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Research Article

STUDY ON GROUNDWATER EXTRACTION COST OF FUNCTIONING WELLS IN TUMAKURU DISTRICT OF KARNATAKA

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Abstract: This demonstrates the extent of inflation in drilling wells as well as in water pumping devices. Apparently, there are indications that the real investment per acre inch of water, Real investment per acre of Gross irrigated area and Real investment per functioning well are all falling over time in GWTI farmers. This study apparently is a pointer towards the role of channel water linkage in promoting ground water recharge. The farms served by System Percolation Tank (GWTI) and Canal percolation (GWCI) have registered the lowest investment for irrigation wells as compared with farms under the command of Non-System Tank (GWSI). This indicates the supremacy of the performance of GWTI and GWCI in heralding agricultural development as irrigation tanks are multipurpose entities.

Keywords: *Investment, groundwater, Amortization, Bore wells, Farmers and real cost*

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Introduction

In the regions without perennial rivers, groundwater recharge suffers as in the Deccan plateau, unlike the Indo–Gangetic plains which receive both snow melt water from the Himalayas as well as the rainwater. Thus, efforts to impound surface water through watershed development programs, Tank distillation, Tank rehabilitation, Construction of percolation ponds are continuing unabated in Southern India, with Karnataka being no exception. Increased groundwater table through recharge is one of the important impacts of Tank Rehabilitation. Both irrigation and drinking water wells are benefited through rehabilitation. Wells in and around get recharged due to tank rehabilitation and supplement tank irrigation and, in some cases, even act as the main source of irrigation during lean period. Thus, the augmented recharge directly benefits the landowning farmers and indirectly benefits the poor and landless through an increase in employment days. The water table in both open and bore wells would be raised on a modest scale due to tank rehabilitation. Even the abandoned wells have been well-revived, leading to water markets. Even the poor farmers without wells know that the easiest way to access water for irrigation is to buy from a neighbouring well owner. The improved productivity of wells due to groundwater recharge is by far the most valuable benefit to farmers associated with tanks Government should provide subsidy for such irrigation systems.

Artificial recharge structures should be constructed in feasible areas for augmenting ground water resource and to improve ground water quality. Recharge ground water by way of artificial recharge structures like percolation tank, desilting of silted tanks, check dams, naala bunds, farm ponds and subsurface dykes. Ground water can be tapped from valley fills of Pennar and its tributaries for drinking purposes. This study is a modest attempt towards the economics of groundwater irrigation under three situations of recharge in Tiptur taluk, Tumkur district of Karnataka.

Here the irrigation wells located under canal command (GWCI) (Gadabanaalli), the irrigation wells located under tank command (GWTI) (Echanur), receiving the Hemavathy river water, with a water spread of 363 acres and another vilallge Kibbanahalli where groundwater wells are located independently or canal or tank irrigation command (called groundwater under sole irrigation GWSI), which depend only on rainfall source have been considered [1-13].

The specific objectives of the study

To analyze the Real coat of groundwater irrigation wells.

Hypothesis of study

Real cost of groundwater irrigation increases with time, groundwater extracted and depth of wells.

Material and Methods

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 comparison of the relative performance of the groundwater recharge in Tiptur taluk, Irrigation wells located under Hemavathy canal command (GWCI), the System tank command (Echanoor) (GWTI) and the groundwater wells under sole irrigation (GWSI), where the recharge is largely by rainfall (Kibbanahalli) have been chosen in consonance with study objectives in the Hemavathy river sub-basin of Cauvery river basin as under:

Groundwater wells for irrigation located under system tank irrigation command (GWTI): here such wells are recharged by system irrigation tank (sample of 35 farmers)

Groundwater wells for irrigation located under canal command (GWCI): here such wells are recharged by canal irrigation command (sample of 35 farmers)
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).

GWTI: Echanur village System Tank

Echanur village in Tiptur taluk is selected for this study to represent GWTI. This village consists of an irrigation tank of 363 acres which is filled by Hemavathy water to supply drinking water to Tiptur and Arasikere. Hence, this tank filled by channel water throughout the year.

GWCI: Gadabanaalli village located in canal command area

Gadabanalli village is 15 Km from Echanur village in Tiptur taluk selected for this study. Here, the Hemavathy irrigation channel passes through the outskirts of this village supplying irrigation water to the right hand side command of the channel. Much of the village area lies on the right hand side of the channel as also in the lower elevation of the channel, and the Gadabanaalli area is assured of channel water at least for six months in a year in the flow process. This area designated as GWCI and is selected after discussions with the technical staff in order to estimate the impact of the channel water on groundwater recharge.

GWSI: Control village Kibbanahalli (GWSI)

Kibbanahalli village in Tiptur taluk is located 6 kms from the Gadabanaalli village Channel command area and is selected as control village situation for comparison. This area has similar agro climatic conditions with respect to rainfall, soil and cropping pattern as that of Echanur (System Tank) and Gadabanaalli (Channel command), but has no connectivity from the irrigation channel or irrigation tank and hence is designated as groundwater use under sole irrigation (GWSI).

Sample Size

For this study, only farmers possessing irrigation wells in each of the three scenarios have been chosen. Hence a random sample of 35 farmers was drawn from each of the three scenarios, thus, totalling 105 for the purpose of this study with distribution as under Table.

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). Methodologies followed to estimate yield of wells, water use in each crop, amortized cost of irrigation are described below.

Well age and well life

The well age and well life were estimated using life table approach. Age of the well refers to the number of years for which wells have been functioning at the time of field data collection. The age of the well was thus estimated as (Year 2008 minus the year of well construction or drilling).

Age of well $= \sum[(f_i X_i) / \sum (f_i)]$

Where,

f_i = frequency of wells yielding irrigation water in each age group

X_i = age group of wells (1, 2, 3...n in years)

i = ranges from 0 to n, where n refers to the longest age of well in the group

Wells constructed during 2008 and still functioning at the time of data collection were assumed to have zero age, as the effect of interference is to increase both the initial and current failures.

The average age of the well should include the age of those wells that are still functioning as well as the life of those wells that have failed. Hence average age of the well is a comprehensive indicator of the average number of years a well provides irrigation services.

Life of well refers to the total number of years a well has functioned and is now no longer functioning. Accordingly, well life is a concept applicable to the totally failed and abandoned wells. The well life is estimated as Year of failure minus year of construction/drilling. All those wells, which suffered from initial failure, obviously have zero life. In order to get the average age of wells, wells, which are functioning and have ceased to function and have failed, were both included and their corresponding age/life was included in finding the average

Average life of well is estimated as:

$$\text{Average life of well} = \sum[(f_i X_i) / \sum (f_i)]$$

Where,

f_i = frequency of wells yielding irrigation water in each group

X_i = age group of wells (1, 2, 3...n in years)

i = ranges from 0 to n, where n refers to the last year of working of the irrigation well.

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. Amortization cost of well was worked out by adopting the following procedure,

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)

Amortized cost of bore well$=[(\text{Compounded cost of bore well})*(1+d)AA*d] / [(1+d)^{AA-1}]$

Where,

AA= Average Age of bore well

BW = Bore Well

d = Discount rate considered at 2 percent

*Compounded cost of BW= Historical cost of BW** $(1+i)^{(2009-\text{ year of drilling})}$

Where,

i = Compound rate of 2 percent

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.

Estimation of Barnet and Morse Scarcity

Estimation of Real cost of groundwater extraction for all wells (functioning and failed)

The functioning well refers to the irrigation wells functioning up to the year of field data collection, October November 2008. The failed well refers to the wells which were not yielding water at the time of field data collection. The farmers may have a combination of functioning and failed wells drilled during different years based on their resource endowments and economic capacities. Therefore, the nominal investment/s on wells which were not functional at the time of data collection have been added and considered "for the year of functioning wells" after deflating by the Wholesale Price Indices. This was attempted in order to accommodate investment on failed wells also on the farm which need to be recovered from the functioning well by the farmer. Thus, the Real Investment on well includes both Real Investment on functioning and failed wells.

Estimation of Real cost of groundwater extraction per functioning well

In order to work out the nominal and real investment per well it is necessary to know whether the well is functioning or not at the time of field data collection. However, since farmers encounter both well failures (premature as well as initial failure) and well successes, investment on both functioning and failed wells has to be considered. Among the two, investment on functioning well is more appropriate since the farmer recover his total investment only from functioning well. In the study area, the chronology of well drilling dates back to 1984 and continues to 2008 as a span of 24 years.

Table-1 *Real Investment on working and real cost per acre inch of ground water irrigation for sample farms in GWTI*

Year of drilling	average depth	Nominal Investment (Rs.)	Wholesale Price index (Base:1970-71=100)	Real Investment (Rs.)	Real investment index (Base:1970-71=100)	acre inch water extracted/year	real cost per acre inch of water	Real Investment per acre of Gross irrigated (Rs.)
1986	130	28630	376.8	7598	100.00	238.82	31.82	1516
1988	200	28200	433.8	6501	85.56	238.82	27.22	1298
1989	190	29130	466.1	6250	82.25	199.02	31.40	1247
1990	210	28508	513.9	5547	73.00	191.06	29.03	1107
1993	160	23720	697.1	3403	44.79	199.02	17.10	679
1994	250	35700	772.7	4620	60.80	199.02	23.21	922
1996	275	41500	885.0	4689	61.72	228.87	20.49	936
1997	313	75680	959.2	7890	103.84	185.75	42.47	1575
1998	278	46591	980.8	4750	62.52	185.75	25.57	948
1999	280	48000	1012.8	4739	62.37	199.02	23.81	946
2000	300	56167	1085.3	5175	68.11	199.02	26.00	1033
2002	320	61065	1162.7	5252	69.12	225.55	23.28	1048
2003	340	70550	1226.1	5754	75.73	238.82	24.09	1148
2004	332	58806	1305.6	4504	59.28	183.10	24.60	899
2005	415	71420	1363.5	5238	68.94	179.12	29.24	1045
2006	350	60033	1436.6	4179	55.00	185.75	22.50	834
2008	220	52640	1505.0	3498	46.03	238.82	14.65	698
Average	268	48020		5269.82		206.78	25.68	1051.71

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 *Real Investment on working and real cost per acre inch of ground water irrigation for sample farms in GWCI*

Year of drilling	average depth	Nominal Investment (Rs.)	Wholesale Price index (Base:1970-71=100)	Real Investment (Rs.)	Real investment index (Base:1970-71=100)	acre inch water extracted/year	real cost per acre inch of water	Real Investment per acre of Gross irrigated (Rs.)
1986	190	23230	376.8	6165	100.00	159.21	38.72	1327
1989	180	26800	466.1	5750	93.26	159.21	36.11	1237
1990	233	32608	513.9	6345	102.92	172.48	36.79	1365
1991	268	38750	584.5	6629	107.53	199.02	33.31	1427
1992	315	43240	643.3	6721	109.02	167.18	40.20	1446
1993	217	31207	697.1	4477	72.62	159.21	28.12	963
1994	320	48473	772.7	6273	101.75	179.12	35.02	1350
1995	265	38680	775.8	4986	80.87	199.02	25.05	1073
1996	327	51333	885.0	5801	94.09	212.29	27.32	1248
1998	321	52914	980.8	5395	87.51	199.02	27.11	1161
1999	308	55575	1012.8	5487	89.00	169.17	32.44	1181
2000	344	57450	1085.3	5293	85.86	176.27	30.03	1139
2001	390	72520	1124.4	6450	104.62	179.12	36.01	1388
2002	368	54908	1162.7	4722	76.60	191.06	24.72	1016
2003	390	63320	1226.1	5164	83.77	185.75	27.80	1111
2004	450	73987	1305.6	5667	91.92	159.21	35.59	1220
Average	305	47812		5707.81		179.15	32.15	1228.25

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-3 *Real Investment on working and real cost per acre inch of ground water irrigation for sample farms in GWSI*

Year of drilling	average depth	Nominal Investment (Rs.)	Wholesale Price index (Base:1970-71=100)	Real Investment (Rs.)	Real investment index (Base:1970-71=100)	acre inch water extracted/year	real cost per acre inch of water	Real Investment per acre of Gross irrigated (Rs.)
1990	260	37900	513.9	7374	100.00	119.41	61.76	1942
1996	330	44438	885.0	5021	68.09	119.41	42.05	1322
1998	397	59951	980.8	6113	82.89	102.35	59.72	1610
1999	423	65947	1012.8	6511	88.29	145.95	44.61	1715
2000	390	63530	1085.3	5854	79.38	139.31	42.02	1541
2001	430	70160	1124.4	6240	84.62	119.41	52.26	1643
2002	570	88090	1162.7	7576	102.74	179.12	42.30	1995
2003	530	82030	1226.1	6690	90.72	139.31	48.02	1762
2004	521	84946	1305.6	6506	88.23	124.39	52.31	1713
2005	543	90833	1363.5	6662	90.34	149.26	44.63	1754
2006	622	101637	1436.6	7075	95.93	139.31	50.78	1863
2007	640	111300	1505.0	7396	100.29	139.31	53.09	1947
Average	471	75063	-	6584.83	-	134.71	49.46	1733.92

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

In each of these years though theoretically we can expect that functioning well is present in every year, it was found that only the wells drilled in the years 1986, 1988, 1989, 1990, 1993, 1994, 1996, 1997, 1998, 1999, 2000, 2002, 2003, 2004, 2005, 2006 and 2008 were functioning at the time of field data collection in October and November 2008. Therefore, the information on real cost pertains to only these years.

Other measures of groundwater scarcity included

Real investment per acre inch of groundwater extracted

Here real investment on all irrigation wells is divided by the number of working wells to obtain the real investment per well. This is further divided by the groundwater extracted in 2008 (the latest year of field study), to obtain the real investment per acre inch of groundwater.

Real investment per acre of gross irrigated area

Here real investment on all irrigation wells is divided by the number of working wells to obtain the real investment per well. This is further divided by the gross irrigated area in 2008 (the latest year of field study), to obtain the real investment per acre.

Results and Discussion

In GWTI the mean depth of working well was 268 ft, the mean nominal investment per working well was Rs, 48020, the real investment per working well ranges between Rs.7598 to Rs. 3403, the average acre inch of water extracted per well per year is about 207, the real cost per acre inch of water is Rs. 25.68 and the real cost per Gross irrigated was ranges between Rs.1575 to Rs. 679 [Table-1]. In the case of GWCI the average depth of working well was 305 ft, the mean nominal investment per working well was Rs, 47812, the real investment per working well ranges between Rs.6721 to Rs. 4477, the average acre inch of water extracted per well per year is about 179, the real cost per acre inch of water is Rs. 32.15 and the real cost per Gross irrigated area was ranges between Rs.1446 to Rs. 963 [Table-2]. For GWSI, the average depth of working well was 471 ft, the mean nominal investment per working well was Rs, 75063, the real investment per working well ranges between Rs.7576 to Rs. 5021, the average acre inch of water extracted per well per year is about 135, the real cost per acre inch of water is Rs. 49.46 and the real cost per Gross irrigated area was ranges between Rs.1995 to Rs. 1322 [Table-3]. Considering the Real Investment on wells in GWTI, GWCI and GWSI. The Real Cost of irrigating per acre reduced with the introduction of water supply through channel. However, the Real Investment per working well did not show reduction in the cost after the introduction of channel water and stands at around Rs. 5000. In GWSI farmers the real investment for working well was falling over the years with a range of Rs. 5021 to Rs. 7396 even though the nominal investment ranged between Rs.37900 and Rs.111300 the mean real investment per well works was Rs.6585, and the mean nominal investment per working well was Rs.75063. Comparing GWTI farms with GWSI farms the average depth, nominal investment, real investment, real cost per acre inch of water, and real investment per acre of gross irrigated area of working wells was higher for GWSI over GWTI by 75, 52, 16, 81 and 53 percent respectively. However, average acre inch of water extracted per working well is higher in GWTI over GWSI by 53 percent. Thus, the GWTI farmers have increased the irrigated area per well compared to GWSI farmers. Considering the nominal cost of extraction of groundwater, it was clear that there was an increasing trend due to inflation and associated factors. However, the real cost of extraction was found to be consistent over the years. Considering Real Cost per acre of irrigation, the real cost has reduced after channel water supply to around Rs. 1000 per acre. Similarly, real cost per acre inch of groundwater extracted has been more consistent after the introduction of channel water between Rs. 15 and Rs. 31per acre inch (channel water was given in the year 1998). The measures Real investment per acre inch of water extracted, Real investment per acre of Gross irrigated area and Real investment per functioning well implicitly includes the cost of negative externality due to initial failure of wells. However, there are broad indications regarding the following:

1. The real investment per acre inch of water extracted varies between Rs. 15 to Rs. 31, with an average of Rs. 26 in GWTI. Rs. 24 to Rs. 40 with an average of Rs. 32 in GWCI and Rs. 42 to Rs. 62 with an average of Rs. 59 in GWSI.
2. The real cost of irrigation per acre of Gross irrigated area varied between Rs. 679 to Rs.1575 with an average of Rs. 1052 in GWTI, Rs. 963 to Rs. 1446 with an average of Rs. 1228 in GWCI and Rs. 1322 to Rs.1995 with an average of Rs. 1734 in GWSI. This also shows that farmers are irrigating their land using 135acre inches of water.
3. The Real investment per functioning well varied from Rs. 3498 to Rs. 7598 with an average of Rs. 5270 in GWTI, Rs. 4477 to Rs. 6629 with an average of Rs. 5708 in GWCI and Rs. 5021 to Rs. 7576 with an average of Rs. 6585 in GWSI. This demonstrates the extent of inflation in drilling wells as well as in water pumping devices.

Apparently, there are indications that the real investment per acre inch of water, Real investment per acre of Gross irrigated area and Real investment per functioning well are all falling over time in GWTI farmers.

Conclusion

This study is a modest attempt towards economic evaluation the groundwater recharge in Tiptur taluk, Tumakuru district of Karnataka. For comparison of this Biligerepalya GWCI, the nearest Echanur tank which is a system percolation tank GWTI receiving the Hemavathy river water, with a water spread of 363 acres and another nearest Kibbanahalli tank which is a Non-system tank GWSI, which totally depends on rainfall sources have been considered to assess the economic impact on agriculture productivity, groundwater recharge, with the focus on the economic impact assessment and to analyze the effects of canals and tanks in groundwater recharge in three situations.

This study apparently is a pointer towards the role of channel water linkage in promoting ground water recharge. The farms served by System Percolation Tank (GWTI) and Canal percolation (GWCI) have registered the lowest investment for irrigation wells as compared with farms under the command of Non-System Tank (GWSI). This indicates the supremacy of the performance of GWTI and GWCI in heralding agricultural development as irrigation tanks are multipurpose entities.

Application of research: Recharging groundwater in Non-System tank through canal water linkage reduces the groundwater extraction cost. Hence efforts should be made by policy makers in this direction especially in river basin areas where such intrabasin transfers are possible. Hemavathy canal project provides irrigation water for Right Bank Canal command. In rainy season, this area is fully flooded with water and at the same time the farmers of Left Bank Canal command are struggling to get drinking water. Thus, water needs to be put to productive and efficient use by linking this water in all lowlevel areas where ever possible. It will increase ground water recharge and improve socioeconomic status of the farmers besides protecting the ground water table.

Research Category: Water management

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