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Who Gains and Who Loses in the Game of Groundwater Markets in Water-scarce Regions

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Abstract

The rights to groundwater belong to the landowner. Therefore, access to this resource is privy to well-to-do farmers and is beyond the reach of resource-poor farmers. The only option left with them is water markets. The present study has aimed at understanding the operations of groundwater markets in fragile conditions and has identified the losers and gainers in the game of water markets in the long-run. It has been found that water markets mitigate inequalities in accessibility to groundwater resource in the short-run. But, faster and excessive use of groundwater may increase inequity among the farming community in the long-run. In water-scarce regions, water markets function on the principles of profit maximization. The different strategies are adopted to make groundwater available for sale. The water markets operate under monopsonic conditions. The terms and conditions of groundwater markets, i.e. kind or cash, vary differently across the regions. The study has suggested that water rights should be redefined and nationalization of groundwater resource is the only alternative for its sustainable management. To restrict the over-exploitation of aquifers, water trading should be allowed in a limited manner. Programmes for recharging aquifer should be initiated on a large scale. A community-based action is required for the efficient use of water resources in water-scarce conditions through effective institutional arrangement.

1. Introduction

The technological and institutional changes have resulted in the increase in demand for irrigation by manifold. Several surface irrigation schemes were launched to meet the increasing water requirement. However, these schemes were not able to provide sufficient water for irrigation. Therefore, groundwater irrigation was recognized as an alternative. Today, groundwater accounts for more than half of the total irrigation in India. In the water

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deficient regions like Rajasthan, groundwater is the major source of irrigation. More than two-thirds of the irrigation demand is met by groundwater. Merely, one per cent of the country's water is available to 5 per cent of the population living in 10 per cent of the total geographical area. The agriculture sector is the major consumer of water, where 90 per cent of the total availability of water is used for irrigation. The scarcity of water resources coupled with fast increase in demand for water has resulted in overexploitation of aquifers.

The right to groundwater belongs to the landowner, as it forms a part of the dominant heritage and land ownership. The consequence of such a legal framework is that only the landowners can have access to groundwater in the country. It leaves out all the landless and tribes who may have community rights over the land. It also implies that rich landlords can be waterlords and indulge in its open selling, as much as they wish (Singh, 1991). As a result access to this resource is privy to well-to-do farmers and it is beyond the reach of resource-poor farmers, who cannot install their own wells. The only option left with these farmers is to buy it from water markets. There are two viewpoints on the issue of water markets. One is in favour of water markets for making them competitive and efficient on the ground of equity in resource distribution (Rosegrant and Binswanger, 1994; Kolavalli and Chicoine, 1987; Strosser and Meinzen-Dick, 1994). The other is against the water markets as it amounts to favouring the rich over the poor by monopoly rents, leading to worsening of income distribution (Barah *et al*., 1993; Janakrajan, 1993; Shah, 1993; Singh, 2002, Saleth, 1996). Both the arguments hold good under different situations. The former may be true in water endowed regions and the latter in water-scarce regions (Singh, 1999). Water markets can be considered as a game in which both buyers and sellers adopt strategies at their own levels. The sellers look at the position of profit maximization through either increasing water sale or charging higher prices. The buyers attempt to gain maximum utility in the given water resource constraints.

Market structure of groundwater is determined by not only its supply but also the institutional mechanism, both formal and informal, which has a strong hold on the operation of water markets. The main difference between formal and informal set up is the way in which water trade is conducted. Under formal framework, government establishes legal tradable water rights to retain and extend the advantages of water markets. Under informal arrangement, users contract for water on their own and no legal recognition is granted to water trade. In the absence of formal rules, a dense social network leads to the development of customs, laws, thrust and normative provisions that constitute an informal framework and has the pervasive influence on the economy (Aron, 2000). Similarly, the market structure of groundwater is ecologically and socially embedded (Dubash, 2000).

On the backdrop of groundwater markets and their implications in diverse conditions, an attempt has been made in the present study to (i) understand the operation of groundwater markets in fragile conditions, and (ii) identify the losers and gainers in the game of water markets in the long-run.

2. Access to Irrigation Facilities and Water Markets

According to the state level estimates, ownership and access to resources including land and water show that nearly one-third area is under irrigation (*see* Table 1). The distribution of irrigation facilities among different categories of farms has shown that there is an inverse relationship between the farm-size and proportion of the area under irrigation. It is because of the fact that only a few farmers have access to irrigation facilities, whereas, a majority of farmers irrigate their land through water markets in very limited proportion, i.e. less than one per cent. It shows the crucial role of water markets in the case of poor categories of farmers.

3. Status of Groundwater Resources

The present section deals with the changing status of groundwater resources across the regions of India. To generalize the implications of groundwater markets of aquifer, the data relating to potential zones estimated by the Department of Groundwater of State Government, were used.

There has been a faster decrease in the availability of groundwater resource in the arid zone as compared to that in the semi-arid zone during the past one and a half decades. On the other hand, a little decrease has been recorded in the semi-arid zone. It may be because the region is surrounded by river basin that enables it to maintain groundwater status, whereas the arid area is largely out of such basin that further leads to low

Table 1. Usage of irrigation facilities across different farm-sizes

Size of farm	Average size of farms	Distribution of irrigation facilities			
		Cultivated area		Unculti-vated area	Area irrigation by water markets
		Irrigated	Unirrigated		
Marginal	0.52	37.83	62.17	5.20	39.27
Small	1.40	39.17	60.83	6.66	28.83
Semi-Medium	2.96	35.25	64.75	10.01	21.07
Medium	6.22	28.82	71.18	11.27	23.97
Large	19.13	25.22	74.78	22.21	0.67
Overall	3.29	30.80	69.20	14.17	18.67

Source: Singh (2000)

groundwater recharge. The difference in climatic and geo-physical conditions results in variations in groundwater availability across the regions. In the arid zone, a drastic increase in groundwater draft has been recorded, i.e. about four times in the past two decades. In absolute terms, it was very small under the semi-arid condition, but it increased substantially. It was inferred that the use of groundwater for irrigation increased rapidly, which caused depletion of the aquifer at a faster rate.

Water balance is the difference between utilizable availability and net draft. Groundwater balance is a commonly used criterion for evaluating this resource. In the present context, estimates of groundwater balance and level of development show that an alarming situation has emerged (*see* Table 2 and Fig. 1). In the arid zone, groundwater balance was going down drastically. In the semi-arid region, a similar situation was emerging. It showed that demand for irrigation water had increased tremendously. To meet the demand of water for irrigation, the well owners, especially the resource-rich, have adopted different technological measures. These measures include use of vertical boring technology that causes depletion of aquifer. Besides, continuous efforts through various institutional interventions are being made to increase agricultural production (Singh, 1998). It ultimately has resulted in increasing the demand for irrigation water that is being fulfilled by water markets in the respective areas.

Table 2. Status of groundwater resources in sample areas

Year	Availability of ground-water	Net groundwater draft	Ground-water balance	Stage of ground-water	Category of develop-ment
	(million cubic metres)			(per cent)	
		Kuchaman (Arid-zone)			
1984	N.A.	N.A.	N.A.	N.A.	N.A.
1991	129.95	42.37	87.58	132.06	Over-exploited
1999	66.67	89.88	-23.21	134.81	Over-exploited
2001	92.21	138.87	-46.66	150.59	Over-exploited
2004	67.50	165.45	-97.95	245.12	Over-exploited
		Rajgarh (Semi-arid zone)			
1984	29.05	15.40	13.65	52.99	White
1991	28.02	34.40	-6.38	122.75	Over-exploited
1999	21.28	21.33	-0.05	100.26	Over-exploited
2001	34.23	47.71	-13.48	139.38	Over-exploited
2004	33.61	48.61	-15.00	144.64	Over-exploited

Source: Various Reports of the Department of Groundwater, Government of Rajasthan, Jaipur

N.A. = Not available

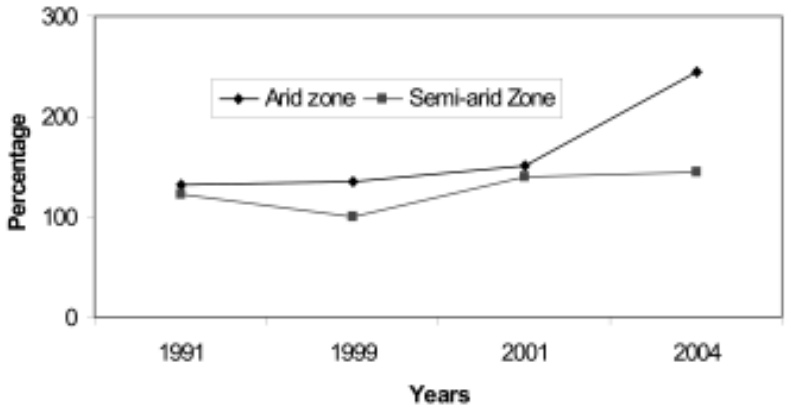

Fig. 1. Stages of groundwater development in selected areas

3. Failure of Water Sources (Wells)

The extent of failure of water sources is also a major indicator of estimating sustainability as well as equity implication. The sharp increase has been recorded in the number of wells, it is 130 per cent in the arid and 99 per cent in the semi-arid regions (*see* Table 3). This shows that it will have serious implications on equity aspect in the long-run. This would increase the use of groundwater, leading to further depletion of aquifer. In such a situation, poor well-owners would not be in a position to undertake deepening of their wells every year. In other words, chasing watertable is beyond the reach of poor farmers. Under such circumstances, they have to depend upon other well-owners for groundwater irrigation. Otherwise, they would be deprived of the access to groundwater on one hand and the resource-rich individuals would chase watertable by making heavy investment in extracting water on the other. It may be inferred that increased use of groundwater results in inequitable distribution of this precious resource.

There has been a wide variation in the proportion of failure of wells across the regions during past three decades (Fig. 2). In the regions, this variation was recorded in one-third to two-thirds of wells, whereas, it increased from one-tenth to one-fourth cases due to depletion of aquifer condition and use pattern. It has also emerged that such an increasing trend in the failure of wells would be a major threat to sustainability of water resource.

4. Operation of Groundwater Markets

Water markets function differently under different conditions. Besides the natural and physical factors like climatic conditions, soil, quality and

Table 3. Changing status of water sources (wells) in tehsils in the seleceted villages

Year	Nawa (Arid zone) Number of wells			Rajgarh (Semi-arid zone) Number of wells		
	In use (pre cent)	Out of use (per cent)	Total	In use (pre cent)	Out of use (per cent)	Total
1971	57	43	4317	90	10	6252
1981	68	32	5661	88	12	7515
1991	57	43	8601	80	20	11035
1996	51	49	8702	78	22	13585
2002	31	69	9775	77	23	11345
2004	29	71	9922	76	24	12465

Source: *District Statistical Outlines* (Nagaur and Alwar), Directorate of Economics and Statistics, Government of Rajasthan, Jaipur (various issues).

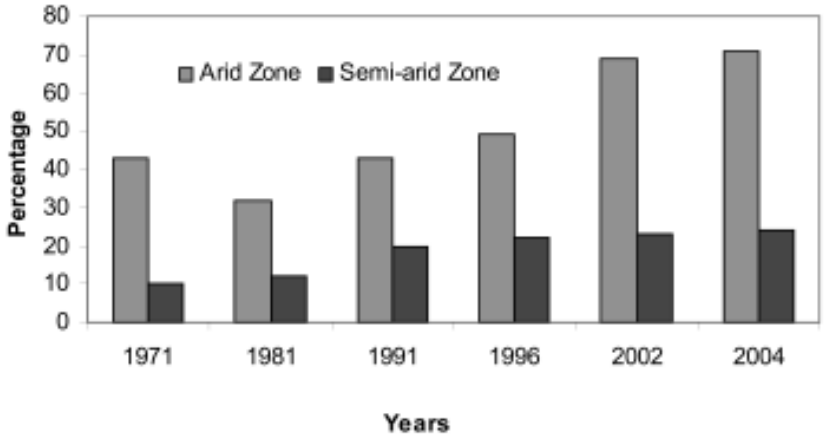

Fig. 2. Failure rate of water sources (wells) in selected areas

quantity of water, depth of watertable, etc., the institutional arrangements also play an important role in this game. Now, the question that arises is: How the various categories of water-users behave in the changing situations and environments?' An attempt has been made to answer this question in this section.

4.1. Who Are the Players in the Game?

To understand the operation of game it is essential to know about the players and their behaviour. Past studies (Meinzen-Dick, 1996; Narayanamoorthy, 1994; Shah, 1993) conducted in different parts of the country showed that the well-owners who owned limited size holdings had a larger participation than those who owned larger size holdings. It is due to

the fact the former have surplus water after irrigating their lands. However, this study does not support this hypothesis. In the arid village, only about one-third of the total water sellers belonged to small and semi-medium categories, whereas two-thirds of them belonged to medium and large farm-size categories. This may be attributed to the following three reasons: (i) The proxy of marginal and small farms to the well owners, (ii) The sellers reduce their own demand and save water for sale by adopting less water-intensive cropping patterns, and (iii) Availability of water is relatively higher with large-size farmers because they have capacity to manage watertable due to their sound economic condition (Singh, 2000; Moench, 1992; Shah, 1985). Ultimately, well owners belonging to large farm-size category have the option of selling water to resource-poor farmers. In the arid village, just half of the buyers belonged to the semi-medium category, followed by marginal and small farm-sizes. In the semi-arid village, unlike the arid village, the sellers were in equal proportion in marginal, small and semi-medium farm-sizes. And this was the major reason of their participation in water markets. The majority of the buyers were marginal farms owners.

In the overall scenario, the sellers of water belonged to medium and large farms and the buyers to marginal and small farms. Therefore, argument of resource-rich households' ability to extract groundwater in larger quantum

Table 4. Distribution of households participating in water marketing according to farm-size

Category	Farms-size (per cent)					Total sample size (No.)
	Marginal	Small	Semi-medium	Mediam	Large	
Arid village (Kukanwali)						
Self-users	0	0	15	77	8	13
Sellers	0	11	21	42	26	19
Buyers	25	13	50	12	0	8
Overall	5	8	25	42	15	40
Semi-arid village (Srichandpura)						
Self-users	17	50	33	0	0	6
Sellers	33	33	34	0	0	6
Buyers	70	15	15	0	0	13
Overall	48	28	24	0	0	25
Overall						
Self-users	5	16	21	53	5	19
Sellers	8	16	24	32	20	25
Buyers	52	14	29	5	0	21
Overall	22	15	25	29	9	65

Source: Singh (2000)

holds true, in general and the arid village, in particular. Certain well-owners having large size of holdings remained out from water business.

4.2. Factors Affecting Participation in Water Marketing

An attempt has been made to identify the factors that affect the participation of farm households in water trading. Broadly, water-users including self-users, sellers and buyers had different reasons under which they participated in water marketing. These were:

(i) Under arid conditions, largely, there was no availability of surplus water with the self-users. It was because of the fact that larger proportion (60%) of the total irrigated area was allocated to water-intensive crops like wheat and barley (see for details, Singh, 2000). Under semi-arid conditions, the proportion of self-users who did not have surplus water was considerably high (83%) (*see* Table 5) The study has also revealed that adoption of water-saving strategies was the pre-condition for participation in water markets. The intensity of wells in the area also influenced the water markets. According to 38 per cent of total self-users in the arid and 17 per cent in the semi-arid conditions, non-availability of water buyers caused their non-participation in water marketing. Difficulties in transportation of water to far-off places and rivalries/ tensions among the village communities were the other reasons that restricted water trading.

(ii) In the arid regions, the quality of water limits water marketing, as according to an estimate, 73 per cent of the India's saline water is in

Table 5. Reasons for participation and non-participation in water marketing

(per cent)

Particulars	Arid village	Semi-arid village	Overall
Self-Users' reasons for non-participation			
• No surplus water	46	83	58
• No buyers	38	17	32
• Quality of Water	16	0	10
Sellers' reasons for participation			
• Surplus water	74	83	76
• Profit earning	26	50	32
• Power policy	26	17	24
Buyers' reasons for participation			
• Owned land but no well	88	46	66
• Limited & fluctuating water supply	12	54	34

Source: Singh (2000)

the arid region of Rajasthan (Rathore, 2001). In the arid village under study, 16 per cent of the total self-users were not involved in water marketing considering that its quality may be deteriorated further due to excessive water extraction. Such perceptions were missing in the semi-arid village. The problem of salinity was very acute all over the water scarce regions, it varied even within small distances.

(iii) The sellers largely enter the water markets because they have surplus water, after irrigating their own fields. Other factors that encouraged the well-owners to sell water were profit earning and the existing power pricing policy. More than one-fourth of water sellers in the arid and half in semi-arid areas sold water for profit. The 'Flat-Rate' power pricing policy had also encouraged participation in water markets.

(iv) Buyers' participation in water markets was a sort of compulsion. These buyers did not have their own water sources and had to depend on well-owners for irrigation of their lands. The proportion of these buyers was quite high, 88 per cent in the arid and 46 per cent in the semi-arid villages. The fluctuating water supply was another major factor effecting buying of water.

4.3. Boundaries of the Game: Terms and Conditions of Water Markets

The players, in general and sellers, in particular have marked boundaries for the game in their respective areas. These boundaries may be known as the terms and conditions for water transactions among the sellers and buyers. Broadly, the two types of terms and conditions were cash-based and kind-based. Each type had wide variations in its operation across the stakeholders. Three types of contracts on which water markets operate, were:

(i) Time-based Contract: Under this contract, the seller provides water to the buyer on hourly charges. It is prevalent in the semi-arid areas. The charges varied according to operation of wells. If the seller owned electric motor and electricity charges were on the flat-rate basis, then the rate was Rs 30/- per hour. In the case of pro-rate system, the charge was Rs 5 per unit of electricity consumed. If the sellers owned and operated diesel oil engine, then the charges were Rs 15/- per hour plus fuel charges.

(ii) Crop and Input Sharing Contract: Under this contract, the seller provides water while the buyer provides land and labour. The paid-out costs on inputs applied for production are shared in equal proportions between buyer and seller. This condition of water trading was prevailing in the arid village. Largely, water markets operated under this condition.

(iii) Crop Sharing Contract: Under this contract, the buyer provides land and the seller provides water. All the paid-out costs on inputs applied for crop production are borne by the seller. The seller provides pre-fixed quantity of agricultural produce (1.60 q/ha) to landowner. This condition also prevailed in the arid village. Only a limited number (12%) of buyers and sellers were involved in water transactions under this contract. Because of small size of holdings and short supply of labour with the landowner on one hand, and socio-economic pressure of resource-rich farmer on poor landowners on the other, the present contract of water markets was being chosen.

The types of contract for water markets are determined by the informal village institutions, viz. village conventions, and seller's priority and motive. The well owners, in general and the sellers, in particular determine the price level of water. It was experienced that price of water was correlated with the cost on energy used in water extraction, i.e. electricity and/ or diesel oil. The seller always tries to get maximum benefit from water trading. Under crop and input sharing contract, the well owner exploits the buyers by using monopsonist power. Crop-sharing contract is quite close to reverse land tenancy wherein land is leased in favour of rich farmer who has better control over key productive resources. But, exploitation of resource-poor farmers continues, as in the case of land tenancy. Due to weak bargaining strength of poor farmers, the resource rich enjoy the hegemonistic power to exploit the former for gains in a number of interlinked markets of the rural economy (Murty, 1998).

4.4. Functioning of Groundwater Markets

In this section, the functioning of groundwater markets across the regions has been examined. In arid village, the average command area of each well (6.40 ha) was substantially higher than that in the semi-arid village (3.62 ha). It was because of the fact in the arid village, the farmers were using sprinkler method of irrigation and grew less water-consuming crops like mustard and gram in larger proportions. In the semi-arid village, the flow method of irrigation was in practice. Thus, water-saving practices adopted by the farming community in water-scarce regions had resulted in larger area under each well (NABARD, 1989). The well owners used nearly two-thirds of the total extracted quantum of water to irrigate their own lands and the rest of water was sold to the buyers. In the semi-arid village, the situation was completely reversed where water was being used largely to irrigate the buyers' land (*see* Table 6).

There was a considerable difference in the income to sellers from the sale of water. It was attributed to variations in the terms and conditions of water markets across the selected villages. In the arid village, sellers received

Table 6. Functioning of groundwater markets in sample villages

Particulars	Arid village (Kukanwali)	Semi-arid village (Srichandpura)	Overall
Area irrigated by sellers (ha)	6.40	3.62	5.53
Proportion of land irrigated by			
Sellers	64.69	38.40	62.93
Buyers	35.31	61.60	37.07
Annual income received from sale of water (Rs)	17368	9237	15417
Annual operation & maintenance (Rs)	17518	7608	15388
Expenditure recovered by sale of water (%)	99.14	121.41	100.19
Average investment made for sale of water (Rs)	12723	6500	11556

Source: Singh (2000)

the water charges in kind, which were substantially higher than the expenditure. There was a considerable difference in the operational expenditure incurred in water extraction in both the selected villages. It was more than double per well in the arid village. One of the reasons for it was the capacity of pumpsets used for withdrawal of groundwater. In the selected villages, the pumpsets were installed up to the capacity of 10 HP capacities. On other hand, a user of pumpsets of higher capacity, 15 HP and above, had to pay higher electricity charges, as fixed by the State Electricity Board (Singh, 2000).

Largely, under the prevailing water markets conditions, the sellers were able to meet all operational expenditures, including annual charges paid for electricity/diesel consumption, maintenance charges and interest paid on the investment made for the sale of water. In the arid and semi-arid villages, the average area of 2.26 ha and 2.23 ha was irrigated through water marketing practices, respectively. It showed that there was slight difference in the area on which the sellers provided irrigation facilities after meeting their own water requirement. In the arid village, the sellers were able to recover the operational and maintenance (O&M) expenditure to a larger extent (about 99%), while in the semi-arid village, not only O&M expenditure was met but the sellers could obtain profit also from water business. The study has shown that water markets function on the principle of profit maximization. The buyers either had to compromise on the terms and conditions of water sellers or migrate elsewhere to earn their livelihood and it generally happened in the water-scarce areas of Rajasthan. Thus, the monopsony power of the sellers dominated the water markets. The

development of groundwater markets was dependent on the accessibility to infrastructural and institutional facilities like transportation and communication, institutional credit and agricultural marketing (Singh, 1998). In the context of availability of basic facilities, farmers always preferred short-term gains in water trade that had unfavorable consequences in the long-run.

4.5. Role of Water Markets in Farm Business

To assess the impact of water markets on farm business, three types of costs were considered, viz. A1, C2 and C3. The cost A1 includes paid-out cost incurred on crop production, cost C2 covers the total cost on cultivation, and cost C3 represents the total cost on production, including management charges. In the arid region, there was no noticeable difference in the net returns among the self-users and sellers of water (*see* Table 7). In the semi-arid regions, buyers and sellers occupied almost similar positions in earning the net returns, except that returns were more for self-users. It may be inferred from the fact that water markets contributed in correcting the inequalities. In the arid region, the condition of buyers was noticeable; they received lower returns, even negative sometimes, may be due to paying of higher water charges. But, the water buyers were compelled to remain in the farm business for food security and lack of other employment opportunities in the region.

Table 7. Farm economic analysis across the regions and water users

Particulars	Players in the game		
	Self-users	Sellers	Buyers
	Arid region		
Cost A1	7,296	7035	13,444
Cost C2	14,928	15,308	21,906
Cost C3	16,421	16,839	24,097
Gross returns	20,326	20,747	22,383
Net returns over cost C2	5,397	5,439	477
Net returns over cost C3	3,904	3,908	-1,714
	Semi-arid region		
Cost A1	6,939	7,060	8,454
Cost C2	15,440	16,474	16,942
Cost C3	16,980	18,121	18,636
Gross returns	24,267	23,299	23,597
Net returns over cost C2	8,827	6,825	6,655
Net returns over cost C3	7,283	5,178	4,961

Source: Compiled from Sharma and Sharma (2004)

5. Who is Loser in the Game? Emergence of Externalities

The externalities are non-reimbursed costs or uncharged benefits occurring to people as a result of some one else's action. Typically, we are concerned about externalities that impose cost on others, for instance, over-extraction of groundwater that results in irreparable loss to the society in the long-run. In the present context, a question that arises is : how development of groundwater markets creates externalities? Efforts have been made to answer this question with the help of Fig. 3. It shows that the seller extracts OQ volume of groundwater at the prevailing OP water price. Under similar conditions, the well owner, in general and sellers, in particular opt for options of water saving by cultivating less water-intensive crops and minimizing the number of irrigations. Thus, the seller makes available water for sale to his buyers out of OQ quantity of the extracted water. Under the existing price mechanism, the resource-rich farmer adopts technological measures to increase the water supply due to his capacity to invest in water extraction equipment. This intervention of the well owner results in increase in the supply from SS to S^1S^1 by extracting OQ^1 volume of groundwater at the same OP price level. Now, the seller sells a lager volume of water to his buyers and earns more profits than that before.

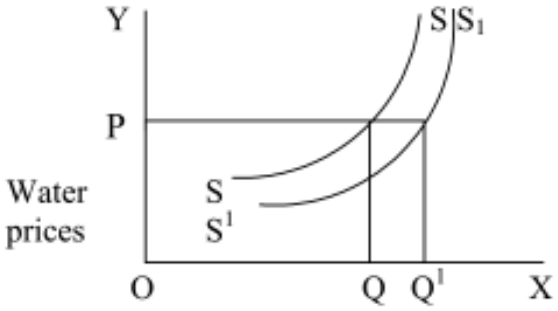

Fig. 3. Water extraction for sale

It may be inferred that when the well owner participates in water business and extracts groundwater at its maximum level then it would result in aquifer depletion. In other words, seller's technological intervention in water extraction creates externalities in the long-run.

6. Conclusions and Policy Implications

The main conclusions that emerge from the study are:

(i) Water markets mitigate the inequalities in the accessibility to groundwater resources. The individuals who do not own their wells,

get access to groundwater irrigation through water markets. Thus, resource-poor farmers can allocate a large proportion of the total cropped area to irrigated crops and make best use of their limited size of holding. However, over-exploitation of water may result in adverse impact in the long-run. Therefore, urgent and serious attention is needed to divert from the emerging adverse implications.

(ii) In water-scarce regions, water markets work on the principles of profit maximization. The sellers adopt strategies at the farm level to make groundwater available for sale. The buyers either purchase water at terms and conditions of sellers or get deprived from groundwater irrigation. Thus, in water-scarce regions, water markets function under monoposony conditions.

(iii) The terms and conditions of groundwater markets, viz. in kind and cash work differently. In water-scarce regions, the water prices remain substantially higher than those in water-endowed regions. Also, the sellers try to make more water available to the buyers with a view to increasing agricultural production so that they may get the maximum crop share as water price.

(iv) Various institutional provisions made to check over-exploitation of groundwater have proved ineffective in regulating water extraction. Often, such measures are taken when the situation reaches an alarming stage. If some precautionary measures are undertaken, then situation may be saved from reaching the critical stage. Under such a situation, water markets make the situation from bad to worse

(v) The study has indicated that the existing institutional set up both formal and informal behaves in an adverse manner. Under existing property rights, groundwater is considered as an open resource over which landholders have absolute rights. This results in unchecked extraction of groundwater. The unrestricted access makes the situation more complicated by converting Common Property Resources (CPRs) into Open Access Resources (OARs). Informal institutional arrangements have also added their undesirable role in groundwater depletion.

Policy Implications

Some important policy implications derived from the study are:

- Water rights should be defined. Groundwater should be treated as a common property resource in the real sense. Nationalization of groundwater resource is the only alternative for its sustainable use, in general and in water-scarce region, in particular.

- An integral approach should be followed at various levels such as different government departments, in general and those concerned with groundwater resources, in particular. The institutional arrangements that manage the groundwater markets under particular conditions should be the major concern of the policymaking and implementing agencies.
- Effective provisions should be made to restrict the over-exploitation of aquifers. Similarly, water trading should be allowed in a limited manner.
- Information system should be made more transparent to initiate action before reaching the alarming stage.
- Programmes for recharging of aquifers should be initiated on a large scale. The involvement of voluntary sector in aquifer recharging should be encouraged.
- A community based action is required for the efficient use of water resources in water-scarce conditions. The model of Pani-Panchayat in Maharastra can be experimented in other water-scarce regions (Pangare and Lokur, 1996). In this model, the community decides the cropping pattern based on availability of irrigation water. The similar efforts should be experimented in groundwater use also.

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