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Rainfall Patterns and Groundwater Dynamics: Implications for Soil and Water Conservation in Kodihalli Sub-Watershed, Haveri District, Karnataka, India

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Authors' contributions

This work was carried out in collaboration among all authors. Author MMV is a Nodal Scientist and Principal Investigator, Reward Project (Hydrology), conceptualized the study, performed the methodology, reviewed and edited the manuscript. Author MSB collected the data and did GIS analysis and wrote original draft. Author NM did data analysis, performed the methodology, reviewed and edited the manuscript. Authors MH and KVB helped as Project Nodal officers. Author SMS helped as Co-Principal investigator. Authors MFH and JH helped as project Assistant. All authors read and approved the final manuscript.

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ABSTRACT

The Kodihalli sub-watershed (4D4D2f) is lies between 14⁰28'23.68"-14⁰34'20.103" North latitudes and 75⁰26'49.224"-75⁰31'44.208" East longitudes and covers an area of about 4398.83 ha. with an average annual rainfall of 783.0 mm (2014-2021). The maximum rainfall of 439.0 mm is received from June to September, 226.0 mm from October to early December and the remaining 118.0 mm is received during the rest of the year. The number of rainy days (>2.5 mm) varied from 13-24 days per year. On an average, the number of rainy-day events likely to produce runoff (20 to 30 mm) are about 2 to 8 rainy days per year with moderate variation across the years. The Actual Evapotranspiration (AET) over the years 2014 - 2021 in the Kodihalli sub-watershed varied from 383.0 to 770.0 mm. During 2014 - 2021, the average annual AET (621.0 mm) was less than the average rainfall (783.0 mm). The average AET/P ratio between 2014-2021 was about 0.79 which is less than the sustainable limit of about 0.80. The soils of watershed viz., sandy clay loam (IR 10 mm/hr) and sandy clay (IR 14 mm/hr) resulted in more infiltration rate than clay (2 mm/hr) and clay loam soils (7 mm/hr). Soil infiltration during a rainstorm is closely related to a number of factors such as the intensity and kinetic energy of the rainfall, soil surface conditions and soil properties such as those related to aggregate stability. For effective soil and water conservation, maximum area of about 3769 ha (85.7%) requires graded bunding and 267 ha (6.06%) area requires contour bunding.

Keywords: Rainfall; watershed; evapotranspiration; groundwater; kriging and soil conservation measures.

1. INTRODUCTION

"The backbone of the Indian economy is agriculture and allied fields which mostly depend upon an abundance of natural resources like rainfall, water resources, soil and forest vegetation. As these resources are limited and depleted yearly, there is an utmost need to stabilize and conserve these resources. Global population growth, climate change, competition from other uses, and increased regulation of agricultural water use are causing water to become increasingly scarce" (Boretti and Rosa, 2019), (Kisekka et al., 2022). "Climate change and its possible impacts on water resources have become a focus of recent research. Water, the most precious natural resource on the globe, is also closely related to human necessities and requirements and thus bears environmental and socioeconomic values" (Li, 2021), (Mani et al., 2024). So, there is an urgent need of advanced technologies are required to optimize water use in agriculture. Sustainable management of land and water resources is essential for food security, maintenance of environment and general well-being of the people. The most important basic natural resources like soil and water that determines the ultimate sustainability of any agricultural system.

"Watershed is the geographical area which is drained by the network of streams to the common outlet. A watershed is a complex and dynamic biophysical system which is identified as planning and management unit. A watershed is also a hydrological rejoinder unit and a multifaceted ecological unit in terms of the resources (materials), energy and information present. The watershed not only is a useful unit for physical analyses, it can also be an appropriate socio-economic-political component for the execution of management strategies. In essence, a watershed is a basic organizing unit to manage resources" (Sadeghi, 2020).

"The planning and management of the watershed are done to accomplish the tasks related to the overall development of the watershed, which may be with respect of water quality and quantity improvement, management of ecosystem, enrichment of the socio-economic status of the watershed inhabitants, enhancing the employment opportunity for the people and selection of most appropriate cropping pattern etc" (Anonymous, 2018).

"Watershed management is the balanced exploitation of terrestrial and aquatic resources for the acquisition of optimal production with petite vulnerability to natural assets. It adopts the rehearsal of soil and water conservational strategies in the watershed, for example, appropriate exploitation of the land, defensive measures of land against anthropogenic pressures, enhancement and management of soil fertility, water conservation for irrigational practices, proper supervision of local water supplies for drainage, protection against flash floods and reduction in runoff and soil erosion, and also escalating the production from all the existing land use patterns. Watershed-level hydrological studies are essential to soil and water resources evaluation, improvement and management. At the field scale, hydrologic studies are engaged in devising and designing of soil conservation practices, management of irrigation water, water quality evaluation and water supply availability etc", (Wurbs et al., 1998). "Hydrological studies are important tools for comprehending the hydrological behaviour of the watersheds. Karnataka State in India ranks second, next to Rajasthan in drought condition" (Jayasree and Venkatesh, 2015). "There is a need for rainfall intensity which has effects on groundwater recharge. Recharge results from effective precipitation (ie., precipitation minus losses from evapotranspiration) which infiltrate into the subsurface from where hydraulic gradients are downward" (Taylor and Martin, 2013). "In many environments, natural groundwater discharge sustains base flow to rivers, lakes and wetlands during periods of low or no rainfall, so increased attention should be given to the effect of rainfall on groundwater recharge - there is a need for more detailed investigations of rainfall intensity effects on groundwater recharge. An increase in soil moisture diminishes the hydraulic gradient, thus decreasing the driving force responsible for water infiltration into the soil" (Liu et al., 2011). "In rainfed areas vegetative measures and other insitu conservation practices are inadequate to handle large flows of water, permanent structures are used as control measures. Hence, planning and adoption of in-situ conservation practices is more important. Planning of in-situ soil and water conservation techniques based on soil loss, rainfall and slope of the land, soil depth salinity, land use land cover and geological information" (Rejani and Rao, 2015). Only limited studies were reported for planning of in-situ soil and water conservation interventions for drylands. Thus, the aim of the research on Rainfall Patterns and Groundwater Dynamics: Implications for Soil and Water Conservation in the Kodihalli Sub-Watershed, Haveri District, Karnataka.

2. METHODOLOGY

2.1 Location and Extent

The Kodihalli watershed is located in Hirekerur Taluk, Haveri District of Karnataka, covering villages of Yalavadhalli, Aladageri, Lingdevarakoppa, Kunchur and Mavinathopa. It lies between 14^{0}28’23.68” - 14^{0}34’20.103” North latitudes and 75^{0}26’49.224”- 75^{0}31’44.208” East longitudes and covers an area of about 4398.83 ha. with its elevation ranging from 480m to 638m above mean sea level (Fig. 1).

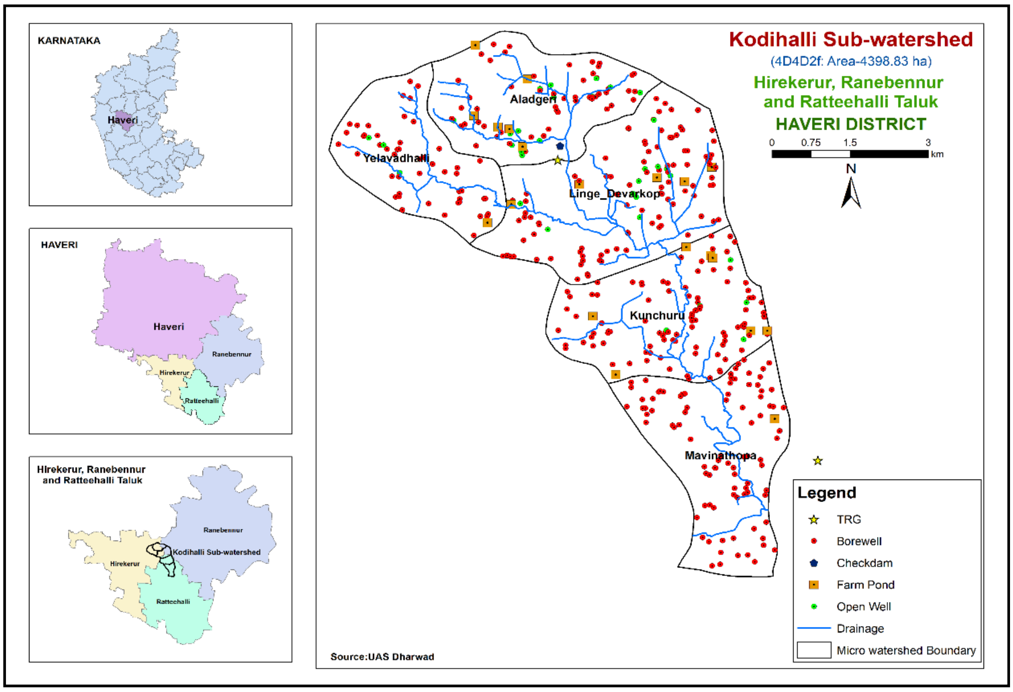

Fig. 1. Location map of Kodihalli Sub-watershed of Haveri district, Karnataka

2.2 Geology, Physiography and Drainage of Haveri District

Kodihalli sub-watershed is underlain by formations of Dharwad schist belt called as Dharwars (supergroup of Archean Eon). The major part of the area is underlain by shale and greywacke. The trend of foliation in the schistose formation is NNW-SSE with dip ranging from 45 to 75 degree to the northeast direction. The weathered thickness of the shale is 60 to 75 m and that of greywacke including different types of schists is about 5 to 20 m. Physiographically, the area has been identified as schistose landscape. The sub-watershed area has been further divided into mounds/ridges, summits, side slopes and moderately sloping, gently sloping and very gently sloping uplands and nearly level plains based on slope and its relief features. The elevation ranges from 636-645 m MSL in the moderately sloping uplands.

Haveri district is drained by Tungabhadra River. The Tungabhadra River flowing on the eastern border of the district is the only perennial river in the district. The Varada and Kumudvati rivers are major tributaries of Tungabhadra and river Dharma a major tributary of Varada drains the district. All the rivers in the district together with their tributaries exhibit dendritic drainage pattern and they form part of Krishna main basin.

2.3 Rainfall and Ground Water Measurement

Groundwater recharge is an important and required necessary activity in managing and developing water resources of a watershed. The seasonal water-level fluctuations in the Kodihalli watershed have been analyzed. The borewell in Koda (Well Code: 90606) representing Kodihalli sub watershed groundwater status. Based on available data obtained from Directorate of ground water, Govt of Karnataka, Bengaluru, characteristics of the groundwater pattern, such as average depth, water level and variability trend in the study area were analysed.

Rainfall is the major source of groundwater recharge. The infiltration of water is mainly governed by lithology, land use practice and elevation of the terrain. Spatial maps were prepared using ArcGIS 10.8. Rainfall data is one of the important data sets in the spatial domain, controlling the water resources budget of the region. Rainfall data for the last eight years were collected from Karnataka State Natural Disaster Monitoring Centre, Govt of Karnataka.

2.4 Point Interpolation: Kriging

Kriging is a geostatistical method for estimating values in unknown areas by considering both the distance and variation between known data points. It involves creating an estimated surface from scattered points with z-values by fitting a mathematical function to nearby points. The process includes statistical analysis, variogram modelling, surface creation, and variance exploration. Predicted values are calculated using a weighted average technique based on the relationship between samples. The search radius can be fixed or variable and generated cell values may exceed the sample range (Mustafaa and Mawlood, 2023).

$$Z(S_0)^N = \sum_{i=1}^{N} \lambda Z(Si)$$

where,

Z(Si) = the measured value at the i th location

λ_i = an unknown weight for the measured value at the i th location

S_0 = the prediction location

N = the number of measured values

The Kriging method is an interpolation method based on principles of zero bias and minimum mean square error. It determines values for a process over an entire domain, finite-volume block or specific point using a linear combination of data values. The summation may be over an entire area or restricted region centered at the estimation point (Varouchakis et al., 2012).

3. RESULTS AND DISCUSSION

3.1 Weather and Rainfall Analysis

To develop the rainfall indices of the Kodihalli sub-watershed, data from the Aladagri rain gauge station in Hirekerur taluk of Haveri district was taken into account. The district falls under hot semi-arid tract of the state and is categorized as drought -prone with an average annual rainfall of 782.5 mm received in last 8 years (Table 1). The maximum of 439.0 mm precipitation is received during south–west monsoon period from June to September, north-east monsoon contributes about 218.9 mm and prevails from October to early December and the remaining 124.7 mm is received during the rest of the year. The monthly precipitation amounts vary considerably from year to year. During the year 2015, 2016, 2017 and 2018 annual rainfall was deficient by 11%, 45%, 11%, and 10.7%, respectively, during 2019 and 2021 the annual rainfall was excess by 33% and 38.6 %, respectively as compared to average annual rainfall (Fig. 2).

During April and May, the temperatures reach up to 36.5°C and in December and January, the temperatures will go down to 16°C. The average monthly Potential Evapotranspiration (PET) is 119.8 mm and varies from a low of 99.8 mm in January to 175.5 mm in the month of March. The PET is higher than precipitation in all the months except end of July to end of October. Generally, length of growing period in Kodihalli sub-watershed ranged from 190 to 200 days (Fig. 3). The length of growing period begins at 19th week (which is May 2nd week) and ends at 47th week (which is November 3rd week). Based on the observation, farmers can schedule sowing and other agronomic practices for short duration and long duration crops. Dry spells/weeks are not found continuous and growth of crops may not be markedly affected if the recommended drought management practices for a given crop/crops are adopted. One protective or life - saving irrigation based on the critical stage of the crop would be of great advantage (Mahadevaswamy et al., 2016).

3.2 Rainfall Distribution

The number of rainy days (>2.5 mm) varied from 13 to 29 days per year. On an average the number of rainy-day events likely to produce runoff (20 to 30 mm) are about 2 to 8 rainy days per year with moderate variation across the years (Fig. 4). The extremely high rainfall peak event days (>30mm) 8 day per year observed in the year 2019 which may cause flood. Which helps in designing conservation and harvesting structure in a watershed. Extreme precipitation is characterized by high spatial variability, the detection of trends induced by changing climate conditions is highly dependent on the quality and quantity of observed rainfall data (Tamm et al., 2023). In Karnataka different watershed areas clearly indicate that rainfed farming in the region is highly vulnerable to rainfall variability and continues to be risk prone for drought (Raizada et al., 2018). Climatic patterns specific to total and average rainfall, number of rainy days, monsoon onset, and intervening prolonged dry spells are some of the important aspects that necessitate the collection of long-term data in order to develop an understanding of possible impacts of climate change on people, natural resources, Agro-ecosystems, and the economy (Mani et al., 2023).

3.3 Spatial and Temporal Estimation of Actual Evapotranspiration

The Actual Evapotranspiration (AET) over the years 2014-2021 in the Kodihalli sub-watershed varied from 383 to 770 mm (Fig. 5). During 2014-2021, the average annual AET (621.0 mm) was less than the average rainfall (782.5 mm). AET was higher than rainfall during the months of January to April, November and December, which forced groundwater withdrawal during these months to meet crop water needs (Fig. 6).

Table 1. Mean monthly rainfall, PET, 0.5 PET at Hirekerur Taluk, Haveri District

Month	Rainfall (mm)	Temp Max (°C)	Temp Min (°C)	Max. RH (%)	Min. RH (%)	PET (mm)	0.5 PET (mm)
January	7.0	31.0	16.6	85.7	32.6	99.8	49.9
February	3.9	33.0	17.2	84.3	25.0	119.1	59.6
March	6.2	35.5	20.1	91.0	25.1	175.5	87.8
April	34.3	36.6	22.4	92.2	29.9	147.3	73.7
May	73.3	34.5	22.6	91.6	46.0	141.8	70.9
June	87.3	30.2	22.2	94.0	61.7	114.3	57.2
July	124.1	27.9	21.7	93.0	70.0	115.3	57.7
August	122.5	27.9	21.3	94.1	73.3	117.1	58.6
September	105.2	29.7	21.4	91.9	62.2	100.4	50.2
October	173.3	30.8	20.8	96.1	57.6	119.6	59.8
November	40.5	30.9	19.0	92.5	46.6	93.0	46.5
December	5.1	31.0	17.3	92.1	42.6	94.5	47.3
Total	**782.5**					**1437.7**	**718.9**

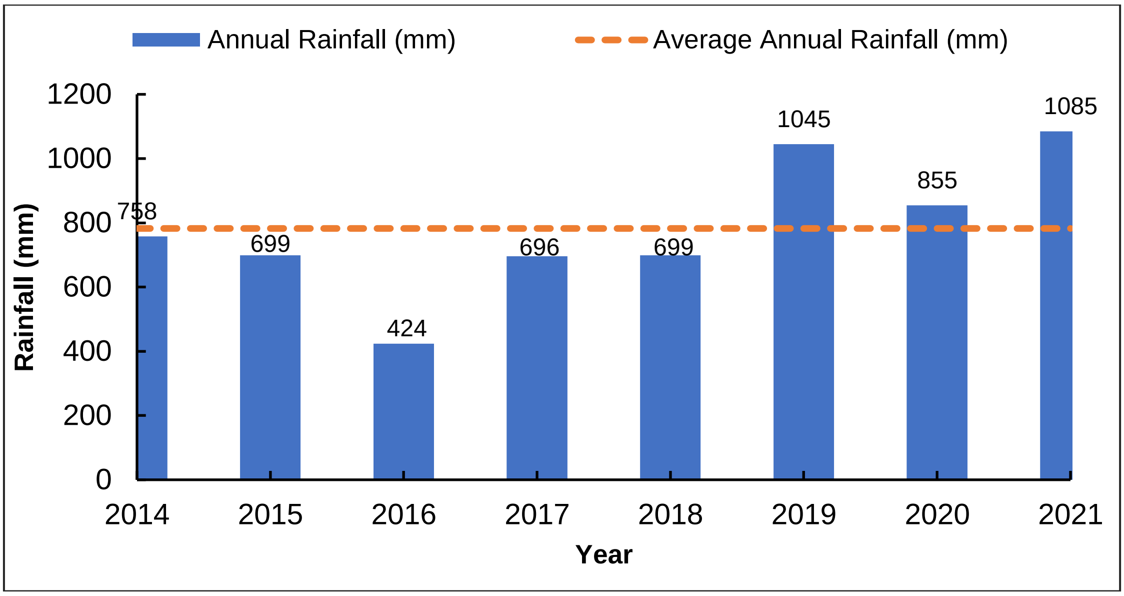

Fig. 2. Average annual rainfall at Hirekerur Taluk, Haveri District, Karnataka

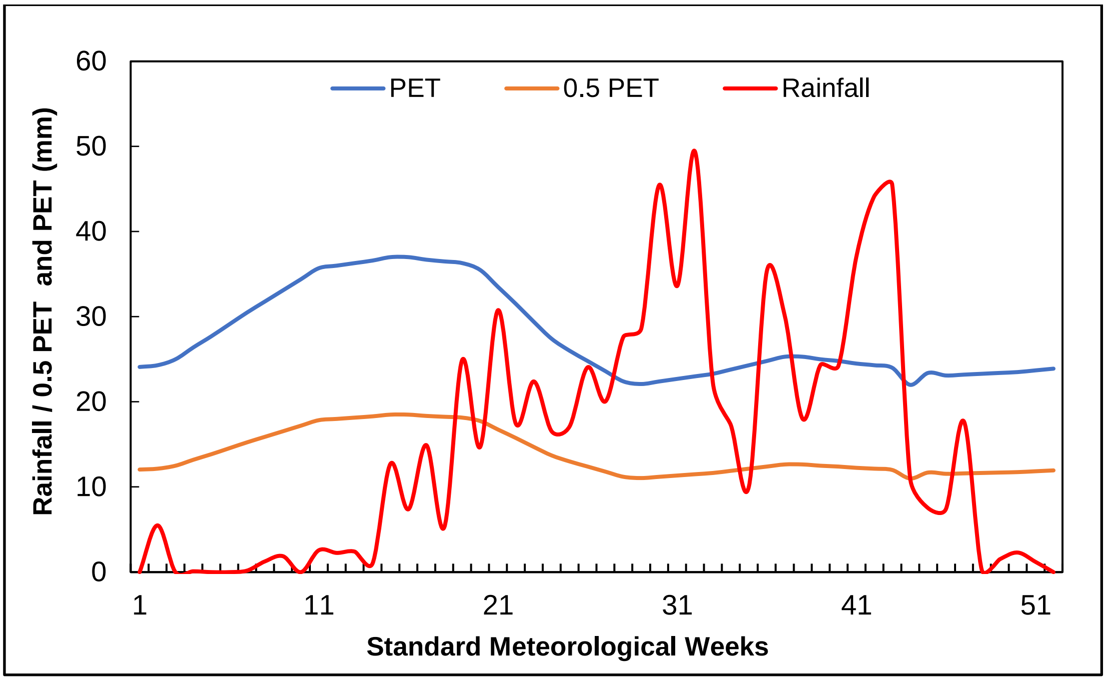

Fig. 3. Mean weekly rainfall, PET and 0.5 PET of Hirekerur Taluk, Haveri District, Karnataka

In the sub-watersheds, the mean annual AET is lower than the mean annual rainfall. This means at the annual time scale of water budget demand side is lower than the supply side. During *kharif season* (June-September), the mean rainfall is higher than the mean AET which means there is surplus water budget in this season for investing in useful water storage. During *Rabi season* (October-January), the mean AET is higher than mean rainfall. During the *summer season* (February-May), the mean AET is close to the mean rainfall.

"The spatial maps of reference and actual evapotranspiration describe that the difference between ET_{ref} and ET_a is less over upper, middle and lower ridges of the watershed (Fig. 7). The ridge-wise analysis in annual actual evapotranspiration shows that the extremely low (565-583 mm) values observed over upper and lower ridge of the watershed and high (721-725 mm) amount of ET_a observed over middle ridge of the watershed. Spatial variability in of actual evapotranspiration was due to soil moisture, vegetation cover and cropping systems adopted in the watershed" (Alexander et al., 2023). "To understand the reason for the variability in ET_a, the seasonal trends are calculated for the major evapotranspiration components including transpiration, bare soil evaporation, interception loss, and open water evaporation during the study period (Mellouli et al., 2023). The transpiration and interception loss from the vegetation has shown a tremendous change in the evapotranspiration" (Raghavendra et al.,2023).

"AET can be more efficiently retrieved at the farm scale using remote sensing techniques that are spatially consistent and temporally continuous. This methodology has the advantage of providing estimates across the entire territory, capturing minor spatial variations between pixels that allow one to assess water use, irrigation, and groundwater recharge efficiency" (Khan et al., 2023), (Ghosh et al., 2023).

3.4 Evapotranspiration Index

Budyko curve is the relationship between the ratio of the actual evaporation amount to the annual precipitation (AET/P) and the ratio of the potential evaporation amount to the annual precipitation (PET/P), called the dryness index or aridity index) based on data obtained from watersheds (Dey and Mishra, 2017). The watershed water balance is in normal condition. For sustainability, the limit of AET/P should be below the Budyko curve for sustainable watersheds from hydrological considerations. This suggests that the cropping choices and irrigation choices have to be altered to reduce the total ET (Fig. 8). The average AET/P ratio between 2014-2021 was about 0.79 which is less than the sustainable limit of about 0.80 (Fig. 9). During 2014 and 2015, AET/P ratio were 1.47 and 1.11 respectively, which indicates receipt of less rainfall in the years and also possibility of ground water being augmented to maintain crop water requirement.

"To build on this and link the Budyko's hypothesis to the complementary relationship between actual evaporation and potential evaporation" (Yang et al., 2006). "The Budyko curve analytically by modelling total evaporation using simple models of interception and transpiration in combination with measurable parameters related to rainfall dynamics and storage availability obtained from remotely sensed data sources" (Kyeung et al., 2021). "The Budyko curve has also been interpreted at a higher physical level as a possible outcome of thermodynamic optimality through the invocation of the maximum entropy production

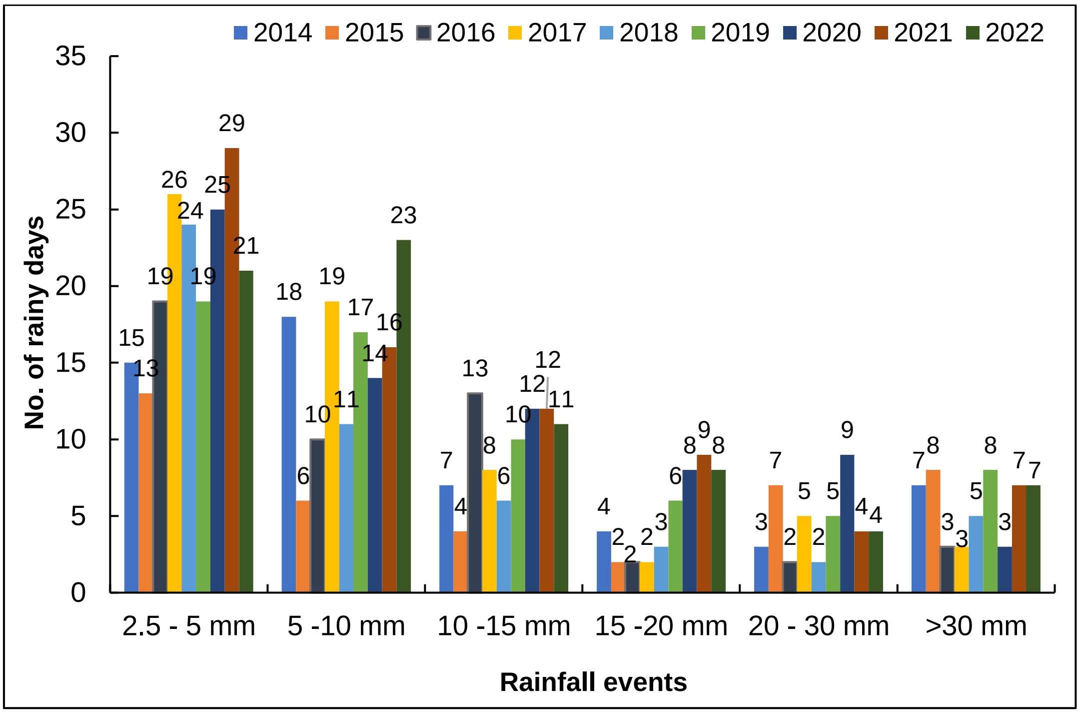

Fig. 4. Distribution of Rainfall in different rainfall events during 2014 to 2022

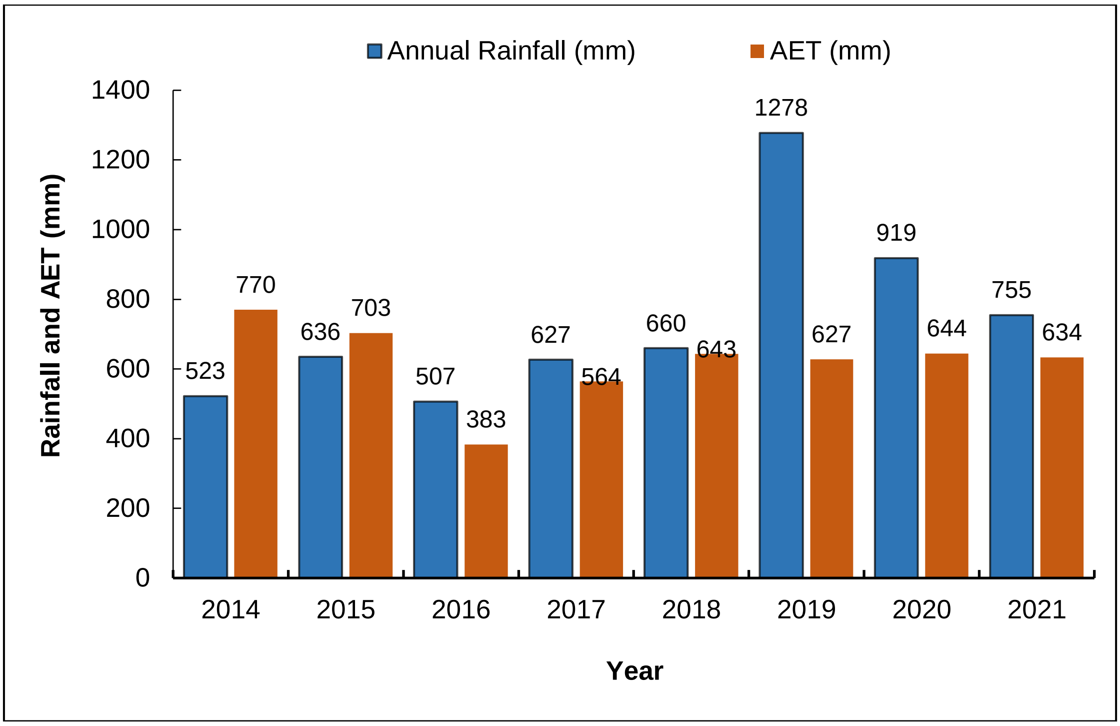

Fig. 5. Actual evapotranspiration (AET) and rainfall over different years (Temporal)

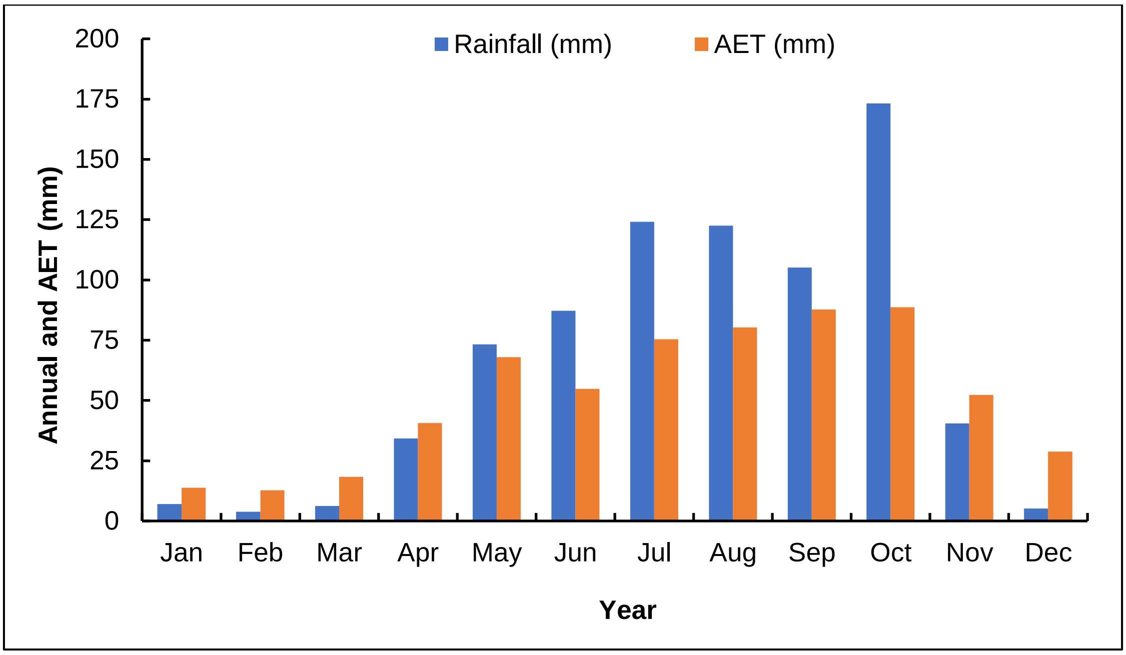

Fig. 6. Month wise Actual evapotranspiration (AET) and rainfall (Temporal)

principle" (Gerrits et al., 2009). "Budyko curve parameter could facilitate and easily utilized by policymakers for watershed quality assessment and hydrological system identification" (Zhao et al., 2016). "The Budyko curve is different for each watershed, and the point on the curve moves due to climate change. Therefore, it is possible to predict when climate changes. It has the advantage of quantitatively evaluating the effect of improving the hydrological system by watershed management" (Dey and Mishra, 2017).

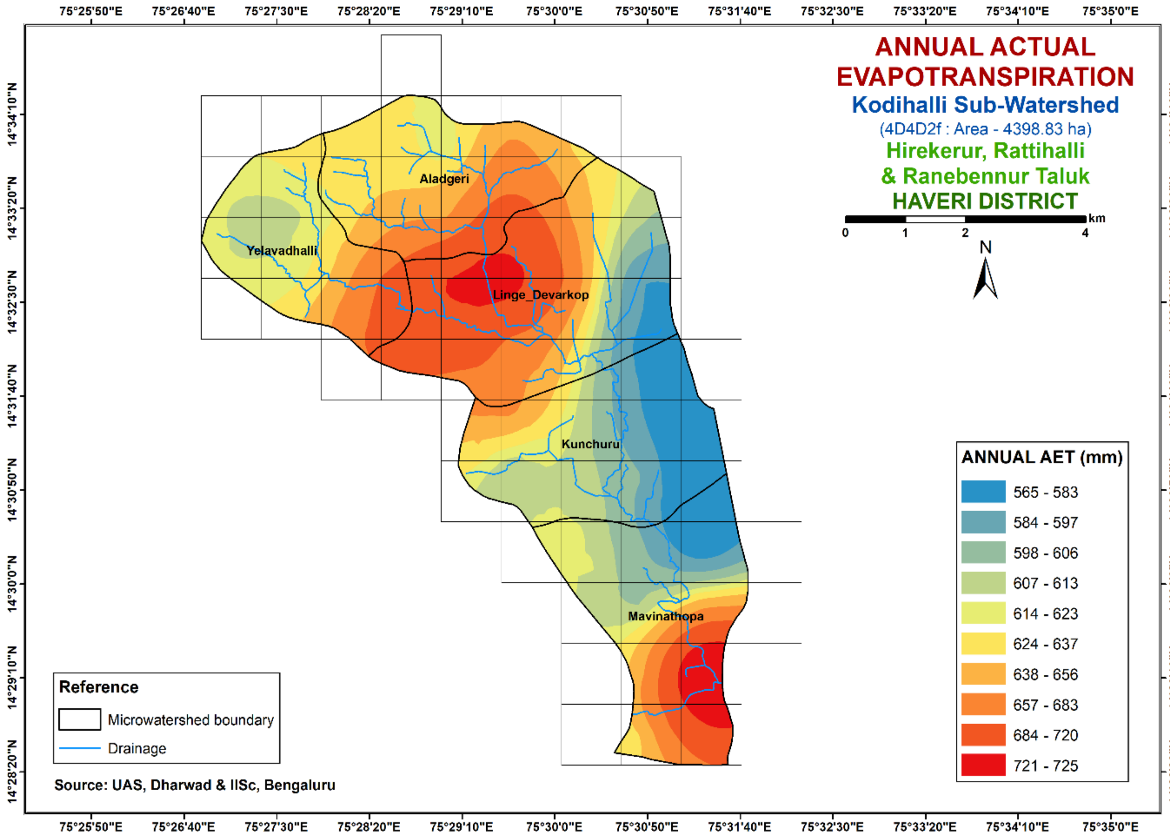

Fig. 7. Spatial Map of the Annual Actual Evapotranspiration of Kodihalli sub-watershed

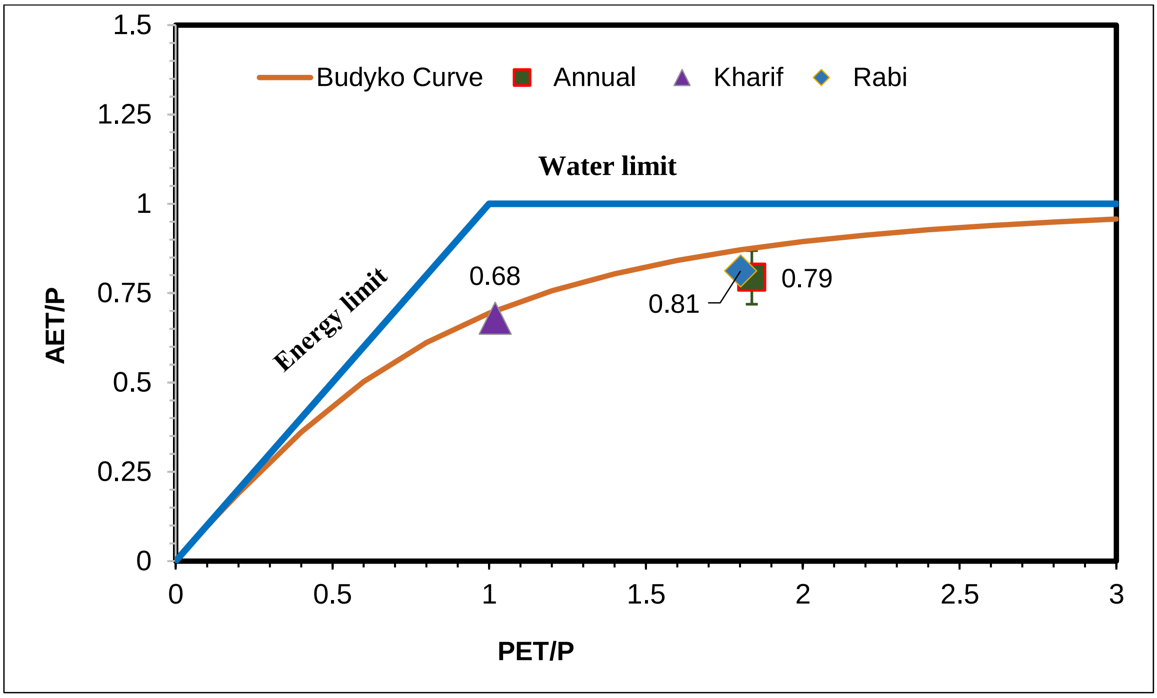

Fig. 8. Seasonal Budyko curve of Kodihalli sub-watershed of Karnataka (2014-21)

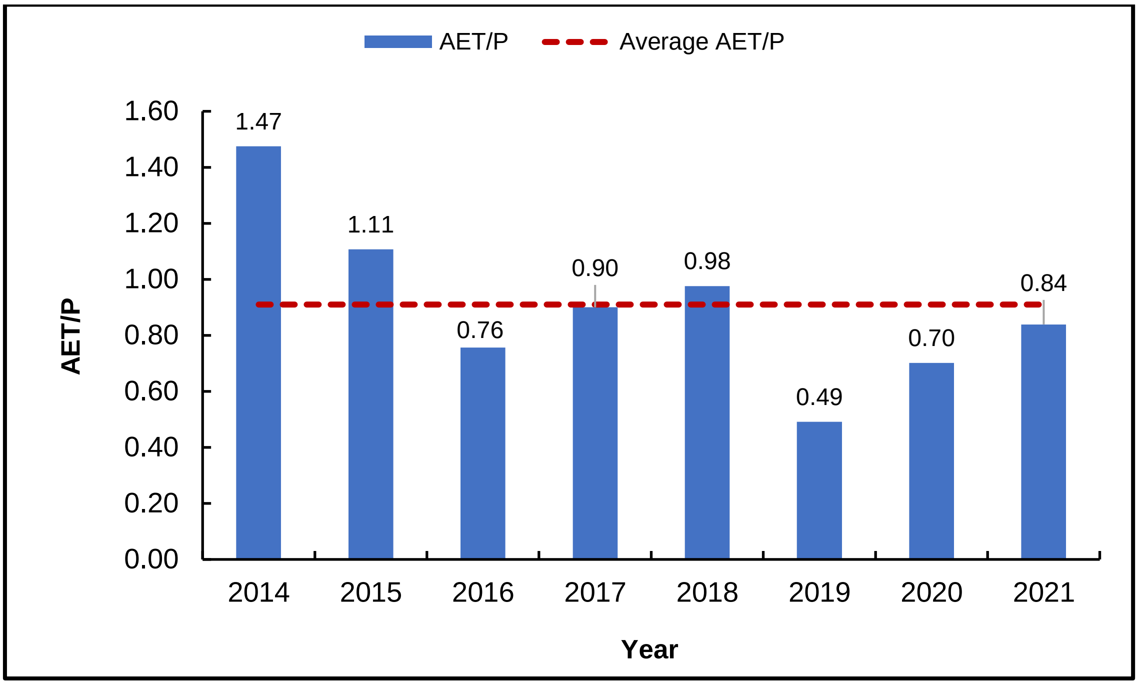

Fig. 9. AET/P Ratio of Kodihalli sub-watershed of Karanatka

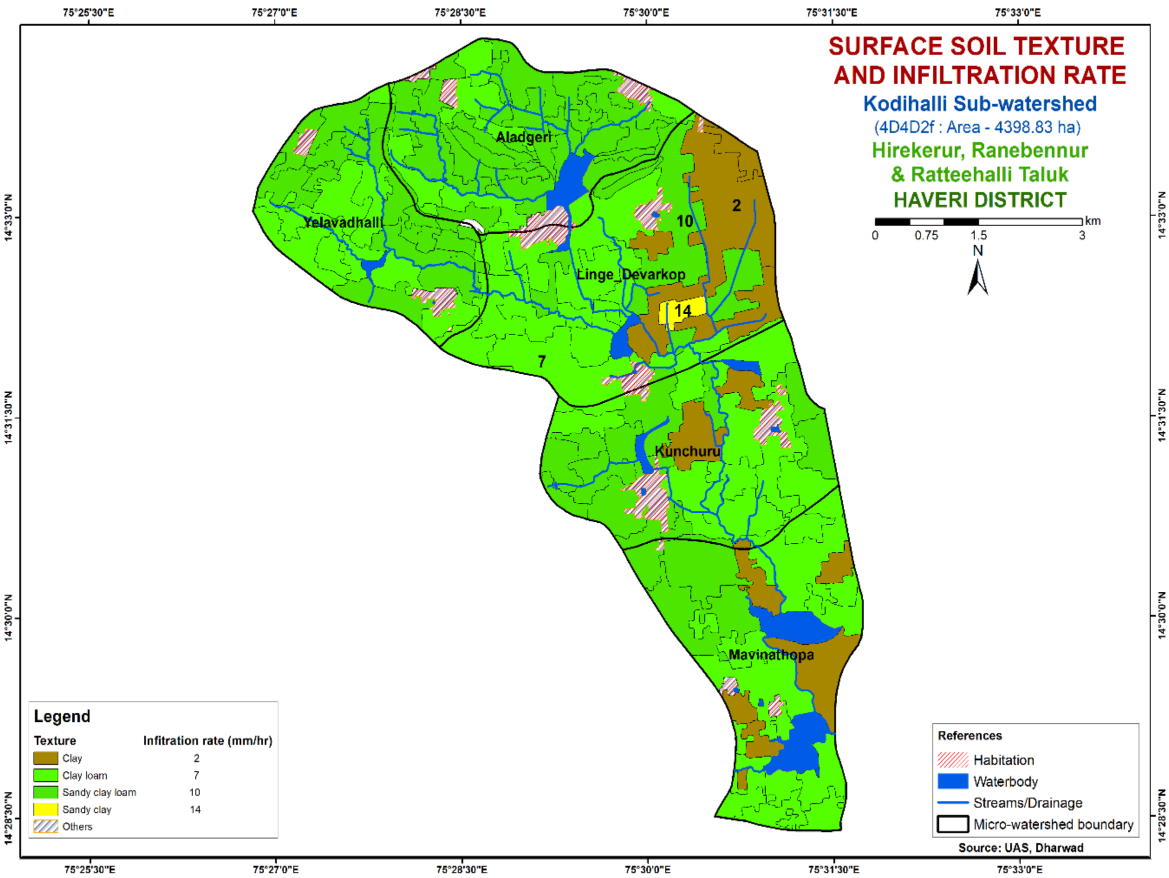

Fig. 10. Surface soil texture and infiltration rate of Kodihalli sub-watershed

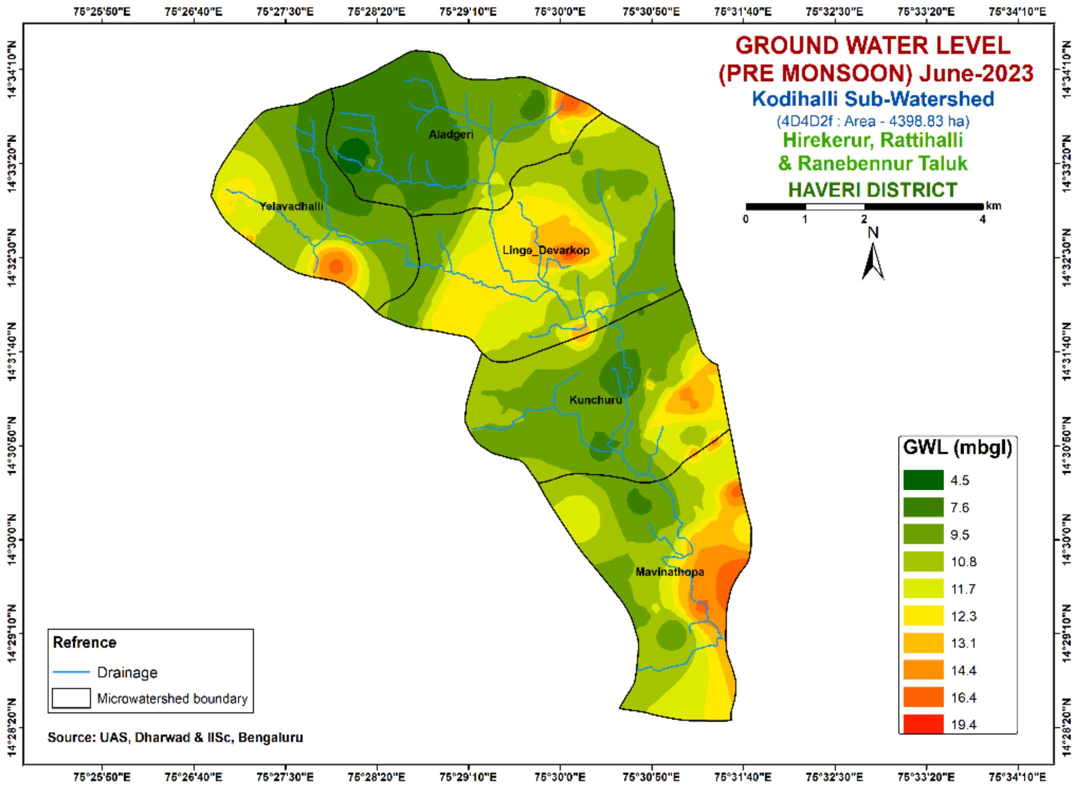

Fig. 11. Pre-monsoon Ground water depth of Kodihalli sub-watershed of Karnataka

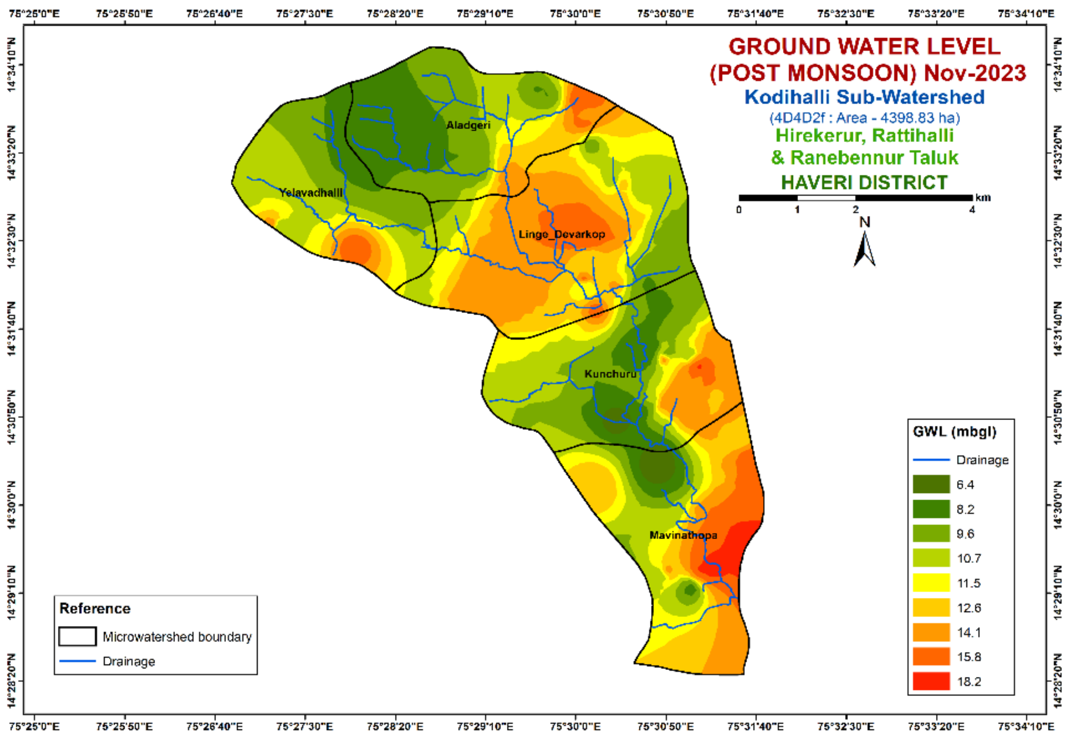

Fig. 12. Post- monsoon Groundwater depth of Kodihalli sub-watershed of Karnataka

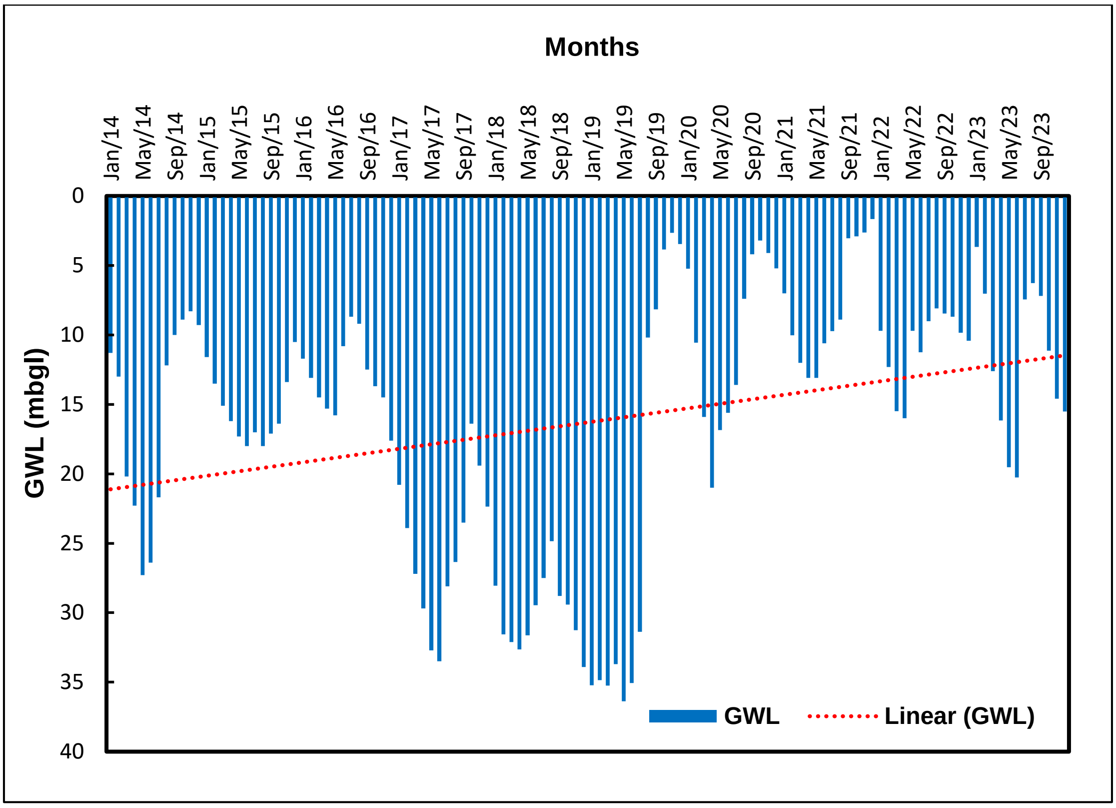

Fig. 13. Ground water status of Kodihalli sub- watershed over different years

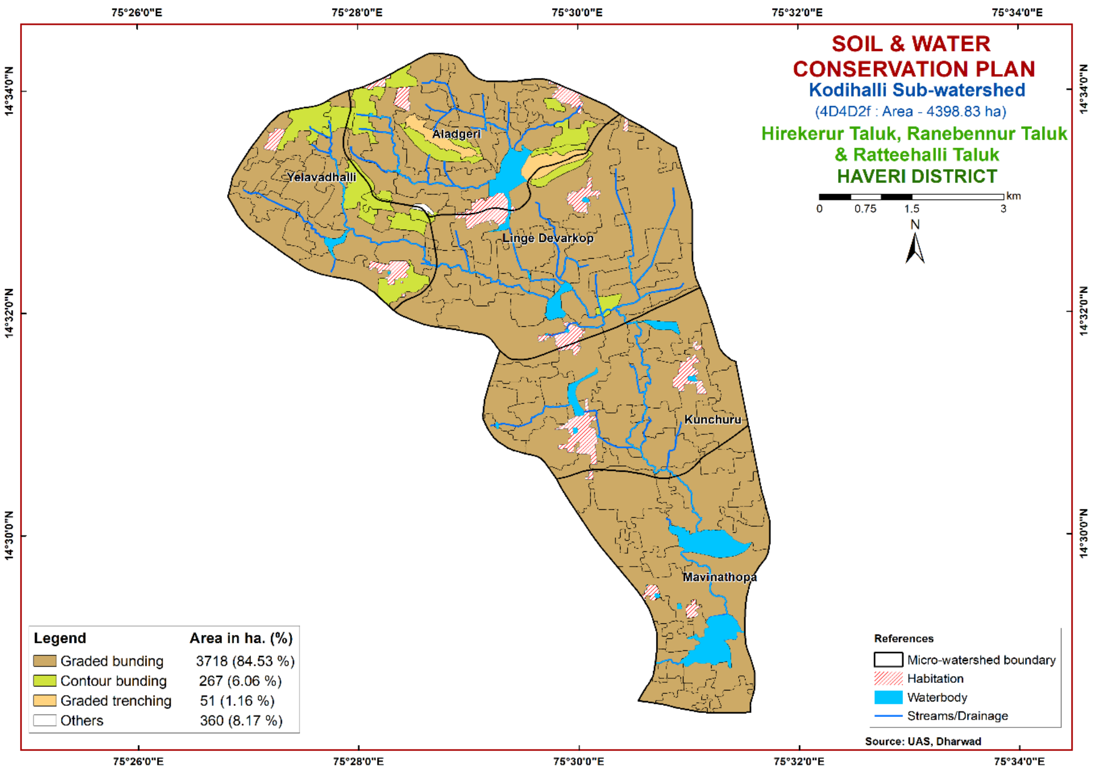

Fig. 14. Soil and Water Conservation Plan map of Kodihalli sub-watershed

3.5 Soil Texture and Infiltration Rate

Texture is an expression to indicate the coarseness or fineness of the soil as determined by the relative proportion of primary particles of sand, silt and clay. It has a direct bearing on the structure, porosity, water infiltration, adhesion and consistence. The textural classes used for LRI were used to classify and a surface soil texture map was generated. The area extent and their geographical distribution in the sub-watershed is shown in Fig. 10. An area of about 551 ha (12.5%) has a clay texture at the surface. The most productive lands concerning surface soil texture are clayey soils (12.5%) with an infiltration rate of 2mm/hr that have a high potential for retention and availability of water and nutrients but, have more problems with drainage, infiltration, workability and other physical problems. The sandy clay loam (1654 ha), clay loam (1811 ha) and sandy clay (20 ha) texture classes occupied the majority of the sub-watershed area. The soils of watershed viz., sandy clay loam (10 mm/hr) and sandy clay (14 mm/hr) resulted in more infiltration rate than clay (2 mm/hr) and clay loam soils (7 mm/hr). The surface soil textural class provides a guide to understanding soil-water retention and availability, nutrient holding capacity, infiltration, workability, drainage, physical and chemical behavior, microbial activity and crop suitability (Basset et al., 2023), (Nawaz et al., 2013). Soil textural classes are pivotal in determining the volume of water that can infiltrate into subsurface formations, thereby influencing groundwater recharge. When evaluating infiltration rates, soil texture and hydraulic properties are important considerations (Huang and Hartemink, 2020).

3.6 Groundwater Depth Measurement and Kriging

The groundwater level data is an important variable in the hydrological budget for estimation of recharge from rainfall or other sources in sub watersheds. Time series data of groundwater level is also useful in understanding the usage patterns of groundwater for irrigation. The data is also useful in assessing the role of managed aquifer recharge or watershed practices in the catchments (Rajashekhar and Chandrakantha, 2020). Groundwater levels fluctuate naturally in response to a sequence of climatic events and to constraints imposed by hydrogeologic and topographic characteristics. The groundwater level is influenced by borewell recharge, discharge, topography of land, soil texture etc. Trend analysis of water table depths indicates marked spatial variations of groundwater levels in the Kodihalli sub-watershed of the study area. The mean depth of groundwater observed from ground level during pre and post-monsoon. During pre and post monsoon the average ground water depth highest of 19.0 mbgl and lowest of 4-5 mbgl (Figs. 11 and 12). These data indicate marked spatial variability in the distribution of wells with distinct rates of change across the different geomorphic units visible (Joshi et al., 2021). The groundwater resource of a region is one of the building blocks for the balanced economic development of the area. The water table represents the groundwater reservoir, and changes in its level represent the changes in groundwater storage (Raghavendra, 2013).

The highest groundwater elevation occurred in the west to the western part of the study area and the lowest groundwater elevation was obtained in the northeastern part of the study area (Figs. 11 and 12). The groundwater elevation gradients are higher in the northern part and gradually decrease towards the southern parts and the general flow occurs from north to south (Nikroo et al., 2010). The groundwater table is deep on the upstream side and shallow on the mid and valley sides. This is possibly due to the flux that the water drains downslope to bring the soil moisture to the field capacity (Addisie, 2022).

The ground water level data have been monitored from the representative wells for pre and post-monsoon seasons for the years 2014 to 2023 has given in Fig. 13. The borewell in Koda (Well Code: 90606) representing Kodihalli sub-watershed groundwater status. Based on available data obtained from Directorate of ground water, Govt of Karnataka, Bengaluru, there was falling trend of depth to water table (25-37 mbgl) in the watershed during 2016 to 2019, as these years were lower rainfall years and indicates utilization of groundwater to buffer the lower rainfall years. The long-term data of depth to Water level is analysed to interpret the behaviour of groundwater over period of time. The groundwater level is observed to show an increasing trend (Manjunatha et al., 2024) Which directly means that, the availability of groundwater is enhanced over the last decade. The pre-monsoon period as well as post-monsoon period shows the increasing trend of groundwater level.

3.7 Soil and Water Conservation Treatment Plan

There are always strong links between measures for soil conservation and measures for water conservation, and this applies equally in semi-arid areas. For preparing the soil and water conservation treatment plan for the Kodihalli sub-watershed, the land resource inventory database was generated and transformed as information through a series of interpretative (Thematic) maps using a soil phase map as a base. A map showing soil and water conservation plan with different kinds of structures recommended has been generated which shows the spatial distribution and extent of area. A maximum area of about 3769 ha (85.7%) requires graded bunding, 267 ha (6.06%) area requires contour bunding and 51 ha (1.16%) requires graded trenching (Fig. 14). The size distributions of the particles (Soil texture) were significantly affected by conservation measures and between conservation types (Yonas et al., 2017). This methodology can be well adopted for the planning and management of insitu soil and water conservation interventions at watershed level or even for large catchments.

4. CONCLUSION

The total geographical area of the Kodihalli sub watershed is 4398.83 ha. and the sub watershed is primarily composed of loamy sand followed by sandy clay loam, sandy loam and clay. The infiltration rates within the sub watershed varied based on the type of soil and ranged from 3 to 14 mm/hr. In sub watershed the mean annual ET is lower than the mean annual rainfall. This means at the annual time scale of water budget demand side is lower than the supply side. There was falling trend of depth to water table (25-37 mbgl) in the watershed during 2016 to 2019, as these years were lower rainfall years and indicates utilization of groundwater to buffer the lower rainfall years. The groundwater map shows the natural topography and prevailing conditions in the watershed are favorable for declining water table. The point recharge and farm ponds may be constructed in the lower most corner of the agricultural fields to increase the natural recharge of rain water during the monsoon period. Soil and water conservation plan with different kinds of structures recommended has been generated which shows the spatial distribution and extent of area. A maximum area of about 3769 ha (85.7%) requires graded bunding, 267 ha (6.06%) area requires contour bunding and 51 ha (1.16%) requires graded trenching.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declares that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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