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Research Article

ECONOMIC PERSPECTIVES OF WELL IRRIGATED AGRICULTURAL FARMS IN HARD ROCK AREAS OF KARNATAKA

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Abstract: Groundwater development in the case of hard rock areas is threatened by uncertainties inter alia nature of rock type, type of aquifer, number and type of wells per unit of utilizable groundwater. However, groundwater is the major source of irrigation in Karnataka especially in rain fed south-eastern districts of Kolar, Bengaluru, Tumakuru and Chitradurga. It is the key component in agricultural development in these areas. In this study, the Economic perspectives of well irrigated Agricultural farms are studied in Tumakuru district in hard rock areas of Karnataka State. The study area is covered the parts of central Dry-Zone of Karnataka comes under the Hemavathy river basin. Tumkur district has emerged as the most over-exploited district in terms of groundwater extraction and use was selected for the study. Simple averages, ratio measures, percentages and proportions are computed in order to draw meaningful inferences and to facilitate comparison of the average farm situation in Irrigation wells located under tank command (GWTI) *i.e.*, System tank, Irrigation wells located under canal command (GWCI) and Irrigation wells located under sole irrigation, *i.e.*, located neither under tank or canal command (GWSI). The proportionate of working to failed well was 1.22: 1 in case of GWSI farms, it was 4: 1 and 4.62:1 in case of GWTI and GWSI farms respectively. Thus, prima facie GWTI and GWCI farmers have greater access to groundwater irrigation compared to GWSI farmers. Thus, the proportion of functioning wells in System tanks (GWTI and GWCI) is 80 percent compared to 55 percent in GWSI. This result confirms the importance of the water linkage through channels for recharging groundwater. This study apparently is a pointer towards the role of channel water linkage in promoting ground water recharge. The farms served by System Tank (GWTI) and Canal command (GWCI) have registered the highest net returns compared with farms in GWSI. This indicates the supremacy of the performance of GWTI and GWCI in heralding agricultural development due to recharge from irrigation tank and canal commands.

Keywords: *Groundwater, Bore well, Agricultural farms, Farmers, Investment and Return*

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Introduction

Karnataka has 13,759 million cubic meters (MCM) of utilizable groundwater for irrigation every year that can irrigate 1.38 million hectares up to one-meter depth. The entire state of Karnataka except the coastal region is classified as hard rock area for hydro geological purposes. Groundwater development in the case of hard rock areas is threatened by uncertainties inter alia nature of rock type, type of aquifer, number and type of wells per unit of utilizable groundwater, while surface water bodies have pervasive influence on groundwater use in a specific region and overexploitation of groundwater is resulting in progressive decline in the productivity of wells, increasing the implicit cost of lifting of water due to declining water levels. However, groundwater is the major source of irrigation in Karnataka especially in rain fed south-eastern districts of Kolar, Bengaluru, Tumakuru and Chitradurga. It is the key component in agricultural development in these areas.

According to the Central Groundwater Board ground water occurs in weathered and jointed zones of gneisses, granites and schists and alluvium in unconfined or water table conditions where it occurs in semi confined to confined conditions in fractured formations. The unconfined aquifer system is extracted by dug wells, shallow bore wells and filter point wells. This zone extends down to 13-20 meters below ground level (mbgl) depth. The groundwater yield of irrigation dug wells is 2754 Gallons per hour to 5506-gallon sper hour, whereas the same in weathered formation is 100 GPH to 2294 GPH. The yield of filter points ranges from 2019 GPH to 2294 GPH. As the filter points are located in alluvium of limited thickness, many of the wells are dry during summer. In addition, due to overexploitation, this zone is gradually getting dried up. In this study, the Economic perspectives of well irrigated Agricultural farms are studied in Tumakuru district in hard rock areas of Karnataka State. The study area is covered by the Hemavathy river basin. The study area is covered the parts of central Dry-Zone of Karnataka comes under the Hemavathy river basin. The river Hemavathy, a tributary of river Cauvery has its origin in Ballarayana Durga in Chikmagalore district of the Western Ghats, at 1,219 metres above MSL. The Hemavathy masonry dam is constructed in Gorur in Hassan District which impounds 78 TMC of water assuming 50 percent dependability. The reservoir fills between June and September, during the south west monsoons. and the depletion period is October to May. The Tumkur branch canal from the Hemavathy left bank canal which brings drinking water to Tumkur city is 240 kilometers long carrying 1429 cusecs of water [1-14]

Specific objectives of the study

Economic analysis of well irrigated Agricultural farms in Hemavathi water basin areas

Hypothesis of the study

The farming areas which are in the Hemavathi water basin are performing well.

Material and Methods

Choice of the study area

The district Tumakuru consists of ten talukas comes under the jurisdictions of Central dry zone of Karnataka and in the state, it was ranked in the descending order of groundwater over-exploitation. It has emerged as the most over-exploited district in terms of groundwater extraction and use. After discussion with the groundwater experts and different institutions, the reconnaissance survey has been conducted in different parts of Tumkur district in order to locate different pockets, which are facing acute groundwater scarcity (groundwater depletion).

Selection of the Sample Villages and Sampling

For identifying the sample villages, the resource persons from department of agriculture, irrigation, biodiversity, forestry (Vanavikasa) cooperative societies and Gram panchayats in the villages were approached. For analyzing the economic perspectives of well irrigated agricultural farms in Tumakuru district under Hemavathi command area classified in to three ground water cannal irrigation (GWCI), ground water tank irrigation (GWTI) (Echanoor), and the groundwater sole irrigation (GWSI), where the recharge is largely by rainfall (Kibbanahalli) have been chosen in consonance with study objectives.

1. Groundwater wells for irrigation located under system tank irrigation command (GWTI): here such wells are recharged by system irrigation tank (sample of 35 farmers)
2. Groundwater wells for irrigation located under canal command (GWCI): here such wells are recharged by canal irrigation command (sample of 35 farmers)
3. Groundwater wells for irrigation located independently of tank or canal command (GWSI); here such wells are recharged largely by rainfall and acts as a control situation (sample of 35 farmers).

Analytical Frame Work

Measures of Central Tendency and Ratios

Weighted average was computed in respect of socio-economic features, cropping pattern, cost of cultivation and returns from crop activities and access to groundwater. Ratios and percentages were employed to analyze the cropping pattern and cropping intensity. Simple averages, ratio measures, percentages and proportions are computed in order to draw meaningful inferences and to facilitate comparison of the average farm situation in Irrigation wells located under tank command (GWTI) *i.e.*, System tank, Irrigation wells located under canal command (GWCI) and Irrigation wells located under sole irrigation, *i.e.* located neither under tank or canal command (GWSI).

Amortized Cost of Bore Well

In order to arrive at the annual share of groundwater irrigation cost, the well investment has been amortized. It varies with amount of capital investment, age of the well, interest rate, year of construction *etc*.,

Amortized cost of irrigation bore well = (Amortized cost of BW + Amortized cost of pump set + Amortized cost of conveyance + Amortized cost of over ground structure + Repairs and maintenance cost of pump set and accessories)

A modest discount rate of two percent is considered for amortizing the cost of irrigation well to represent the compound rate of interest in the costing well components like construction cost, drilling cost, pump set, and accessories and so on.

Yield of Irrigation Well

The yield of well was recorded as perceived by farmers as 1 inch = 1000 GPH, 2 inches = 2000 GPH and 3inch = 3000 GPH and so on.

Economics of Irrigation

The cost of cultivation is the summation of amortized cost of irrigation, cost of human labour, bullock labour, machine hours, seeds and fertilizers, application of manure, plant protection measures, bagging, and transporting, cost of irrigation for each crop. The cost of production is the cost of cultivation + interest on variable cost. Gross return for each crop is the value of the output and the by-product at the prices realized by farmers.

Net returns from well irrigation are the gross returns from gross irrigated area minus the cost of production of all crops. Notably the cost of cultivation of all crops includes the cost of irrigation.

The gross cropped area (GCA) is calculated as, the sum of area under crops in all the three seasons (*Kharif, Rabi and summer*) +2 times the area under perennials such as coconut and arecanut. The net cropped area (NCA) is calculated as, the sum of area under crops for a season (*Kharif*) +one-time area under perennials.

Gross irrigated area (GIA) is the sum of irrigated area under all crops in all the three seasons + 2 times the area under perennials. Net irrigated area (NIA) is the irrigated area under all crops in *kharif* season + 1 time the area under perennials.

*Cropping intensity (CI) =(gross cropped area / net cropped area)*100*

*Irrigation intensity (II)=(gross irrigated area / net irrigated area)*100*

Gross Returns for each crop are total value of the output at the prices realized by farmers. Net returns from well irrigated area = Gross Returns from gross irrigated area minus the cost of production of all crops (for the year 2008).

Annual Externality Cost

The annual externality cost (AEC) of irrigation is estimated as the difference between the amortized cost per well and the amortized cost per functioning well.

AEC=amortized cost per well minus amortized cost of functioning well.

If the amortized cost per well is same as the amortized cost per functioning well, then all wells are working and there is no well failure. But if the amortized cost per well is lower than the amortized cost per functioning well, then the difference between amortized cost per functioning well minus the amortized cost per well is considered to reflect the negative externality suffered by each irrigation well. If the failure rate is large, the gap between these two would also be more. And hence the externality cost is included as the cost of well failure due to cumulative interference of irrigation wells.

Net Returns per Rupee of Irrigation Cost

Net return per rupee of irrigation cost was derived to compare the net return per acre-inch of groundwater used with irrigation cost per acre-inch of groundwater. Analyzed by dividing net returns per acre-inch of groundwater used divided by irrigation cost per acre-inch of groundwater.

Synergistic role of Irrigation wells located under system tank command (GWTI) was calculated by incremental net returns per acre of gross cropped area over Irrigation wells not located under tank or canal command (GWSI) minus net returns from rain fed crops per acre of gross cropped area.

Results

Distribution of irrigation wells across different types of farmers

In GWTI farmers, considering the distribution of wells across different holding sizes, 54 percent are medium farmers followed by small farmers (34 percent) and large farmers (12 percent). Considering all the farmers, 20 percent of the wells had failed and the remaining 80 percent were functional at the time of data collection. Earliest well was drilled in 1984 and latest during 2008. In GWTI farmers, out of 60 bore wells, highest no of wells belongs to medium farmers (36, 60 percent.), followed by small farmers (13, 22 percent) and large farmers (11, 18 percent). Among 36 borewells of medium farmers, 28 were yielding ground water and 8 wells were failed. Among 13 borewell 0f small farmers, 12 were yielding ground water and 1 was failed. Among 11 borewells of large farmers, 8 were yielding ground water and 3 were failed. Medium farmers had 58 percent of working borewells followed by small farmers 25 percent and large farmers 17 percent [Table-1]. In GWCI sample farmers, 54 percent are medium farmers followed by small farmers and large farmers (23 percent each). Considering all the farmers, 19 percent of bore wells had failed and the remaining 81 percent were functional at the time of data collection.

Earliest well was drilled in 1985 and latest during 2005. In GWCI, out of 73 bore wells highest no wells belong to medium farmers (39, 53 percent.), followed by large farmers (24, 33 percent) and small farmers (10, 14 percent). The no of bore wells owned by medium farmers comprises to 39 out of which 31 were functioning and 8 were failed during data collection. In 24 well 0f large farmers 19 were yielding ground water and 5 were failed. In 10 wells of small farmers 9 were yielding ground water and 1 was failed.

Table-1 *Distribution of irrigation wells across different types of farmers in GWTI, GWCI and GWSI*

Type of farmers	Size of holding (acres)	No. of farmers (percentage)	No of working wells (proportion of working wells)	No of failed wells (proportion of failed wells)	Total no of wells	Range of years
GWTI						
Small Farmers (< 5 acres)	1.75 - 4.75	12(34.28)	12 (25)	1 (8)	13(22)	1997-2008
Medium Farmers (5-10 acres)	5.00 - 9.50	19(54.29)	28 (58)	8(67)	36(60)	1985-2006
Large Farmers (> 10 acres)	11.84 - 20.00	4 (11.43)	8 (17)	3 (25)	11(18)	1984-2004
All farmers	6.66	35(100)	48 (80)	12 (20)	60(100)	1984-2008
GWCI						
Small Farmers (< 5 acres)	1.98 - 4.70	8(23)	9(15)	1(7)	10(14)	1990-2000
Medium Farmers (5-10 acres)	5.25 - 9.79	19(54)	31(53)	8(57)	39(53)	1985-2004
Large Farmers (> 10 acres)	10.04 - 16.50	8(23)	19(32)	5(36)	24(33)	1985-2005
All farmers	7.33	35(100)	59(81)	14(19)	73(100)	1985-2005
GWSI						
Small Farmers (< 5 acres)	3.00 - 4.85	15(43)	15(35)	11(31)	26(33)	1987-2006
Medium Farmers (5-10 acres)	5.00 - 8.00	14(40)	16(37)	15(43)	31(40)	1985-2007
Large Farmers (> 10 acres)	11.50 - 17.50	6(17)	12(28)	9(26)	21(27)	1986-2008
All farmers	6.31	35(100)	43(55)	35(45)	78(100)	1985-2008

Note: Figures in the parentheses indicate percentage to respective total. GWTI: Groundwater use under System percolation tank, GWCI: Groundwater use under Canal irrigation, GWSI: Groundwater use under sole irrigation, dependent only on rainfall for recharge

Table-2 *Profile of irrigation wells of sample farmers in GWTI, GWCI and GWSI*

SN	Particulars	GWTI (1)	GWCI (2)	GWSI (3)	Percentage change 1 over 3	Percentage change 2 over 3	Percentage change 1 over 2
1	Sample farmers (No.)	35	35	35			
2	Functioning bore wells (No.)	48 (80)	59(81)	43(55)	11.63	39.53	-18.64
3	Non-functioning Bore wells (No.)	12 (20)	14(19)	35(45)	-65.71	-62.85	-14.28
4	Total bore wells (No.)	60(100)	73(100)	78(100)	-23.08	-6.41	-17.80
5	Average age of functioning wells (years) as on 2009	10.52	12.20	7.33	43.52	66.44	-13.77
6	Average life of (failed) wells (years) as on year of failure	7.92	5.64	7.54	05.04	-25.20	40.43
7	Average age of all wells (years) as on 2009	10.00	10.95	7.42	34.77	47.57	-8.68
8	Modal age of functioning wells (years) as on 2009	11.00	11.00	5.00	120.00	120.00	0.00
9	Depth of Bore wells (feet)	285	315	429	-33.57	-26.57	-9.52
10	Yield of well (Gallons per Hour- GPH)	2016	1877	904	123.01	107.63	7.41
11	Year Range of wells drilled	1984-2008	1985-2005	1985-2008			
12	Investment per well	45158	44373	55700	-18.93	-20.34	1.77
13	Investment per functioning well	51015	49040	77118	-33.85	-36.41	4.03
14	Investment per failed well	21731	22832	29385	-26.05	-22.30	-4.82
15	Amortized cost per well (Rs.)	6490	6505	8232	-21.16	-20.98	-0.23
16	Amortized cost per functioning well (Rs.)	7447	7368	11458	-35.01	-35.70	1.07
17	Annual Externality cost (Rs.) (16-15) (Rs)	957	863	3226	-70.33	-73.25	10.89
18	Amortized cost per failed well (RS)	2660	2519	4269	-37.69	-40.99	5.60

Note: Figures in the parentheses indicate percentage to the respective total GWTI: Groundwater use under System percolation tank, GWCI: Groundwater use under Canal irrigation, GWSI: Groundwater use under sole irrigation, dependent only on rainfall for recharge

** Amortized cost is relatively higher due to higher rate of well failure (45 %) as against 20 % and lower age of 7.33 years in GWSI as against 12.20 years in GWCI command.*

Medium farmers had 53 percent of working wells followed by large farmers 32 percent and small farmers 15 percent [Table-1]. Thus, the proportion of functioning wells in System tanks (GWTI and GWCI) is 80 percent compared to 55 percent in GWSI. In GWSI sample farmers, 43 percent are small farmers followed by medium farmers (40 percent) and large farmers (17 percent). Among all the farmers 55 percent of the bore wells were functioning and 45 % were failed. Earliest well was drilled in 1985 and latest during 2008. In GWSI, out of 78 bore wells highest no of bore wells belongs to medium farmers (31, 40 percent.), followed by small farmers (26, 33 percent) and large farmers (21, 27 percent). Among 31 wells of medium farmers 16 were yielding ground water and 15 wells were failed. 26 bore wells were owned by Small farmers out of which 15 were functioning and 11 were failed. Out of 21 bore wells owned by large farmers 12 were functioning and 9 were failed. Medium farmers had 37 percent of working wells followed by small farmers 35 percent and large farmers 28 percent [Table-1]. Considering the distribution of wells across different holding sizes in the study area, in the GWTI, 54 percent were medium farmers followed by small farmers (34 percent) and large farmers (12 percent). About 80 percent of the wells were functional at the time of data collection. The earliest well was drilled in 1984 and the latest during 2008. Considering all the farmers, the average size of holding was 6.66 acres. Small farmers, possessed 25 percent of working wells and 8 percent failed wells with an average size of land holding was 3.43 acres; the medium farmers possessed 58 percent of working wells and 67 percent failed wells with an average size of land holding was 6.71 acres. The average land holding of large farmers was 16.24 acres and possess 17 % of functioning wells and 25% of failed wells.

Irrespective of functional and failed bore wells, in GWCI 53 percent of wells were owned by medium farmers, 33 percent by large farmers and 14 percent of wells were possessed by small farmers. Medium farmers possessed 52 percent working wells and 62 percent of failed wells. Small farmers in the sample had irrigation wells since 1990. Thus, in GWCI on an average the proportion of well success was 81 percent and the remaining 19 percent was failure rate during 2008, at the time of data collection. The ratio of working to failed wells was 9:1 for small farmers, 3.88:1 for medium farmers and 5:1 for large farmers. Thus, prima facie all farmers have greater access to groundwater irrigation.

In GWSI, out of 35 farmers 43 percent belong to small farmers 40 percent medium farmers and 17 percent large farmers. The average holding size is 6.31 acres for all the sample farmers. Medium farmers had 31 wells, with 37 percent of working bore wells and 43 percent of failed bore wells. In GWSI on an average the proportion of well success was 55 percent and the remaining 45 percent was well failure at the time of data collection. The ratio of working to failed wells was 1.36:1 for small farmers, 1.07:1 for medium farmers and 1.33:1 for large farmers. Thus, prima facie all farmers don't have greater access to groundwater irrigation in GWSI. The ratio of working to failed wells was 4:1 for GWTI farmers, 4.62:1 for GWCI farmers and 1.22:1 for GWSI farmers. Thus, prima facie GWTI and GWCI farmers have greater access to groundwater irrigation compared to GWSI farmers. Thus, the proportion of functioning wells in System tanks (GWTI and GWCI) is 80 percent compared to 55 percent in GWSI. This result confirms the importance of the water linkage through channels for recharging groundwater.

Table-3 *Economics of agricultural farms of sample farmers in GWTI, GWCI and GWSI.*

SN	Particulars	GWTI (1)	GWCI (2)	GWSI (3)	Percentage change (1 to 3)	Percentage change (2 to 3)
1	No of farms selected for study	35	35	35		
2	No of functioning wells in each farm	48	59	43	11.63	39.53
3	Net cropped area (acre)	233.27	256.45	220.75	5.67	16.17
4	Gross cropped area (acre)	455.91	489.86	377.85	20.65	29.64
5	net irrigated area (acre)	173.89	223.46	135.51	28.32	64.90
6	Net irrigated area per functioning well	3.62	3.72	3.15	14.92	18.10
7	Gross irrigated area per functioning well	7.94	7.19	6.20	28.06	15.96
8	Gross cropped area per farm (acre)	13.03	14.00	10.80	20.64	29.63
9	Net returns per acre of gross cropped (Rs.)	12210	10912	9292	31.40	17.43
10	Net cropped area per farm (acre)	6.66	7.33	6.31	5.55	16.16
11	Net cropped area per functioning well (acre)	4.86	4.27	5.13	5.56	20.14
12	Net returns per acre of net cropped (Rs.)	20750	18704	12289	68.85	52.20
13	Cropping Intensity (percent)	195.44	191.02	171.17	14.18	11.60
14	Irrigation intensity (percent)	219.25	189.94	180.24	21.64	5.38
15	Net returns per farm (Rs) (agriculture)	138297	137045	77511	78.42	76.81
16	Net returns per farm (Rs) (rain fed crops)	5297	4720	6666	-20.54	-29.19
17	Net returns per farm (Rs) (irrigated crops)	133000	132325	70845	87.73	86.78
18	Net returns per farm (Rs) (livestock)	20243	13700	9972	103.00	37.38
19	Number of functioning wells per farm	1.37	1.71	1.23	11.38	39.02

GWTI: Groundwater use under System percolation tank, GWCI: Groundwater use under Canal irrigation, GWSI: Groundwater use under sole irrigation, dependent only on rainfall for recharge

Age, Depth and Yield of Irrigation Wells in the Study area

The total numbers of functioning wells were 48, 59, and 43 in GWTI, GWCI and GWSI respectively. The proportion of functioning wells was 80 percent in GWTI, 81 percent in GWCI and it was only 55 percent in GWSI farmers. The proportion of well failure was the highest in GWSI (45 percent) followed by GWTI (20 percent) and GWCI (19 percent). The percentage of well failure in GWTI is 66 percent less as compared to GWSI and 14 percent less as compared to GWCI. The percentage of well failure in GWCI is 63 percent less as compared to GWSI [Table-2]. The average age of borewells was 10.00 years in GWTI and 10.95 years in GWCI which is comparatively higher than GWSI (7.42 years). The average age of bore wells is 34.77 percent more in GWTI and it is 47.57 percent more in GWCI as compared to GWSI. These differences do make a distinct impact in terms of additional net income which is much higher in GWTI and GWCI as compared to GWSI [Table-2]. The average depth of borewells was lower in GWTI (285 ft) and GWCI (315 ft) while it was higher in GWSI (429 ft). As compared with GWSI, average depth of borewells in GWTI and GWCI was lower by 33.57 and 26.57 percent respectively. It was 9.52 percent less in GWTI as compared to GWCI. This can have a noticeable impact on the overall bore well economy [Table-2]. The groundwater yield of borewells was higher in the GWTI (2016 GPH) and GWCI (1877 GPH) as compared to GWSI (904 GPH). The average ground water yield is 123.01 and 107.63 percent more in GWTI and GWCI respectively, as compared to GWSI. The average ground water yield is 7.41 percent more in GWTI as compared to GWCI [Table-2].

Investment on irrigation wells

Considering the investment on irrigation bore wells in the three situations, investment per well was the highest (Rs.55700) for GWSI farms followed by GWTI farms (Rs.45158) and GWCI farms (Rs.44373). It was 18.93 percent less for GWTI farms and 20.34 percent less for GWCI farms as compared to GWSI farms. The investment per functioning bore well in the GWTI farms (Rs. 51015), is lower by 33.85 percent compared to GWSI farms (Rs.77118) and it was (Rs 49040) for GWCI farms, it was 36.41 percent lesser as compared to GWSI farms.

Amortized cost per bore well for GWTI farms (Rs. 6490) is lower by 21.16 percent as compared to GWSI farms (Rs. 8232). Amortized cost per bore well in GWCI farms was (Rs 6505), lesser by 22.30 percent as compared to GWSI farms. However, amortized cost per functioning well is lower by 35.01 percent in GWTI farms (Rs. 7447) as compared to GWSI farms (Rs. 11458) and it is (Rs 7368) in case of GWCI farms [Table-2]. Annual Externality cost for GWTI farms was (Rs. 957) is lower by 70 percent as compared to GWSI farms (Rs. 3226). Annual Externality cost for GWCI farms was (Rs 863), lesser by 73 percent as compared to GWSI farms. In the GWCI the proportion of well failure was 62 percent below that of GWSI. The age of functioning wells was 66 percent higher than the GWSI. The depth of borewells was 27 percent lower and the yield of well was 108 percent higher than GWSI. Considering economic parameters, the investment per functioning well was 36 percent lower, the amortized cost per well was 21 percent lower, the amortized cost per functioning well was 36 percent lower and more importantly the annual externality cost was 73 percent lower. The externality cost per well in GWSI was Rs. 3226, it was a mere Rs. 826 in the GWCI. These are apparent indicators of economic performance of GWCI over GWSI. And are clear pointers of groundwater recharge. Thus, the Irrigation Department of the Government needs to examine the possibilities of such linkages from the Hemavathy channel to help the farmers cultivating perennial crops since these crops are low water users compared to annual and seasonal crops. In addition, it is relatively economical to adopt drip and sprinkler irrigation for perennial crops compared to annual and seasonal crops.

The proportion of functioning bore wells was higher in GWTI (80 percent) as well as in GWCI (81 percent) than that in GWSI (55 percent). The proportion of well failure was the highest in GWSI (45 percent) followed by GWTI (20 percent) and GWCI (19 percent). The average depth of bore wells was comparable in both GWTI (285 ft) and in GWCI (315 ft) but it was 429 feet in GWSI. However, the average age of irrigation wells was higher in GWTI (10.00 years) and GWCI (10.95 years) compared to GWSI (7.42 years). The relationship between channel water linkage and yield of bore wells is understandable since the yield of wells greatly differ with degree of weathering and groundwater recharge efforts than with depth. There is a misconception that deeper the well, higher is the yield. This is disproved by poor correlation between depth and yield. The Annual Externality Cost is lower in GWTI (Rs. 957) and GWCI (Rs. 863) than in GWSI (Rs. 3226) because the proportion of failed wells was less in GWTI and GWCI. Similarly, the cost per acre inch of groundwater is lower in GWTI (Rs.34) and GWCI (Rs. 45) than in GWSI (Rs.113) which is another impact of channel water linkage. In GWTI and GWCI, annual externality cost is lower by 70 percent and 73 percent respectively; as compared to GWSI. At the same time the Net returns per acre in GWTI and GWCI is higher by 33 percent and 13 percent respectively compared to GWSI. Both these parameters are indicators of the effect of channel water on ground water recharge and the corresponding benefits to farmers.

Economic Impact of channel water in the study area is reflected through cost of irrigation and net return to groundwater used. Irrigation cost per acre inch of groundwater used was lower in GWTI and GWCI (Rs.34 and Rs. 45 respectively) as compared to non GWTI (Rs.113). This shows that there is positive impact of channel water on cost and returns. Net return per rupee of irrigation cost was higher in GWTI and GWCI compared to GWSI by 175 percent and 221 percent respectively.

In the GWCI the proportion of well failure was 62 percent below that of GWSI. The age of functioning wells was 66 percent higher than in the GWSI. The depth of Borewells was 27 percent lower and the yield of well was 108 percent higher than in GWSI.

Considering economic parameters, the investment per functioning well was 36 percent lower, the amortized cost per well was 21 percent lower, the amortized cost per functioning well was 36 percent lower and the annual externality cost was 73 percent lower. The externality cost per well in GWSI was Rs. 3226; it was a mere Rs. 826 in the GWCI. These are apparent indicators of economic performance of GWCI over GWSI. And are clear pointers of groundwater recharge. Thus, the Irrigation Department of the Government needs to examine the possibilities of such linkages from the Hemavathy channel to help the farmers cultivating perennial crops since these crops such as Coconut and Arecanut are perennial crops and are low water users compared to annual and seasonal crops. In addition, it is relatively economical to adopt drip and sprinkler irrigation for perennial crops compared to annual and seasonal crops.

Economics of agricultural farms in GWTI, GWCI and GWSI

The no of farms selected in each situation, *i.e.*, GWTI, GWCI and GWSI was 35. The no of functioning well was highest in GWCI 59 followed by GWTI 48 and GWSI 43. The net cultivated area was 223.46 acres in GWCI higher by 64.90 percent as compared to GWSI (135.51 acres). It was higher by 28.32 percent in GWTI (173.89 acres) as compared to GWSI. The gross cropped area per farm was 14.00 acres in GWCI higher by 29.63 percent as compared to GWSI (10.80 acres). It was higher by 20.64 percent in GWTI (13.03 acres) as compared to GWSI. Net return per acre of gross cropped area was Rs. 12210 in GWTI higher by 31.40 percent as compared to GWSI (Rs 9292). It was higher by 17.43 percent in GWCI (Rs. 10912) as compared to GWSI [Table-3].

The net cropped area per farm was 7.33 acres in GWCI higher by 16.16 percent as compared to GWSI (6.31 acres). It was higher by 5.55 percent in GWTI (6.66 acres) as compared to GWSI. Net return per acre of net cropped area was Rs. 20750 in GWTI higher by 68.85 percent as compared to GWSI (Rs 12289). It was (Rs. 18704) in GWCI higher by 52.20 percent as compared to GWSI. The cropping intensity was higher in GWTI (195.44 percent) higher by 14.18 percent as compared to GWSI (171.17 percent) and the same is higher by 11.60 percent in GWCI (191.02 percent) as compared to GWSI. The net return per farm from agriculture was higher in GWTI (Rs. 138297) higher by 78.42 percent as compared to GWSI (Rs. 77511) and the same is higher by 76.81 percent in GWCI (Rs. 137045) as compared to GWSI. The net return per farm from livestock was higher in GWTI (Rs. 20243) higher by 103 percent as compared to GWSI (Rs. 9972) and the same is higher by 37.38 percent in GWCI (Rs. 13700) as compared to GWSI [Table-3]. From irrigated crops, the net return per rupee of water, the net return per kg of output, is higher in both GWTI and GWCI compared to GWSI. Even though the net return per acre inch of groundwater showed mixed results, the crucial parameter is the net return per rupee of groundwater, which is the maximum in the case of GWCI and GWTI compared to GWSI. The cost of cultivation per kg of output is also the lowest in the GWCI and GWTI compared to GWSI. These are the other indictors reiterating the supremacy of System tank over the Non-System tank. The net return from irrigated crops per farm was higher in GWTI farmers (Rs. 133000) and GWCI (Rs. 132325) as compared to GWSI farmers (Rs. 70845), because in GWTI and GWCI the average size of gross irrigated area per farm was higher (10.89 acres and 12.13 acres respectively) as compared to GWSI farmers (7.62 acres).

Conclusion

This research aimed to study Economic perspectives of well irrigated Agricultural farms in hard rock areas of Karnataka, based on quantitative and qualitative analysis of impact of channel water linkage in dry land farming. It can be concluded that the agricultural farms under GWTI and GWCI are performing well compared to the farms under GWSI with respect to the gross irrigated area net returns per farms and Number of functioning bare well. The net returns per acre are higher in GWTI and GWCI situations compared to GWSI situations. This shows the role of system irrigation tank on crop yield and farm economy.

Among the 60 bore wells in GWTI farms, 48 bore wells are yielding groundwater, 6 bore wells suffered initial failure and 6 bore wells were failed. The overall failure rate was 20 percent. In the GWCI, 59 wells were yielding groundwater. 8 Borewells suffered initial and 6 Borewells were failed, the overall failure rate was 19 percent. Among the 78 Borewells in GWSI farms, 43 bore wells are yielding groundwater, 15 Borewells suffered initial failure and 20 Borewells were failed, the overall failure rate of Borewells was 45 percent. This indicates importance of water linkage for recharge of ground water which indirectly helps the farmers to improve their farm income.

This study apparently is a pointer towards the role of channel water linkage in promoting ground water recharge. The farms served by System Tank (GWTI) and Canal command (GWCI) have registered the highest net returns compared with farms in GWSI. This indicates the supremacy of the performance of GWTI and GWCI in heralding agricultural development due to recharge from irrigation tank and canal commands.

The Irrigation Department needs to examine the possibilities of linking irrigation tanks in Hemavathy command area through channels from Hemavathy reservoir. This will ensure water availability throughout the year for irrigation well farmers through groundwater recharge and facilitate to cultivate crops including perennial commercial crops like Coconut and Arecanut since, these crops are low water users compared to annual and seasonal crops.

Application of the Research

The Agricultural farms under Hemavathi water basin were performing well with respect to gross irrigated area, net returns per farm, cropping intensity, No of functioning wells, life of bore wells, water yield etc., in this regard the policy maker should think to connect dry areas with channel water so that the ground water level can be improved which may help the farmers to produce more and can lead the respectable life in the society with sustainable management of natural water resources.

Research Category: Sustainable management of water

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