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Research Article

HYDROLOGICAL ASSESSMENT OF HEBBURU MICRO-WATERSHED OF TARIKERE TALUK, CHIKKAMAGALURU DISTRICT, KARNATAKA

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Abstract: The inventory and documentation of spatial and temporal changes in hydrological components of Hebbur Micro-Watershed (4D3E4P2b) in Tarikere Taluk, Chikkamagluru District, has been undertaken for integrated planning, development and management. Hebbur Micro-Watershed is located between 13º 46' 14.81" N to 13º 44' 23.95" N Latitude and 75º 58' 24.38" E to 76º 0' 41.14" E Longitude, covering an area of 1038 ha. The Micro-watershed falls under Ajjampura (4D3E4P) Sub-Watershed. Hydrological assessment of basic parameters namely, rainfall pattern, relations among PET, AET and rainfall, soil moisture change, mapping unit wise runoff generation and change in ground water status are presented in the paper which will help in making decisions regarding, cropping choices, artificial recharge and improved harvesting operations and conservation structures. Average annual rainfall of the area is 874 mm. Budyco curve analysis showed that watershed is not under sustainable condition. The mean annual rainfall recharge factor found approximately 16 percent. The groundwater use for irrigation is higher in the upper regions of the watershed and hence artificial recharge and harvesting operations should be taken up in the higher bore well density areas in the upland parts of the catchment.

Keywords: *Micro-watershed, Hydrological assessment, Budyco curve and Artificial recharge*

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Introduction

A watershed is defined as an area of land in which all of the incoming precipitation drains to the same place or the same topographic low area. To understand and describe how landscapes and water interact, it is important to understand use of water & it's cycling through watershed. The major components of the hydrologic cycle are precipitation, evaporation, transpiration, soil water, groundwater and streamflow [1]. Watershed management is a holistic approach which aims at optimising the use of land, water and vegetation in an area to alleviate drought, moderate floods, prevent soil erosion, improve water availability and increase fuel, fodder and agricultural production on a sustained basis [2]. Soil and water constitute the essential resources of the country. These two elements nourish and support the living beings. The prosperity and welfare of humanity is also depending on water, which is irreplaceable resource. Hence, judicious management of these resources is a pre-requisite for overall development of the country. The common characteristics of rainfed areas are low and erratic rainfall, inadequate concentration of *in situ* moisture, soil erosion, degradation of soil fertility, deforestation and ecosystem imbalance in addition to low income and low purchasing capacity of the farmers [3]. In Karnataka, more than 60 per cent of the population live in rural areas and depend on agriculture and allied activities for their livelihood [4]. The challenges in agriculture are seriously threatening the livelihood of a large number of farmers. The ever-rising temperatures and unpredictable rainfall patterns are testing farmers in their efforts to survive in farming and sustain their livelihood. Climate change continue to bring more and more unpredictable situations in the agrarian sector as well. The details of hydrological and water resources are necessary for the sustainable use of water resources and also for higher productivity. In this view Karnataka state Watershed Development Department since 2013 initiated Karnataka Watershed Development Project (KWDP-II), Sujala-III, across 11 Districts namely, Bidar, Kalburagi, Yadagiri, Koppal, Gadag, Davanagere, Chamarajanagar, Raichur, Tumakur, Vijayapur and Chikkamagalur. This project is segmented based on the needs of stake holders and implemented. This project is implemented in 2531 MWS covering approximately 13.27 lakh ha area in order to device region wise plans. In Sujala-III project, hydrological assessments of basic parameters are being carried out in 14 model micro-watersheds in various agro-climatic zones of Karnataka. The present hydrological studies were undertaken in Hebburu model micro-watershed of Tarikere taluk, Chiukkamagaluru district of Karnataka by UAHS Shivamogga under SUJALA-III Project for assessment of basic hydrological parameters namely, rainfall pattern, relations among PET, AET and rainfall, soil moisture change, mapping unit wise runoff generation and change in ground water status.

Materials and methods

Study area

The Hebbur micro watershed of Ajjampura sub-watershed, Tarikere taluk, Chikkamagaluru district has been selected for Hydrology, Soil and Water conservation studies under KWDP-II, SUJALA-III Project [Fig-1]. The study area comes under semi-arid region with average annual rainfall of 874 mm. Area covered mostly of black soils however it also contains small portion of red and sandy textured soil. The major crops grown in study area are Maize, Ragi, Onion, Ginger, Potato and Chilly during Kharif, whereas Chick Pea, Jawar, Safflower, Wheat and Horse gram during *Rabi* season. Major horticulture crops grown are Arecanut, Coconut, Banana, Mango and Pomegranate. Rainfall data was collected form KSNDMC, Bengaluru and analysis were done for annual and seasonal basis. Watershed sustainability analysis was carried out using Budyco curve method. The ground water level data is important variable in the hydrological budget (*e.g.* estimation of recharge from rainfall or other sources, to know usage patterns of ground water for irrigation *etc*.).

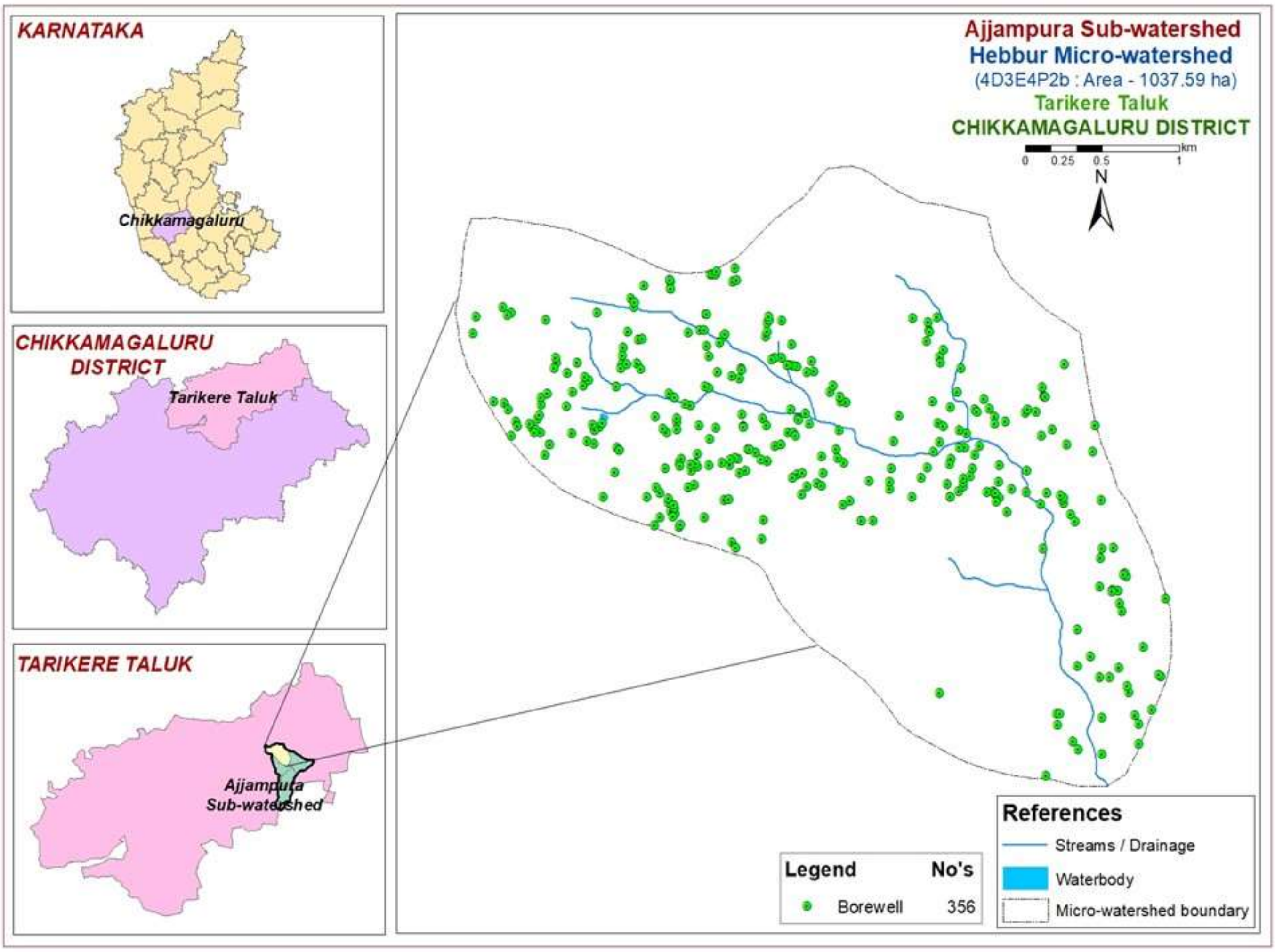

Fig-1 Location map of Hebbur micro-watershed

A ground water level sensing probe with a graduated tape was used for measurement of depth to water table in the selected 150 borewells. Discharge (lpm) measurements in the micro-watersheds were done using volumetric bucket and stopwatch method during different cropping seasons. The profile soil moisture is measured at every ten days frequency using TDR Probe. Mapping unit wise runoff was estimated using rainfall events and land use inventory information.

Results and discussion

Rainfall analysis

Rainfall data was collected from KSNDMC, Bengaluru. The long term average annual rainfall (1980-2017) was found 874 mm for Tarikere taluk station. The 15 minutes interval rainfall data (2009-2017) of Ajjampura Hobli station is considered for temporal analysis of rainfall, as the station is near to the micro-watershed. Years of 2011 (7.68 %), 2012 (41.31 %), 2016 (38 %) and 2017 (24.16 %) were found deficient years between 2009-2017. Year 2014 received 42 percent excess rainfall [Fig-2]. The Kharif (May-August), *Rabi* (September-December) and Summer (January-April) rainfall found, 60 percent, 33 percent and 6 percent of average annual rainfall. Temporal variation of rainfall was fund high in the watershed.

Evapotranspiration analysis

During 2001 to 2014, the average annual actual evapotranspiration, AET (825 mm) was lower than the average annual rainfall of 874 mm [Fig-3]. During the months of July to November rainfall was higher than AET so there was excess water budget in this period [Fig-4]. During Kharif average rainfall and AET were found 525 mm and 411 mm respectively, whereas in *Rabi* it was about 297 mm and 264 mm. Sustainability analysis of watershed was carried out using Actual Evapotranspiration (AET), Potential Evapotranspiration (PET) and Rainfall using Budyco curve method.

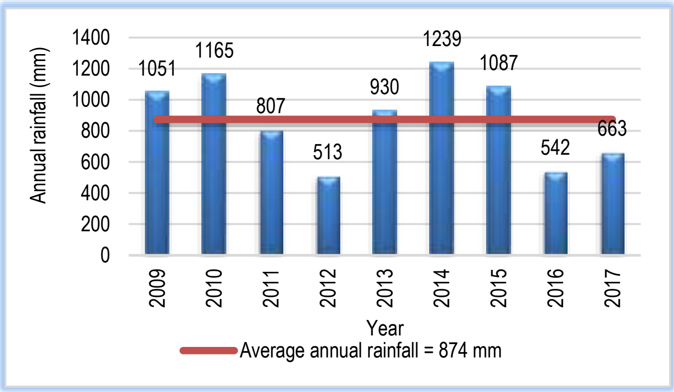

Fig-2 Temporal variation of annual rainfall between 2009-2017

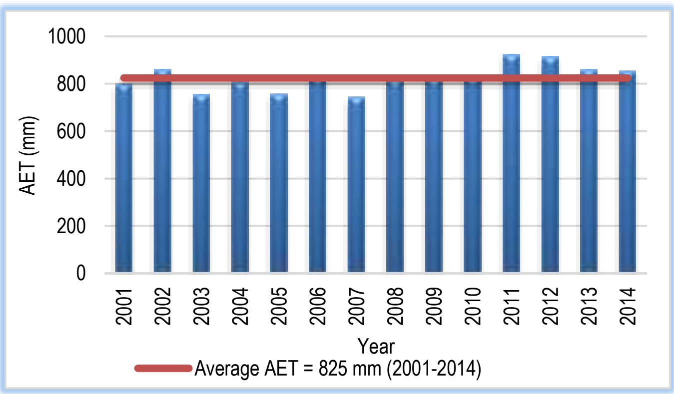

Fig-3 Variation of Actual Evapotranspiration

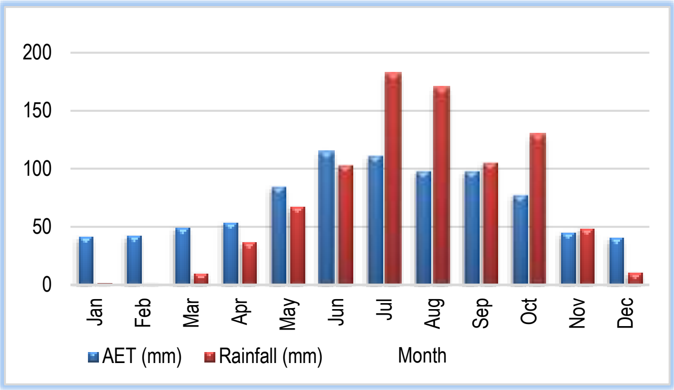

Fig-4 Comparison of average monthly rainfall and AET

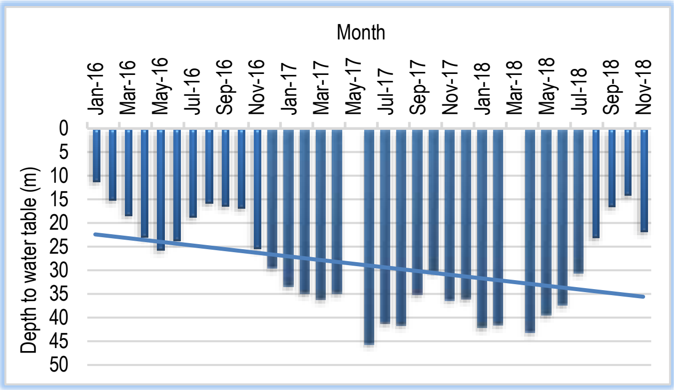

Fig-7 Depth of groundwater levels during 2016-2018

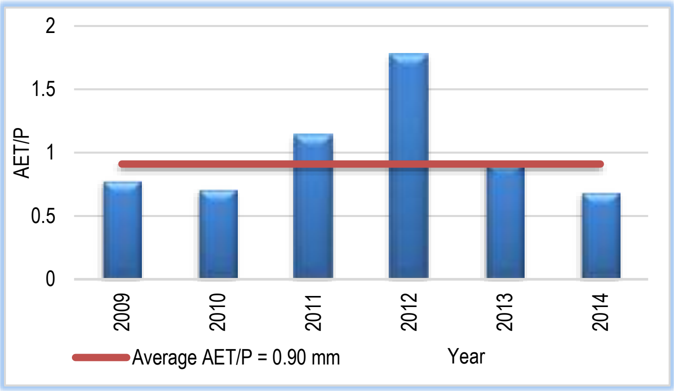

Fig-5 Evapotranspiration index

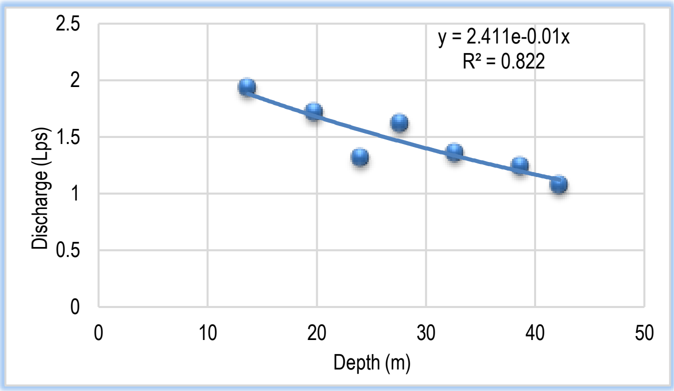

Fig-8 Variation of discharge with depth

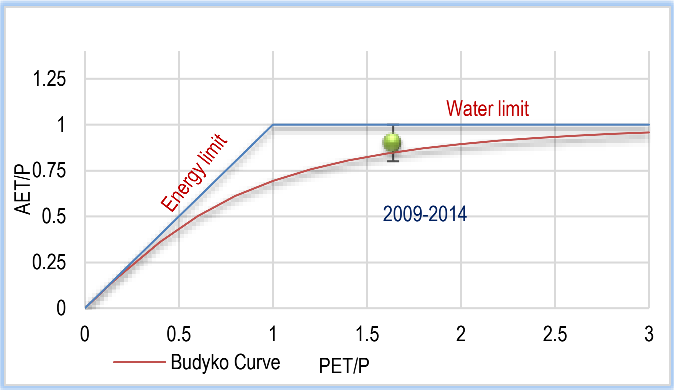

Fig-6 Budyco curve

The average AET/P ratio between 2009-2014, was about 90 percent [Fig-5], which is higher than the sustainable limit of about 80 percent in the Budyco curve [Fig-6]. Even during lower rainfall years (2012) AET found above average of 830 mm [Fig-3]. This suggests the presence of water storage and utilization from other sources (such as groundwater), which buffered the lower rainfall.

Ground water

Out of 356 wells present in the Hebbur micro-watershed, selected only 150 wells for detailed monitoring of hydrological characteristics like fluctuation of water table depth and discharge during the year 2016 to 2018. There was increasing trend of depth to water table in the watershed during 2016 and 2017, as these years were lower rainfall years and indicates utilization of groundwater to buffer the lower rainfall years [Fig-7]. Moreover, the groundwater use was relatively higher and there is scope to reduce the use by utilizing the marginally under-utilized runoff through harvesting and conservation practices. The mean depth of ground water observed from ground level during the different months (since Jan 2016) was found 28.89 m with highest and lowest level of 45.54 (June 2017 m) and 11.18 (Jan 2016 m) respectively. The ground water yield in cubic meter per day was measured in more than 100 bore wells in the micro-watershed.

Corresponding ground water depth was also recorded. This data provides relationship between bore well yield and depth to groundwater. The bore well yield decreased modestly with increase in depth to groundwater [Fig-8]. Large spatial variability of groundwater level existed in the micro watershed. It was observed that, in north-western parts of the watershed groundwater levels found at deeper depths all the seasons. Shallow water levels were observed at the outlet of the watershed. The water levels towards the northern parts have gone down due to higher bore well density. [Fig-9] presents the spatial variations of spatial ground water levels in Hebbur micro-watershed. Groundwater recharge was estimated using rainfall and observed groundwater level between 2008-2017 using groundwater tool box [Fig-10]. The groundwater level trends are strongly correlated with annual rainfall. The mean annual rainfall recharge factor is approximately 16 percent, which results in good mean annual recharge of about 140mm and are sustaining groundwater irrigation. The drought year of 2012 had a lower recharge factor of 13 percent (annual recharge of 75 mm). The coefficient of variation of annual rainfall, recharge and discharge are 31percent, 35 percent and 19 percent respectively.

Runoff estimation

Runoff was estimated using infiltration method by considering LRI information *viz.*, soil texture, land use type, area of watershed and hydrology information *viz.*, rainfall intensity, rainfall duration, constant infiltration rate and number of runoffs causing events. Runoff causing rainfall events were extracted from 15 minutes intensity (2009-2017) data obtained from KSNDMC, Bengaluru. For an average annual rainfall of 889 mm (2009-20017), estimated 102 mm runoff was generated from the watershed under existing watershed condition. Runoff available after effective interventions (*e.g.* bunding) was 60 mm. Allowing 30 percent (18 mm) for ecological balance from 60 mm, 42 mm can be harvested by constructing various structures like farm ponds, check dams *etc.*

Soil moisture dynamics

The profile soil moisture dynamics were recorded at different locations of micro-watershed using TDR probe at ten-day interval.

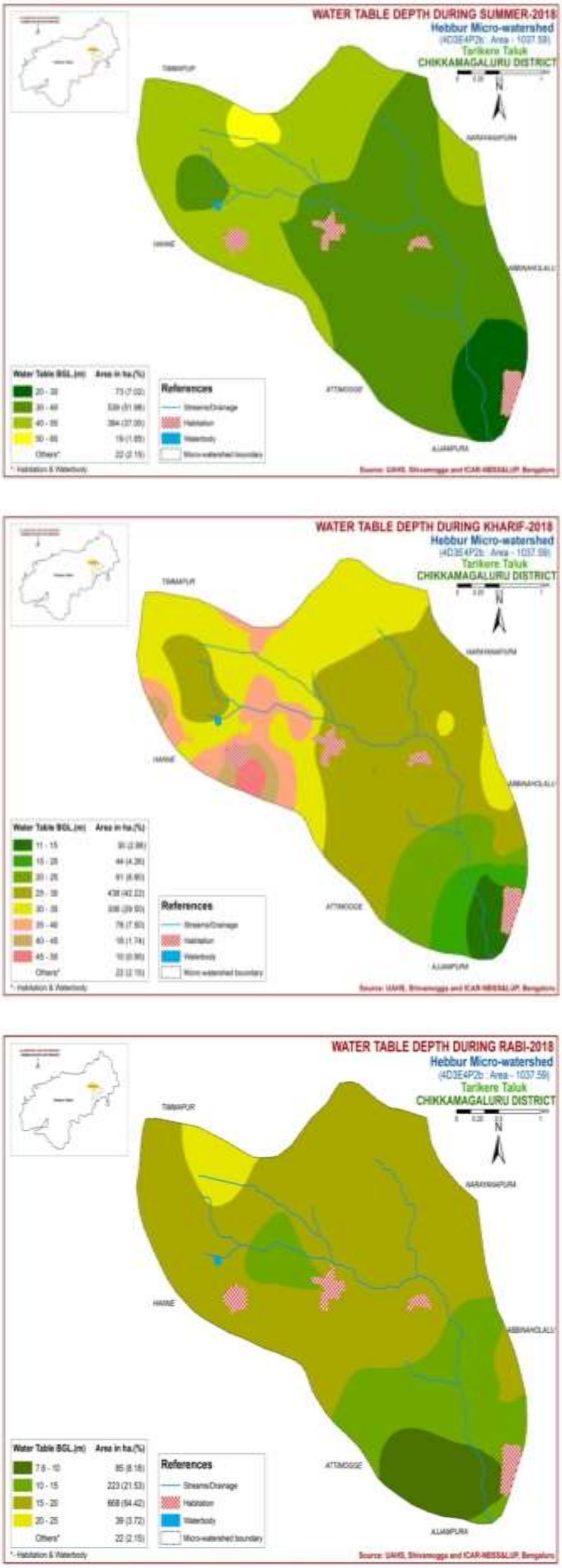

Fig-9 Spatial variation of groundwater level during 2018

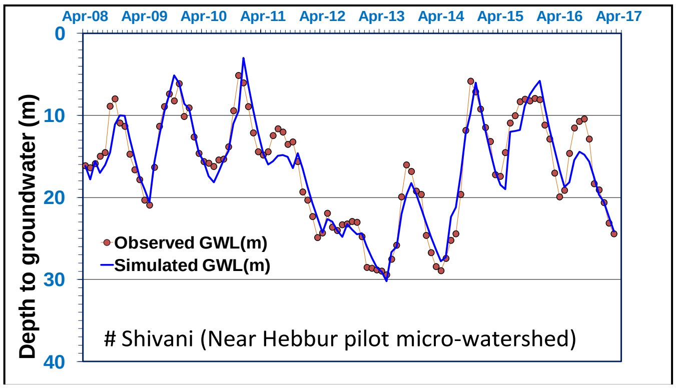

Fig-10 Observed and forecasted groundwater levels

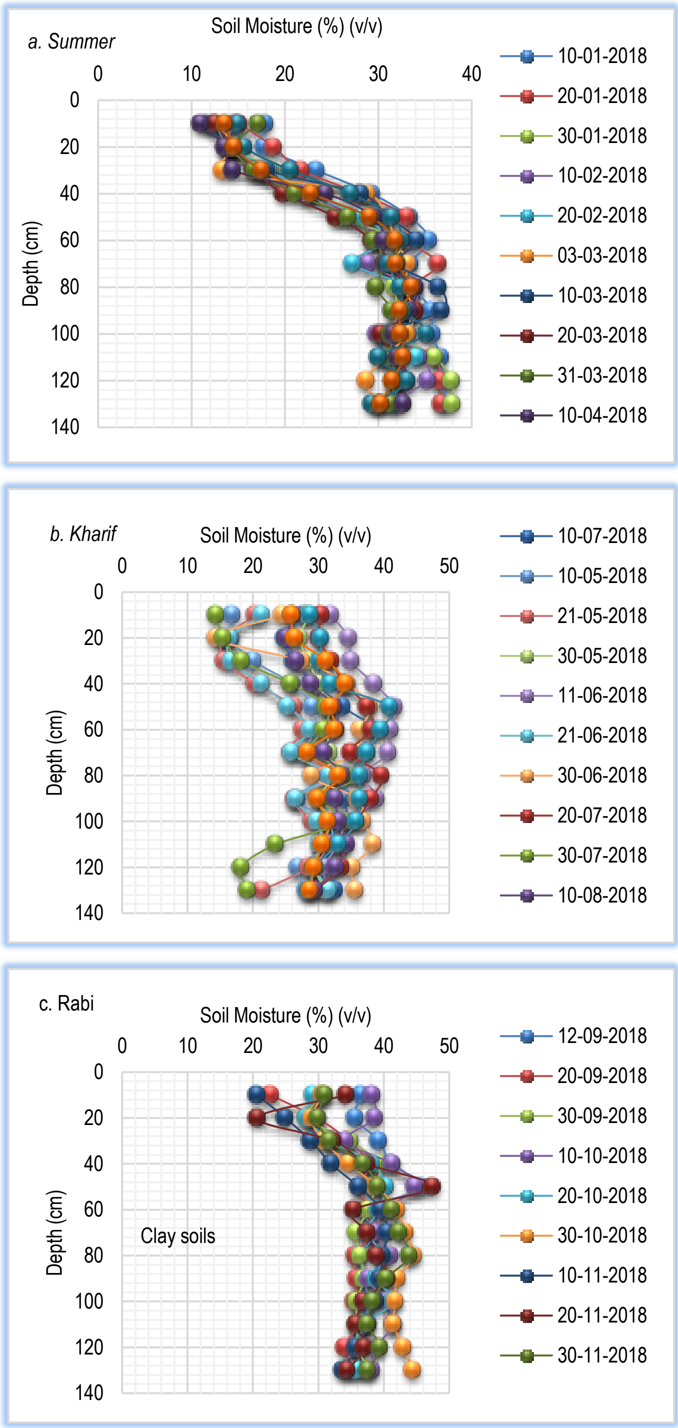

Fig-11 a. b. c. Variation of profile soil moisture in different seasons in clay soil

It was observed that soil moisture was homogeneous with depth after 20 cm for clay soils for Kharif and *Rabi* seasons. The soil moisture does not exhibit variability during *Rabi* season and moderate variations in Kharif. The soil moisture was lower in the top 60 cm while it was good in the lower layers for summer season and this behaviour was uniform for all the summer season [Fig-11 a. b. c].

Conclusion

On an average 60 percent of annual average rainfall was received during Kharif and 33 percent in *Rabi* season. In a nine-year window, three years received low rainfall. The continuous monitoring of soil moisture at different depths combined with soil depth mapping from LRI indicates an available soil moisture store of 300 mm for kharif and *rabi* seasons together. The estimated runoff available to use is 84 mm for an annual rainfall of 890 mm (2009-2017). The utilizable groundwater is 98 mm (70 % of 140 mm recharge estimated). This means the total available water resource combining the soil moisture store and utilizable runoff plus recharge is 482 *i.e*. approximately 500 mm. The average actual evapotranspiration estimated in the watershed based on the current land use and irrigation practices for the kharif and *rabi* seasons was 675 mm. Hence, the amount of water uses for kharif and *rabi* seasons may be estimated as 844 mm (*i.e*., 125 % of AET). This demand for the two seasons is higher by 344 mm. From a hydrological point of view, currently the watershed is not in sustainable limits. It is required to reduce the demand by about 350 mm, through improved irrigation practices and changed crop choices. The groundwater use for irrigation is higher in the upper regions of the watershed and hence artificial recharge and harvesting operations should be taken up in the higher bore well density areas in the upland parts of the catchment.

Application of research: This research will help in making decisions regarding, cropping choices, artificial recharge and improved harvesting operations and conservation structures.

Research Category: Watershed Development

Abbreviations:
UAHS: University of Agricultural and Horticultural Sciences
KWDP: Karnataka Watershed Development Project
MWS: Micro Watershed
AET: Actual Evapotranspiration
PET: Potential Evapotranspiration

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Author Contributions: All authors equally contributed

Author statement: All authors read, reviewed, agreed and approved the final manuscript. Note-All authors agreed that- Written informed consent was obtained from all participants prior to publish / enrolment

Study area / Sample Collection: Hebbur micro watershed of Ajjampura sub-watershed, Tarikere taluk, Chikkamagaluru district

Cultivar / Variety name: Nil

Conflict of Interest: None declared

Ethical approval: This article does not contain any studies with human participants or animals performed by any of the authors.
Ethical Committee Approval Number: Nil

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