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Estimation of Probable Groundwater Recharge Under Semi-arid Agro Climatic Conditions of Raichur Region

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Abstract: *Explosion in population, has led to increase in demand of various natural resources* i.e. *water, especially for agricultural purposes. Over exploitation of water affects the ecology of the region and affects the sustainability. Thus, a judicious use of water in semi-arid and rural areas is must. Even though India has good average annual precipitation, but its poor distribution in space and time has lead to the scarcity of groundwater. Thus an attempt has been made to study the probable groundwater recharge for agricultural utilization in the Patapur micro-watershed, which is located in semi-arid region of Raichur district. For the investigation rainfall, runoff and peak discharge of the micro-watershed were estimated and it was found to be about 211 mm, 85, 6, 95.00 (cum) and 793.07 (cum/min) respectively. Total crop evapotranspiration (ETc in mm) values at different stages of crop development were also estimated, it was found about 2, 6, 06.77 mm. Available moisture holding capacity of clay loam was 35.28 cm and sandy clay loam was 19 cm. Estimated recharge quantity in area of clay loam soils was found to be about 90.43 mm or 265601.94 $m^{3,}$ in area of sandy clay loam soils it was found to be about 100.41mm or 248695.5 m^3.The total estimated recharge quantity in the micro-watershed was about 514297.4 m^3 or 94.99 mm. From the investigation it was concluded that the groundwater availability was good and even though it was suggested to construct the groundwater recharge structures (check dams, nala bunding, form ponds etc.) for storage of this precious resource.*

Keywords: *Available moisture holding capacity, groundwater availability, groundwater recharge, micro-watershed, peak discharge.*

INTRODUCTION

Water with its different forms of availability including groundwater is an essential resource for all forms of life and is a fundamental resource for human survival and socio-economic development besides for maintaining ecosystems. Groundwater as a critical source plays vital role in supporting human health, economic development, ecological diversity and economic provision of potable water supply in both urban and rural environment. Groundwater table falling in every arid and semi arid regions of the world due to increased dependence of population pressure is immediate concern.

Present utilization of water (surface and groundwater) is about 606 BCM leaving 536 BCM of utilizable water as unutilized .Of this, the usage for irrigation, domestic, industrial, energy and other purpose is at 501.0, 30.4, 20.0, 34.0 and 20.0 BCM respectively as explained by Trivedi *et al*., 2012[1]. The major source of groundwater recharge in India would be achieved through monsoon rainfall (68%)

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and the share of other sources *viz.* canal seepage, return flow from irrigation, recharge from tanks, ponds, and water conservations structures together contribute (32%) to a smaller extent as reported by Anonymous, 2013 [2].The present rate of annual gross withdrawal is 16.45 Mha-m.The groundwater draft exceeds the annual available recharge for irrigation in 1,645 assessment units of the country.

Singh, 2001, [3] studied on impact of land-use change on groundwater in the Punjab-Haryana plains. In order to fulfill the requirements for agricultural, domestic and industrial purposes, the dependency on groundwater is rapidly increasing. Major groundwater resource problems result from indiscriminate exploitation, particularly for irrigation, and contaminant inputs from a variety of sources such as urban runoff, fertilizers used in agriculture, seepage from contaminated industrial sites, and industrial discharges.

A well-planned groundwater resource management strategy is essential to make economical, efficient and judicious use of ground water, so as to make the availability of ground water, sustainable. Creating awareness among the water users on ground water conditions in the different terrain conditions and encouraging its judicious use, adaptation of conjunctive use techniques of ground water and surface water can improve the ground water scenario.

MATERIALS AND METHODS

The present study was taken up in Patapur micro-watershed having an area of 541.39 ha being located at Patapur village in Manvi taluk of Raichur district in Karnataka. The study area lies between the 16° 07′ 35.9″ Latitude and 76° 51′ 33.3″ Longitudes and 16° 08′ 22.3′′ Latitude and 76° 53′ 27.7′′ Longitudes with an average elevation of 447 m above the mean sea level (MSL) and falling under the Survey of India toposheet of 56 D/16 (1:50, 000). The climate of the region could be termed as semi-arid with mild winters and hot summers. December is the coldest month with mean daily minimum temperature of 17.7ºC, while May month being the hottest month with mean daily maximum temperature of 39.8ºC. Relative humidity of around 75 percent observed during monsoon period. Wind speed exceeding 15 km/h during the months of June and July.

The land holding size in the study area varies from 0.81-6.30 ha with an average annual rainfall of 621 mm. The major soil types found in the area were clay loam, sandy clay loam and sandy clay and the major crops grown were sunflower, cotton, pigeonpea, paddy, vegetables and groundnut. In the Patapur micro-watershed the main source of irrigation has been supplied from the tube wells. There were 13 tube wells which have been identified during investigation and depth of tube wells in the watershed varies from 18.28-35.05 m. The necessary data required for the groundwater investigation (tube well owners name, well location, survey number, holding size, soil type, depth of the tube well, number of irrigation, crop details, crop duration etc) and the crops grown under protective groundwater irrigation during both kharif and rabi season were collected and noted from the owner of the tube wells. At the outlet of the micro-watershed runoff and silt monitoring setup was established through which rainfall and runoff measured during each rainfall event. The digital automatic rain gauge is catered continuous rainfall situated at the roof top of silt monitoring station (Plate 1).

For preparation of land use and land cover map, the coverage files IRS (Indian Remote Sensing) L4FX 17-Nov-2013 was collected from NRSC (National Remote Sensing Center) Hyderabad. Land use/land cover map showing the spatial distribution of different land use/land cover categories such as irrigated agricultural land, rain fed agricultural land, wasteland and settlements was generated on 1:50,000 scales for supervised classification for the year 2013 is shown in Figure 1.

The crop evapotranspiration (ET_c, mm/day) of each crop under agriculture use and also other land use system during wasteland and settlements were estimated by using product of crop coefficient (K_c, dimensionless), value of land use at different seasons of crop growth and reference crop evapotranspiration (ET_o, mm/day), during each kharif and rabi seasons were estimated. Mathematically it is expressed as follows

$$ET_c = ET_o \times K_c$$

Plate 1: Synoptic view of Silt monitoring station established at the Patapur micro-watershed.

The groundwater recharge component was estimated based on assumption that the part of rainfall event beyond the available moisture holding capacity (AMHC) of the prevailing soil type would be to groundwater in the form of deep percolation. The available moisture holding capacity of each soil type (Clay loam and sandy clay loam) were estimated using the standard relation.

$$AMHC = (FC - PWP) \times rd \times d$$

Where

AMHC = Available Moisture Holding Capacity

FC = Field Capacity, percentage/volume

PWP = Permanent Wilting Point, percentage/volume

rd = Bulk density (g/cc)

D = Depth of root zone (m)

RESULTS AND DISCUSSION

Land use/land cover map in supervised classification showing the spatial distribution of different land use/land cover categories such as irrigated agricultural land, rain fed agricultural land, wasteland and settlements. Which are presented in Table 1. In the year 2013, irrigated agricultural land was occupied by 166.15 ha (30.68%) of the total watershed area, rain fed agricultural land was occupied by 181.48 ha (33.53%) of the total watershed area, wasteland was occupied by 147.49 ha (27.24%) and settlements was occupied by 46.27 ha (8.55%) of total geographical area of watershed.

Table 1
Land use/land cover supervised classification of Patapur micro-watershed for the year 2013.

Sl. No.	*Land use/Land cover Category*	*Area (ha)*	*Percentage of total geographical area*
1.	Irrigated agricultural land	166.15	30.68
2.	Rain fed agricultural land	181.48	33.53
3.	Wasteland	147.49	27.24
4.	Settlements	46.27	8.55
	Total	541.39	100

The four events of runoff recorded and corresponding rainfall (685mm), runoff volume (85695m^3) and peak discharge (m^3/s) and time to peak are given in the Table 2.

Table 2
Event wise measured Rainfall (mm) – runoff depth (cum) during 2013

Sl. No.	*Rainfall Event*	*Runoff causing Rainfall (mm)*	*Runoff (cum)*	*Peak Discharge (cum/min)*
1.	13-6-2013	48	28529.00	238.37
2.	22-6-2013	57	20735.00	216.87
3.	8-9-2013	64	26963.00	245.70
4.	13-9-2013	42	9468.00	92.13
	Total	211	85, 6, 95.00	793.07

Out of 685 mm of annual rainfall spread over the year, in which during the monsoon season a total of 301 mm as contributed towards causing runoff (85695 m^3) which would be equivalent to runoff causing depth of 15.57 mm and passed out of watershed during the study period.

The Table 3 gives the estimated values of available moisture holding capacity in each of two soil types.

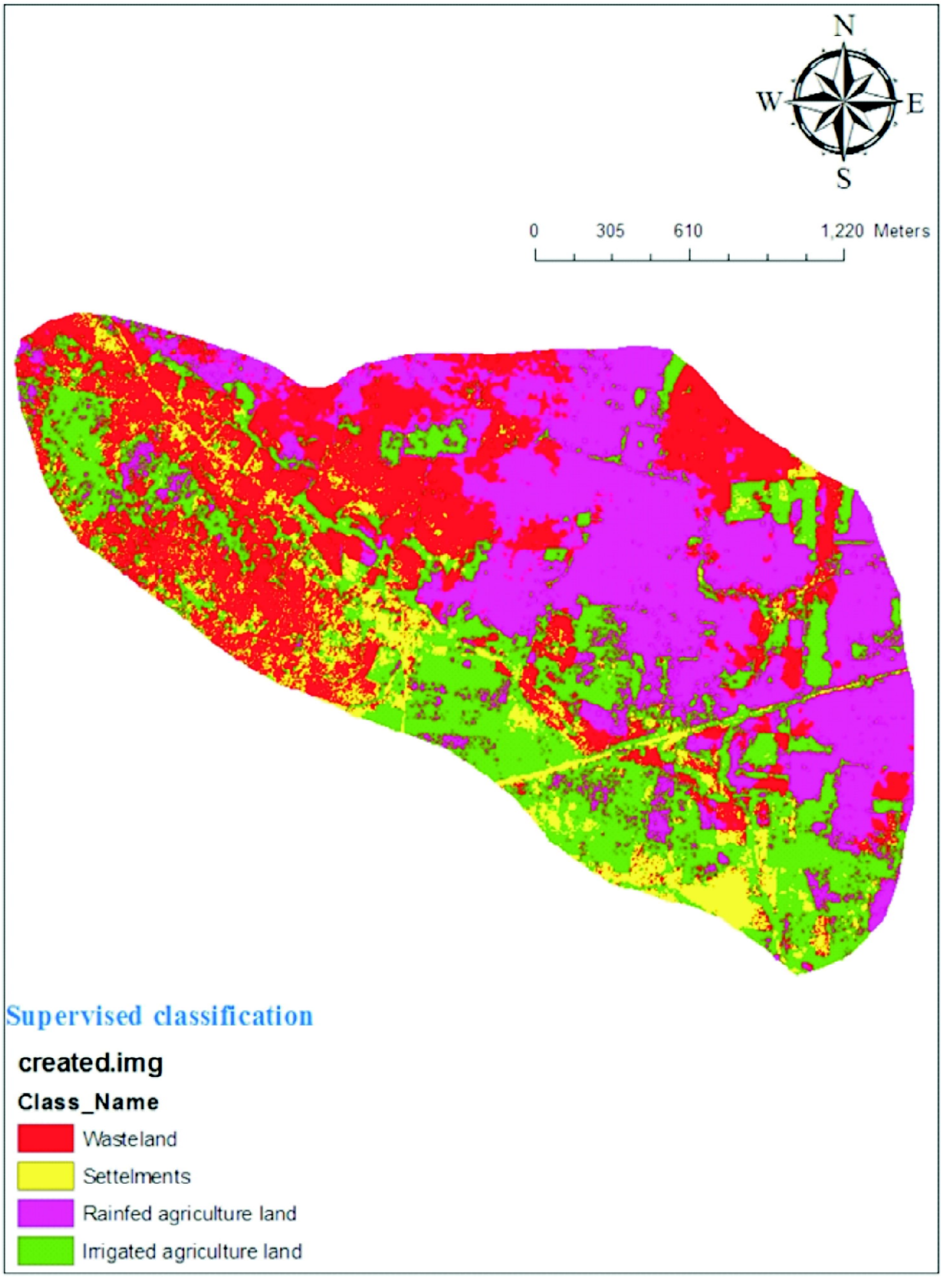

Figure 1: Land use classification of Patapur micro-watershed.

Table 3
Estimation of available moisture holding capacity

S. No.	*Soil*	*rd (g/cc)*	*FC (%)*	*PWP (%)*	*Depth (m)*	*AMHC (cm)*
1.	Clay loam	1.12	35	14	1.5	35.28
2.	Sandy clay loam	1	30	11	1	19

(*rd = bulk density of the soil)

The total estimated crop evapotranspiration (ETc) is about 2, 6, 06.77 mm. Stage wise values are presented in Table 4.

Out of the total crop water requirement (2606.77mm), annual crop like cotton and pegeion pea were 807.76 mm and 301.92 mm respectively. Out of total area of watershed (54, 13, 9, 00 m^2), the area under clay loam soil is 29, 37, 1, 00 m^2 and 24, 76, 800 m^2 is under sandy clay loam. The clay loam contributed recharge depth of 90.43 (Table 5) mm as compared to sandy clay loam soil (100.41 mm) (Table 6) where in latter soil contribution was more. The total recharge depth released during the investigation period by both soils of 94.99 mm.

Table 4
ET_c (mm) values at different stages of crop development

S. No.	Land use	Initial stage	Development stage	Middle stage	Late stage	Etc (mm)
1.	*Agriculture*					
	Cotton	60.49	85.22	391.96	270.09	807.76
	Sunflower	15.85	33.76	137.09	29.25	215.96
	Sorgham	21.83	31.02	135.48	77.15	265.48
	Groundnut	22.99	34.08	119.36	37.84	214.7
	Pegeonpea	52.53	47.74	152.63	49.02	301.92
	Greengram	30.13	53.17	37.41	45.15	165.86
	Bajra	25.06	42.00	71.24	32.98	171.28
2.	Wasteland					462.81
3.	Settlements					1
	Total					2,6,06.77

Table 5
Estimation of recharge quantity in area of clay loam soils in Patapur micro–watershed

Sl. No.	Rainfall event	Rainfall depth (mm)	Runoff depth		AMHC*	AMC**		RDFC***	Deep percolation	
			m^3	Mm	Mm	%	mm	Mm	mm	m^3
1.	13/02/2013	48	28529	5.27	420	95	399	21	21.75	63881.93
2.	22/02/2013	57	20735	3.63	420	90	378	42	11.37	33394.83
3.	09/07/2013	28	–	–	–	–	–	–	–	–
4.	24/07/2013	21	–	–	–	–	–	–	–	–
5.	12/08/2013	22	–	–	–	–	–	–	–	–
6.	19-Aug	19	–	–	–	–	–	–	–	–
7.	08/09/2013	64	26963	4.94	420	95	399	21	38.06	111786
8.	13/19/13	42	9468	1.75	420	95	399	21	19.25	56539.18
	Total	301	85,6,95	15.57					90.43	265601.94

Further the replenishment of groundwater due to monsoon rains was to an extent of 134 mm, which suggests good recharging conditions prevailed normal monsoon years. However in case of escalated pumping for want of intensive irrigation to the paddy, in a situation of growing similar high water consuming crops or in a situation of expansion of well irrigated area, enhanced stress cannot be ruled out in the future years. In case there would be possibility of increased stress on aquifer subjected to monsoonal rains and crop water requirement (ETc).The present study gives an idea about the functioning at present groundwater region which was not at critical stress. The well balanced cropping plan followed by minimum augmentation of groundwater potential has to be planned for watershed basis essentially.

CONCLUSIONS

Groundwater is a natural shielded resource which is protected from high evaporation in high temperature region like Raichur. In an era of easily available high technology, the farmers can easily access this invaluable resource. The micro-watershed consisted of both clay loam and sandy clay loam. Available moisture holding capacity of

Table 6
Estimation of recharge quantity in area of sandy clay loam soils in Patapur micro–watershed

Sl. No.	Rainfall event	Rainfall depth (mm)	Runoff depth		AMHC*	AMC**		RDFC***	Deep percolation	
			m³	Mm	Mm	%	mm	Mm	mm	m³
1.	13/02/2013	48	28529	5.27	190	85	161.5	28.5	14.23	35244.86
2.	22/02/2013	57	20735	3.63	190	90	171	19	34.37	85127.62
3.	09/07/2013	28	–	–	–	–	–	–	–	–
4.	24/07/2013	21	–	–	–	–	–	–	–	–
5.	12/08/2013	22	–	–	–	–	–	–	–	–
6.	19–Aug	19	–	–	–	–	–	–	–	–
7.	08/09/2013	64	26963	4.94	190	85	161.5	28.5	30.56	75691.01
8.	13/19/13	42	9468	1.75	190	90	171	19	21.25	52632.00
	Total	301	85, 6, 95	15.57				95	100.41	248695.5

* = Available Moisture Holding Capacity.

** = Antecedent Moisture Content.

*** = Replenishing Depth to bring Field Capacity.

clay loam was 35.28 cm and sandy clay loam was 19 cm. Recharge quantity in area of clay loam soils in Patapur micro-watershed was found to be about 90.43 mm or 265601.94 m^{3,} in area of sandy clay loam soils it was found to be about 100.41 mm or 248695.5 m^3. Total estimated recharge quantity of the micro-watershed is about 514297.4 m^3 or 94.99 mm.

The study gives an idea about the functioning at groundwater region which was not at critical stress and it was concluded that the groundwater availability was good and even though it was suggested to construct the groundwater recharge structures (check dams, nala bunding, form ponds etc.) for storage of this precious resource. The well balanced cropping plan followed by minimum augmentation of groundwater potential has to be planned for watershed basis essentially.

References

Trivedi, T.P., Sharma, R.P., Shashi, A.V., Aruna, T.K. and Sudhir, P., (2012), Water resource of India: Potential and utilization., Handbook of Agriculture. ICAR, New Delhi., pp. 239-249.

Anonymous, (2013), Groundwater information booklet, Raichur district. Central groundwater board, ministry of water resources government of India. pp, 1-28.

Singh, R.B., (2001), Impact of land-use change on groundwater in the Punjab-Haryana plains, India. Impact of Human Activity on Groundwater Dynamics (Proceedings of a symposium held during the Sixth IAHS Scientific Assembly at Maastricht, The Netherlands, IAHS Publ. no. 269.