Water Resource potential and its utilization prospects: A case study on Yettinahole project in South Karnataka, South India

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Abstract: In India many inter-basin water transfer projects are pending implementation. And hence the spatial and temporal unequal distribution of availability and demand for water persists. Western Ghats in south India, which receive very high rainfall, are the source of water for the west flowing rivers in the region. Considerable quantity of water in the west flowing Netravathi River flows into the Arabian Sea without much utilization in the south west monsoon season. Annual yield from the discharge data measured at Bantwala of Dakshina Kannada district between the years 2003 and 2015 of Netravathi river reveals that the minimum yield is 2187.06 Mm^3 (77.18 TMC) and maximum yield is 5502.32 Mm^3 (194.16 TMC) for the total catchment area of 3267.71 km^2. In the present study involving the analysis and presentation of data collected is used in SWAT model for the assessment of water resource in Yettinahole project area which is a sub basin of Netravathi basin. While in inter basin transfer of the water the environmental conservation and diversity of wildlife habitats issues related to water must be addressed.

Keywords: Western Ghats; Netravathi River; SWAT, Yield, TMC.

1. INTRODUCTION:

In a Study on the water availability in 16 sub-basins of Cauvery River basin by Jain et al., (2005) observed that nine sub basin, were found to be water-short even after considering conjunctive use. Among these Kabini, Suvarnavathi, Arkavathi, Bhavani and Amaravathi sub-basins are the most severe water shortage sub-basins in the Cauvery River basin.

Toshka project (Warner, 2013) is one of the mega water diversion projects. Nile river water is planned to be diverted to the Toshka desert for the development of a new settlement in and around the Toshka project to accommodate large population and to reduce the stress of growing population in Egypt on the bank of Nile River. The project has not fulfilled the desired objectives even after large investment. Though the work was commenced long back it has not been completed.

In a study on changes in ecosystems and ground water depth due to the emergent water diversion practices in the lower reaches of the Tarim River, (Aishan, 2013), has found significant effect on ground water depth.

Li et al., (2014) has made a study on the effect of river diversion on longitudinal river bed profile and morphology of river, and it is found that there was change in equilibrium of river bed and morphology.

Putty et al., (2014) carried out investigation on the feasibility of sheet water (surface runoff) extraction through the contour canal (garland canal) for the diversion of Netravathi river water to Hemavathi River basin proposed by Paramasivaiya in 2000. The study indicates the large difference in estimated amount of water that can be extracted by Putty (10.5 TMC) and Paramasivaiya (44 TMC). In the study they estimated the total yield of water as about 410 TMC (12,000 Mm^3) in the whole of the Netravathi river.

Population growth and economic progress of the nation is demanding more water for various purpose was enumerated in the study by Li et al., (2014) on upper reach of the Yangtze river, an improved hybrid optimal method combined with decomposition method was adapted in the study for systematic allocation of water in the region along with the hydro-power generation and the method was found to be efficient.

West Rapti River, one of the dynamic and economically important basins of Nepal was investigated by Perera et al., (2015). Simulation for flood disaster by considering the impact of climate change for future flood frequencies, intensities, and consequent damages in the area has shown a significant increment.

Ramachandra et al., (2015) studied the impact of water diversion on ecology and environment in the Yettinahole which is a tributary of Netravathi River. Rainfall data from department of economics and statistics revels that the catchment receives 3000 mm to 4000 mm of rainfall in a year. The total yield is estimated at about 9.55 TMC in contrast to the yield estimated about 24.01 TMC as given in detailed project report presented by KNNL and 22 TMC as per Karnataka Power Corporation (KPC).

In a study by Zhang et al, (2019), two-well parameterised digital filter was used to separate baseflow from observed daily total streamflow on the Weihe River basin to assess the interaction of ground water and surface runoff and role of base flow in sustaining the aquatic ecosystem.

Karnataka Neeravari Nigam Limited (KNNL) a Karnataka government department is executing Yettinahole project for the diversion of 24.01 TMC of water, for drinking purpose and ground water recharge by filling Minor Irrigation (MI) tanks in Kolar, Chikkaballapur districts (East) and other needy areas enroute, from identified streams on the upper reaches of Netravathi River in Western Ghats near Sakleshpur (West). There are eight weirs/Jack wells are under construction, details of which are available in the Detailed Project Report (DPR) prepared by KNNL. They are given in Table-1 below. Lifting of water up to the ridge is planned by pumping from each weir and five intermediate Delivery Chambers (DC) in the present project, pipes of diameter between 1.5 m to 3.0 m (1.5m, 1.6m, 1.9m, 2.4m, 2.9m, and 3.0m) are used for pumping of water.

Table-1 Give the details of the weirs, location, name of respective streams, Latitude-longitude, elevation of weirs above MSL and catchment area for each weir.

Weir No	Name	Longitude	Latitude	Name of Stream	Elevation	Catchment Area
1	Kumbardi	75° 44' 11" E	12° 54' 35" N	Yettina Hole 1	800	48.80
2	Heggadde	75° 42' 46" E	12° 52' 23"N	Yettina Hole 2	813	7.20
3	Heggadde	75° 41' 01" E	12° 53' 22" N	Yettina Hole 3	860	9.80
4	Kadumane Estate	75° 39' 03" E	12° 54' 26" N	Kadumane Halla1	903	13.79
5	Kadumane Estate	75° 39' 31" E	12° 53' 37" N	Kadumane Halla2	955	7.49
6	Kadagarahalli	75° 43' 07" E	12° 49' 52" N	Keri Hole	775	24.25
7	Kadagarahalli	75° 42' 42" E	12° 48' 04" N	Hongadahalla	733	53.80
8	Alavalli	75° 43' 27" E	12° 51' 46" N	Yattina Hole 4	743	11.61

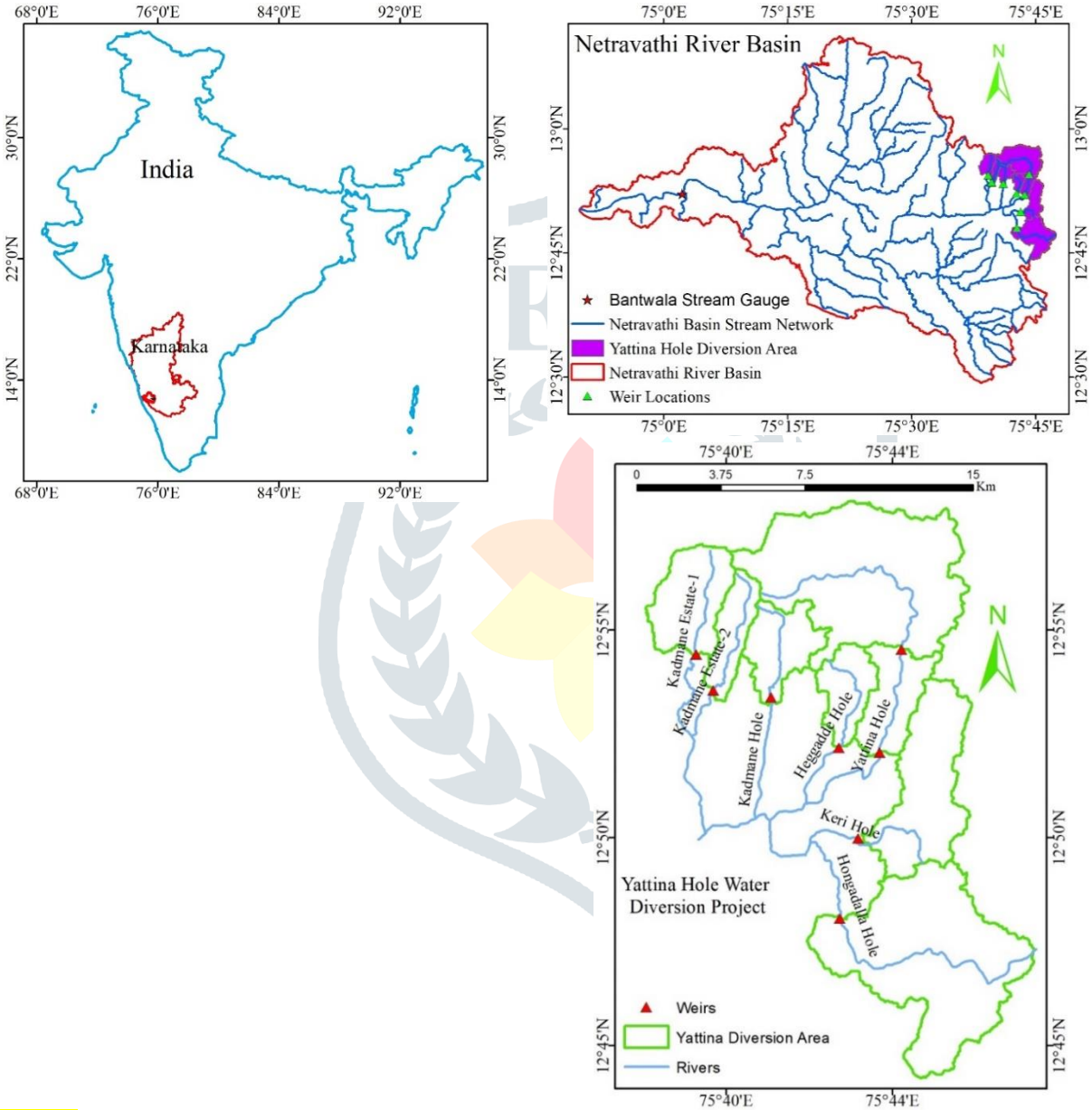


Figure 1: Index map showing stream network of Netravathi basin and Yettinahole project area

1. STUDY AREA

Yettinahole project catchment area 166.32 km^2 is located in upstream reaches of Netravthi River basin in the Western Ghats of south India and it extends between 12^{0}44'13.2 -12^{0}58'4.8" latitude and 75^{0}38'2.4"-75^{0}47'24" longitude. Elevation of the area varyies between 758 m to 1295 m above MSL. High southwest monsoon, hilly terrain and dense stream network is the significant feature of the area. Details of stream network of Netravathi river basin, stream gauge station across Netravathi river at Bantwala, Yettinahole and it six tributaries, location of eight weirs of Yettinahole project and Yettinahole project catchment area are shown in Figure 1.

First weir is located across Yattinahole (upstream) at Kumaradi near Bangalore Mangalore highway; second weir is located across Kadmanehole at Kadmane village; third weir is located across Heggaddehole at Maranahalli village near Bangalore Mangalore highway, fourth weir is located across Kadmane Estate Hole-1; fifth weir is located across Kadmane Estate Hole-2; sixth weir is located across Keri Hole at Kadaravalli village; seventh weir is located across Hongadahalla Hole at Moganalli near Kadaravalli village; and eight weir is located across Yettinahole (downstream) at Alavalli village are presented in the index map given in the

Figure-1. Details of streams and weirs, catchment area corresponding to each of the weirs, latitudes and longitudes of location of weirs, minimum and maximum elevation of catchment area are presented in the Table-2.

Netravathi river having catchment area of 3414.76 km^2 is surrounded by Gurupura River basin (Phalguni River, Pachamagaru Hole) on its north-west side, Tunga Bhadra river basin on its north-east side, Hemavathi River basin on its east side, Harangi Hole on its south-east side. Uppala River (Kalai River), Shriya river and (Chandragiri Payaswini) River are surrounding Netrabathi river on its south side.

Table 2: Rivers/streams, name, location with longitude and latitude, maximum and minimum elevation of catchment area of each of the project sub-basins in Yettinahole Project.

Sl No	Name of River	Location name of weirs/pump house	Location of Weir/Jock well/ Pump house		Elevation		Area in Km^2
			Longitude	Latitude	Min	Max	
1	Yattina Hole u/s	Kumbaradi	$75^0$44'12.84"	$12^0$54'31.32"	811.00	1293.00	48.32
2	Kadmane Hole	Kadmane	$75^0$41'02.75"	$12^0$53'26.37"	896.00	1106.00	9.98
3	Heggadde Hole	Maranahalli	$75^0$42'42.84"	$12^0$52'09.68"	820.00	1020.00	7.73
4	Kadmane Est Hole1	Kadmane Estate1	75^0 39'16.92"	$12^0$54'24.48"	917.00	1295.00	13.17
5	Kadmane Est Hole2	Kadmane Estate2	$75^0$39'41.04"	$12^0$53'32.64"	958.00	1185.00	7.13
6	Keri Hole	Kadaravalli	$75^0$43'10.92"	$12^0$49'58.80"	792.00	1048.00	22.46
7	Hongadahall	Kadaravalli	$75^0$42'43.92	$12^0$48'03.60"	761.00	1179.00	47.04
8	Yattina Hole d/s	Alavalli	$75^0$43'41.52"	$12^0$52'02.64"	758.00	1002.00	10.55

2. DATA FOR STUDY:

Four Topographic sheet (Topo-Sheet) from Survey of India, of 1: 50000 scale, (Open Series Map numbers 48P9, 48P10, 48P13 and 48P14) are mosaicked and extracted for the study area is presented in Figure-2(a). Digital Elevation Model (DEM) of 30m resolution from Shuttle Radar Topography Mission (SRTM) is extracted from Global Land Cover Facility (GLCF), is given in Figure-2(b). Land Use Land Cover (LULC) map of Yettinahole water diversion area extracted from the LULC map prepared by National Remote Sensing Centre (NRSC), Hyderabad is presented with the description of LULC classification in Figure-2(c). Soil map of study area, extracted from soil map of 1:50,000 scale for Hassan district, prepared by National Bureau of Soil Centre (NBSC), Bangalore, government of India is presented in Figure-2(d). Study area consists of soil units 24, 26 & 28 whose description is given in the Table-3.

Table-3: Description of soil units of the study area

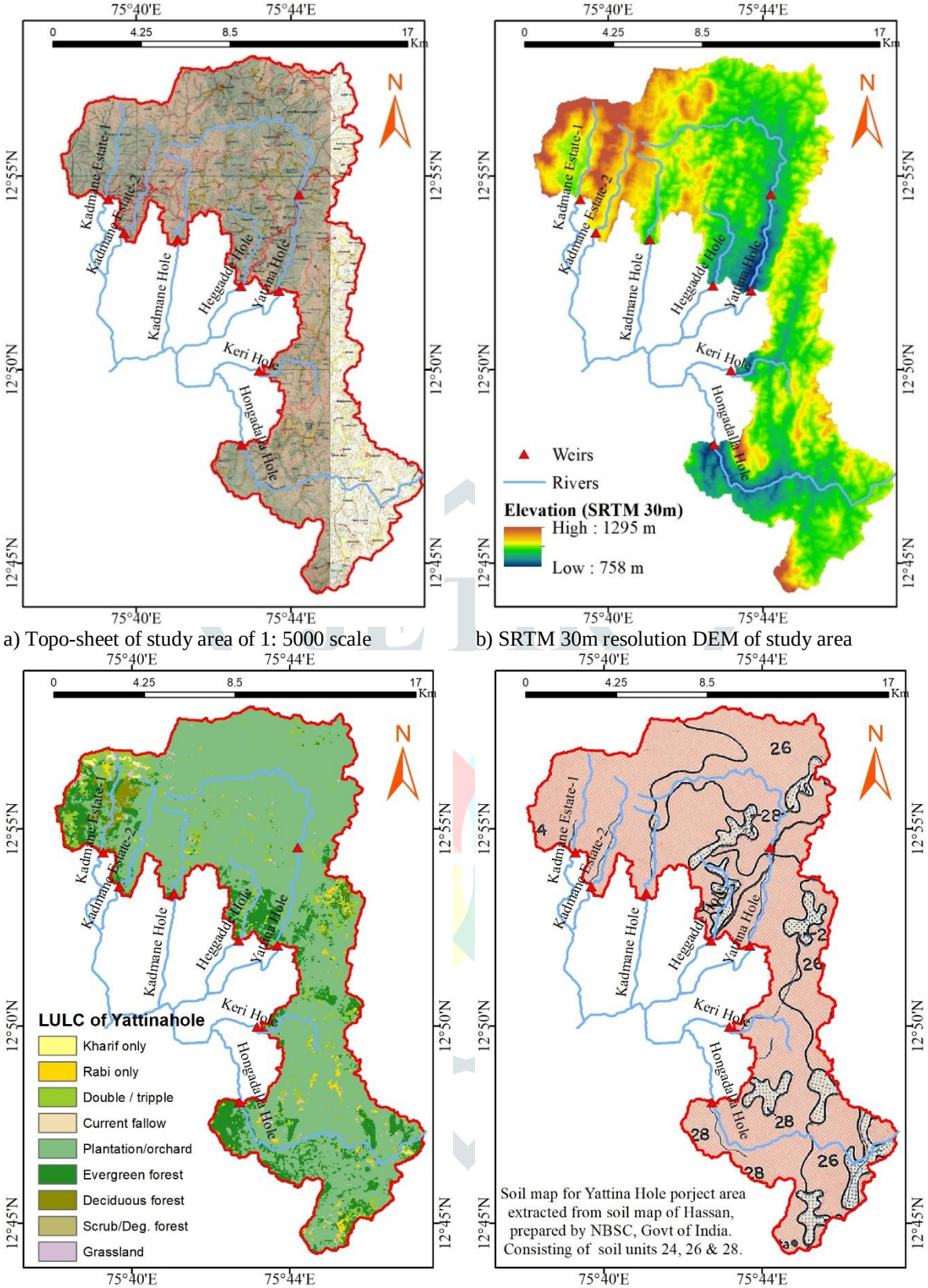
Physiography	Mapping unit symbol	Brief description	Classification
Moderately to steeply sloping	24	Very deep dark brown to yellowish red, clay loam to gravelly clay, gravel 10 to 20 %	Oxic Ustropept
Moderately to steeply sloping	26	Very deep dark brown to yellowish red, clay loam to gravelly clay, gravel 10 to 20 %	Oxic Ustropept
Valley	28	Very deep yellowish brown to greyish brown calcareous, sandy clay to sandy loam	Typic Ustorthent

Yettinahole project catchment area was visited to verify the location of weir with a Geographical Positioning System (GPS) of name Garmin Montana 680 device of 40 inch accuracy, and collected latitude and longitude of all eight weirs. Picture of weir locations along with the streams are given in Figure-3.

Daily Rainfall data at Maranahally raingauge station for 78 years was collected from the department of economics and statistics is used in the present study. Measured stream flow at Bantwala gauging station for Netravathi River of catchment area 3267.71 km^2 is available with WRDO for the duration 2003 to 2015 was collected and used in the present study.

1. ANALYSIS OF THE DATA

SRTM 30m resolution DEM is used for the declination of Catchment area corresponding to the outlet points of study area in the GIS platform and the same is verified in topographic sheet of SOI of 1:50,000 scale. Catchment area map of the Netravathi River basin corresponding to 10 locations are generated. First location is selected at outlet of Netravathi River where it confluences with Arabian Sea at Mangalore with a basin area of 3414.76 km^2. Second cross section of river is selected at Bantwala, where the WRDO stream gauge station is located corresponding catchment area is 3267.71 km^2. Remaining eight cross sections are selected at each of the weirs under construction/constructed across tributaries of Yettinahole/Kemphole river in the Yettinahole project area. The details are (Name of stream, location, elevation, catchment area) listed in Table-2 and are marked across the streams in Figure-2. The total area of the sub-basin is 166.38 km^2.



a) Topo-sheet of study area of 1: 5000 scale

b) SRTM 30m resolution DEM of study area

c) LULC classification map collected from NRSC, Hyderabad.

d) Soil map of 1: 50,000 scale procured from SBSC Bangalore, indicating soil unit.

Figure-2: Map data used for the study of the Yettinahole project area a) topo sheet b) DEM map c) LULC map and d) soil map

a) U/S of weir under construction near Kumbaradi across Yettinahole

b) Pumping house under construction in Kadumane village across Kadumane Halla

c) D/S of weir under construction at Maranahalli village across Heggadde Halla

d) U/S of weir constructed inside the Kadumane estate across Kadumane estate Halla - 1

e) U/S of weir constructed inside the Kadumane estate across Kadumane estate Halla - 2

f) D/S of weir under construction near Kadaravalli across Keri Halla

g) U/S of weir under construction near Kadaravalli across Hongadahalla Halla

h) View from U/S of weir under construction near Aluvalli across Yettinahole at D/S.

Figure-3: Picture of location of weirs, Jock well and pumping house under construction at eight locations of information given in Table-2 of Yettinahole project is under execution by Karnataka Neeravari Nigam Limited.

Daily rainfall data of Maranahalli raingauge station within the Yettinahole project area are collected from the department of economics and statistics of government of Karnataka for the duration of 78 years and are used to prepare monthly and yearly rainfall data series and monthly mean for all twelve months of the 78 years. The annual mean of 78 years of rainfall data is 4970.83 mm and maximum of rainfall was observed in the year 1923 with a magnitude 8508.2mm and least rainfall was observed in the year 1970 with a magnitude of 2091.2mm. The number of annual rainfall magnitudes between 2001-3000 mm are 4; between 3001-4000 are 11; between 4001-5000 are 28; between 5001-6000 are 18; between 6001-7000 are 12; between 7001-8000 are 4 and greater than 8001 is 1. Plot of 78 years annual rainfall data indicates the negative trend ($Y = -17.684X + 5726.1$, where Y is change in magnitude of rainfall and X is in number of years) as shown in the Figure-3. Yearly rainfall data is arranged in ascending order of rainfall magnitude, monthly rainfall data corresponding to neighbourhood of minimum and maximum rainfall (four years each) and rainfall of magnitude nearly equal to the estimated monthly mean rainfall for three years are selected and presented in the Figure-3. Whether it is low rainfall year or high rainfall year or average rainfall year the major portion of rainfall occurs in south west monsoon during the months June to September (~ 90.6%) and rainfall received during North-east monsoon (October to December), pre-monsoon (March to May) and during winter (January and February) is the least (~9.4%) and it can be visualised in Figure-4. During south-west monsoon July and August is contribute 63.64% of annual rainfall.

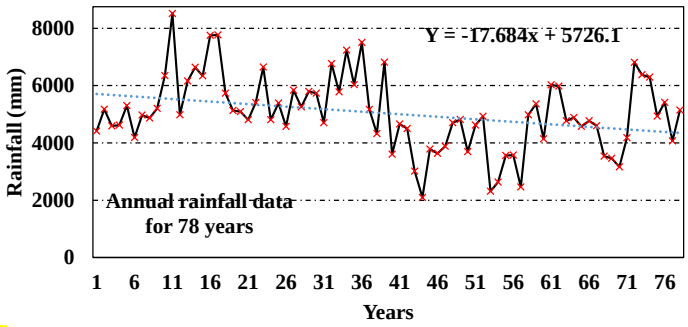
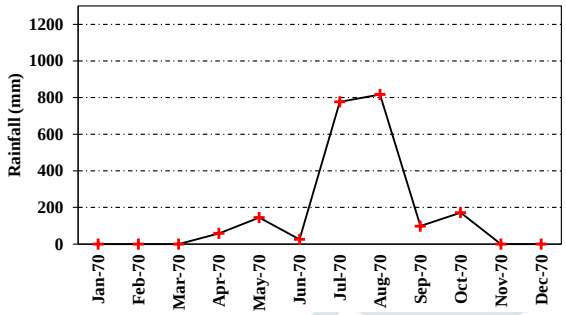
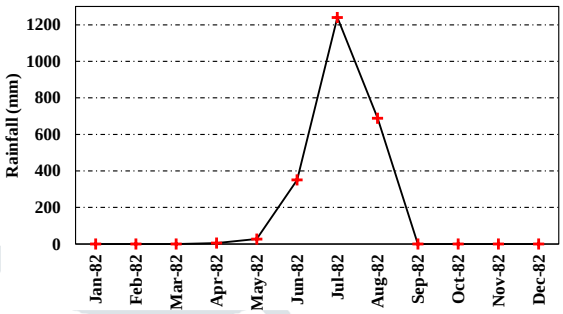


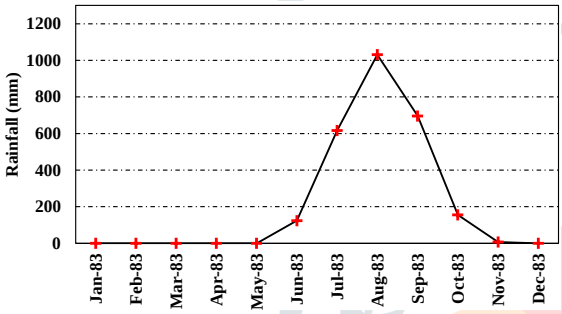
Figure 4: Plot of annual rainfall at Maranahally Raingauge station for 78 years



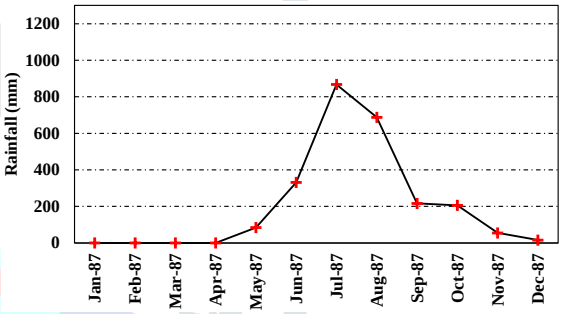
a) Plot for montly rainfall for year 1970



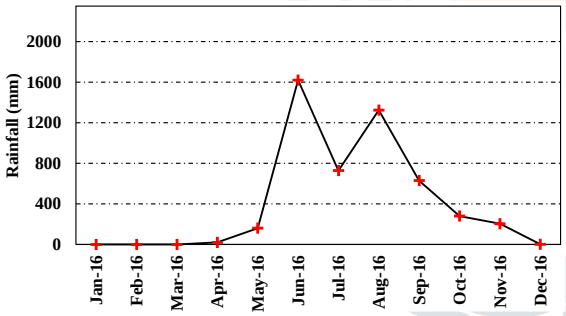
b) Plot for montly rainfall for year 1982



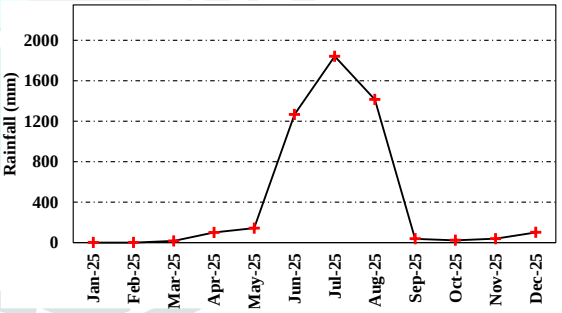
c) Plot for montly rainfall for year 1983



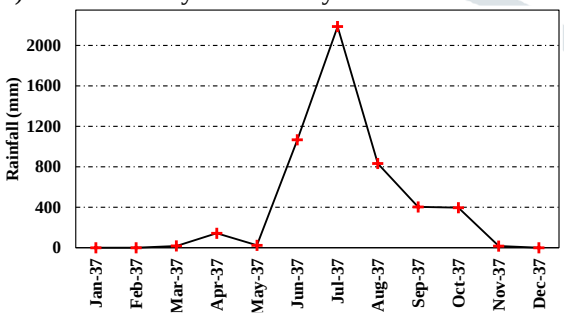
d) Plot for montly rainfall for year 1987



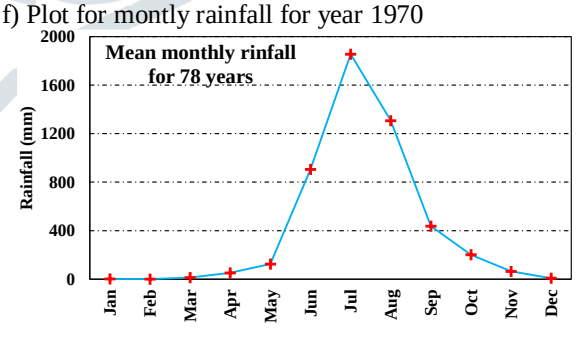
e) Plot for montly rainfall for year 1970



f) Plot for montly rainfall for year 1970



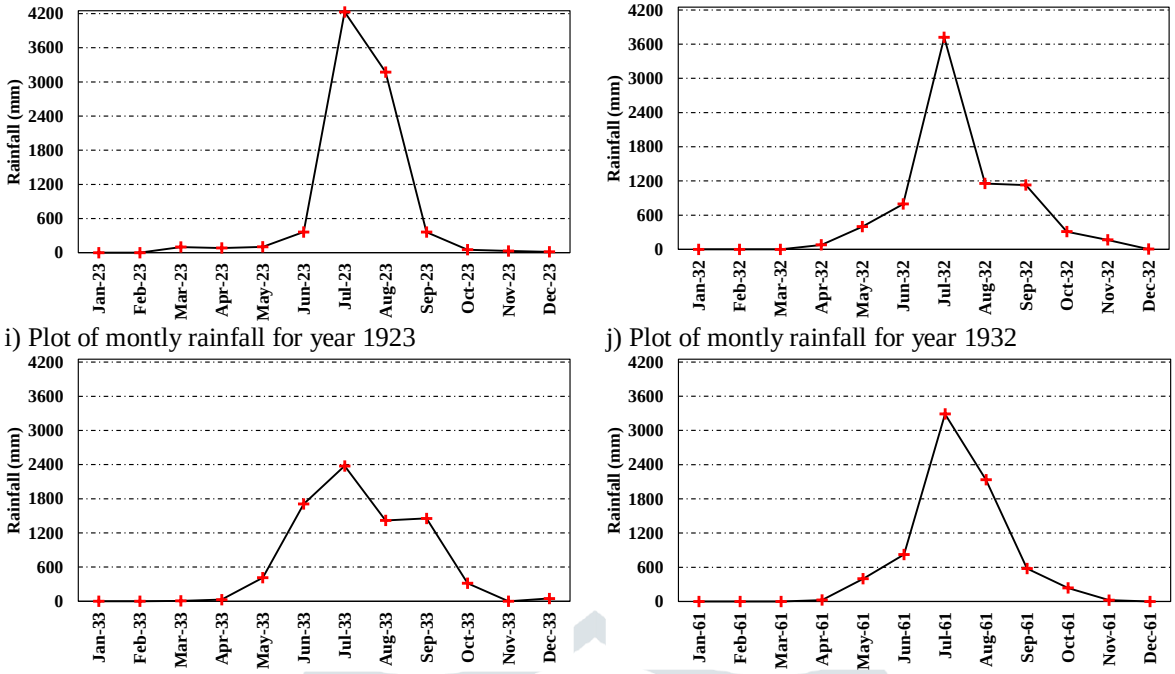
g) Plot of montly rainfall for year 1970



h) Mean Monthly rainfall for 78

Figure 5: Monthly rainfall at Maranahally raingauge corresponding to neighbourhood minimum rainfall (a, b, c and d), average rainfall (e, f and g) and monthly mean rainfall for 78 years (h).

Major portion of Yettinahole project area is covered with evergreen dense forest and coffee plantations as shown in the Figure-2(c) which increase the infiltration and reduce the surface runoff due to land covered with thick litter. Often cultivation in plantations further reduces surface runoff and increase the infiltration and delayed flow like base flow. Yettinahole project area is hilly terrain as shown in Figure-2(b) and located in western side of Western Ghats; it increases the surface runoff. Soil characteristics of the area is shown in Figure-2(d) and Table-3; it is consisting of soil of unis 24 and 26 which is 10% to 20% of gravel and sand would increase the infiltration.

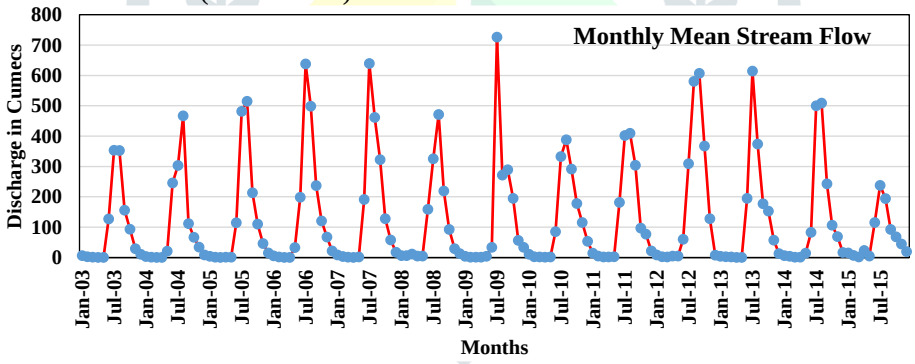


i) Plot of montly rainfall for year 1923 j) Plot of montly rainfall for year 1932

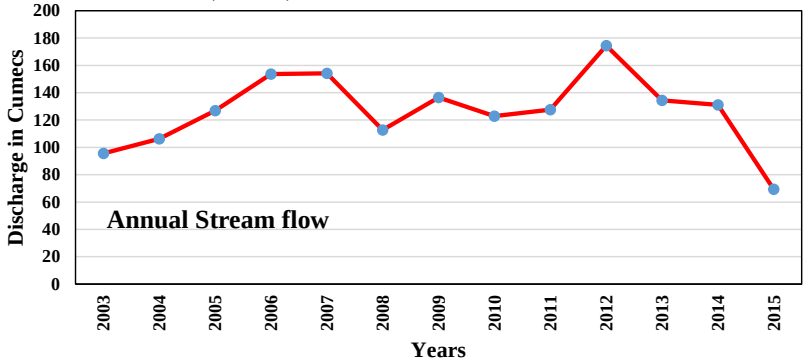
k) Plot of montly rainfall for year 1933 l) Plot of montly rainfall for year 1961

Figure 6: Monthly rainfall at Maranahally Raingauge corresponding to maximum neighbourhood rainfall (i, j, k and l).

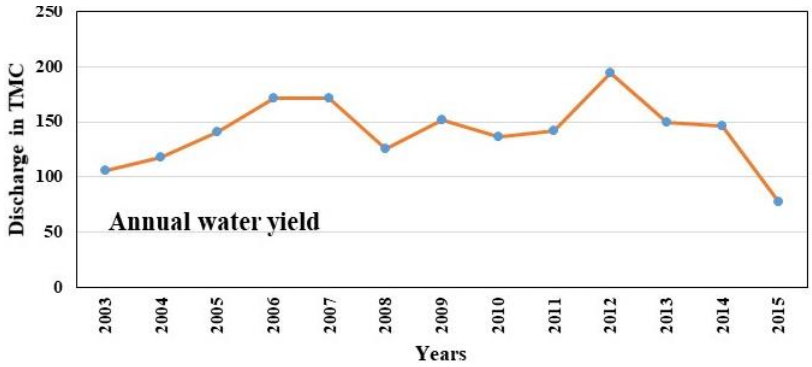
Central water commission (CWC) of government of India and Water Resource Development Organisation (WRDO) of government of Karnataka are monitoring stream gauge at Bantwala across the Netravathi River and daily stream flow data collected from WRDO is used in the present study. Monthly mean stream flow, annual mean stream flow and annual yield of water for catchment area of 3267.71 km^2 (given in Table-4) corresponding to Bantwala stream gauging station are estimated and presented in section a, b and c of Figure-5. Yettinahole project catchment area is 166.38 km^2 and it is estimated at about 5.09% of the catchment area corresponding stream gauge station at Bantwala (3267.71 km^2). The minimum yield of water 77.18 TMC (2187.06 Mm^3) was observed in the year 2015 and maximum yield of water 194.16 TMC (5502.32 Mm^3) was observed in the year 2012, the average yield for thirteen years is found to be 140.84 TMC (3991.27 Mm^3) at Bantwala. By making the assumption of uniform rainfall in Netravathi catchment area yield form the Yettinahole project catchment area is estimated, approximately, by taking 5.09 % of yield of whole catchment area corresponding to the gauging station at Bantwala. The yield of Yettinahole project area is estimated at a maximum of 9.88 TMC (280.07 Mm^3) in in the year 2015 and a maximum of 3.93 TMC (111.32 Mm^3) in the year 2012 and the average of 13 years of data is 7.17 TMC (203.16 Mm^3).



(a) Monthly mean stream flow in cumec (m^3/sec)



(a) Annual mean stream flow in cumec (m^3/sec)



(a) Annual yield in TMC

Figure-7: Stream flow measured between Jan 2003 to July 2015 at d/s Bridge near Bantwala, Dakshina Kannada corresponding to total catchment area of 3267.71 km^2

Table-4: Water yield measured between Jan 2003 to July 2015 at d/s side of the Bridge near Bantwala, Dakshina Kannada corresponding to total u/s catchment area of 3267.71 km^2 of Netravathi basin

Year	Water Yield (TMC)	Year	Water Yield (TMC)
2003	106.31	2010	136.83
2004	118.15	2011	141.91
2005	141.11	2012	194.16
2006	170.94	2013	149.50
2007	171.62	2014	145.90
2008	125.40	2015	77.18
2009	151.94	2010	136.83

2. CONCLUSION

Analysis is made on the catchment area of Netravathi basin and Yettinahole project area to assess the hydrological characteristics by using 30m resolution SRTM DEM data, 1:50000 scale Topographic sheet and SOI, LULC map from NRSC, Daily Rainfall data for 78 years at Maranahalli gauge station and streamflow data for 13 years at Bantwala gauging station. The estimated yield is varying between a maximum of 9.88 TMC (280.07 Mm^3) in the year 2015 and a minimum of 3.93 TMC (111.32 Mm^3) in the year 2012 and average of 13 years of data is 7.17 TMC (203.16 Mm^3).

3. FUTURE SCOPE OF THE STUDY

Due to the lack of stream flow data for Yettinahole project area it is required to use advanced methods for the estimation of yield by using Soil and Water Assessment Tool (SWAT) for ungauged stations by estimating the common parameter for both Netravathi basin and Yettinahole basin by calibration and validation of SWAT model by using stream flow data at Bantwala gauging station. It is also necessary to collect the stream flow data for a long time period for the Bantwala stream gauging station for use in SWAT model. Some more sets of rainfall data at various raingauge stations in whole of Netravathi River necessary for the estimation of mean rainfall in both Netravathi basin area and Yettinahole project area and to use in SWAT model. Some other rational and empirical methods can be explored for the estimation of yield from the catchment. For the proposed water lifting system in the study area, it is required to estimate minimum discharge in stream to lift the water corresponding to the pipe diameter/length/elevation and pumping capacity of each unit from weirs and between five Delivery Chambers (DC) of the project.

ACKNOWLEDGEMENT

I would like to express my sincere gratitude to WRDO for providing streamflow data for Netravathi River, IMD for providing meteorological data, NRSC for providing LULC data, FAO for soil map and USGS for providing DEM data for use in the study of the hydrology of Netravathi river basin.

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