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Groundwater Markets Across Climatic Zones: A Comparative Study of Arid and Semi-Arid Zones of Rajasthan

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Groundwater is the major factor in the agricultural economy of Rajasthan as 70 per cent of the irrigation demand is met by groundwater at present as compared to only 52 per cent in the early 1960s. The compound growth rate of the net area irrigated by groundwater in Rajasthan during 1981-1996 was 10.11 per cent per annum whereas for canal irrigation, it was only 3.14 per cent per annum (Sharma and Varghese, 1998). This uncontrolled extraction of groundwater and low groundwater recharge due to changed rainfall pattern, shrinkage in rechargeable area and loss for surface run-off lead to a continuous decline in groundwater table. In 1984, there were only 33 blocks, which were categorised as 'dark' and 'gray' and the figure has increased to 101 blocks as over-exploited, dark and gray blocks[1] in 1998. This decline in water table has, in turn, led to the drying up of open wells and increasing well failures[2] causing higher costs of installing new wells, deepening of existing wells, and pumping and other maintenance activities (Moench, 1992; Shah, 1985). Competitive deepening of wells or installing deep tubewells makes the distribution of access to groundwater increasingly skewed in favour of large and resource rich farmers leaving the resource poor farmers out of the race (Bhatia, 1992; Janakarajan, 1993; Shah, 1993 and Saleth, 1996). It is in this scenario that groundwater markets (GWMs) have emerged as an alternative water management strategy for making equitable and efficient use of scarce water resource (Satyasai, 1987; Shah and Raju, 1988; Shankar, 1991 and Shah, 1993). Now the question arises that how these transactions in water business takes place? And who benefits from this water trade? In this paper an attempt is made to study groundwater markets in the arid and semi-arid regions of Rajasthan.

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OBJECTIVES AND SCOPE

The overall objective of the paper is to evaluate the nature, magnitude and impact of groundwater markets on farm economy in the arid and semi-arid regions of Rajasthan based on primary data collected. The specific objectives are: (i) to study the nature and magnitude of groundwater markets in the study area, (ii) to understand the conduct of GWMs including the terms of transactions, (iii) to evaluate the costs and returns in water trade and the impact on farm business, and (iv) to conclude with the major implications for theory and policy in the realm of GWMs.

DATA AND METHODOLOGY

The farmers were selected using multi-stage sampling technique. Two districts from each region; Jodhpur and Nagaur from arid, and Alwar and Jaipur from semi-arid Rajasthan, were selected purposively on the basis of groundwater development. These districts were categorised as over-exploited or critical in groundwater development where the net annual groundwater draft was more than 100 per cent or in the range of 90-100 per cent, of the net annual groundwater recharge, respectively. One of the over-exploited blocks from each selected districts was drawn randomly and a cluster of two villages from each chosen block was sampled randomly from the list of the villages where the practice of groundwater buying and selling prevails. Fifteen per cent or more, to make a suitable size of sample, farmers were drawn randomly from the list of farmers. In this way a total of 280 farmers comprising 137 farmers from the semi-arid region and 143 farmers from the arid region were selected for the study. After their selection the sample farmers were classified into the following six categories[3]: self-users, self-users + sellers, self-users + sellers + buyers, self-users + buyers, buyers and non-users. Self-users and non-users categories of farmers do not enter into the water market. Self-users have their own water extraction mechanisms (WEMs) to irrigate their fields only and non-users neither have any WEM nor purchases water for irrigation.

The study uses primary data collected from these 280 farmers from the four districts representing both the arid and semi-arid regions of Rajasthan. Primary data on various aspects of groundwater markets were collected through household survey from the selected farmers with the help of specifically structured and pre-tested schedules. The survey data pertains to the agricultural year 1999-2000.

Groundwater Potential of the Study Area

To provide the context and background to the analysis of water transaction with the study regions a brief discussion on the regional and temporal pattern in groundwater potential and use can be very instructive. The study was conducted in the arid and semi-arid regions of Rajasthan spread over in the western and north-eastern parts and the state, respectively. The rainfall is lowest in the western part and

moderate in the north-eastern region. The groundwater is the only source of irrigation in both the regions as more than 90 per cent of the irrigation demand is met by groundwater. But, the groundwater potential of these two regions show considerable differences as shown in Table 1. Of the total water availability in the state only 20 per cent is available in the arid (57 per cent of total geographical area) and about 40 per cent in the semi-arid (35 per cent of total area) region. Groundwater is comparatively less scarce in the semi-arid region while, it is most scarce in the arid region as clear from the fact that the groundwater level was 150-200 feet deep in the arid region while in semi-arid region, it was 80-120 feet deep (Table 1). The depth of tubewells was 400-600 feet in the arid region and 200-400 feet in the semi-arid region. The dug wells and dug-cum-bore wells were almost abandoned in the arid region while in the semi-arid region, it was about to be so in the absence of adequate water recharge facility. The installed capacity of water lifting devices was in the range of 30-40 hp in the arid region, but the same was in the range of 7.5-12 hp in semi-arid region.

TABLE 1. GROUNDWATER CONDITION IN ARID AND SEMI-ARID REGIONS OF RAJASTHAN

Particulars (1)	Arid (2)	Semi-arid (3)
1.Groundwater condition	More scarce limited recharge	Less scarce moderate recharge
2. Source of irrigation	Groundwater	Groundwater
3.Depth of water level (ft.)	150-200	80 - 120
4.Depth of tubewell (ft.)	400 – 600	200 - 400
5.Capacity of pumpsets (hp)	30 – 40	7.5 - 12
6.Drop in water level (ft.)* (1984-1999)	20 – 138	10 - 66

Source: Field survey.

* Reports of Ground Water Department, Government of Rajasthan, Jodhpur for the years 1984 and 2000.

Declining Groundwater Resources

This section deals with the changes in groundwater resources in the study area over time. The data relating to groundwater recharge and draft estimated by Ground Water Department, Government of Rajasthan and status of wells in use and out of use are presented in Table 2 to show the declining groundwater resources in the districts under study.

The table shows that the availability (recharge) of groundwater has shown a declining trend in the arid as well as in semi-arid regions except in Alwar district. The success in the latter case is due to the efforts made by the non-governmental organisation called Tarun Bharat Sangh and the villagers of Alwar district, to increase groundwater recharge by rejuvenating traditional water harvesting system, such as *Johads* and, increasing groundwater availability (Kalakdina, 1998). The draft of groundwater had increased in all the selected districts but the change in groundwater

draft was more or higher in the arid region than in semi-arid region. In Rajasthan state, the draft of groundwater has increased by 77 per cent and the availability has declined by 9 per cent in 1998 over 1984.

TABLE 2: CHANGING STATUS OF GROUNDWATER IN STUDY AREA

Particulars	Semi-arid		Arid		
	Alwar	Jaipur	Jodhpur	Nagaur	Rajasthan
(1)	(2)	(3)	(4)	(5)	(6)
		Availability (mcm)			
1984	675	1385	434	557	13789
1998	765	626	314	795	12602
Per cent change	13	-55	-28	-11	-9
		Draft (mcm)			
1984	447	710	135	123	4930
1998	755	828	413	554	8708
Per cent change	69	17	206	350	77
		Stage (Per cent groundwater development)			
1984	66.22	51.27	31.09	22.05	35.75
1998	96.68	132.25	131.63	112.00	69.10
		Wells in use (No.)			
1970-71	31,201	88,545	6,778	9,624	6,61,997
1999-00	53,269	1,05,574	12,285	22,818	10,35,707
Per cent change	70.73	19.23	81.25	137.10	56.45
		Wells out of use (No.)			
1970-71	7,394	21,772	2,949	8,903	2,33,212
1999-00	19,536	26,301	6,904	23,082	3,15,475
Per cent change	164.21	20.80	134.11	159.26	35.27

Sources: Various reports of Groundwater Department, Government of Rajasthan, Jodhpur, and Directorate of Agriculture, Government of Rajasthan, Jaipur.

The increasing number of well failures also shows the declining groundwater resources. The percentage increase in well failures during 1999-2000 over that during 1970-71 was around 150 per cent for Jodhpur, Nagaur and Alwar districts while it was only 19 per cent in Jaipur district mainly due to the emergence of a new district, Dausa, bifurcated from Jaipur district. The declining water levels and over-exploitation of groundwater leads to equity and sustainability problems and deteriorating socio-economic conditions. This clearly underlines the importance of groundwater recharge in arid and semi-arid Rajasthan.

Groundwater Markets

Water market works differently under different conditions. For the development and efficient working of groundwater markets, it is essential for the policy makers and professionals to know about the structure and functioning of GWMs in the area. Water availability under different forms of water markets has given rise to issues related to the structure and conduct of GWMs.

Accessibility to Water Market

Farm size-wise distribution of households participating in groundwater markets is presented in Table 3. The results of the study show that in the semi-arid region, almost 66 per cent of the total farm households were participating in water trade either fully or partially. The sellers of water were 30 per cent while about 50 per cent of the total households were engaged in buying of water for irrigation.

The farm size wise analysis revealed that about 45 per cent of the small farmers were involved in buying of groundwater, whereas only 2 per cent indulged in selling activity. About 95 per cent of non-users of water were small farmers and remaining were semi-medium farmers. About 70 per cent of the semi-medium farmers were engaged in buying of groundwater while 27 per cent indulged in selling activity. The corresponding figures were 49 per cent and 51 per cent for medium farmers and 35 per cent and 43 per cent for the large farmers. This showed that groundwater buying activity decreased with the farm size while, selling activity increased.

TABLE 3. FARM-SIZE WISE DISTRIBUTION OF HOUSEHOLDS ACROSS VARIOUS FORMS OF WATER MARKETS IN ARID AND SEMI-ARID RAJASTHAN

(*per cent*)

Farm holdings	Self-users	Self users + sellers	Self users + sellers + buyers	Self users + buyers	Buyers	Non-users	Total households (Numbers)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
			Semi-arid region				
Small	7	2	0	7	38	46	42
Semi-medium	10	17	10	30	30	3	30
Medium	27	24	27	20	2	0	51
Large	43	21	21	15	0	0	14
Overall	19	15	15	17	19	15	137
			Arid region				
Small	0	0	0	0	63	37	48
Semi-medium	0	17	0	29	47	8	24
Medium	25	30	25	14	6	0	49
Large	36	28	26	0	0	0	22
Overall	14	17	14	10	31	14	143

Note: The farm holdings were categorised as small (less than 2 hectares area with them), semi-medium (2-4 hectares), medium (4-10 hectares) and large (above 10 hectares area with them).

In the arid region the sellers of water were 31 per cent of the total households and the buyers were 55 per cent. Almost 63 per cent of the small farmers were involved in groundwater buying activity while none of them indulged in selling. On the other hand, 64 per cent of the large farmers indulged in selling of groundwater while none of the large farmers purchased groundwater. Seventy five per cent of the semi-medium farmers and 45 per cent medium farmers were engaged in buying groundwater while only 17 per cent semi-medium farmers and 55 per cent medium farmers indulged in selling activity. This explicitly explained that sellers of water were the farmers with larger holdings who have the financial capacity and break-even land to install their own WEMs and sell surplus water after meeting their own requirements while the buyers were the farmers with smaller holding who do not

have financial capacity and break-even land to install their own water extraction mechanisms. However, Meinzen-Dick (1996), Narayanamoorthy (1994), Shah and Raju (1988) reported in their studies that the well owners with small holdings had a higher extent of participation in water selling than those with larger holdings because the former tend to have surplus water even after irrigating their own fields. In contrast, the results from this study in the arid and semi-arid regions of Rajasthan revealed that due to deeper water levels in the area, cost of construction of tube wells was higher; therefore, most (about 80 per cent) of the modern WEMs were in the hands of medium and large, or resource rich farmers who have break-even land to install a WEM. That is why farmers with larger holdings emerged as water sellers.

Magnitude of Groundwater Buying

The distribution of area irrigated by own WEMs and by buying groundwater under different forms of water markets are given in Table 4. The results of the study revealed that in the semi-arid as well as arid region, the self-users and self-users + sellers had their land irrigated fully with their own WEMs while the land of buyers from the water market was irrigated totally by buying groundwater from the other farmers. On an average, of the total owned irrigated area under study, nearly 84 per cent in the semi-arid region and 82 per cent in the arid region was commanded by owned WEMs whereas, 16 per cent of the total area in the semi-arid region and 18 per cent in the arid region was irrigated by buying groundwater. This implied that in the absence of groundwater markets, nearly one-fifth of the total area would have remained unirrigated and added to non-users category. In other words, the prevalence of groundwater markets supports about one-fifth area of the total land irrigated by groundwater in Rajasthan. However, Saleth (1998) estimated that water markets were providing water for about 6 million hectares or 15 per cent of the total area irrigated by groundwater in India.

TABLE 4. EXTENT OF IRRIGATED AREA SUPPORTED BY WATER MARKETS IN ARID AND SEMI-ARID REGIONS OF RAJASTHAN.

Water markets	Percentage of owned area irrigated by		Total owned area irrigated (ha)
	Own WEMs	Buying water	
(1)	(2)	(3)	(4)
	Semi-arid region		
Self-users	100.00	0.00	177.66
Self-users + sellers	100.00	0.00	123.63
Self-users + sellers + buyers	79.33	20.67	124.63
Self-users + buyers	71.57	28.43	114.09
Buyers	0.00	100.00	34.57
Total / All	83.85	16.15	574.58
	Arid-region		
Self-users	100.00	0.00	168.28
Self-users + sellers	100.00	0.00	178.72
Self-users + sellers + buyers	81.98	18.02	170.76
Self-users + buyers	71.40	28.60	69.36
Buyers	0.00	100.00	64.08
Total / All	82.38	17.62	481.81

Note: Non-users were not included because farmers of this category have unirrigated area with them.

TERMS OF TRANSACTIONS IN GROUNDWATER MARKETS

Studies have shown that the terms of groundwater transactions might tend to be rather exploitative. Still, in the wake of failure of traditional irrigation system the farmers may opt for purchase of water at higher cost rather than going without it. In the groundwater markets, two broad types of transactions were observed in the study area, i.e., cash-based and kind-based. Such types of transactions were also reported by Satyasai *et al*. (1997), Shah (1993) and Singh (2000). The types of contracts on the basis of which GWMs operates in the study area were hourly contract and crop output sharing contract. Hourly contract is one in which the sellers provide water to the buyers and water price was charged at hourly rate on cash basis. This type of contract was prevalent in the semi-arid region. In Jaipur district where only electric operated WEMs were in operation, the rate was Rs. 30 per hour whereas, in Alwar district, if water was purchased from electric operated WEMs, then buyers have to pay Rs. 50 per hour and if it is purchased from diesel operated WEM then water price was Rs. 75 per hour (Table 5). Crop output sharing contract is one in which sellers provide water and buyers of water have to surrender a part of their crop output as water price to the sellers of water. This type of contract was observed in the arid region. In this in-kind contract, it is observed that 40 per cent of crop output was charged from the buyers of water at the time of harvest.

TABLE 5. TERMS OF TRANSACTIONS FOR GROUNDWATER MARKETS

	Semi-arid region	Arid region
	Cash	Kind
(1)	(2)	(3)
Water charges	Rs. 30 per hour[a] Rs. 50 per hour[b] Rs. 75 per hour[c]	40 per cent of crop produce as water charges

Note: a. Charges for water from electric operated WEMs in Jaipur ; b. Charges for water from electric operated WEMs in Alwar and c. Charges for water from diesel operated WEMs in Alwar.

The well owners in general and sellers in particular determine these terms and conditions. The temporal changes in these terms of contracts take place with the changes in energy price. The transactions of water among the buyers and sellers were made by water turn or *osarabandi* system where water delivery follows a set rotation among all users. The sellers of water decide the water turn. This is the informal market institution prevailing in the study areas in which the sellers of water act as oligopolists and charge cartel prices from the buyers of water.

The in-kind transactions were prevalent in the arid region because this region is a water scarce region compared to the semi-arid region. The terms of water transactions differ considerably across the regions due mainly to the availability of water, stage of market development and states' power pricing policy. The arid region is water scarce region and the farmers of the arid region have to pay a fixed amount, i.e., flat-rate, for electricity use. Whereas, the semi-arid region is comparatively water abundant region

and some of the new electricity connections were charged metered price for electricity use. Regarding the organisational character of groundwater markets, GWMs in semi-arid region have taken almost an agribusiness proportion with cash-based commercial transactions. In water scarce arid region, on the other hand, GWMs appear to fall somewhere in between feudal character involving water rent, kind based transaction, and commercial character where fixed water rent (40 per cent of crop output) was charged by water sellers and GWMs were impersonal where sellers usually do not distinguish between various buyers in terms of selling or the quality of service provided on the ground of caste, economic or social status.

Conduct of Groundwater Markets

An attempt has been made in this section to analyse the conduct of groundwater markets in the study areas and to work out the number of buyers, each seller was supporting. For calculating buyers per seller, the households of self-users + sellers + buyers form of groundwater markets were considered in both sellers as well as buyers category.

TABLE 6. EXTENT OF GROUNDWATER MARKETS

	Particulars	Semi-arid region	Arid region
1.	No. of sellers*	41	45
2.	No. of buyers/seller	2.27	2.53
3.	Average area irrigated by sellers	8.91	14.37
	a. Own field (per cent)	60.93	49.31
	b. Buyers field (per cent)	39.07	50.69
4.	Hours operated per WEM	869	1454
	a. Own field (per cent)	56.92	40.37
	b. Buyers' field (per cent)	43.08	59.63

Note: * Sellers include self-users + sellers and self-users + sellers + buyers.

While there were 41 sellers facing 93 buyers in the semi-arid region, there were 45 sellers facing 114 buyers in the arid region. That is each seller, on an average, supported 2.27 buyers in the semi-arid region and 2.53 buyers in the arid region. The average area irrigated by each seller was 8.91 ha in semi-arid region and 14.37 ha in arid region. On an average, each seller of water in the semi-arid region supported buyers' land up to the extent of 39.07 per cent of the total area irrigated by the sellers and the corresponding figure is 50.69 per cent for the arid region (Table 6). Of the total hours operated per WEM by sellers of water, about 43 per cent hours in the semi-arid region and 60 per cent hours in the arid region were used to irrigate buyers' field. Thus both in terms of area and the number of irrigation hours, the extent of groundwater markets seems to be considerable. One point worthy of note here in the arid region, of the total water pumped more was used to sell out to the other farmers. The sellers continue to make efforts available more water to their buyers, as revealed from Table 8, with a view to increasing agricultural production so that the sellers may get maximum crop share as water price. This practice was prevalent because of state's

water pricing policy as fixed charges of electricity use. This induced the farmers to over use their pump sets because for electricity charges do not vary with the extent of use of pumps.

Cost and Returns from Water Selling

Cost of water extraction and selling price may be regarded as the indicators of efficiency of water markets. If the cost of water extraction is equal to the selling price, water markets can be considered as efficient, if it is greater than selling price, then water markets are inefficient one and if selling price of water is greater than cost of water extraction then water markets can be considered as an exploitative one.

The total cost of water extraction worked out to Rs. 23.09 per hour in the semi-arid region and Rs. 31.39 in the arid region. This was higher in the arid region due to higher installed capacity of motors (30-40 HP). That is why operating cost of water extraction was also higher in the arid region. The per hour average selling price worked out to Rs. 122.8 in the arid region and Rs. 35.46 in semi-arid region which was substantially higher than operational cost as well as total cost of water extraction in both the regions (Table 7). This implied that groundwater markets were exploitative in nature for buyers of water. The exploitation of buyers was more in kind-based contracts than in semi-arid region. In the arid region, the buyers of water have to surrender two-fifth of their crop output to the sellers of water as water price and this was exorbitant for buyers of water. Most of the buyers were farmers with smaller land holdings and they have limited livelihood options with them under the arid and semi-arid conditions of Rajasthan, therefore, they have to participate in water trading on the existing terms and conditions for their assured employment opportunities and food security. The higher water prices in kind-based contracts were also reported by Janakarajan (1993), Palanisami and Balasubramanian (1998), Satyasai *et al.* (1997) and Shah (1993).

TABLE 7. COST OF WATER EXTRACTION AND RETURNS FROM WATER SELLING

(Rs. per hour)

	Particulars	Semi-arid region	Arid region
	(1)	(2)	(3)
1.	Cost of water extraction		
	a) Fixed cost on WEM[a]	16.65 (72.11)	14.92 (47.53)
	b) Operating cost on WEM[b]	6.44 (27.89)	16.47 (52.47)
	c) Total cost	23.09	31.39
2.	Average selling price	35.46	122.80
3.	Net Income		
	a) Over operating cost	18.81	107.88
	b) Over total cost	12.37	91.41

*Note :*Figures in parentheses are percentages of total cost.

a. It includes depreciation and interest on fixed investment of tube well installation, pump sets and water conveyance structures, etc. b. it includes operating and maintenance charges and interest on working capital.

The sellers of water earned a net profit of Rs. 18.81 per hour over operational cost and Rs. 12.37 per hour over total cost of water extraction in semi-arid region and Rs. 107.88 per hour and Rs. 91.41 per hour, respectively in the arid region. Thus, selling water was an economically remunerative business for sellers of water.

Cost of Irrigation and Share in Inputs Cost

An examination of the irrigation use and its share in total inputs cost per hectare for cultivation of all crops together grown on sample farms across different forms of water markets revealed that in semi-arid region, the self-users and sellers used slightly more irrigation hours compared to the buyers of water while in the arid region buyers of water used more irrigation hours than self-users and sellers. This implied that the buyers of water had fairly equal access to groundwater for irrigation through GWMs. In other words, GWMs helps to mitigate inequality in access to irrigation water.

The irrigation cost as well as total inputs cost was the highest for buyers followed by self-users + buyers and self-users + sellers + buyers while the least on inputs was incurred by non-irrigators in both the regions due to the obvious reason that the non-users had not paid for irrigation charges and followed unirrigated crops in cropping pattern. While the buyers of water had paid higher charges for purchased irrigation water, self-users and self-users + sellers incurred less cost on irrigation and total inputs as well due mainly to use of owned irrigation service. The water price, total inputs cost as well as share of irrigation in total inputs cost were observed to increase with the increase in the proportionate area under buying groundwater under different forms of GWMs in both the regions. As farmers under buyers form of water markets irrigated their fields totally by buying groundwater and almost one-third of the total inputs cost in the semi-arid region and half in the arid region was shared by irrigation cost only (Table 8) for farmers under buyers form of water markets. It was markedly higher in the arid region due to kind-based payments for purchased irrigation water.

TABLE 8. IRRIGATION COST AND TOTAL INPUTS COST FOR ALL CROPS TOGETHER

Particulars	Self-users	Self-users + sellers	Self-users + sellers + buyers	Self-users + buyers	Buyers	Non-users
(1)	(2)	(3)	(4)	(5)	(6)	(7)
			Semi-arid region			
No. of irrigation hours	79	76	74	74	75	-
Irrigation price (Rs./hour)	7.08	6.49	14.22	16.76	41.57	-
Irrigation cost (Rs./ha)	559	493	1,052	1,240	3,118	-
Share in TIC (per cent)	6.87	6.29	12.41	14.05	29.47	-
Total inputs cost (Rs./ha)	8,131	7,838	8,475	8,823	10,581	5,345
			Arid region			
No. of irrigation hours	56	57	58	62	66	-
Irrigation price (Rs./hour)	25.91	15.16	33.52	54.90	117.91	-
Irrigation cost (Rs./ha)	1,451	864	1,944	3,404	7,782	-
Share in TIC (per cent)	16.86	10.55	20.85	31.15	50.91	-
Total inputs cost (Rs./ha)	8,607	8,185	9,326	10,929	15,286	4,868

Farm Business Analysis

The returns that a farmer is earning from his resources decide the success or failure of the farm business from the farmers' point of view. The overall cost of cultivation and returns, calculated using the methodology of Acharya and Agarwal (1994), were used for the purpose of assessing returns; all crops were considered together.

The farmers under buyers form of GWMs incurred highest paid-out cost (cost A_1) as well as total cost of cultivation (cost C_2) and the total cost of cultivation including management charges (cost C_3) in both the regions on account of higher charges paid for purchased irrigation water and in turn received less net returns over cost C_2 as well as cost C_3. In the arid region buyers received least returns even less than the net returns which the non-irrigators earned (Table 9) due mainly to kind-based higher payments made for purchased irrigation water by them. But, due to unavailability of other sources of livelihood in Western Rajasthan, they have to remain in business for the employment and food security needs of their families. Otherwise, they would be compelled to migrate outside for livelihood. Self-users and self-users + sellers used owned irrigation services, and therefore, incurred less cost on cultivation of crops and in turn received higher net returns in both the regions.

TABLE 9. FARM BUSINESS ANALYSIS FOR ALL CROPS TOGETHER

(Rs. per hectare)

Particulars	Self-users (2)	Self-users + sellers (3)	Self-users + sellers + buyers (4)	Self-users + buyers (5)	Buyers (6)	Non-users (7)
			Semi-arid region			
Cost A_1	6,939	7,060	7,217	7,366	8,454	3,805
Cost C_2	15,440	16,474	15,532	15,797	16,942	8,099
Cost C_3	16,980	18,121	17,085	17,377	18,636	8,909
Gross returns	24,267	23,299	23,461	23,220	23,597	8,051
Net returns over cost C_2	8,827	6,825	7,929	7,423	6,655	-48
Net returns over cost C_3	7,283	5,178	6,376	5,843	4,961	-858
			Arid region			
Cost A_1	7,296	7,035	7,944	9,354	13,444	3,273
Cost C_2	14,928	15,308	15,910	17,726	21,906	7,746
Cost C_3	16,421	16,839	17,501	19,499	24,097	8,521
Gross returns	20,325	20,747	20,531	21,763	22,383	8,775
Net returns over cost C_2	5,397	5,439	4,621	4,037	477	1,029
Net returns over cost C_3	3,904	3,908	3,030	2,264	-1714	254

CONCLUSIONS AND POLICY IMPLICATIONS

The nature, magnitude and impact of groundwater markets in the arid and semi-arid regions differ considerably. About 51 per cent of the farmers and 16 per cent of total area in the semi-arid region benefited through GWMs by buying irrigation water as against 55 per cent farmers and 18 per cent area in the arid region. This means that in the absence of GWMs, about one-fifth of total land in the study area would have remained unirrigated in both the regions. Most of the buyers of groundwater were farmers with smaller and fragmented holdings, who are unable to install their own

WEMs. On the other hand, sellers of water were medium and large farmers, who have the financial capacity to install their own WEMs.

Cash-based hourly terms of contract in the semi-arid region were prevailing for groundwater trade, whereas kind-based crop output sharing contract prevailed in the arid region. This difference in terms of contract was mainly due to groundwater availability in the region, power pricing policy of the state and the stage of market development in the area. The average selling price of groundwater was markedly higher than the operational cost as well as total cost of water extraction, particularly in the arid region, implying thereby the exploitative nature of GWMs. Water selling activity was economically remunerative for sellers of water in both the regions. Kind-based contracts in the arid region were more exploitative for buyers of groundwater than cash based contracts. The development of GWMs helped to mitigate inequality in both the regions in access to irrigation water among the resource rich, large farmers and resource poor, marginal and small farmers in physical terms on the one hand. In economic terms, on the other hand, GWMs widen the gap between resource rich and resource poor farmers by charging exorbitant water price from buyers of water, mainly in the arid region, as the buyers of water received lower net returns from cultivation of crops on account of higher charges paid by them for purchased irrigation water.

Some specific policy implications which could be derived from the results of the study are:

- The development and efficient working of GWMs with certain legal and policy reforms (by making necessary amendments in the model bill to regulate and control groundwater use of the Government of Rajasthan, defining clear-cut water rights - rights of use not of ownership and making well recharging essential for sellers of water) is a strong alternative for achieving 'social equity with distributive justice' and also for efficient and sustainable use of groundwater resources. Also kind-based transactions for groundwater trading should be banned urgently.

- Installing public tubewells, managed by village community institutions, to provide cheap irrigation water on hourly basis to the poor farmers, particularly in the arid region, will decrease water price and increase the competition in the water market which will eventually be beneficial to the poor farmers of the state and will also help in sustainable use of scarce water because buyers of water have to pay by use, on an hourly basis.

- The existing power pricing policy needs to be changed urgently from flat or fixed power tariff basis, as this encourages farmers to overuse their pumpsets because they do not pay by the quantity or time of electricity use, to the metered or variable power tariff basis which would strengthen the inducement to save on electricity bill by economising on electricity use.

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NOTES

1. The block in which net groundwater draft was below 65 per cent, 65-85 per cent, 85-100 per cent or above 100 per cent of net annual groundwater recharge were classified as white, gray, dark and over-exploited blocks, respectively.

2. In Rajasthan, 217994 wells were out of use in the year 1980-81 and the figure had increased to 315475 wells in the year 1999-2000, implying an almost 45 per cent increase just in two decades.

3. The categories such as SU+S, SU+S+B, SU+B and Buyers are the different forms of water markets, the farmers of which were engaged in either selling of water or buying or both the activities.

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