmits the runoff to the water table in the sub surface of ground, thus causes recharge to the aquifer. Nala bund is one such kind of recharge structure, which is more suitable for recharge to unconfined aquifers (shallow aquifers). In the current work, an attempt is made to illustrate the effect of nala bund on ground water replenishment. Here nala bund means check dam.

R-Environment modeling method to determine recharge caused due to check dam in a village in Rajkot district of Gujarat state, India. From this study, it was found that, the total storage of check dam is 26000 cubic meters and 3% of runoff volume will recharge ground water table [1].

Dijuma et-al-2017, has used SWAT modeling method to illustrate the impact of check dam on replenishment of ground water. In this case, the check dam was built across the epherimal stream and it was found that, the rate of ground water replenishment was 1 MCM annually.

Thiyagirajan et al-2017, has used physical measurement method to evaluate the impact of check dam on open wells and bore wells. 5 meters increase in water head was found in dug wells. The effect of check dam was studied by Department of Minor Irrigation, Government of Karnataka, India for 5 open wells in the year 2017. It was found that, there is 5 meters rise in water head in the dug well.

Sachin Pathirana et-al, 2021, estimated the depth of fluctuation using HYDRUS-1 D model, it was found that, the R^2,value between simulated readings and observed readings was 0.92, hence, there is good agreement in the estimated ground water heads with respect to observed values.
Jirka Samnuak -2015 has demonstrated the use of HYDRUS-1D modeling software for estimation f recharge to ground water table.
Sarhat Tonkul et al-2019, has demonstrated the use of HYDRUS-1D modeling software for estimation of recharge to ground water table.Ground water regime is a dynamic system in which water is absorbed at the land surface and eventually recycled to the surface, in return. The movement to the ground water occurs through the porous unconsolidated sediments and through the interconnected openings in the rocks that mantle the earth. The availability and flow depends on geo-hydrology of the formations at the sub surface levels. Deccan part of India is covered under hard rock, Predominantly basalt, trap and granitic formations. The classical concept of discontinuous aquifer has been developed during the seventies, which are the result of large drillings in Africa (Detay et al.,1989). It considers that, such type of aquifers are formed are tectonic open fractures. These are decreasing from past several years.

1.1 **Objective:** Determining the effect of recharge due to existing check dams on ground water levels in unconfined aquifer.

1.2 **Region of Study**

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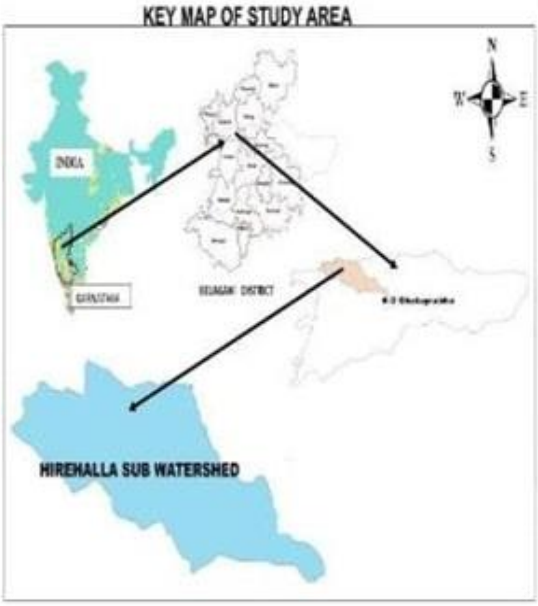
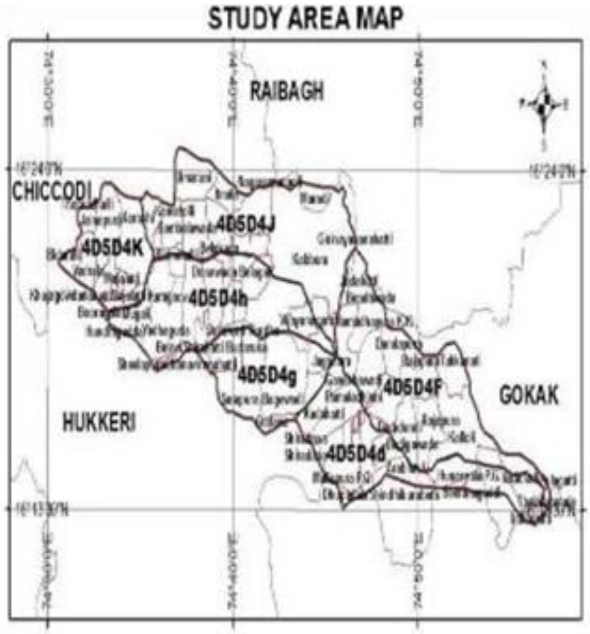
The region of study is a sub water shed (4D5D4) lies in Ghataprabha sub basin, Belagavi district, and it is surrounded by Riabagh, Hukkeri, Chiccodi, Gokak taluks. The research area's average yearly rainfall is 600 mm. Population of the study region is around 2 lakhs. Sugar cane is the main crop. The sub watershed name is Hirehalla sub water shed with geographical area of 435 square kilometers. In this study area, there are about 1500 open wells as per Land use / Land cover data in the year 2020





1.3 LU/LC

According to LU / LC statistics (2020) , out of 435 square kilometers, 355 square kilometers is under crop land, 18 square kilometers under settlement, 4.3 square kilometers under water bodies, 58 square kilometers is under waste lands. Hence, it is evident that, majority area is covered under agriculture; water resource planning is much required for the region.

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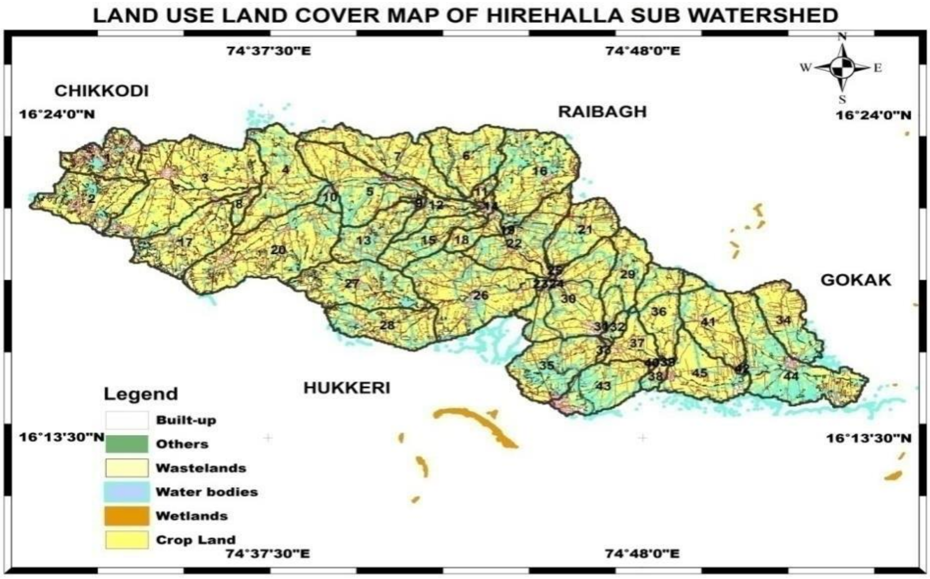


Figure-2 -LU / LC –Map of Hirehalla Sub watershed

1.4 Soil map

30% of the study region is covered under loamy soil, 20 % region is covered under clayey soil,35 % region is covered under loamy skeletol soil and 5% is covered under very fine soil. Hence, it is evident that, predominantly, the region of study is covered under loamy, loamy skeletol and clayey soils.

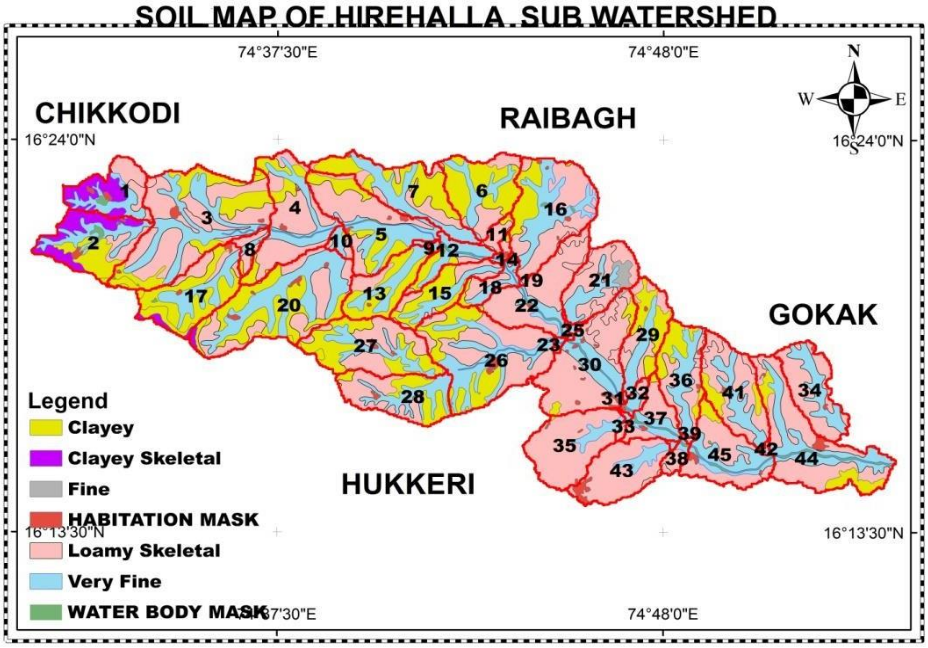


Figure-3- Soil Map of Hirehalla Sub watershed

1.5 Slope Map

70 % of the study region fall under gentel slope (0 to 5% slope), 20 % falls under medium slope (5 to 10% slope) and remaining 10 % , falls under steep slope (10% to 18% slope). The steep slope is located in the peripherals, followed by moderate and gentel slope towards main stream.

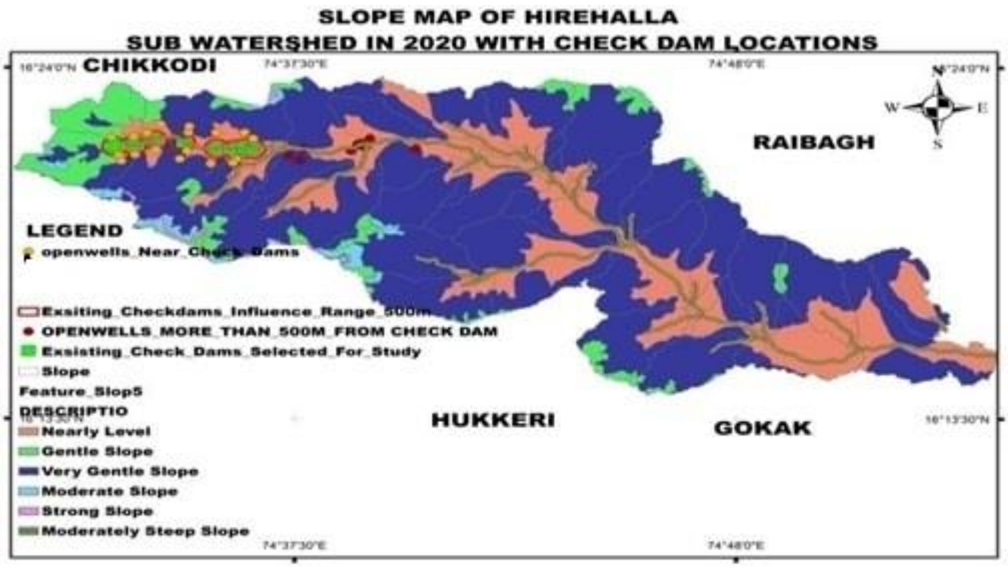


Figure-4- Slope Map of Hirehalla Sub watershed

1.6 Drainage

The study region consists of 655 numbers (455 KM), 350 (225 KM), 20 (30 KM) and 1 (56 KM) 1st , 2nd , 3rd and 4th order streams of different lengths respectively. The region is elongated in shape with length of 60 kilo meters in east west direction and 30 kilo meters from north to south..

1.7 Rainfall:

The research area's average yearly rainfall as observed from the past 30 years (from year 1990 to year 2020) is 630 milli meters. In years 2005, 2018,2019, 2021, the average annual rainfall was 1800 milli meters which is 3 times more than the actual average annual rainfall.

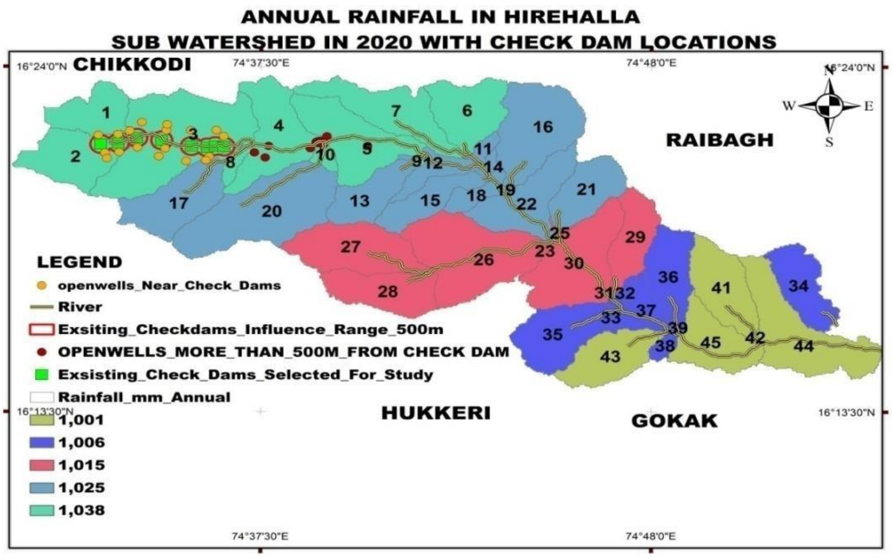


Figure-5-Annual Rainfall in Hirehalla Sub watershed

2. Methodology

2.1 Data Collection

2.1.1 Values for soil properties, the soil samples were collected during field visits to the check dam sites, these samples were tested in the laboratory for the index properties of soil , such as porosity, soil moisture content, bulk density, water retention capacity and saturated water content. Further, saturated hydraulic conductivity of soil specimens were determined using Gulp- Permeameter. Water retention capacity was determined using pressure plate apparatus.

2. 1. 2 Infilteration test was carried out in the site in the in situ condition, using double ring infilterometer near to check dams, to determine the infiltration rate near check dams (less than 500 meters on the downstream of the check dam)

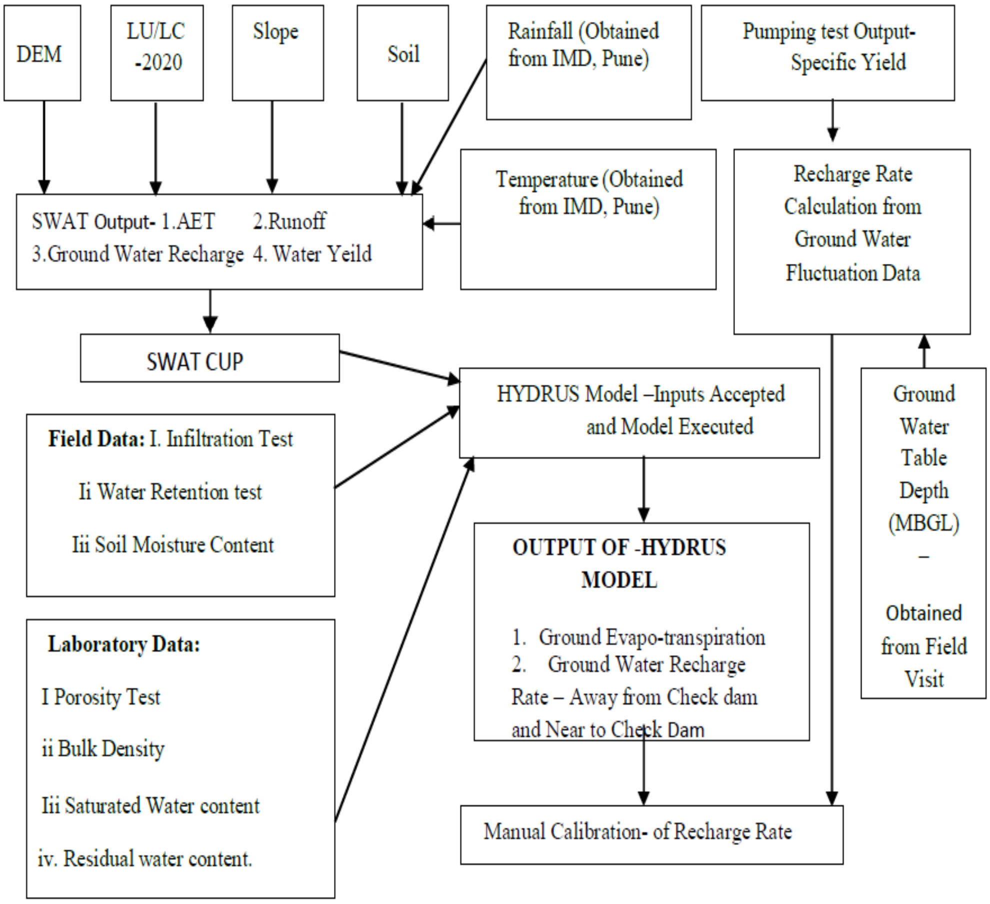


Figure-6-Flow Chart of Methodology of Assessment of Recharge Effect of Check Dam

2.1.3 Pump tests were carried out in 8 locations near to the check dam to find out specific yield. This was done for 5 hours period of continues pumping out of water from wells. The method adopted in pumping test was constant head method, before start of pumping, the, static water level was noted down.

2.2 Data Processing:

LU/LC, Soil and slope shape files were converted to raster format for SWAT input in ARCGIS 10.1, Net CDF files of rainfall were converted into XL spread sheets format in ARCGIS 10.1, temperature data was converted to XL spread sheets using C-program. For observations made in field tests (infiltration test, GW fluctuation readings and pump test) and for tests conducted in laboratory (soil moisture content, saturated hydraulic conductivity, water retention, porosity and bulk density) , separate XL spread sheets were prepared. For runoff, data was obtained from Gokak falls stream gauge station, a separate spread sheet is maintained for this purpose.

2.3 Procedure of Work:

I) Data Acquisition-Field visit to capture GPS readings to locate check dam positions in site, soil samples collection, infiltration and pump tests, KSRSAC and download rainfall data from IMD data and runoff data acquisition from Gokak falls stream guage station .

ii) Data Processing -Conversion of acquired and downloaded data formats to the format required for model input.

iii) Carry of laboratory tests for model input

IV Rainfall Trend Analysis – Done to find influence of rainfall on natural ground water recharge.

V) Modelling

A.SWAT Modeling: The DEM is given as input to ARCSWAT, HRU ae formed, Slope, LU/LC, Soil slope shape files are converted to raster data and are given as input to ARCSWAT, including rainfall and temperature (obtained from IMD). The simulation period is from year 2014 to year 2022. The outputs of SWAT model VIZ runoff, AET, Ground water recharge and water yield are obtained and are calibrated in SWAT-CUP-2012, using SUFI-2 algorithm. The statistics of discharge (observation Function) viz Net CLIFF, R2, PBIAs are obtained. The outputs obtained from SWAT model are given as input to HYDRUS-1D model, as shown in figure-2.

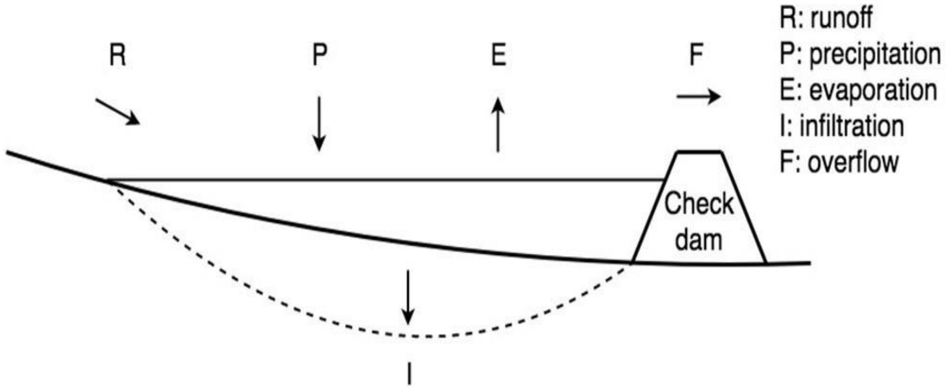
B.HYDRUS Modeling:

The data obtained from SWAT is given as input to HYDRUS model. Apart from SWAT input, field data such as infiltration, water retention and soil moisture content, ground water table fluctuation, are also given as input for HYRUS-1D model. The saturated hydraulic conductivity is calculated using Richard equation, the data required for this purpose is determined using van Geutchen model and hydraulic conductivity function. This data i,e saturated hydraulic conductivity is also given as input to HYDRUS-1D. Then, this is followed by Simulation of the model from 2014 year to 2021.

Vi) Output of HYDRUS-1D modeling: The output obtained is manually calibrated to find effect o check dam on ground water table

Vii Location of check dams

Check Dam: This is a small height barrier with masonry construction, (Masonry height < 3 meters) (Concrete or Stone Masonry) constructed across a flowing water body (probably 2nd or 3rd order streams) to store runoff to the extent of 0.2 MCM and improve ground water recharge and irrigation potential, at the radius of approximately 800 meters with in the location of the dam.



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Location of check dams was done using GPS (Garmin receiving set,) was used and also verified for proper positioning of check dam on stream. This was done during field visit to the check dam sites.

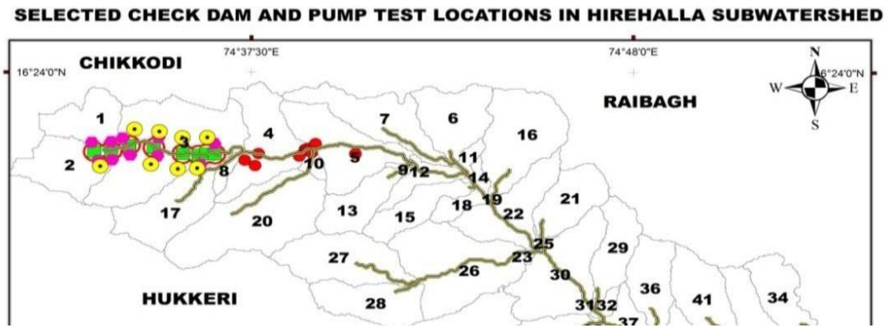

Figure-7- Water Balance Components of Check Dam

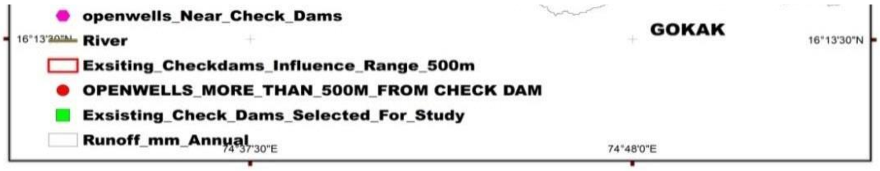

Figure-8- Location of Check Dam, Pump Test Locations

2.4 SWAT input data i,e LU/LC, soil, slope

This data is collected from KSRSAC, Bangalore in the form of shape files, CARTOSAT-1 DEM of the study area of resolution 30 meters X 30 meters is downloaded from ISRO BHUVAN portal, rainfall and temperature data are downloaded from IMD, Pune portal, inthe form of NetCDF files, observed runoff data was obtained from Gokak falls stream gauge station from year 2015 to year 2021.

2.5 Ground water table fluctuation data was generated by measuring ground water levels (in meters) (MBGL), which was done during field visits. This data was collected in every rainfall season from year 2015 to year 2021 and XL spread sheet form of the fluctuation data was prepared.

2.6 values for soil properties viz- Porosity, bulk density, soil moisture content, water retention capacity and saturated water content were determined by laboratory tests on soil samples collected during field visits. ,

2.7 Infiltration test is done in the in situ condition, using double ring infilterometer, near to check dams (less than 500 meters horizontal distance on the downstream of the check dam)

2.8 Pump tests were carried out in 8 locations near to the check dam to determine specific yield. This was done for 5 hours period of continues pumping out of water from wells. The method adopted in pumping test was constant head method, before start of pumping, the, static water level was noted down.

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2.9 SWAT Model Equation

$$SWt = SW0 + \sum_{i=1}^{t}(Rday - Qsurf - Wseep - Ea - Qgw) \rightarrow (1)$$

Swt-Final Soil Water content (mm) ,

Sw0—initial soil water content at monthly time step (mm)

Rday- Amount of Precipitation at monthly time step ,i (mm)

Qsurf-Amount of Surface runoff at monthly time step, i (mm)

Wseep- Amount of waterentering vadose zone at monthly time step, i (mm)

Ea- Amount of Evapotranspiration at monthly time step, i (mm)

Qgw- Amount of returnflow at monthly time step, i (mm)

2.10 Water Retention equation:

This is needed to model the movement of water in unsaturated zone and to determine thewater retention.

$Se = (\theta-\theta r)/(\theta s-\theta r) = [1+ \alpha\ |h|^{n}]^{m}$ for $h < 0$ Se- Water retention--→(2)

$Se = 1$ for $h > 0$

Se- Water retention h—Soil water pressure
m,n,α-- Van Gunetchen Model Parameters
θ—Exsisting Water content or observed or insitu water content θr- Residual water content
θs- Saturated water content

2.11 Hydraulic Conductivity Conductivity

$K= Ks\ S_e^{1/2} [1 – (1 – Se^{1/m})^{m}]^{2}$ -------------→ (3)

Ks-Saturated Hydraulic conductivity, determined using laboratory tests.
Se- Water Retention
m- Van Gunetchen Model Parameter = 1- (1/n) K- Hydraulic Conductivity

3 .0 Results

3.1. Rainfall Trend Analysis

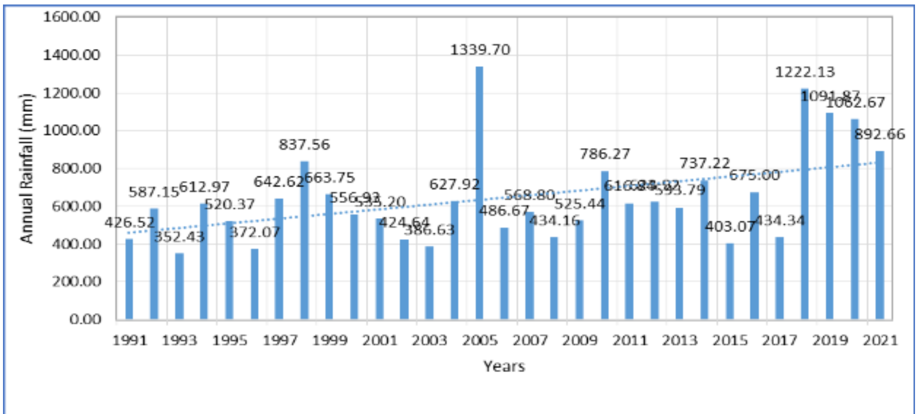

Figure : Rainfall Variation During the Last Three Decades

Figure-9-Rainfall Trend Analysis Graph

Characterization of rainfall is of paramount importance in the design of hydrologic system for water use and management. In some arid areas of the world failure to account for the drainage of storm water sometimes causes tremendous inconvenience. In the study region considerable amount of water is lost by Evapo-transpiration, where it intermittently exceeds quantity of water supplied by precipitation. The highest annum rainfall occurred in year 2005 , which was 1339.70 milli meters and least was in the year 1993, which was 352 millimetres. Rainfall trend of Hirehalla watershed for the last three decades is presented in figure-9. The numerical pattern of rainfall data shown, the coefficient of variation (CV) as 31.8 %, which indicates the inconsistency of the rainfall occurrence and distribution in the study area. Many Rainguage stations have shown kurtosis as negative indicating that a distribution is more flat than the normal distribution. Skewness for most of the stations is positive indicating that the low rainfall happens frequently. But, in the recent years I,e from year 2018 to year 2021, the rainfall depth is more than the mean annual average rainfall, which was around 1000 millimeter, which is around 40% more than the mean annual rainfall of the studyarea, which is 630 millimeter. The Mann- Kendall trend analyzed for Hirehalla sub watershedshowed that, at 95% level of significance (p-value $\geq$ 0.05), statistically insignificant upward trend values for all the time periods in the time series analysis were observed. This means, less than 5 % chances are present for the rainfall occurrence in the study region, with depth more than 630 millimeters.

3.2 .Infiltration Rate Bulk Density, Porosity % and Saturated

In the study area, 8 sites were selected based on geomorphology, soil and land use pattern for the purpose of study of the infiltrations process in the study area. Infiltration rate was determined in situ, using double ring infilterometer. The experiments reveal that the infiltration rate in the study area vary from minimum value of 4.87 mm/hr to a Maximum value of 8.67 mm/hr. Depth-wise infiltration rate ranges from 2.7 mm/hr to 3.98 mm/hr. In the mixed soil area, the average rate of infiltration varied between 4.5 mm/hr and 11.55 mm/hr.. Grain size, distribution of grains, porosity, soil type, are the deciding factors that decide, how rainfall will infiltrate and move through the soil, i.e., whether water will move downwards or laterally. From the present study, it is known that, the soil transform from clay loam to clay, due to which the movement of water is reduced with respect to depth. This reduction in movement of rainfall with respect to depth is also causeddue to presence of more number of impervious layers such as rock or bc soil layer Rainfall intensity data, i s normally less than 15 mm/hr which is relatively considered as low and therefore, the probability of Hortonian overland flow is quite occasional. However, the hydro geological cross-section of the region reveals that, majority of the rocks are moderately weathered, in many locations of the study area, particularly, on downstream side of all check dams, to a depth of 12 meters to 15 meters. Hydro geological data showed the presence of amygdaloidal basalts in certain parts of the study area substantiating the possibility for the recharge and storage of groundwater.

Table-1- Infiltration and Saturated Hydraulic Conductivity Results at Different Check Dam Locations

sl. n0	Locations	Bulk Density (g/cc)	Porosity %	Mean rate of Infiltration (mm /hr)	Saturated Hydraulic Conductivity(mm /hr)
1	CD-1	1.31	41	8.67	6.2
2	CD-2	1.36	38	6.92	6.76
3	CD-3	1.19	44	7.13	6.13
4	CD-4	1.47	39	6.24	3.16
5	CD-5	1.58	36	5.5	3.87
6	CD-6	1.35	44	5.85	3.65
7	CD-7	1.44	39	4.87	3.66
8	CD-8	1.63	38	5.27	3.45

3.3 Hydraulic Conductivity

Hydrological soil parameters were determined in the field particularly with reference to individual recharge structures (check dams). In each location six tests were conducted and the mean values are presented in Table below. In the region, 8 sites were selected based ongeomorphology, soil and land use pattern. Using, Guelph Permeameter, saturated hydraulic conductivity is determined (Ks) and its average value for the upper soil layer (0 centimeter to 45 centimeter) was 0.339 cm /hour and for lower soil layer (45 cm to 150 cm) , it was 0.648 cm/hour and near the check dam sites, its value ranges from 3.66 mm /hour to 6.2 mm/hour and in black cotton soil the value is from 3 mm/ hour to 6 mm/hour. In the mixed soil zone, the variation was between 6.2 mm/hour to13 mm/hour, away from the check dam sites . To determine the Ks value of sub surface soil layer, Vangunetann parameters are used which are α and n

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Table-2- Vann Gnatt Parameters to find Saturated Conductivity at Subsurface Level

Station (Near check dam500 meters away)	Ks (cm/hour)	θr	θs	α	n
CD1	1.66	0.11	0.38	0.0148	1.563
CD2	0.60	0.09	0.32	0.0045	1.760
CD3	0.007	0.06	0.43	0.0154	1.358
CD4	0.58	0.14	0.41	0.0134	1.310
CD5	0.58	0.16	0.43	0.0070	1.444
CD6	0.18	0.28	0.53	0.0235	1.300
CD7	0.58	0.13	0.31	0.0120	1.596
CD8	0.60	0.20	0.45	0.0125	1.688
Average	0.648	0.121	0.394	0.0095	1.4212

3.4 SWAT MODEL OUTPUT –

Runoff AET, GWR Characteristics of the Hirehalla Watershed Runoff, Evapotranspiration, Groundwater Recharge and Water yield were estimated using SWAT model (ref). The Hirehalla sub watershed was divided into 8 individual units with reference to recharge structures (eight check dams were identified on the main stream channel). The rainfall in the region varies between 1027.16 mm and 1035.63 mm. The inputs given to SWAT model include Land Use/Land Cover map of year 2020, slope map, soil map and DEM (Obtained from CARTOSAT-1, ISRO BHUVAN portal).The runoff coefficient of individual watersheds varied from 41.22% to 42.44% and the evapotranspiration ranges from 27.35% to 28.57%. Both the components showed very low spatial variation uniformity of soil layers and higher soil moisture holding capacity. In most of the cases, the runoff coefficient is 0.41. However, groundwater recharge vary from 8.66% and 25.73%.

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Table-3-SWAT Modeling Output

Check Dam	**Watershed Area (Sq Km)**	**Water Rainfall(mm)**	**Runoff Coeffcient**	**ET** % (of rainfall)	**GWR %** **(of runoff)**	**Water Generating Capacity per Sq kmMCM**
CD-1	41.9	1032.44	0.42	27.77	18.16	0.593556
CD-2	38.95	1033.99	0.4244	28.57	17.08	0.596149
CD-3	20.17	1027.16	0.4178	27.8	8.66	0.60585
CD-4	23.69	1035.63	0.4267	27.88	10.55	0.612073
CD-5	30.02	1031.92	0.4273	28.08	13.23	0.600266
CD-6	40.17	1034.04	0.4148	27.35	17.03	0.602689
CD-7	40	1032.47	0.4139	28.53	25.73	0.593076
CD-8	28.98	1032.44	0.4122	28.18	12.26	0.570048

3.5 SWAT Calibration Output

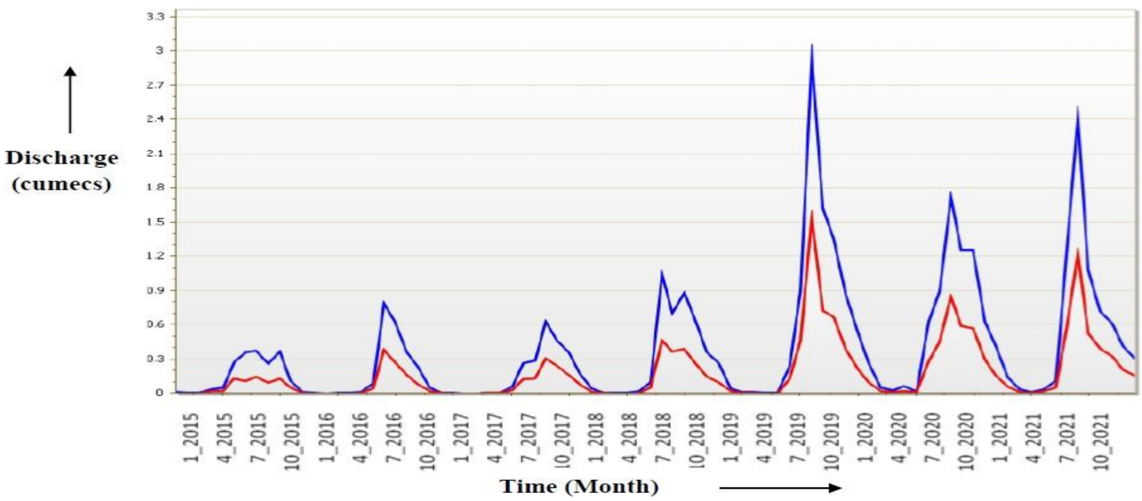

Figure-10-SWAT Calibration Output

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The model was calibrated in SWAT CUP 2012, the R^2 value is 0.96, NS= 0.7,Percentage BIAS = 0.20

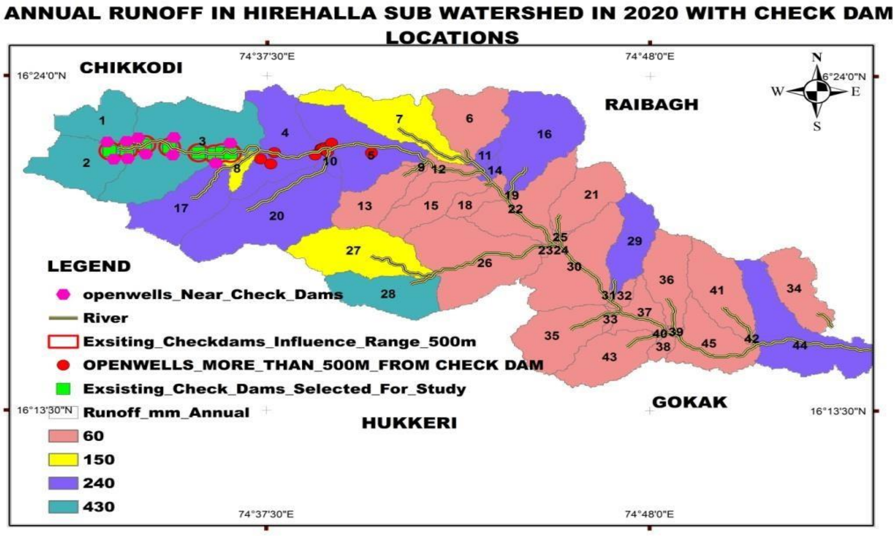

Figure-10-SWAT-CUP Calibration

Figure-11- SWAT Output- Annual Run off Spatial Distribution In Hirehalla Sub watershed

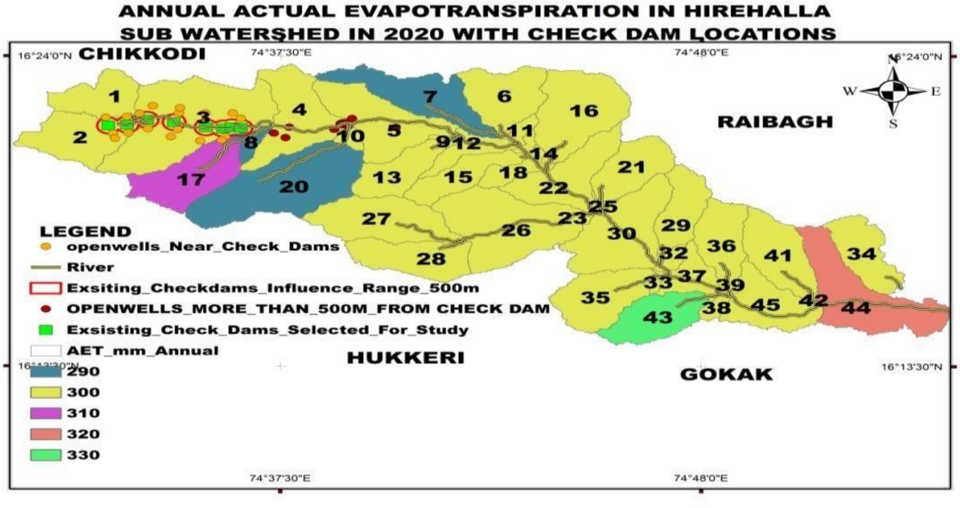

Figure-12- SWAT Output - Annual AET Spatial Distribution In Hirehalla Sub watershed

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3.6 Ground water level Fluctuation and Rainfall Relation

Monthly groundwater levels of the dug wells in the last ten years (2014 to 2023) showed a significant decline from January to May. It is also reported that groundwater level fluctuation has been increased considerably as reported by Majumdar et al 1995; Venkatesh gouda patil 2024 which clearly demonstrated the over-exploitation of groundwater through shallow aquifers and also using bore-wells from deeper layers . Though, the basic pattern of LU/LC has not changed significantly, the production of sugarcane and other intermediate crops have been increased thereby affecting the well storages. The yield characteristics of a dug well are dependent on the saturated depth of aquifer, and also on hydraulic conductivity of both saturated and unsaturated zones. The pumping test indicate that, there is gradual drop in values of hydraulic properties irrespective of any aquifer and also, the yield of individual wells have been decreased. The pumping tests of dug wells carried out in selected locations close to artificial recharge structures at a distance 2000 meters from the recharge structure, showed the drying up wells very frequently in-spite of having large diameter wells where the diameter ranged between 20 meters to 30 meters and with water level fluctuation ranging from less than 2m to more than 15m. The rock mass permeability varied from 0.08 meters / hour to 0.346 meters/hour. Maximum inflow capacity to the wells ranged from 1.543 cum/hour to 13.43 cum/hour. It is observed that, except rock permeability, none of the components showed correlations with depth of the well. However, the permeability showed a considerable decrease with depth in all eight locations where the pumping tests were conducted It is also found that the recovery of water in each well showed moderate to low level of correlation with cross sectional area of the well, thereby, demonstrating the need of large diameter wells for recharge and storage. Using the pumping test and field data and laboratory tests data, the inputs are given to HYDRUS-1D model and the model was simulated for the period 2014-2021. Accordingly the groundwater recharge was estimated in the vicinity of nala banks and also away from the banks (1-2 km). Hence, the areas covered by basalts have very "low specific yield" and the

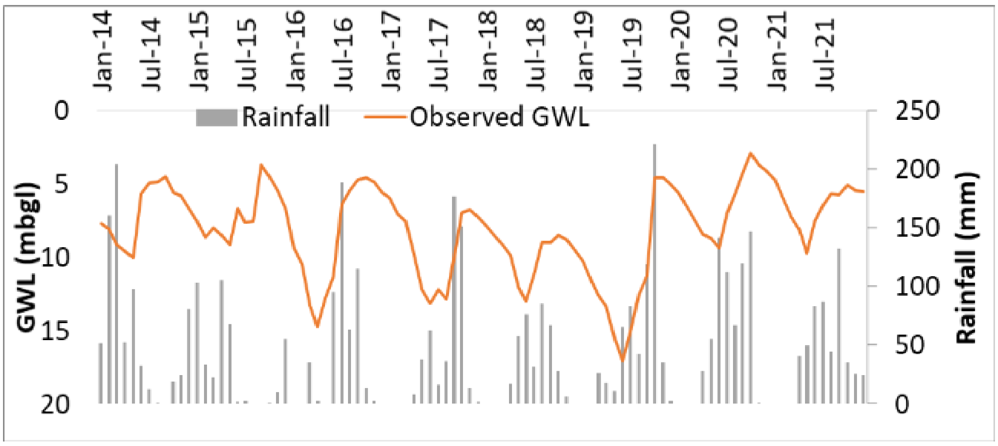

Figure-13- Ground Water Fluctuation With Respect to rainfall

Ground water recharge dependence on the residence period of the storage in the respective structures. Further, the recharge effect is 8.72 % to 45.66 % for the wells near to check dams (less than 500 meters from check dam on downstream side of check dams), with the improvement in ground water levels. But, for the open wells away from the check dam by more than 500 meters horizontal distance, the recharge percentage was between 8 % to 12 % as indicated in table number.

3.7.HYDRUS -1D SIMULATION RESULTS and Pumping Test Results

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And Effect of Check Dams on Recharge

Table-4- HYDRUS-1D Output-Check Dam Recharge Percentages

Check dam Nos.	GWL Before installation of ARS	GWL after installation of ARS	GWL Fluctuation	Range of Sp. yield % (determined using pumping test)	Range of recharge % within 500 m	Range of recharge away from 0.5 km
CD-1	8.18	5.15	3.03	0.95-1.70	11.95- 27.15	7.99- 9.89
CD-2	8.26	5.07	3.19	0.88-1.20	8.72-23.05	6.85-8.015
CD-3	9.74	4.26	5.48	1.024-3.55	37.45-45.66	6.44-8.56
CD-4	8.90	5.76	3.14	1.45-4.80	27.77- 33.84	6.85-7.95
CD-5	10.08	3.25	6.83	0.98- 2.80	23.25-27.15	5.84- 7.18
CD-6	12.90	3.1	9.80	0.77- 1.59	25.10-36.9	5.22-8.34
CD-7	8.75	7.25	1.50	2.45-4.30	15.24-18.05	6.67-8.79
CD-8	4.53	2.68	1.85	2.87-4.45	19.45-25.22	7.80-11.34

Table-5- HYDRUS-1D Output-Check Dam Recharge Percentages

CD NUMBER	Observed GWL Fluctuation For Open wells near check dam (m)	Simulated GWL Fluctuation For open wells near check dam (m)
CD-1	1.5	1.62
CD-2	1.85	2.50
CD-3	3.03	3.7
CD-4	3.14	3.4
CD-5	3.19	4.8
CD-6	5.48	7.8
CD-7	6.83	6
CD-8	9.8	7.20

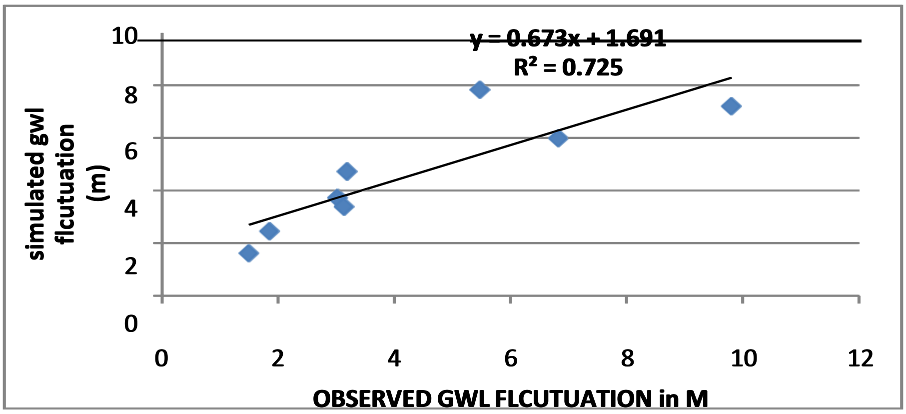

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Figure-14- Plot of Simulated versus Observed Ground water Fluctuation

In the present study, the effect of artificial recharge structures has been carried out on unconfined aquifers. This objective is attained by execution and calibration of the SWAT model results, in which, the calibration is done in SWAT-CUP. The R^2 value was 0.98, PBIAS was 0.2. This indicates that, the model results are acceptable for assessment of check dam effect. Further the outputs of SWAT model, viz-runoff, evapotranspiration, ground water recharge were given as input to the HYDRUS-1D software, apart from these, field tests such as infiltration test, pumping test, permeability test and laboratory test such as bulk density test, porosity tests were conducted o know the hydraulic properties of the sub surface soil. These tests reveal that, porosity varies from 36 percent to 44 percent. Hence, porosity is almost same throughout the entire study region. After the data input, HYDRUS-1D model is simulated from 2014 year to 2021 year. The simulated values obtained from HYDRUS-1D indicate that, the recharge percentage is higher in the open wells near to the check dam within 500 meters compared to the open wells away from the check dam above 500 meters. The same phenomenon is observed in ground water fluctuation also. Hence there is the effect of check dam on unconfined aquifer, which results in maximum recharge percentage of 45.22 % on the open wells present near the check dam. The R^2 value of simulated output of HYDRUS – 1D plotted versus observed values, is 0.725. Hence, the simulated recharge values of HYDRUS-1D are acceptable.

5. References

- CGWB Artificial Recharge Guide -2008
- Raghwendra N. Shandilya a,b, Etienne Bresciani a,c, Anthony C. Runkel d, Carrie E. Jennings e, Seunghak Lee a,b,f, Peter K. Kang g,h, “Aquifer-scale mapping of injection capacity for potential aquifer storage and recovery sites: Methodology development and case studies in Minnesota,” USA, Journal of Hydrology: Regional Studies-2022
- N. Dwivedi, , R. R. Shukla, Rakesh Singh, S. K. Adhikari, K. A. Nambi, S. S. Purty andG. K. Roy Determining the recharging capacity of an injection well in a semi-confined alluvial aquifer, Semantic Scholar.September-2015
- G. Zheng,J.R. Cao X.S,. Cheng D. Ha, F.J. Wang “Experimental study on the artificial recharge of semi confined aquifers involved in deep excavation engineering” Journal of Hydrology -2018
- Prahlad Soni Yogita Dashora , Basant Maheshwari Peter Dillon Pradeep Singh and Anupama Kumar Managed Aquifer Recharge at a Farm Level: Evaluating the Performance of Direct Well Recharge Structures, Water Journal , MDPI publications, 9th April-2020
- Ismail Chenini n, Abdallah Ben Mammou , “Ground water recharge study in arid region: An approach using GIS techniques and numerical modelling” Computers and Geosciences Journal, Elsevier Publications-2010

- 7.Dr.B.K.Purundara, Dr.Nagaraj Patil, Dr.Santosh, Dr.Venkatesh Gowda," Assessment of Groundwater in Ghataprabha Sub-Basin Using Visual MODFLOW" International Journal of Science and Engineering ISSN 0974-5904, August 2016

- 8 G. Thiyagarajan, A. Valliammai, A. Raviraj and S. Panneerselva " Effect of Artificial Recharge Structures in Improving Groundwater Level", International Journal of Current Microbiology and Applied Sciences ISSN: 2319-7706, Volume 9 ,November- 2 ,2020

- 9. M. Niranjannaik, Amit Kumar, Zafar Beg, Abhilash Singh, Somil Swarnkar and Kumar Gaurav "Ground water Variability in a Semi-Arid River Basin, Central India" Hydrology Journal , MDPI publishers, December 2022.

- Jacob Kofi Mensah , Eric A. Ofosu Sandow Mark Yidana , Komlavi Akpoti Amos
- T. Kabo-bah," Integrated modeling of hydrological processes and groundwater recharge based on land use land cover, and climate changes: A systematic review " Journal of Environmental Advances July -8, 2022.

- M.; Kim, M.-G.; Chang, S.W, Lee, J.E ,"Impacts and Implications of Land Use Land Cover Dynamics on Groundwater Recharge and Surface Runoff in East African Watershed " Water Journal, MDPI publishers, June 2022

- P RADHAN MANTRI KRISHI SINCHAYEE YOJANA (PMKSY), BELAGAVI DistrictReport ,2021Manual on Design of Check dams, Department of public works, Gujarat state India- 2001

- CGWB Report on AQUIFER MAPPING AND MANAGEMENT PLAN Chikkodi , Belagavi District, Karnataka-2017

- Gloria Mozzi , Paul Pavelic, Mohammad F. Alam, Catalin Stefan and Karen G. Villholth "Hydrologic Assessment of Check Dam Performances in Semi-Arid Areas: A Case Study From Gujarat, India" , Journal of Frontiers of Water -2021

- Hakan Djuma , Adriana Bruggeman , Corrado Camera , Marinos Eliades and Konstantinos Kostarelos" The Impact of a Check Dam on Groundwater Recharge and Sedimentation in an Ephemeral Streams", Water Journal, MDPI Publishers, October-2017.

- S. P. Shinde · V. N. Barai Nadhir Al-Ansari B. K. Gavit· S. A. Kadam· A. A. Atre R. D. Bansod Ahmed Elbeltagi " Characterization of basaltic rock aquifer parameters using hydraulic parameters, Theis's method and aquifer test software in the hard rock area of Buchakewadi watershed Maharashtra, India",Applied Water Science, Springer Publishers-August-7,2022

- Vijay Bhusari and Y. B. Katpatal and Pradeep Kunda ,"An innovative artificial recharge system to enhance groundwater storage in basaltic terrain: example from Maharashtra, India" Hydrogeology Journal, March 2016

- Chinmaya Panda, Dwarika Mohan. Das, B. C. Sahoo, B. Panigrahi and K. K. Singh "Spatio-temporal modeling of surface runoff in ungauged sub-catchments of Subarnarekha river basin using SWAT " Mausam Journal,2021.

- Zhanbin Luo ,"Precipitation recharges the shallow groundwater of check dams in the loessial hilly and gully region of China" Science of The Total Environment Journal, Volume 742, 10 November 2020.

- Suraj Lamichhana, Narendra Man Shakya " Shallow aquifer groundwater dynamics due to land use/cover change in highly urbanized basin: The case of Kathmandu Valley, Nepal", Journal of Hydrology: Regional Studies-2020

- Anna Gumuła-Kawęcka a, Beata Jaworska-Szulc a, Adam Szymkiewicz a, Wioletta Gorczewska-Langner a, Małgorzata Pruszkowska-Caceres a, Rafael Angulo-Jaramillo b, Jirka ˇSimůnek," Estimation of groundwater recharge in a shallow sandy aquifer using unsaturated zone modeling and water table fluctuation method" ,Journal of Hydrology, Elsivier Publishers-February-2022.

- Rejuvenation of dug wells in Gokak Taluk Under PMKSY-WDC , Under watershed development activities -2020
- Omid Rahmati Zahra Kalantari Mahmood Samadi Evelyn Uuemaa Davoud Davoudi Moghadda Omid Asadi Nalivan Georgia Destouni Dieu Tien Bui "GIS-Based Site Selection for Check Dams in Watersheds: Considering Geomorphometric and Topo-Hydrological Factors-Sustainability Journal-2019

- Serhat Tonkul & Alper Baba & Celalettin Şimşek & Seda Durukan & Ali Can Demirkesen & Gökmen Tayfur "Groundwater recharge estimation using HYDRUS 1D model in Alaşehir sub-basin of Gediz Basin in Turkey"Environment Assessment and Monitoring , September - 2019
- Darwizal Daiwood ,Fifi Novia Azhari, Masril Syukar, R udy Ferial, "Study of Effects of Check Dam Construction on the Lmau Manih River Using GIS".ICDMM Journal-2021
- 27 Sashini Pathirana, Lakshman Galagedara, Jagath Gunatilake," Estimation of Depth To The Ground Water Table Fluctuations With HYDRUS-1D Model " 5th International Conference of the International Commission of Agricultural and Biosystems Engineering (CIGR) Virtually from Québec City, Canada – May 11-14, 2021.

- Madison J Stafford, Hartmut.M.Hollander, Karen Dow ,"Estimating groundwater recharge in the assiniboine delta aquifer using HYDRUS-1D", Agriculture Water Management Journal, Volume 267, Elsievier Publishers, June-2022. https://doi.org/10.1016/j.agwat.2022.107514

- Jirka Šimůnek " Estimating groundwater recharge using HYDRUS-1D" ,Engineering Geology and Hydrology, Bulgerian Academy of Sciences, 2015.

- Kibreab Amare Assef and Allan D. WoodburY "Transient, spatially varied groundwater recharge modelling", Water Resources research, Volume 49, 2013

- Achamyeleh G. Mengistua, Leon D. van Rensburga, Yali E. Woyessab "Techniques for calibration and validation of SWAT model in data scarce arid and semi-arid catchments in South Africa", Journal of Hydrology: Regional Studies, Elsivier Publishers, Volume 25, 2019

- Samuel S. Guug Shaibu Abdul-Ganiyu Raymond A. Kasei," Application of SWAT hydrological model for assessing water availability at the Sherigu catchment of Ghana and Southern Burkina Faso", Hydro Research Journal, KeAi Publishers- 2020.
- Soumendra N. Bhanja, Abhijit Mukherjee R. Rangarajan , Bridget R. Scanlon , Pragnaditya Malakar, and Shubha Verma "Long-term groundwater recharge rates across India by in situ measurements" Hydrological . Earth Systems Science Journal- 2019.
- Shima Nasiri Hossein Ansari Ali Naghi Ziae" Determination of water balance equation components in irrigated agricultural watersheds using SWAT and MODFLOW models: A case study of Samalqan plain in Iran", Journal of Groundwater Science and Engineering, Volume 10, Ferdowsi University of Mashhad, Iran.-2019
- A Book on Integrated Hydrological Data (Non Classified River Basins), Central Water Commission, Government of India, 2005.
- Detay, M., P. Poyet, Y. Emsellem, A. Bernardi, and G. Aubrac. 1989. Development of the Saprolite reservoir and its state of Saturation: Influence on the hydrodynamic characteristics of drillings in crystalline basement. C. R. Acad. Sci. Paris Series II pp.429-436.
- 37 Perroux, K. M. and White, I. 1988. Designs for disc permeameters. Soil Science Society of America Journal, 52:1205-1215.