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RE-VISITING AGRICULTURAL POLICIES IN THE LIGHT OF GLOBALISATION EXPERIENCE: THE INDIAN CONTEXT

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Returns to Irrigation, Natural Resource Management, Research and Extension

Lack of awareness about optimal groundwater extraction and utilisation among farmers, policies pertinent to rural electrification, weak institutions and governance in relation to groundwater, increasing rate of initial and premature failure/s of borewells exacerbated the magnitude of reciprocal negative externality are the factors responsible for increasing farmer investments on new irrigation borewell/s striking groundwater at deeper depths. Studies at University of Agricultural Sciences, Bangalore have indicated a conservative estimate, groundwater irrigation costs around Rs. 500 per acre inch (or hectare centimeter) on volumetric basis and Rs. 10,000 per acre for less water intensive crop (vegetables/flowers) to Rs. 20,000 per acre for high water intensive crops (banana/paddy) on area basis. However, in the CACP/farm management surveys of the State Departments of Agriculture, irrigation cost is devoid of water cost in general and cost of groundwater irrigation in particular. The water rate charged for canal irrigation is also a poor reflector of the true cost of canal water (Nagaraj *et al.*, 2003).Thus, even though there is physical/economic scarcity of groundwater signaled through costs/prices, they are not reflected in MSP as well as market price. Hence output/input prices are distorted which correspondingly result in distorted crop pattern and net returns for farmers.

The resulting deterioration of groundwater resource has seriously impacted the over exploited hard rock areas (like Kolar district) and is continuing to damage other areas. This calls for rational water policy towards sustainable use of groundwater and land resources for shaping the economy of marginal and small farmers who bear the brunt of weak institutions, markets and policies. This paper deals with resource economic costing of irrigation for different crops demonstrating estimation of costs and returns groundwater irrigation and natural resource management with implications on research, extension and policy.

Costing Groundwater for Irrigation

Paradoxically, even with innumerable number of organisations on water – such as Central Water Commission, Ministry of Water Resources, Central Groundwater Board, National water development authority, State Water Resource Departments, State Departments of Mines and Geology, urban and rural water supply development boards, efforts towards volumetric measurement of water applied are still crude and approximate. Thus, irrigation water cost is not properly accounted in any of the costing procedures including the Commission on Agricultural Costs and Prices

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(CACP) which have no adequate information on water use in the RT forms.[1] Therefore there are no compelling reasons to accept that the costs of cultivation and the MSP are properly estimated, and they are grossly underestimated. The CACP methodology at best computes depreciation of irrigation structure over number of years which is subjective and left to the discretion of field assistant who obtains data from farmers. This study provides details of costing groundwater resource for irrigation considering the hard rock areas of Karnataka.

Limitations of the CACP Methodology on Costing Irrigation Water

To cost account irrigation water, the current methodology followed by CACP computes depreciation over number of years (which is subjective as it is not mentioned in the RT forms). For example, if an irrigation borewell is drilled in 2005 and is still yielding water, and if the data are collected in 2012, then the age at present will be 7 years. The remaining life of the irrigation borewell has to be estimated, for which no basis has been given. For instance in one of the RT forms, life of the well is recorded as 20 years and the remaining life is 20 – 7 years = 13 years. If the investment made on the borewell is Rs. 40000, the junk value is taken as 10 per cent of the investment as = Rs.4000. Thus, the value of borewell is taken as Rs. 40000 – Rs 4000 = Rs. 36000.The annual depreciation is calculated as 36000/20 = Rs.1800. The value of borewell at present (in 2012) is recorded as Rs. 1800 *13 years of remaining life = Rs. 23400. In the similar way, the value of IP set/s is worked out. Keeping apart the poor basis of computation of depreciation, the methodology ignores the ground reality of increasing cost of groundwater irrigation in hard rock areas due to increasing negative externalities exacerbated due to mushrooming of irrigation borewells in violation of the isolation distance.

Sampling

The sample farmers from Chitradurga and Kolar districts representing central dry zone and eastern dry zone, respectively were selected. Field data from 30 sample farmers each, representing supply side groundwater intervention (i.e. farms with on-farm or point borewell recharge) and groundwater institution (farms with shared irrigation borewell/s among heirs) were selected. To represent demand side interventions such as micro irrigation, 30 sample farms with drip irrigation for broad spaced crops and 30 sample farms with drip irrigation for narrow spaced crops were selected. Field data on cropping pattern, land holdings, source of irrigation, investment on irrigation borewell, investment on micro-irrigation structure, investment on recharge structure, cost and returns of various crop and livestock enterprises for the agricultural year 2012-13, considered as normal rainfall year was elicited.

Why and How to Cost Account Groundwater Irrigation

After 1990, increasing probability of initial and premature failure of borewells/tubewells have made it indispensible to treat investment on drilling and casing of irrigation wells as variable cost which was hitherto considered as fixed cost. Thus, total cost of groundwater irrigation can be divided into variable cost and fixed cost component. Though, farmers are not charged for electricity to pump groundwater for irrigation, they still incur the component of variable cost due to increased drilling of borewells on the farm due to high rate failures. The variable cost of groundwater represents the cost of drilling and casing since farmers are forced to invest on new borewells due to high probability of initial and premature failures. However, as the farmers use the irrigation pumpsets and accessories, conveyance structure, drip irrigation, borewell recharge, water storage structure, and electrical installation, investment on these are considered for depreciation for around ten years, irrespective of failure of irrigation wells. The variable cost and fixed cost is divided across volume of groundwater used for irrigation. The labour cost of irrigation is considered along with labour costs of other cultural operations. The annual cost of irrigation thus, pertains to amortised variable cost of all irrigation borewells on farm. This total cost of irrigation is then apportioned for each crop according to the volume of groundwater used in each crop. Thus, cost of irrigation per acre-inch or ha cm = [Total annual cost of irrigation]/ [volume of water used for the crop in acre inches of groundwater used].

Life of Well

Initial failure of borewell refers to a borewell which failed to yield any groundwater at the time of drilling and thereafter. Subsistence life of borewell refers to the number of years a borewell yielded groundwater for the Pay Back Period (PBP). The payback period is obtained by dividing the sum of the total investment on drilling, casing, IP set, conveyance structure, storage structure, drip/sprinkler structure, recharge structure, electrification charges of borewell by the annual returns per farm. The hypothesis is that an irrigation borewell is considered to have served its purpose. This implies that PBP indicates the period in which a borewell recovered the investment made. **Premature failure** refers to the borewell which served below the subsistence life or the PBP. **Economic life/age of borewell** refers to the number of years a borewell yielded groundwater beyond the PBP.

Amortised Cost of Borewell

The annual share of groundwater irrigation cost was obtained by amortization. The investment made on borewell exploration equal to the cost of drilling and casing renders as a variable cost and investment on IP sets and accessories and other costs of electrification as a fixed cost. This variable cost or investment is amortized over the average life/economic life of the well whichever is pertinent. Thus, the amortized cost varies with amount of capital investment, age of the borewell, discount rate and year of construction/drilling of borewell. The amortisation methodology suggested by Palanisami employed by Diwakara and Chandrakanth (2007) is used in this study.

Compounding Investment on Borewells

Since, farmers invest on irrigation well/s during different time periods, their wells have different vintages. In the study, it was found that the investment on borewells is increasing at the compound growth rate of 2 per cent by comparing the investment made on the first well and the last well on farms. Thus, in order to bring all historical costs on borewells on par, investments made by different farmers in different years, were compounded to the present (2013) at a discount rate of two per cent. The compounded investment is later divided into the fixed cost component (= irrigation pumpsets plus conveyance structure, drip irrigation structure and so on) amortizing over ten years, plus the variable cost of drilling and casing the borewell, amortized over the actual life of borewell, since farmers lose drilling cost and casing cost once the well fails. Hence, these two costs are separately amortized to obtain the yearly variable cost and fixed cost of irrigation borewell.

The amortized cost of borewell was worked out as under:

Amortized cost of irrigation = (Amortized cost of Borewell + Amortized cost of pump set + Amortized cost of conveyance + Amortized cost of over ground structure + annual Repairs and maintenance cost of pump set and accessories) given by

$$\text{Amortized cost of BW} = (\text{Compounded cost of BW}) \times \frac{(1+i)^{AL} \times i}{(1+i)^{AL} - 1]} \quad ....(1)$$

where,

AL= Average Age or life of borewell, i = 2 per cent

$$\text{Compounded cost of B} = (\text{Historical investmenton BW}) \times (1+i)^{(2013 - \text{year of drilling})}$$

$$\text{Amortized cost of Pumpsets and Accessories} = (\text{Compounded cost of P and A}) \times \frac{(1+i)^{10} \times i}{(1+i)^{10} - 1]} \quad ....(2)$$

The working life of Pumpsets (P) and Accessories (A) is considered to be ten years since farmers used them for at least 10 years.

$$\text{Compounded cost of Pumpset and Accessories} = (\text{Historical cost of P and A}) \times (1 + i)^{(2013 - \text{year of installation of P and A})}$$

$$\text{Amortized cost of conveyance structure (CS)} = (\text{Compounded cost of CS}) \times \frac{(1+i)^{10} \times i}{(1+i)^{10} - 1]} \quad \text{....(3)}$$

The working life of conveyance structure (CS) is considered as 10 years. The usual mode of conveyance of groundwater is through PVC pipe

$$\text{Compounded cost of CS} = (\text{Historical cost of CS}) \times (1 + i)^{(2013 - \text{year of installationof CS})}$$

$$\text{Amortized cost of micro irrigation structure} = (\text{Compounded cost of MIS}) \times \frac{(1+i)^{10} \times i}{(1+i)^{10} - 1]} \quad \text{....(4)}$$

The working life of micro (drip) irrigation structure (MIS) is considered to be 10 years since farmers usually replace them after 10 years. Here

$$\text{Compounded cost of} = (\text{Historical cost of MIS}) \times (1 + i)^{(2013 - \text{year of installation of MIS})}$$

As a coping mechanism to endure with the persistent problems imposed by variations in supply of voltage in electricity to run irrigation pumps and supply of electricity during off- peak load hours and low yields of borewell, farmers have built over ground storage structures. The amortized cost of over ground storage structure is estimated as under

$$\text{Amortized cost of overground storage structure} = (\text{Compounded cost of OSS}) \times \frac{(1+i)^{10} \times i}{(1+i)^{10} - 1]} \quad \text{....(5)}$$

$$\text{Compounded cost of OSS} = (\text{Historical cost of OSS}) \times (1 + i)^{(2013 - \text{year of construction of OSS})}$$

$$\text{Amortized cost of borewell recharge structure} = (\text{Compounded cost of BRS}) \times \frac{(1+i)^{AL} \times i}{(1+i)^{AL} - 1]} \quad \text{....(6)}$$

Here, AL= Average life/ age of borewell

$$\text{Compounded cost of Borewell recharge structure BRS} = (\text{Historical cost of BRS}) \times (1 + i)^{(2013 - \text{year of construction of BRS})}$$

Yield of Irrigation Borewell

The groundwater yield of borewells was calculated by recording the number of seconds taken to fill a bucket or over ground storage structure of known volume. Before recording, the borewell was put on for ten minutes so that the initial pump yield bias is avoided. This was linearly extrapolated to obtain the groundwater yield in gallons per hour.

Groundwater Use in Conventional Irrigation System

The acre-inches (or ha cms) of groundwater used for each crop in each season (summer, kharif, rabi) in conventional system of irrigation is estimated as = [(area irrigated in each crop) * (frequency or number of irrigations per month) * (number of months of crop) * (number of hours for one irrigation for the cropped area in question) * (Average yield of borewell in Gallons Per Hour)] /22611= groundwater use for each crop in acre inches.

Groundwater Use in Drip and Sprinkler Irrigation System

The groundwater used for irrigation in each crop (acre inches) in Drip irrigation = {Number of drips or emitters for the cropped area X groundwater discharged per emitter per hour (liters per hour) X No. of hours to drip irrigate the cropped area for one irrigation X frequency of irrigations per month (in number) X Duration of crop irrigated in months /4.54/22611}.

The groundwater used for irrigation in each crop (acre inches) in sprinkler irrigation = {Number of sprinklers for the cropped area X No. of hours to irrigate the cropped area for one irrigation X groundwater discharged per sprinkler (in liters per hour) X frequency of irrigation per month (in number) X Duration of crop irrigated in months /4.54/22611}.

One acre inch is equivalent to 22611 gallons or 3630 cubic feet and one cubic feet is equivalent to 28.32 litres. Total groundwater use per farm is total acre inches of groundwater used in all seasons across all crops including perennial crops.

Annual Cost of Irrigation

In Karnataka, farmers using irrigation pumpsets (below 10 hp capacities) for groundwater are not charged for electrical power. Government of Karnataka however, imposed a flat charge of Rs. 300 per hp per year up to 10 hp pump set since April 1997. However, the KPTCL/Government of Karnataka have been soft towards seeking electricity dues from farmers for the reasons of political economy. Hence, there are no explicit payments towards electricity for pumping groundwater, other than annual operation and maintenance charges of the irrigation pump set and borewell up to 10 hp.

The electricity tariff for Irrigation Pumpsets: Instead of tariff, there is subsidy. The amount of subsidy to be paid by the Government towards free supply of electricity to 21.06 lakhs Irrigation Pumpsets below 10 hp, and 22.90 lakh Bhagyajyothi / Kuritjyothi households is increased to Rs.5381 crores for 2013-14 from Rs.4722 crores paid for 2012-13. The bulk of this increase is on account of the increase in the consumption of Irrigation Pumpsets users which are going up from 15318 million units estimated for 2012-13 to 16679 million units in 2013-14.[2]

However, the implicit cost of irrigation is relevant for farmers in hard rock areas due to high probability of initial and premature borewell failure, which forces farmers to invest in additional borewell(s) to at least remain on the original production possibility curve. The investment on failed borewells is increasing due to violation of isolation distance between irrigation borewells, over extraction or mining of groundwater, lack of efforts to recharge groundwater, and reciprocal negative externality. The resulting transaction costs are due to forced investment on drilling and casing of additional borewells, since borewells drilled failed initially or prematurely to yield groundwater**.**

Returns to Groundwater Irrigation

The cost of cultivation is obtained as the sum of cost of human labour, bullock labour, machine hours, seeds and fertilisers, application of manure, plant protection measures, bagging, and transporting, cost of irrigation for each crop, interest on working capital @ seven per cent, risk premium @ two per cent and management cost @ five per cent on variable cost. Gross return for each crop is the value of the output and the by product at the prices realised by farmers.

Net returns from borewell irrigation are the gross returns from gross irrigated area minus the cost of production of all crops. The cost of cultivation of all crops in this study accordingly includes the cost of irrigation explicitly since volumetric measurements of groundwater applied are made for all crops.

RESULTS

The average size of land holding was the highest among farmers who have artificially recharged irrigation well/s on the farm (15 acres) in Central Dry Zone followed by farms with drip irrigation connected to narrow spaced crops in Eastern Dry Zone. Accordingly, the gross irrigated area and net irrigated area was also the highest among borewell recharge farms compared with all other categories of sample farmers. The volume of groundwater extracted per farm was the highest among borewell recharge farms (140 acre inches) followed by shared well farms (88.75 acre inches).

The variable cost of groundwater per acre inch was the highest for farms connected to narrow spaced crops in Eastern Dry Zone (Rs. 2089 per acre inch) forming 71 per cent of the total water cost, while fixed cost component forms (Rs. 865 per acre inch) the remaining 29 per cent. The next in the hierarchy was the farms connected with drip serving broad spaced crops in Central Dry Zone, where the variable cost component formed 69 per cent and fixed cost component formed remaining 31 per cent. The total cost of water on borewell recharge farm was Rs. 586 per acre inch. Out of the total water cost, variable cost formed 43 per cent; the lowest among all the sample category and fixed cost formed remaining 57 per cent. The total cost of groundwater was lowest among shared well farmers which were to the tune of Rs. 358 per acre inch with variable and fixed cost forming 56 and 44 per cent, respectively.

Economics of Groundwater Irrigation

The cost of groundwater irrigation formed 11 to 22 per cent of the total cost of cultivation of broad spaced crops with drip irrigation (Table 1). In absolute terms the cost of groundwater irrigation varied from Rs. 7269 per acre of coconut to Rs. 23601 per acre in papaya. The cost of groundwater irrigation formed 13 to 36 percent of the total cost of cultivation considering drip irrigation for narrow spaced crops (Table 2). In absolute terms, the cost of groundwater irrigation ranged from Rs. 7321 per acre of cauliflower to Rs. 25944 per acre of beans. What is crucial to note is that the cost of groundwater forms substantially lower proportion of total cost in all crops on farms with on farm borewell recharge. For instance, the groundwater cost ranged from 4 to 9 per cent of the total cost of cultivation. In absolute terms, the groundwater cost ranged from Rs. 1416 per acre of onion to Rs. 9458 per acre of papaya (Table 3). The groundwater cost formed the lower proportion of the total cost in all the crops on farms sharing irrigation well water among siblings. The ground water cost ranged from 1 to 16 per cent of the total cost of cultivation. In absolute term, the groundwater cost ranged from Rs. 1175 per acre of maize to Rs. 10642 per acre of arecanut (Table 4).

The net returns per acre inch of groundwater used was the highest among those sample farmers with drip irrigation for narrow spaced crops (Rs. 7610) followed by farmers with drip irrigation for broad spaced crops (Rs. 7398). The net returns per acre inch were Rs.3674 on borewell recharge farms. The economic efficiency reflected in terms of net returns per rupee of irrigation water cost was the highest among farmers who shared their groundwater among their relatives (Rs. 10.83) followed by farms with on-farm borewell recharge technology (Rs. 8.17), whereas the net returns per rupee of groundwater cost was Rs. 5.08 for farms with drip irrigation for broad spaced crops (Rs. 5.08) and Rs. 2.57 for farms with drip irrigation for narrow spaced crops (Table 5).

TABLE 1. ECONOMICS OF CROPS WITH DRIP IRRIGATION FOR BROAD SPACED CROPS IN HARD ROCK AREAS OF KARNATAKA

(Rs. per acre)

	Seed/Planting material (Kgs.)		Labour (mandays)		Machine Labour	FYM (tractor loads)		Soil (tractor loads)		Chemical Fertilisers	Plant protection chemicals	Marketing and commission charges	Water used in acre inches	Variable cost of water	Fixed cost of water
Crop	Qty.	Rs.	Qty.	Rs.	Rs.	Qty.	Rs.	Qty.	Rs.	Rs.	Rs.	Rs.		Rs.	Rs.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(!3)	(14)	(15)	(16)
Arecanut			96	24015	4490	3	8696	10	4412	3061		1402	12	8553	409
Coconut			25	6219	2629	1.5	4679	28	8341				8	6876	393
Papaya	1000	10000	78	19603	4875		20375		5500	19000	21300		14	21107	2494
Pomogranete	300	10500	120	30117		6	19684	12	5894	19203	30759		10	17250	514
Bannana	700	2000	54	13402	3625	3	8802	15	7448	18313		11453	32	18293	271

Crop	Total water cost Rs.	Proportion of groundwater cost	Consultation Charges Rs.	Stalking charges Rs.	Interest on working capital@7 per cent Rs.	Risk Premium @ 2 per cent Rs.	Management cost @ 5 per cent of operational cost Rs.	Total cost of cultivation Rs.	Output Qtl.	Price per quintal Rs.	Gross returns Rs.	Net returns including water cost Rs.	Net returns excluding water cost Rs.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Arecanut	8962	14			3853	1101	2752	62743	9	13309	114824	52080	61043
Coconut	7269	22			2040	583	1457	33216	4635	8	36502	3286	10555
Papaya	23601	17			8698	2485	6213	141649	193	1213	233500	91851	115452
Pomogranete	17764	11	3204	11142	10379	2965	7413	169025	39	8734	340540	171515	189279
Bannana	18564	19			5852	1672	4180	95312	41	2798	114531	19219	37784

Note: Yield of coconut is measured as number of nuts per acre

TABLE 2. ECONOMICS OF CROPS WITH DRIP IRRIGATION FOR NARROW SPACED CROPS IN HARD ROCK AREAS OF KARNATAKA

(Rs. per acre)

Crop	Seed/planting material(grams /kgs/numbers)		Labour in mandays		Machine labour in hours	FYM (tractor load)		Fertilisers	Plant protection chemicals	Cost on stalking materials	Twining material	Drip fertigation	Marketing commission charges
	Qty.	Rs.	Qty.	Rs.	Rs.	Qty.	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Coriander	15	3944	32	7878	4888			5700	822				9722
Potato	10	13795	42	10473	5346	1.3	6109	5732	5711				32462
Cabbage	17809	5000	75	18724	3714	3.5	5328	10695	29381			1548	34571
Knol kohl	1673	4466	50	12420	4800	0.6	1333	6016	7867				
Tomato	7298	3649	148	36902	4587	2.6	5832	4512	11618	9895	3113	3721	39268
Beans	8	5348	110	27479	2943			3427	5649	11227	1718	2236	21954
Capsicum	10000	10000	85	21250	10000	8.0	16000	6000	20000			5000	22500
Red onion	10	2065	50	12400	3867			2706	4400			5333	15589
Cauliflower	18545	6436	45	11291	2272	1.0	2272	5091	8909			4181	14909
Carrot	1	5000	39	9700	5428	2.4	4571	3357	1571			1754	17157

Crop	Water used in acre inches	Variable water cost	Fixed water cost	Total water cost	Proportion of ground-water cost to total cost	Interest on working capital @ 7 per cent	Risk premium @ 2 per cent	Management cost @ 5 per cent	Total cost	Crop yield	Gross returns	Net returns including water cost	Net returns excluding water cost
		Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	Qtl.	Rs.	Rs.	Rs.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Coriander	4.70	11765	7328	19093	32	3643	1041	2602	59334	150	75000	15666	34759
Potato	11.92	25778	762	26540	22	7432	2123	5308	121032	227	211012	89980	116520
Cabbage	10.05	24045	2304	26349	17	9472	2706	6766	154253	230	230476	76223	102572
Knol kohl	12.08	22324	3776	26100	36	4410	1260	3150	71822	155	90666	18844	44944
Tomato	12.16	20840	2107	22947	14	10223	2921	7302	166490	11	238689	72199	95146
Beans	10.31	25944	4251	30195	24	7852	2244	5609	127881	7	182500	54619	84814
Capasicum	8.18	17583	6067	23650	15	9408	2688	6720	153216	5	180000	26784	50434
Red onion	9.32	19034	5625	24659	30	4971	1420	3551	80962	96	136693	55731	80390
Cauliflower (No.)	8.54	7321	2308	9629	13	4549	1300	3250	74089	14545	118182	44093	53722
Carrot	7.59	17349	2120	19469	25	4760	1360	3400	77528	109	108571	31043	50512

TABLE 3. ECONOMICS OF CROPS ON BOREWELL IRRIGATION FARMS WITH ARTIFICIAL RECHARGE TO BOREWELL

(Rs./acre)

Crop	Seed /planting material		Labour in mandays		Machine labour in hours	Soil (tractor load)		FYM (tractor load)		Cost of chemical fertilisers	PP chemicals expenses	Stalking cost	Consultation charges	Marketing commission charges
	Qty.	Rs.	Qty.	Rs.	Rs.	Qty.	Rs.	Qty.	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Pomegranate			154	38467		10	4968	8	19162	13200	24000	11616	2413	8516
Papaya	750	6000	84	20885	3000			4	9714	15714	12714	2476		14547
Banana	536	2145	62	15408	4363	6	2909	3.2	8000	8436				15712
Arecanut			117	29281	3402	9	4328	4.5	11178	2619				2000
Coconut			28	7040	2100	20	10000	1.6	4000					2880
Mango			63	15825	3706			8	20170	4170				10595
Sapota			75	18807	6071	3	1607	7	16892		2500			9643
Onion	5	4681	37	9280	2802			0.6	1385	5232	1034			8506
Maize	10	1346	33	8137	2750					4463				1600

Crop	Water used in acre inches	Variable water cost	Fixed water cost	Total water cost	Proportion of groundwater cost to total cost	Interest on working capital @ 7 per cent	Risk premium @ 2 per cent	Management cost @ 5 per cent	Total cost of cultivation	Crop yield	Gross returns	Net returns including water cost	Net returns excluding water cost
		Rs.	Rs.	Rs.	Per cent	Rs.	Rs.	Rs.	Rs.	Qtl..	Rs.	Rs.	Rs.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Pomegranate	11.46	9087	154	9241	6	9211	2632	6579	150005	2553	217982	67977	77218
Papaya	15.25	9359	189	9548	9	6622	1892	4730	107842	127	145476	37634	47182
Banana	36.24	4729	213	4942	7	4334	1238	3096	70583	44	157121	86538	91480
Arecanut	12.16	4910	285	5195	8	4060	1160	2900	66123	8	116726	50603	55798
Coconut	8.41	2490	355	2845	9	2021	577	1443	32906	4880	57600	24694	27539
Mango	12.36	2775	221	2996	5	4022	1149	2873	65507	29	105957	40450	43446
Sapota	12.03	2281	217	2498	4	4061	1160	2901	66141	102	96428	30287	32785
Onion	13.28	1476	265	1741	4	2426	693	1733	39514	71	85062	45548	47289
Maize	9.89	1616	182	1798	8	1407	402	1005	22907	24	32952	10045	11843

Note : Output of coconut is number of nuts per acre.

TABLE 4. ECONOMICS OF CROPS CULTIVATED ON BOREWELL IRRIGATION FARMS SHARING BOREWELL WATER AMONG SIBLINGS

(Rs./acre)

Crop	Seed/planting material (Kgs)		Labour (mandays)		Machine Labour in hours	FYM (Tractor load)		Soil (Tractor load)		Chemical Fertilisers	Plant protection chemicals	Marketing and commission charges	Water used in acre inches
	Qty.	Rs.	Qty	Rs.	Rs.	Qty.	Rs.	Qty.	Rs.	Rs.	Rs.	Rs.	
(1)	(2)	(3)	(4).	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Crossandra			990	247494		4	11631	28	14123	16468	12702	65288	22.89
Maize	10.00	1283	24	5998	2100					3198		1389	10.77
Palak	6.67	1333	49	12154		1.5	1538			2191	1333	7692	3.97
Menthe	10.66	586	22	5500	266	1	1111			2106	1066	2722	2.91
Onion	5.50	4909	50	12577	2319	1.5	1589			6890	1858	5375	16.19
Cucumber	0.25	500	55	13705	1888					1511	1444	4100	6.36
Arecanut			121	30228	3578	2.5	6325	11	5572	2861		1000	13.06
Chrysanthemum		4933	255	63687	2000	1.1	3200			5418	44000	40646	39.52

Crop	Variable cost of water	Fixed cost of water	Total water cost	Proportion of water cost to total cost	Interest on working capital @ 7 per cent	Management cost @ 5 per cent	Risk premium @ 2 per cent	Total cost of cultivation	Output	Price	Gross returns	Net returns including water cost	Net returns excluding water cost
	Rs.	Rs.	Rs.	Per cent	Rs.	Rs.	Rs.	Rs.	Qtl	Rs.	Rs.	Rs.	Rs.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Crossandra	4293	345	4638	1	26064	18617	7447	424472	26115	25	652885	228413	233051
Maize	1100	75	1175	7	1060	757	303	17263	24	1273	30198	12935	14110
Palak (bunches)	2079	1109	3187	10	2060	1471	589	33550	38462	2	57692	24143	27330
Menthe (bunches)	1549	658	2207	12	1089	778	311	17743	13333	2	21667	3924	6131
Onion	1952	95	2047	5	2629	1878	751	42823	95	1000	94989	52166	54213
Cucumber	672	739	1411	5	1719	1228	491	27997	86	819	70444	42447	43858
Arecanut	10443	199	10642	16	4214	3010	1204	68635	8	13734	112759	44124	54766
Chrysanthemum (stringed in metres)	4603	259	4862	3	11812	8437	3375	192370	19433	20	397000	204630	209492

TABLE 5. RETURNS TO GROUNDWATER IRRIGATION ACROSS GROUNDWATER INSTITUTIONS AND TECHNOLOGIES IN EASTERN AND CENTRAL DRY ZONE OF KARNATAKA

Particulars (1)	Drip farms connected to narrow spaced crops, Kolar (n=30) (2)	Drip farm connected to broad spaced crops, Chitradurga (n=30) (3)	Shared well farms, Chitradurga (n=30) (4)	Borewell recharge farms , Chitradurga (n=30) (5)
Average size of land holding (irrigated land area) (acres)	9.38 (4.61)	7.87 (6.07)	8.17 (4.77)	15 (9.89)
Gross irrigated area per farm (acre)	6.62 (1-26)	12.2 (2.4-43.4)	7.93 (0.75-21)	17.03 (4-47)
Net irrigated area per farm (acre)	3.01	6.44	3.40	8.08
Groundwater extracted per farm (acre inches per year)	72.94 (11-261)	69.21 (15.58-267)	88.75 (16 -238)	140 (26.18-397)
Variable cost of groundwater (Rs per ha cm or acre inch)	2089 (71%) (295-9255)	972 (69%) (68-9517)	199 (56%) (18.59-1874)	251 (43%) (43-1127)
Fixed cost of groundwater (Rs per acre inch or ha cm)	865 (29%) (317-3791)	428 (31%) (156-2046)	159 (44%) (39-875)	335 (57%) (97-1564)
Net returns per acre inch or ha cm of groundwater (Rs) Range	7610 (784-22603)	7398 (1470-37554)	3888 (1277-16418)	3674 (1859-14533)
Net returns per rupee of irrigation cost (Rs) Range	2.57 (0.08-15.75)	5.08 (1.74-28)	10.83 (1.6-61.88)	8.17(1.32-18.29)

Note : figures in the parenthesis indicate range

CONCLUSION

The groundwater irrigation cost ranges from 11 per cent to 36 per cent of the total cost across different crops cultivated. At present, since the groundwater irrigation cost is not computed while working out the cost of cultivation; the net returns are over estimated to the extent of the cost of groundwater. Hence, in hard rock areas, as groundwater is a vital source of irrigation, groundwater cost needs to be computed at least for food crops, in order that their MSP properly accounts for the cost of the natural resource and is accordingly paid for. It is crucial to revise the methodology followed by CACP, NABARD, Commercial Banks, Cooperatives and State Departments by properly accounting for cost of groundwater as suggested in this study. Further this calls for capacity building programmes for policy makers, farmers and stake holders regarding the costing methodology of groundwater as well as the need for wise use/sustainable use of groundwater in order that the cost of groundwater is well contained as in the case of borewell irrigation with recharge. This needs the support of agricultural extension/irrigation extension through creation of Irrigation Management Service (on lines of Arizona groundwater management) which can educate farmers and stake holders regarding all aspects of groundwater resource, extraction, sustainable use, irrigation as well as the recharge and the economics of irrigation. The band of agricultural engineering graduates from SAUs needs to be utilised for educating farmers in this regard.

NOTES

1. The RT 440 of CACP, has the information pertaining to type of well, number of wells, HP of pump, command area irrigated, percentage owned, year of drilling, age at present, remaining life, amount invested, value at present, salvage value. However there is no information on expected age or life of wells which is subjective and is assumed to be 10 or 20 years as left to the discretion / imagination of Field Assistant who collects the data. RT 441 deals with change in well, and indicates when the well destroyed (or failed), when new well was constructed. There is no information on volume of groundwater yield of well/s extracted by farmer.
2. https://www.karnataka.gov.in/kerc/court-orders/court-orders-2013/tariff_order_13-14/press_note/press_note_english.pdf browsed on 18th July 2014.

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