



Water Production Efficiency of Groundwater in Hirekere Watershed in Raichur District in Karnataka

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ABSTRACT

The present study was taken up in Hirekere watershed which is draining to Krishna river through Nallavagu stream and is located near Singanodi and Mandalgeri villages in Raichur district of Karnataka. The physiography is gently sloping. The normal rainfall of the study area is 632 mm. The mean maximum temperature varies from 30.3°C in December to 40.6°C in May while the minimum temperature ranges from 15.7°C in December to 25.3°C in May. The soil is covered by *Alfisols* of red sandy loam. From the study of water production efficiency of groundwater usage farmers it was found that the farmers' practice of water application was 1.30 times more than the actual water required. It was also revealed that there is a need for better management of irrigation scheduling and operation such that excessive irrigation is to be minimized. The depth of application during each irrigation needs to be measured with suitable devices like H-flumes, Parshall flumes, V-notches etc which will minimize the excessive irrigation.

Key words : Groundwater, Water Production Efficiency, Watershed.

Out of the net irrigated area of 58.5 m ha in India, the area irrigated through groundwater accounts for 35 m ha (60%). Over the last quarter century, 89% of the total incremental net irrigated area was contributed using groundwater through private investment; 75% share was tube well irrigation only (Anonymous, 2008). The groundwater schemes are comprised of dug wells, dug-cum-bore wells, shallow and deep tube wells and filter points each having command area between 1 and 5 ha. Even in the several command areas of major irrigation projects, farmers often use groundwater as a matter of routine to supplement canal water to maximize agricultural production.

The constructions, operations and maintenance of groundwater schemes are done wholly by the farmers themselves. In general, these schemes are labour-intensive with short gestation period and subsidized energy makes them attractive. The ground water irrigation is under the direct control of the farmers and is amenable to precision agriculture and higher irrigation efficiency of 70 to 80 per cent compared to 25-45 per cent in the canal irrigated areas (Anonymous, 2007).

Over exploitation of the available water resources either by way of excessive flooding from surface storage or by way of unscrupulous pumping rates imposed on the underground aquifer reserves

contributing to the irrigation wells, eventually would result in a drastic water supply-demand gap, warranting alternate water availability arrangements. Whatever may be the domain, in which, water is used for beneficial purposes, be it the agricultural sector or the industrial usage or the domestic consumption, the replenishment of both the surface as well as the subterranean water reserves depends on the single most refilling source called the rainfall. However, the occurrence and distribution of rainfall itself is on par with agriculture, a gamble with monsoon. The failure of rainfall results in occasional or periodic droughts depending on the latitude and longitude of agro-climatic region. Though rainwater harvesting is an age-old art, the present situation warrants infusion of scientific ways and means in harvesting the maximum rainwater for both the surface and underground water storage for future usage during non-rainy season.

The present study is taken to evaluate the prevailing groundwater use efficiency (WUE) under existing cropping pattern in such groundwater over exploited area of the Hirekere watershed with a geographical area of 218 ha is situated at about 700 m west of Mandalgeri village, which is about 15 km east of Raichur Town in Karnataka. The soil type consists of medium to deep *alfisols* (sandy

loam). The topography is flat with mild sloping ranging from 1 to 4 per cent. Nearly 86 per cent of the area ie 187.5 ha is under cultivation. The water requirement of the existing cropping pattern is met with rainfall and also with the underground water from wells only. The majority of the crop cultivated under the wells irrigation is paddy for both *kharif* and *rabi/summer*. This is leading to the unsustainable groundwater management.

MATERIAL AND METHODS

The watershed is affected by frequent drought conditions and groundwater becomes a scarce commodity. The study area is situated in the North-Eastern dry zone (Zone-2 of Region-1) of Karnataka at 16° 12' 24.29" N latitude and 77° 28' 19.40" E longitudes to 16° 12' 54.77" N latitude and 77° 29' 15.21" E longitudes and elevation is from 390 m to 415 m above the mean sea level (MSL). This watershed is draining to Krishna river through Nallavagu stream. The study area is falling under the Survey of India toposheet of 56 H/8 NE (1:25000).

The Hirekere watershed has basically granite terrain. The granite is coarse and fine grained at different places. Most of the area has shallow basement without fracturing. From the groundwater point of view, the watershed has very high temperatures and winds and hence the evapotranspiration is also very high resulting in reduced soil moisture.

The watershed fields are cultivated both under rainfed cultivation and with well irrigation. The Cotton is the major crop of the area, followed by castor, groundnut, redgram and sunflower in rainfed area. Under well irrigation, majority of the area is cultivated with paddy followed by cotton and in small area with groundnut, tobacco, sunflower and vegetables. Under the horticulture crops mango is the major crop in the study area. Regarding the social forestry, eucalyptus is cultivated in the area.

The geomorphology in the study area is Pediplain, Pediplain weathered/buried. The Lithology is Crystalline rocks with Charnockite rock type. The geology of the structure is lineament (Anonymous, 2005). The groundwater prospect in the study area is moderate to good. The study area is already declared as the over exploited area regarding the groundwater development by Central

Groundwater Board (Anonymous, 2008).

In general, watertable is continuously falling and most of the open wells are dried up and presence of water is only for short period and which are replaced by deep bore wells. Even some farmers faced the problem of failure of new bore wells in the watershed. During the summer, the cropped area is facing acute shortage of water.

The irrigation water use is calculated by both total water requirement of crop by FAO CROPWAT 8.0 and actual water applied by the well irrigated farmers by pumping the well water for growing the crops for the year 2009-10. By analysis of this, the prevailing groundwater use efficiency can be evaluated under existing cropping pattern by finding out whether the farmer is using the required quantity of water or over irrigating or under irrigating the crops by well irrigation water in the watershed.

RESULT AND DISCUSSION

For each well irrigated farmer, plot wise study was made by using the water use efficiency. The water use efficiency is calculated by dividing the crop yield with unit of water used. The water production efficiency (WPE) was calculated for measured and estimated quantity of applied well water for both *kharif* and *rabi/summer* the crops grown by the farmers in the watershed area.

The results showed that in case of paddy crop, measured WPE was ranged in between 1.86 to 6.39 kg/ha/mm of irrigation applied during *rabi/summer* (Table 1). However, the estimated WPE for same yield was in the range of 2.77 to 5.92 kg/ha/mm (Table 2). This shows that there was a difference in measured and estimated irrigation quantity. The measured irrigation quantity was more and ranged from 635.29 mm to 3914.46 mm as against estimated quantity of 1289.82 mm (Table 3). In most cases the measured depth was higher which can be attributed towards excessive irrigation applied during crop period and conveyance losses. Wherever, the well yield is less the application of water is also less than the estimated quantity. This resulted in low yield and low WPE. The differences between measured WPE and estimated WPE of paddy in *rabi/summer* were also made (Table 4).

In paddy crop, measured WPE was ranged in between 1.88 to 8.18 kg/ha/mm during *kharif*. However, the estimated WPE for same yield was

Table 1. Measured quantity of water production efficiency (WPE) of paddy in *rabi/summer*.

Sl. No	Farmers name	Survey No.	Type of well	Cropped area, ha	Punping Hr	Well Discharge rate, m3/hr	Water pumped per day
1	Amarappa	102/1	1 D cum BW	0.4047	2.5	17.524	43.81
2	Rangappa Malabadi	102 E	1 BW	0.4047	5	3.625	18.13
3	Narasappa S/o Pavuguntappa	102 A	1 BW	0.4047	6	6.269	37.61
4	Timmappa S/O Bhimaiah	101/2	1 BW	0.4047	4	10.166	40.66
5	Erappa S/O Shivanarasappa	110	1 BW	0.4047	4	7.557	30.23
6	Yerra Rangappa S/o Bheemaiah	112	1 BW	0.4047	4	7.410	29.64
7	Narasappa s/o Basaiah Berk	101 & 103/1 & 2	2 BW	0.8094	6	6.926	41.56
8	Sarfuddin S/O Badesab	48	1 BW	0.4047	6	5.661	33.97
9	Nagappa S/O Bajarappa	47	1 BW	0.6071	5	7.250	36.25
10	Mechanic Hanumanthu S/O Thippaiah	51/1	1 BW	0.4047	6	6.879	41.27
11	Shamshuddin S/O Badesab	52	1 BW	0.4047	6	17.602	105.61
12	Gokharisab S/O Aji Sab	53/3	1 BW	0.4047	6	6.893	41.36
13	Bada Meheboob S/O Gurusab	54/1	1 BW	0.4047	6	3.975	23.85
14	Chota Meheboob S/O Gokari	54/2	1 BW	0.4047	6	7.603	45.62
15	Basha S/O Ajasab	58/2	1 BW	0.4047	4	8.949	35.80
16	Zindawali S/O Badesab	58/3	1 BW	0.4047	6	4.742	28.45
17	Gokharisab S/O Aji Sab	58/5	1 BW	0.4047	6	3.727	22.36
18	Aslam sab S/O Husensab	60	1 BW	0.2024	4	5.760	23.04
19	Hampana gouda S/O Badesab	76	1 BW	0.4047	6	4.382	26.29
20	Khaja Sab S/O Gokharisab	76/1A	1 BW	0.4047	6	10.814	64.88
21	Mainsab S/O Husen sab	76/3	2 BW	0.1012	6	13.275	79.65
22	Gokari hussen sab S/O Noormohamad	70A	3 BW	0.2024	5	1.714	8.57
23	Puchha Narasappa	70/B	4 BW	0.4047	6	4.073	24.44
24	Yellapa S/O Narasappa	70E	2 BW	0.4047	4	13.425	53.70
25	Jambaiah S/O Narasappa	70/P2	1 BW	0.4047	5	5.446	27.23
26	Ganapathi S/O Bheemaiah	160/P2/1 & 161 /1	2 BW	0.8094	6	22.727	136.36
27	Ramegouda S/O Laxmaiah	161/P2/1	1 BW	0.4047	6	11.854	71.12
28	Basavaraj S/O Thimmaiah	155/2	1 BW	0.4047	6	12.159	72.95
29	Ramesh S/O Thimmaiah	155/4/2	1 BW	0.2024	4	7.356	29.42
30	Hanumanthu S/O Bheemaiah	155/E	1 BW	0.8094	5	7.281	36.41
31	Rajan reddy S/O Nagireddy	93,94,95	1 OW	1.2141	3	110.930	332.79
32	Guru Basappa S/O Nagireddy	88	1 D cum BW	0.8094	3	13.049	39.15
TOTAL				14.6700			

(D cum B W= dug cum bore well, BW=bore well, OW=open well)

Table 1. cont.....

Sl. No	Farmers name	Water pumped per season, m ³	Total Water applied, mm	Effective Rfall, mm	Applied water depth, mm	Crop yield, Kg/ha	Crop WPE, Kg/ha/mm
1	Amarappa	6571.50	1623.80	0.00	1623.80	6500.00	4.00
2	Rangappa Malabadi	2718.75	671.79	0.00	671.79	4120.00	6.13
3	Narasappa S/o Pavuguntappa	5642.10	1394.14	0.00	1394.14	6640.00	4.76
4	Timmappa S/O Bhimaiah	6099.60	1507.19	0.00	1507.19	7150.00	4.74
5	Erappa S/O Shivanarasappa	4534.20	1120.39	0.00	1120.39	6750.00	6.02
6	Yerra Rangappa S/o Bheemaiah	4446.00	1098.59	0.00	1098.59	6640.00	6.04
7	Narasappa s/o Basaiah Berk	6233.40	770.13	0.00	770.13	4050.00	5.26
8	Sarfuddin S/O Badesab	5094.90	1258.93	0.00	1258.93	6650.00	5.28
9	Nagappa S/O Bajarappa	5437.50	895.73	0.00	895.73	4280.00	4.78
10	Mechanic Hanumanthu S/O Thippaiah	6191.10	1529.80	0.00	1529.80	6550.00	4.28
11	Shamshuddin S/O Badesab	15841.80	3914.46	0.00	3914.46	7420.00	1.90
12	Gokharisab S/O Aji Sab	6203.70	1532.91	0.00	1532.91	7250.00	4.73
13	Bada Meheboob S/O Gurusab	3577.50	883.99	0.00	883.99	5650.00	6.39
14	Chota Meheboob S/O Gokari	6842.70	1690.81	0.00	1690.81	6750.00	3.99
15	Basha S/O Ajasab	5369.40	1326.76	0.00	1326.76	7125.00	5.37
16	Zindawali S/O Badesab	4267.80	1054.56	0.00	1054.56	4050.00	3.84
17	Gokharisab S/O Aji Sab	3354.30	828.84	0.00	828.84	3750.00	4.52
18	Aslam sab S/O Husensab	3456.00	1707.93	0.00	1707.93	7240.00	4.24
19	Hampana gouda S/O Badesab	3943.80	974.50	0.00	974.50	4030.00	4.14
20	Khaja Sab S/O Gokharisab	9732.60	2404.89	0.00	2404.89	7250.00	3.01
21	Mainsab S/O Husen sab	11947.50	11808.75	0.00	11808.75	7125.00	0.60
22	Gokari hussen sab S/O Noormohamad	1285.50	635.29	0.00	635.29	3820.00	6.01
23	Puchha Narasappa	3665.70	905.78	0.00	905.78	3920.00	4.33
24	Yellapa S/O Narasappa	8055.00	1990.36	0.00	1990.36	7080.00	3.56
25	Jambaiah S/O Narasappa	4084.50	1009.27	0.00	1009.27	4280.00	4.24
26	Ganapathi S/O Bheemaiah	20454.30	2527.09	0.00	2527.09	7540.00	2.98
27	Ramegouda S/O Laxmaiah	10668.60	2636.17	0.00	2636.17	7350.00	2.79
28	Basavaraj S/O Thimmaiah	10943.10	2704.00	0.00	2704.00	7180.00	2.66
29	Ramesh S/O Thimmaiah	4413.60	2181.17	0.00	2181.17	7590.00	3.48
30	Hanumanthu S/O Bheemaiah	5460.75	674.67	0.00	674.67	4270.00	6.33
31	Rajan reddy S/O Nagireddy	49918.50	4111.56	0.00	4111.56	7640.00	1.86
32	Guru Basappa S/O Nagireddy	5872.05	725.48	0.00	725.48	3570.00	4.92
TOTAL		252327.75					

(D cum B W= dug cum bore well, BW=bore well, OW=open well)

Table 2. Estimated water production efficiency of paddy in *rabi/summer*.

Sl. No	Farmers name	Survey No.	Type of well	Cropped area, ha	Total water required, mm	Crop yield, Kg/ha	Crop WPE, Kg/ha/mm
1	Amarappa	102/1	1 D cum BW	0.4047	1289.82	6500.00	5.04
2	Rangappa Malabadi	102 E	1 BW	0.4047	1289.82	4120.00	3.19
3	Narasappa S/o Pavuguntappa	102 A	1 BW	0.4047	1289.82	6640.00	5.15
4	Timmappa S/O Bhimaiah	101/2	1 BW	0.4047	1289.82	7150.00	5.54
5	Erappa S/O Shivanarasappa	110	1 BW	0.4047	1289.82	6750.00	5.23
6	Yerra Rangappa S/o Bheemaiah	112	1 BW	0.4047	1289.82	6640.00	5.15
7	Narasappa s/o Basaiah Berk	101 & 103/1 & 2	2 BW	0.8094	1289.82	4050.00	3.14
8	Sarfuddin S/O Badesab	48	1 BW	0.4047	1289.82	6650.00	5.16
9	Nagappa S/O Bajarappa	47	1 BW	0.6071	1289.82	4280.00	3.32
10	Mechanic Hanumanthu S/O Thippaiah	51/1	1 BW	0.4047	1289.82	6550.00	5.08
11	Shamshuddin S/O Badesab	52	1 BW	0.4047	1289.82	7420.00	5.75
12	Gokharisab S/O Aji Sab	53/3	1 BW	0.4047	1289.82	7250.00	5.62
13	Bada Meheboob S/O Gurusab	54/1	1 BW	0.4047	1289.82	5650.00	4.38
14	Chota Meheboob S/O Gokari	54/2	1 BW	0.4047	1289.82	6750.00	5.23
15	Basha S/O Ajasab	58/2	1 BW	0.4047	1289.82	7125.00	5.52
16	Zindawali S/O Badesab	58/3	1 BW	0.4047	1289.82	4050.00	3.14
17	Gokharisab S/O Aji Sab	58/5	1 BW	0.4047	1289.82	3750.00	2.91
18	Aslam sab S/O Husensab	60	1 BW	0.2024	1289.82	7240.00	5.61
19	Hampana gouda S/O Badesab	76	1 BW	0.4047	1289.82	4030.00	3.12
20	Khaja Sab S/O Gokharisab	76/1A	1 BW	0.4047	1289.82	7250.00	5.62
21	Mainsab S/O Husen sab	76/3	2 BW	0.1012	1289.82	7125.00	5.52
22	Gokari hussen sab S/O Noormohamad	70A	3 BW	0.2024	1289.82	3820.00	2.96
23	Puchha Narasappa	70/B	4 BW	0.4047	1289.82	3920.00	3.04
24	Yellapa S/O Narasappa	70E	2 BW	0.4047	1289.82	7080.00	5.49
25	Jambaiah S/O Narasappa	70/P2	1 BW	0.4047	1289.82	4280.00	3.32
26	Ganapathi S/O Bheemaiah	160/P2/1 & 161 /1	2 BW	0.8094	1289.82	7540.00	5.85
27	Ramegouda S/O Laxmaiah	161/P2/1	1 BW	0.4047	1289.82	7350.00	5.70
28	Basavaraj S/O Thimmaiah	155/2	1 BW	0.4047	1289.82	7180.00	5.57
29	Ramesh S/O Thimmaiah	155/4/2	1 BW	0.2024	1289.82	7590.00	5.88
30	Hanumanthu S/O Bheemaiah	155/E	1 BW	0.8094	1289.82	4270.00	3.31
31	Rajan reddy S/O Nagireddy	93,94,95	1 OW	1.2141	1289.82	7640.00	5.92
32	Guru Basappa S/O Nagireddy	88	1 D cum BW	0.8094	1289.82	3570.00	2.77
TOTAL				14.6700			

(D cum B W= dug cum bore well, BW=bore well, OW=open well)

Table 3. Comparison between estimated and applied water depth of paddy in *rabi/summer*.

Sl. No	Farmers name	Survey No.	Applied water (measured) depth, mm	Estimated water depth, mm	Excess depth applied, mm	Per cent excess/deficit water as per crop need
1	Amarappa	102/1	1623.80	1289.82	0.21	20.57
2	Rangappa Malabadi	102 E	671.79	1289.82	-0.92	-92.00
3	Narasappa S/o Pavuguntappa	102 A	1394.14	1289.82	0.07	7.48
4	Timmappa S/O Bhimaiah	101/2	1507.19	1289.82	0.14	14.42
5	Erappa S/O Shivanarasappa	110	1120.39	1289.82	-0.15	-15.12
6	Yerra Rangappa S/o Bheemaiah	112	1098.59	1289.82	-0.17	-17.41
7	Narasappa s/o Basaiah Berk	101 & 103/1 & 2	770.13	1289.82	-0.67	-67.48
8	Sarfuddin S/O Badesab	48	1258.93	1289.82	-0.02	-2.45
9	Nagappa S/O Bajarappa	47	895.73	1289.82	-0.44	-44.00
10	Mechanic Hanumanthu S/O Thippaiah	51/1	1529.80	1289.82	0.16	15.69
11	Shamshuddin S/O Badesab	52	3914.46	1289.82	0.67	67.05
12	Gokharisab S/O Aji Sab	53/3	1532.91	1289.82	0.16	15.86
13	Bada Meheboob S/O Gurusab	54/1	883.99	1289.82	-0.46	-45.91
14	Chota Meheboob S/O Gokari	54/2	1690.81	1289.82	0.24	23.72
15	Basha S/O Ajasab	58/2	1326.76	1289.82	0.03	2.78
16	Zindawali S/O Badesab	58/3	1054.56	1289.82	-0.22	-22.31
17	Gokharisab S/O Aji Sab	58/5	828.84	1289.82	-0.56	-55.62
18	Aslam sab S/O Husensab	60	1707.93	1289.82	0.24	24.48
19	Hampana gouda S/O Badesab	76	974.50	1289.82	-0.32	-32.36
20	Khaja Sab S/O Gokharisab	76/1A	2404.89	1289.82	0.46	46.37
21	Mainsab S/O Husen sab	76/3	11808.75	1289.82	0.89	89.08
22	Gokari hussen sab S/O Noormohamad	70A	635.29	1289.82	-1.03	-103.03
23	Puchha Narasappa	70/B	905.78	1289.82	-0.42	-42.40
24	Yellapa S/O Narasappa	70E	1990.36	1289.82	0.35	35.20
25	Jambaiah S/O Narasappa	70/P2	1009.27	1289.82	-0.28	-27.80
26	Ganapathi S/O Bheemaiah	160/P2/1 & 161 /1	2527.09	1289.82	0.49	48.96
27	Ramegouda S/O Laxmaiah	161/P2/1	2636.17	1289.82	0.51	51.07
28	Basavaraj S/O Thimmaiah	155/2	2704.00	1289.82	0.52	52.30
29	Ramesh S/O Thimmaiah	155/4/2	2181.17	1289.82	0.41	40.87
30	Hanumanthu S/O Bheemaiah	155/E	674.67	1289.82	-0.91	-91.18
31	Rajan reddy S/O Nagireddy	93,94,95	4111.56	1289.82	0.69	68.63
32	Guru Basappa S/O Nagireddy	88	725.48	1289.82	-0.78	-77.79

in the range of 6.32 to 9.05 kg/ha/mm. This showed that there was a difference in measured and estimated quantity of water application as the yield is taken as same in both the cases. The measured irrigation quantity was ranged from 604.97 to 2402.82 mm as against the estimated quantity of 767.25 mm. The measured depth was higher which

can be attributed to excessive irrigation applied during crop period. This showed the difference between measured WPE and estimated WPE of paddy in *kharif*.

Similarly in case of cotton, measured WPE was ranged in between 1.25 to 3.00 kg/ha/ mm of water applied during *kharif*. However, the

Table 4. Comparison between estimated and applied WPE for paddy in *rabi/summer*.

Sl. No	Farmers name	Survey No.	Measured WPE, Kg/ha/mm	Estimated WPE, Kg/ha/mm
1	Amarappa	102/1	4.00	5.04
2	Rangappa Malabadi	102 E	6.13	3.19
3	Narasappa S/o Pavuguntappa	102 A	4.76	5.15
4	Timmappa S/O Bhimaiah	101/2	4.74	5.54
5	Erappa S/O Shivanarasappa	110	6.02	5.23
6	Yerra Rangappa S/o Bheemaiah	112	6.04	5.15
7	Narasappa s/o Basaiah Berk	101 & 103/1 & 2	5.26	3.14
8	Sarfuddin S/O Badesab	48	5.28	5.16
9	Nagappa S/O Bajarappa	47	4.78	3.32
10	Mechanic Hanumanthu S/O Thippaiah	51/1	4.28	5.08
11	Shamshuddin S/O Badesab	52	1.90	5.75
12	Gokharisab S/O Aji Sab	53/3	4.73	5.62
13	Bada Meheboob S/O Gurusab	54/1	6.39	4.38
14	Chota Meheboob S/O Gokari	54/2	3.99	5.23
15	Basha S/O Ajasab	58/2	5.37	5.52
16	Zindawali S/O Badesab	58/3	3.84	3.14
17	Gokharisab S/O Aji Sab	58/5	4.52	2.91
18	Aslam sab S/O Husensab	60	4.24	5.61
19	Hampana gouda S/O Badesab	76	4.14	3.12
20	Khaja Sab S/O Gokharisab	76/1A	3.01	5.62
21	Mainsab S/O Husen sab	76/3	0.60	5.52
22	Gokari hussen sab S/O Noormohamad	70A	6.01	2.96
23	Puchha Narasappa	70/B	4.33	3.04
24	Yellapa S/O Narasappa	70E	3.56	5.49
25	Ganapathi S/O Bheemaiah	160/P2/1 & 161 /1	2.98	5.85
26	Ramegouda S/O Laxmaiah	161/P2/1	2.79	5.70
27	Basavaraj S/O Thimmaiah	155/2	2.66	5.57
28	Ramesh S/O Thimmaiah	155/4/2	3.48	5.88
29	Hanumanthu S/O Bheemaiah	155/E	6.33	3.31
30	Rajan reddy S/O Nagireddy	93,94,95	1.86	5.92
31	Guru Basappa S/O Nagireddy	88	4.92	2.77

estimated WPE for same yield was in the range from 3.83 to 4.58 kg/ha/mm. This showed that there is a difference in measured and estimated water depth. The measured irrigation quantity was ranged from 683.21 mm to 1920.33 mm as against the estimated quantity of 535.48 mm. The measured depth was higher which can be attributed towards excessive irrigation applied during crop period. This showed the difference between the

measured WPE and the estimated WPE of cotton in *kharif*.

The actual quantity of water required for growing paddy in 27.22 ha and cotton in 2.83 ha in *kharif*, 2009-10 was 2,23,999 m³ taking water requirement of paddy and cotton

767.25 mm and 535.48 mm, respectively. But the total quantity of water applied by the farmers through flood irrigation was 4,26,906 m³.

From this it was found that the farmers practice of water application was 1.90 times more than actually required.

In case of groundnut measured WPE was 3.06 and 3.10 kg/ha/mm of irrigation applied during *rabi*. However, the estimated WPE for same yield was 4.33 and 4.42 kg/ha /mm. This showed that there was a difference in measured and estimated irrigation quantity. The measured irrigation quantity was 799.76 mm to 805.63 mm as against estimated quantity of 565.24 mm. The measured depth was higher which can be attributed towards excessive irrigation applied during crop period. This showed the difference between measured WPE and estimated WPE of groundnut in *rabi*.

In case of tobacco measured WPE was 0.89 and 2.44 kg/ha/mm of irrigation applied during *rabi*. However, the estimated WPE for same yield was 0.80 and 1.38 kg/ha/mm. This showed that there was a difference in measured and estimated irrigation quantity. The measured irrigation quantity was 197.06 mm and 922.40 mm as against the estimated quantity of 596.96 mm. The measured depth was higher which can be attributed towards excessive irrigation applied during crop period. This showed the difference between measured WPE and estimated WPE of tobacco in *rabi*.

In case of vegetable crop measured WPE was ranged from 22.46 to 47.01 kg/ha/mm of irrigation applied during *rabi*. However, the estimated WPE for same yield was ranged from 24.05 to 49.11 kg/ha/mm. This showed that there was a difference in measured and estimated irrigation quantity. The measured irrigation quantity was ranged from 328.64 to 1050.42 mm as against the estimated quantity of 642.46 mm. The measured depth was higher which can be attributed towards excessive irrigation applied during crop period. This showed the difference between measured WPE and estimated WPE of vegetable crop in *rabi*.

The actual quantity of water required for growing of paddy in 14.67 ha, groundnut in 0.40 ha,

tobacco in 0.61 ha and vegetables in 2.63 ha in *rabi/summer*, was 2,12,016 m³ taking water requirement of paddy, groundnut and vegetables as 1289.82 mm, 565.24 mm, 596.96 mm and 642.46 mm, respectively. But the total quantity of water applied by the farmers through basin and flood irrigation from the wells was 2,75,287 m³. From this it was found that the farmers' practice of water application was 1.30 times more than the actual water required.

The higher measured depth was attributed towards excessive irrigation applied during crop period, whereas lower measured depth indicated deficit irrigation applied during crop period. There is a need for better management of irrigation scheduling and operation such that excessive irrigation is minimized. The depth of surface irrigation needs to be measured with suitable devices namely H- flumes, Parshal flumes, V-notches etc which will minimize the excess irrigation. The conveyance and application losses can be minimised to a great maximum extent by use of drip and sprinkler irrigation. In flood irrigation, pipes will improve the water production efficiency. Further, due to the practical problems in getting regular power supply for an assured duration in a day, the farmers usually go for prolonged pumping during the day of irrigation.

LITERATURE CITED

- Anonymous 2007** Eleventh Five-Year plan, Planning Commission of India, Govt. of India, New Delhi.
- Anonymous 2008** Water resources at a glance, Central Water Commission, Govt. of India, New Delhi.
- Anonymous 2008** Groundwater information booklet, Raichur district, Karnataka, Central Groundwater Board, South Western Region, Bangalore (Min. of Water Resource, Govt. of India).
- www.wtcer.ernet.in

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