Mysore J. Agric. Sci., 55 (1) : 73-77 (2021)

Estimation of Water Balance in Halayapura-1 Micro-Watershed in Tumkur District of Karnataka

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ABSTRACT

It is important to understand the available quantity of water resource on spatially and temporally to use water resource efficiently. The study was carried out in Halayapura-1 micro-watershed, Tumkur taluk of Tumkur district located at 13° 08' 31" to 13° 10'04" North latitude and from 77° 05' 45" to 77° 07' 19" East longitude, covering an area of 503 ha. Out of total average annual rainfall of 851.3 mm, *kharif* rainfall accounted for 54.2 per cent, *rabi* rainfall for 24.3 per cent and *summer* rainfall for 21.5 per cent. The average actual evapo-transpiration (AET) of the study area is estimated in the watershed based on the current land use and irrigation practices for the *kharif* and *rabi* seasons is 585.1 mm. Hence, the amount of water use for *kharif* and *rabi* season may be estimated as 731.3 mm (*i.e.,* 125 % of AET). This demand for the two seasons is greater by 475.4 mm. From a hydrological point of view, currently the watershed is not in sustainable limits. It is required to reduce the demand by about 404.9 mm, through improved irrigation practices and change in cropping system. The study indicated the 851.3 mm of average annual rainfall, 782.2 mm of average annual actual evapo-transpiration, 141.4 mm of soil moisture storage, 59.6 mm of ground water storage and 150.6 mm of runoff. Currently about 19.4 per cent of the utilizable runoff is being used and 9 per cent of runoff excess is promoted by water harvesting and conservation structures.

Keywords : Actual evapo-transpiraton (AET), Runoff, Soil moisture, Ground water storage

WATER balance is a useful tool to understand the hydrologic behaviour of a study area. It also enables to get an assessment of quality of the data and detect discrepancies. Water is almost constantly in motion and is able to change state from liquid to a solid or vapour under appropriate conditions. Conservation of mass requires that, within a specific area over a specific period of time, water inflows are equal to water outflows, plus or minus any change of storage within the area of interest.

The overall contribution of rainfall to the country's annual ground water resource is 68 per cent and the share of other resources, such as canal seepage, return flow from irrigation, recharge from tanks, ponds and water conservation structures taken together is 32 per cent. Due to the increasing population in the country, the national per capita annual availability of water has reduced from 1,816 cubic metre during 2001 to 1,544 cubic metre during 2011. This is a reduction of 15 per cent (Suhag, 2016).

Agriculture-related problems like intensive cropping pattern, over irrigation, excess use of chemical fertilizers and pesticides are observed in various watersheds. The soil erosion and water resources depletion are found to be the major problems mainly in upstream areas. Therefore, innovative water technologies, management systems and institutional arrangements are necessary to achieve the multiple objectives of equity, environmental integrity and economic efficiency (Martinez *et al*., 2010).

The study was taken at Halayapura-1 micro-watershed, Hosalaya sub-watershed in Tumkur taluk of Tumkur district. It was selected for data base generation under batch V (KWDP-II) of Sujala III project, University of Agricultural Sciences, Bangalore. The total area is 503 ha, out of which large area is under red sandy loam soil.

MATERIAL AND METHODS

Location of the Study Area

Halayapura-1 micro-watershed (Code– 4B3C5N1a) is a part of Hosalaya sub-watershed, Tumkur taluk, Tumkur district covering an area of 503 ha is located at North latitude 13^0 08' 31" and 13^0 10' 04" and East longitude 77^0 05' 45"and 77^0 07' 19" spread across Thondagere, Niduvalolu, Chikkanahalli, Thavarekere, Thondagere kavalu and Sugganahalli villages. Average annual rainfall of the area is about 851.3 mm (2009-2018) and covers large area under red sandy loam soil. Major field crops cultivated in the area are Maize, Finger millet, Sorghum, Cowpea and Red gram together with Arecanut, Coconut and other Horticulture crops. Fig. 1 shows the location map of the study area.

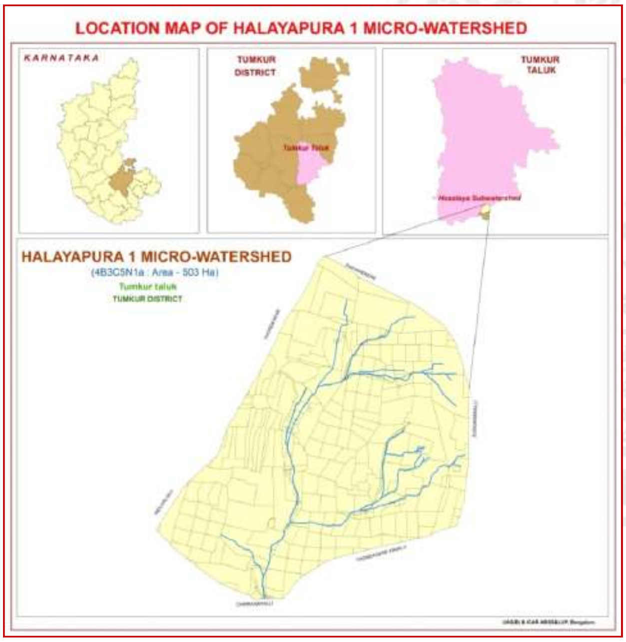

Fig.1 : Location map of study area

Reconnaissance Survey

Information about the hydrology aspects was collected within the watershed boundary (bore wells, farm ponds, check dams, irrigated lands etc.) was collected along with other information from Gram Panchayath.

Hydrology parameters were collected from Karnataka State Natural Disaster Monitoring Centre and Weathers Station, it is installed in Halayapura-1 micro watershed of both spatial and temporal observation were recorded at 15 minutes interval. Rainfall, Evapo-transpiration, ground water, soil moisture and climate datas were used from standard sources for developing water balance model. Infiltration studies were carried extensively based on soil series wise and compared with different soil phases and scenarios (Jagadale *et al.*, 2012). Instantaneous runoff process was estimated from each 15 minutes rainfall intensity over basic infiltration capacity of each soil phase. Quantity of runoff stored in the existing bunds, storage tanks and harvesting structures were considered for total water balance. Water budgeting is the process of assessing the volume of additional rain water to be harvested in the watershed area and to plan harvesting structures accordingly. It also involves calculating the volume of water required for human, livestock, agriculture and for maintaining the ecological balance sustainably. Quantity of runoff allowed as environmental flow is estimated for sustainability of cascade tanks (Anonymous, 2015).

RESULTS AND DISCUSSION

Rainfall

The rainfall data of Hebburu Hobli station (KSNDMC) is considered for study as it is nearer to Halayapura-1 micro-watershed. The long term average annual rainfall (1901-2018) was found to be 740.3 mm. Drought years were observed during 2009 (750.56 mm), 2010 (795.36 mm), 2011 (774.49 mm), 2012 (430.85 mm), 2013 (713.64 mm) and 2016 (770.7 mm) which is deficit with respect to average annual rainfall. In the year 2017, 29.8 per cent excess rainfall was received than the average annual rainfall (851.30 mm) which is indicated in Table 1.

Actual Evapo-transpiration

Actual Evapo-transpiration data was collected from Indian Institute of Science, Bangalore. The graph indicated the average actual evapo-transpiration is 782.1. From 2009 to 2014, the average Annual Actual Evapo-transpiration (AET) was 804.1 mm which is higher than the average annual rainfall (744.1 mm), it shows that moisture deficit in the study area (Fig. 2).

TABLE 1
Rainfall (mm) of Halayapura-1 micro-watershed

Month / Year	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Average
Jan	1.00	17.98	0.00	0.10	0.07	0.00	0.05	1.50	1.60	0	2.23
Feb	0.00	0.00	1.50	0.40	7.78	0.02	0.01	0.00	0.00	14.4	2.411
Mar	36.50	0.00	5.00	6.80	1.48	58.19	5.90	0.00	10.00	38.8	16.267
Apr	22.50	67.16	65.05	122.20	21.55	30.55	87.55	11.20	54.20	21.6	50.356
May	243.00	66.72	155.44	30.70	49.44	84.80	116.93	134.60	256.20	292.8	143.063
Jun	111.50	21.60	30.50	14.95	114.92	120.96	92.54	98.20	84.00	112.2	80.137
Jul	47.50	102.61	78.00	38.80	71.49	86.29	50.19	249.60	85.80	92	90.228
Aug	61.32	77.00	146.50	101.10	72.83	160.65	80.41	99.80	182.60	100	108.221
Sep	188.48	167.50	44.50	31.20	196.12	219.70	249.11	55.80	386.40	257.8	179.661
Oct	13.00	156.28	146.50	26.50	129.17	207.42	149.12	66.20	142.40	59.6	109.619
Nov	23.26	118.50	101.50	56.10	45.49	19.20	187.71	3.20	7.00	45.8	60.776
Dec	2.49	0.00	0.00	2.00	3.30	11.64	10.98	50.60	2.40	0	8.341
Total	750.56	795.36	774.49	430.85	713.64	999.42	1030.50	770.70	1212.60	1035.00	851.312

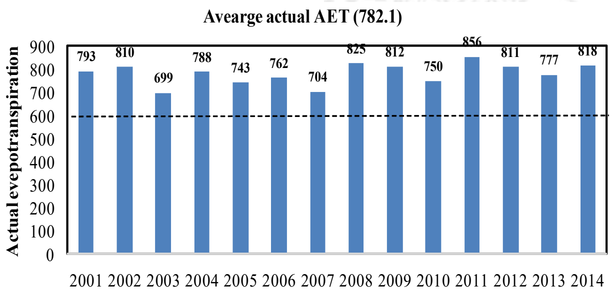

Fig. 2 : Actual Evapo-transpiration of Halayapura-1 micro-watershed

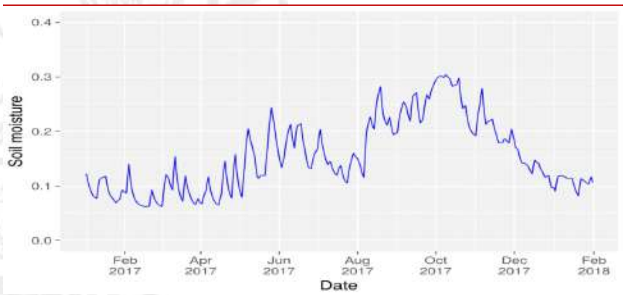

Fig. 3 : Satellite retrieved soil moistureof Halayapura-1 micro-watershed

Soil Moisture

The method developed for retrieving soil moisture from multi-satellite observations allowed to observed surface soil moisture behaviour in the micro-watershed. The available surface moisture varied in the range of 13 to 30 per cent in *kharif* season and 27 to 10 per cent in *rabi* season in the micro-watershed as shown in Fig. 3. The spatial soil moisture status indicate more soil moisture observed in middle reach of the micro watershed during *kharif* and *rabi* 2017-18 (Fig.4). This observation is helpful for providing life saving irrigation during critical crop growth stages of the crops grown in different texture of soil.

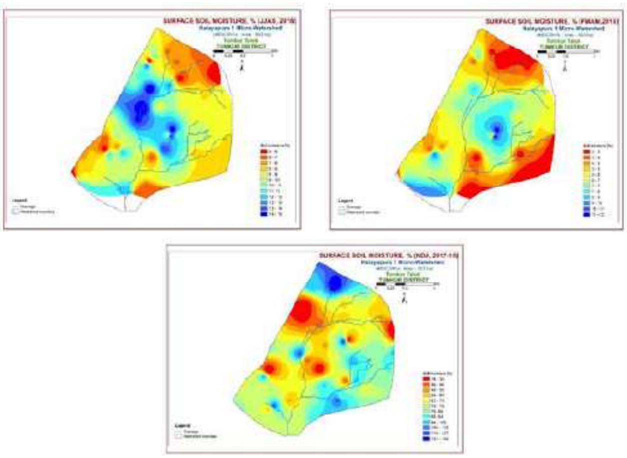

Fig.4 : Soil moisture distribution maps of Halayapura-1 Micro-watershed

Ground Water

In total 125 borewells (83 defunct and 42 live bore wells) were selected in Halayapura-1 micro-watershed. The soil texture wise ground water level fluctuation was measured from 2015 to 2018 during different months indicated in the Ground water level graph. Based on available data from selected bore wells, there was slight falling trend of the depth to water table in the watershed area from 2015 to 2018 (Fig. 5), due to lower rainfall in these years. Moreover, the groundwater usage is relatively higher and there is a scope for runoff harvesting and harvesting techniques.

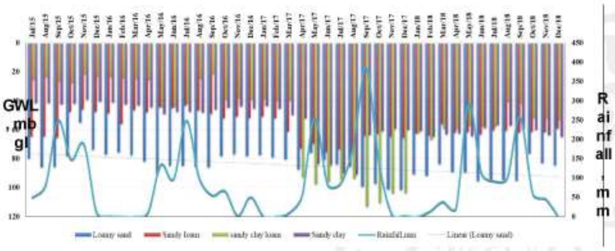

Fig. 5 : Ground water status of Halayapura-1 micro-watershed

Runoff

In Halayapura-1 micro watershed, out of 774.5 mm of rainfall during 2011, About 88 per cent of rainfall could be absorbed through infiltration and within bunding system, runoff available in existing storage structures is 19.4 per cent and remaining 2.4 per cent is allowed as environmental flow, while remaining is 9.4 per cent of runoff water is available for harvesting as shown in Table 2.

TABLE 2

Runoff distribution in Halayapura-1 micro-watershed

Particulars	Runoff Distribution (mm)
Rainfall (2011)	774.50
Runoff availability with existing conditions	150.62
Runoff availability with effective interventions (Bunds, Trenches etc.)	91.14
Runoff excess for harvesting by construction of structures	72.91
Runoff allowed as environmental flow at the outlet	18.23

Water Balance

The study conducted in Halayapura-1 micro-watershed indicated 782.2 mm of average annual actual evapo-transpiration, 851.3 mm of average annual rainfall, 141.1 mm of soil moisture storage, 59.6 mm of ground water storage and 150.6 mm of runoff as shown in Table 3. From a hydrological point of view, currently the watershed is not in sustainable limits. It is necessary to reduce the evapotranspiration, through improved irrigation practices and changed crop choices.

TABLE 3

Total water balance of Halayapura-1 micro-watershed

Particulars	Quantity (mm)
Rainfall	851.3
Actual evapo-transpiration	782.2
Soil moisture storage	141.4
Ground water storage	59.6
Runoff	150.6

The human population on Earth continues to grow, so will its demands for water. Balancing the water needs of humans with those of the many ecosystems on Earth will continue to be a challenge. Water budgets provide a means for evaluating the availability and sustainability of a water supply. The link among all components of a water budget serves as a basis for predicting how a natural or human-induced change to one component, such as ground-water extraction, may be reflected in other components, such as stream flow or evapo-transpiration.

The results indicates that the proper conservation and runoff harvesting structures should be carried by suggesting suitable structures at upper, middle and lower reaches of the watershed based upon spatial decisions and field visit in drainage line and the crops choice and method of irrigations have to be altered to reduce actual evapo-transpiration. Proper water balance and runoff distribution at different scenarios helps the policy makers to take decision for allocation of 20 per cent as environmental flow for sustainability of cascade tanks. Currently about 19.4 per cent of the utilizable runoff is being used and 9 per cent of runoff excess is promoted by water harvesting and conservation structures.

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(*Received :* November 2020 *Accepted :* February 2021)