punjab geographer

A DOUBLE BLIND PEER REVIEWED JOURNAL OF APG AND KSS-ISPER INDIA

VOLUME 18 ISSN: 0973–3485 OCTOBER 2022

CHARACTERISTICS AND SIGNIFICANCE OF GROUNDWATER MARKETS FOR IRRIGATION IN HARYANA: A COMPARATIVE STUDY OF DIFFERENT GROUNDWATER AVAILABILITY REGIMES

Jitender Kumar

Abstract

In the northern part of India, especially in Punjab and Haryana, groundwater overdraft increases the cost of its withdrawal for irrigation and causes inequality in its access to farmers. Therefore, groundwater markets are gradually emerging as pervasive agrarian institutions. The present study assesses the significance of groundwater markets for irrigation in different groundwater availability regimes in Haryana. The study reveals that groundwater markets help to mitigate the growing inequalities in access to groundwater. About two-fifths of farmers in the state participate in groundwater markets. Its size is largest in low groundwater availability regime and shrinks with the increasing groundwater availability. The intensive use of groundwater purchased through groundwater markets in a high groundwater availability regime has been attributed to cultivation of water-intensive crops like rice and wheat. The conjunctive use of tubewell and canal water reduces the intensity of purchased groundwater use in the moderate groundwater availability regime. Groundwater scarcity and fragmentation of landholdings have been observed as important factors for the participation of farmers in groundwater markets. Furthermore, crop sharing has been found to be the most common groundwater transaction mechanism.

Keywords: Groundwater markets, Groundwater availability, Irrigation, Landholding size, Haryana.

Introduction

Groundwater markets are village-level set up through which owners of tubewells supply water at a price to the farmers who do not own tubewells. It is an arrangement through which a tubewell owner sells groundwater to other farmers for pecuniary consideration (Mukherji, 2007). This water supply mechanism for irrigation has also been widely considered as a means of achieving accessibility to groundwater. The groundwater market is generally not a formal mechanism for selling and purchasing water. It is an informal amorphous arrangement of sale and purchase of water for irrigation purposes. The sellers and buyers have contracts and choices that have no legal validity. Most groundwater markets in South Asia are informal, as groundwater rights are inalienable to land owners (Shah and Ballabh, 1997).

The sellers of groundwater often have surplus water after meeting their irrigation demand. They extract excess groundwater exercising their right to water through their land rights, and sell it. In the wake of undefined groundwater rights, the land entitlements have provided the right to landowner over groundwater resources. Consequently, large farmers dominate the supply side of groundwater markets. While, marginal and small farmers are the buyers because, they generally lack

sufficient capital to invest for the installation of tubewells. The fragmentation of landholdings also encourages groundwater markets as farmers cannot install tubewells in every segment of land. Groundwater resources in many parts of India are beyond the reach of poor farmers, particularly to landless tenants. Since groundwater harnessing rights exclusively lie with the landowners. Therefore, wealthy and large farmers have better access to groundwater than marginal and small farmers (Singh, 2007). One positive aspect of groundwater market, as an institution, is that it has stepped in to balancing the growing inequalities in groundwater utilization. It is particularly true in arid and semi-arid regions where marginal and small farmers own very few tubewells (Mukherji, 2008; Mukherjee and Biswas, 2016). However, the groundwater market does not always help for a good cause as it may lead to overexploit-ation of groundwater resources.

The diffusion of water-intensive crops such as rice and wheat in Haryana has induced groundwater mining to the level of its depletion. Since 1980s, tubewell irrigation has emerged as a dominant source of irrigation in the state. The decline in the water table and drying up of shallow tubewells have forced the farming community to install new submersible tubewells. A continuous decline in water table and increasing groundwater drafting has made the groundwater utilization highly inclined towards large and resource-rich farmers leaving the small and marginal farmers out of the race. The tubewell ownership mostly confines with resource-rich and large farmers who have emerged as groundwater sellers. Various studies have highlighted the characteristics of groundwater markets in India (Dubash, 2002; Singh, 2002; Sharma and Sharma, 2004; Mukherji, 2007, 2008). The present study, therefore, has been carried out to explore various characteristics of groundwater markets across different regimes of groundwater availability in Haryana.

Objectives

Major objectives of the study are:

- to assess the structure of groundwater markets and the factors associated with them and
- to analyze the breadth and depth of groundwater markets in different groundwater availability regimes of Haryana.

Study Area

The state of Haryana in India is located between 27º 39' to 30º 56' N latitudes and 74º 27' to 77° 36' E longitudes, covering an area of 44,212 km² (Fig. 1). The state has warm and semi-arid climatic conditions. It receives over 75 per cent of the total annual rainfall from the south-westerly monsoon from July to September. The state's average annual rainfall is 560 mm, varying from less than 300 mm in south-western parts to over 1000 mm in the north-eastern hilly areas. The state is chronically deficient in surface water resources and mainly depends on groundwater for irrigation. It has experienced a fast expansion of area under irrigation since the initiation of the green revolution in the 1960s. Since 2000, there has been no significant horizontal expansion in the area under irrigation. However, there has been a tremendous increase in vertical expansion of the area under irrigation during last one and a half decades. Canal and tubewells are two dominant sources of irrigation in Haryana. However, the share of canal irrigation has continuously declined. Haryana is one of the

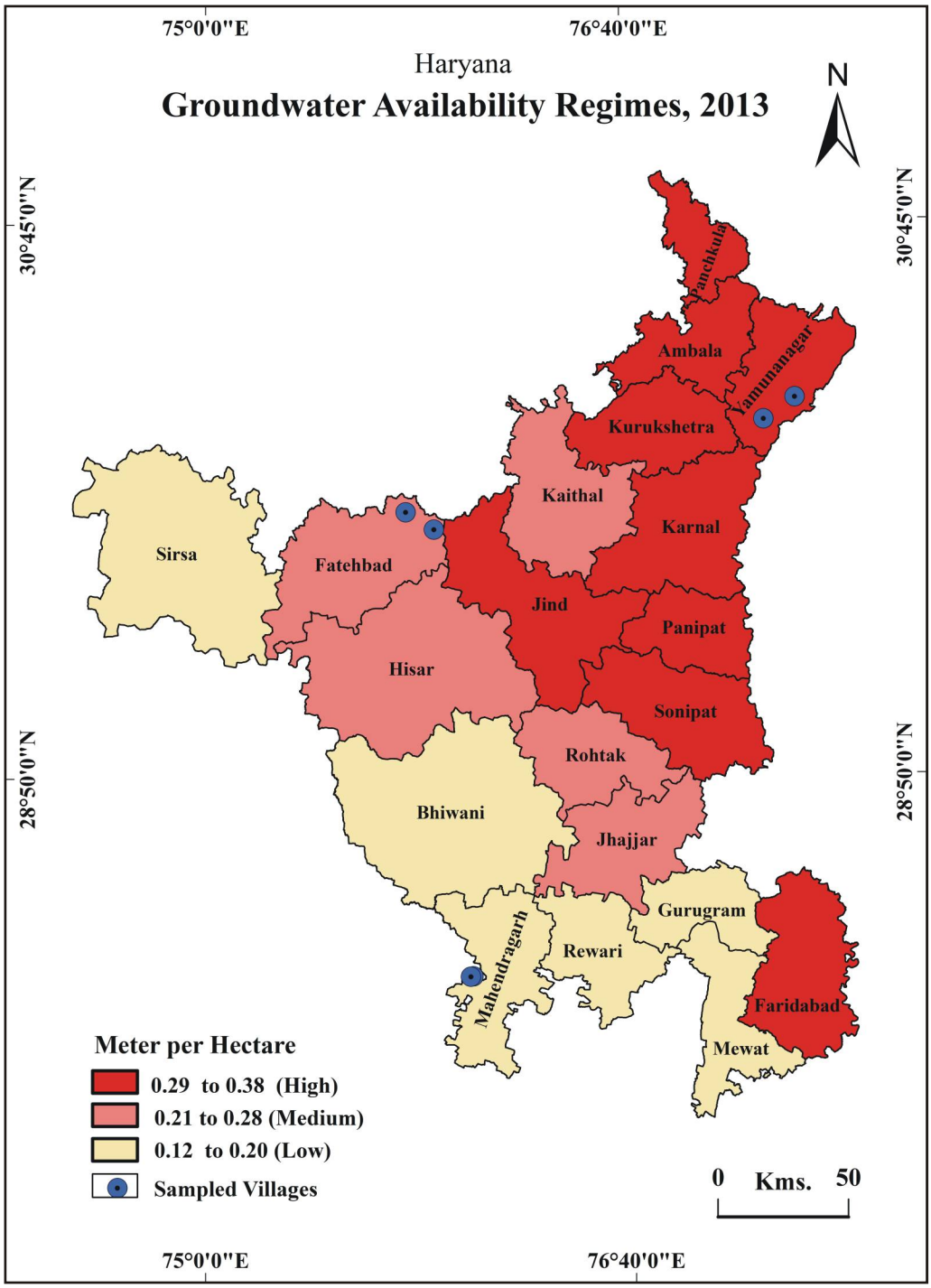
75°0'0"E
76°40'0"E
Haryana
Groundwater Availability Regimes, 2013
N
30°45'0"N
28°50'0"N
Panchkula
Ambala
Yamunanagar
Kurukshetra
Kaithal
Karnal
Sirsa
Fatehbad
Jind
Panipat
Hisar
Sonipat
Rohtak
Bhiwani
Jhajjar
Gurugram
Rewari
Mahendragarh
Faridabad
Mewat
Meter per Hectare
0.29 to 0.38 (High)
0.21 to 0.28 (Medium)
0.12 to 0.20 (Low)
Sampled Villages
0 Kms. 50

Fig. 1

leading Indian states in terms of agricultural performance. It is self-sufficient in food production and the second largest contributor to India's central pool of food grains. The major crops produced in Haryana are wheat, rice, sugarcane, cotton etc.

Database and Methodology

This study has utilized both primary and secondary data. The district-wise groundwater volume data have been obtained from Central Ground Water Board, Faridabad, Haryana (CGWB, 2013). The groundwater regimes denote the magnitude of groundwater availability which has been computed for different districts of the state as:

$$IA=V/A,$$

where, IA is an index of groundwater availability (m/ha), V is the volume of groundwater in district/state (ha-m), and A is the area of district/state (ha).

Based on the district-wise groundwater availability index computed above, the groundwater availability regimes have been delineated. The High Groundwater Availability Regime (HGAR) is primarily a groundwater-rich area. Low Groundwater Availability Regime (LGAR) comprises mainly a groundwater scarcity zone. The Moderate Groundwater Availability Regime MGAR lies between these two zones (Fig. 1).

To collect primary data, multistage sampling technique has been adopted. At stage I, one district has been selected purposively from each groundwater availability regime. Thus, Mahendergarh, Fatehabad and Yamunanagar districts have been selected from LGAR, MGAR and HGAR, respectively. At stage II, two villages from each district, like Baproli and Chinalia from Mahendergarh, Dangra and Narel from Fatehabad and Jathlana and Alipur from Yamunanagar district have been randomly selected. At stage III, 75 farmers from each sample village have been randomly selected for the survey. Thus, 150 farmers have been surveyed from each of the three groundwater availability regimes making the total sample size of 450 farmers. To assess variations in groundwater market across the farm size, the sample farmers have been classified as marginal farmers (having land up to 1.00 ha), small farmers (1.01-2.00 ha), medium farmers (2.01-4.00 ha), large farmers (4.01-8.00 ha), and very large farmers (more than 8.00 ha).

Based on their relationship with groundwater markets, the sample farmers have been classified as *self-users* (farmers who own tubewells but do not participate in groundwater markets), *buyers* (farmers who do not own tubewells but depend on groundwater sellers to irrigate their fields), *non-users* (farmers who neither own tubewell nor buy groundwater for irrigation) and *sellers* (farmers who sell or barter groundwater with other farmers).

Breadth and Depth of Groundwater Markets

The breadth of groundwater market has been expressed in percentage which indicates the ratio of net area irrigated by groundwater markets (ha) to net area irrigated by all sources (ha). The depth of groundwater market refers to the depth in cm/hectare/year of purchased groundwater from the groundwater market by the farmers. The volume of groundwater extracted from the tubewells of different horsepower has been measured by filling a container of tubewell water in a given time using a stopwatch. The volume of water (liter/hour) has been converted into ha-cm/hour.

Results and Discussion

Structure and Size of Groundwater Markets

The structure of groundwater markets means the linkage between sellers and buyers of groundwater. Groundwater markets structure comprises the size (number of buyers and sellers) and intensity (number of transactions), which are the result of natural circumstances and are not governed by economics (Dubash, 2002). Table 1 reveals that out of total sample of farmers, about 36 per cent participate in groundwater markets either fully or partially. The size of groundwater markets has been found largest in LGAR, where about 61 per cent of farmers participate in groundwater markets as buyers or sellers. The market size is relatively smaller in MGAR as only 41 per cent of farmers participate in groundwater markets. The size of the groundwater market is lowest in the case of HGAR (Table 1).

There are variations in the participation rate of groundwater market across the size and class of farmers. About half of the marginal and very large farmers have participated in groundwater markets. In the case of small and medium farmers, the participation rate is 29 and 28 per cent, respectively. It has been observed that about 46 per cent of marginal farmers buy groundwater, whereas only 13 per cent of them sell groundwater to other farmers. About one-fourth of small farmers are also buying groundwater, while only 12 per cent sell it. The corresponding figures are 21 per cent and 11 per cent, respectively for medium farmers, 21 per cent and 23 per cent for large farmers, and 26 per cent for very large farmers. It has been found that the proportion of buyers is higher in marginal and small size landholdings, while the share of sellers has been found relatively high among large size farmers.

The participation in groundwater markets has been found highest in LGAR. Here, about 70 per cent of marginal farmers participate in groundwater markets, followed by small farmers (65 per cent), medium farmers (54 per cent), and large farmers (28 per cent). About 65 per cent of marginal farmers buy groundwater, whereas only 18 per cent indulge in selling (Table 1). About half of the small farmers are also engaged in buying groundwater while one-fourth of them sell groundwater. The corresponding figures are 46 per cent and 21 per cent for medium farmers and 17 per cent and 11 per cent for large farmers.

In MGAR, about forty per cent of the farmers are involved in groundwater transactions. However, there is no discernible pattern in their participation across the size and class of farmers. The participation of farmers in groundwater markets have been found relatively low in HGAR (about 7 per cent). Here, buyers are primarily marginal, and small farmers and sellers are large farmers. Higher availability and accessibility of groundwater in this regime are the significant factors for low participation of farmers in groundwater markets.

It is evident from the above that groundwater markets in the state have flourished the most in LGAR. The proportion of groundwater buyers increases with the decline in the size of landholding. A small proportion of large and medium farmers also buy groundwater when their landholdings are fragmented. Interestingly, the size of the groundwater markets has declined with the increasing availability of groundwater. The proportion of self-user has been found high in the area having better groundwater availability. In MGAR and HGAR, even small and marginal farmers have

Table 1
Haryana: Participants and Non-Participants in Groundwater Markets across Landholding Size Classes in Different Groundwater Availability Regimes

Land Holding Category	Participants (No. of Farmers)				Non-Participants (No. of Farmers)		Total (No. of Farmers)
	Self-user+ Seller	Self-user + Seller+ Buyer	Self-user+Buyer	Buyer	Self-user	Non-user	
Low Groundwater Availability Regime (LGAR)							
Marginal Farmer	03 (05.26)	07 (12.28)	14 (24.56)	16 (28.07)	13 (22.81)	04 (07.02)	57 (100.00)
Small Farmer	06 (11.76)	07 (13.73)	15 (29.41)	05 (09.80)	17 (33.33)	01 (01.96)	51 (100.00)
Medium Farmer	02 (08.33)	03 (12.50)	06 (25.00)	02 (08.33)	07 (29.17)	04 (16.67)	24 (100.00)
Large Farmer	02 (11.11)	00 (00.00)	03 (16.67)	00 (00.00)	13 (72.22)	00 (00.00)	18 (100.00)
Very Large Farmer	00 (00.00)	00 (00.00)	00 (00.00)	00 (00.00)	00 (00.00)	00 (00.00)	00 (00.00)
Total	**13 (08.67)**	**17 (11.33)**	**38 (25.33)**	**23 (15.33)**	**50 (33.33)**	**09 (06.00)**	**150 (100.00)**
Moderate Groundwater Availability Regime (MGAR)							
Marginal Farmer	00 (00.00)	07 (19.44)	00 (00.00)	10 (27.78)	12 (33.33)	07 (19.44)	36 (100.00)
Small Farmer	02 (05.00)	02 (05.00)	02 (05.00)	02 (05.00)	27 (67.50)	05 (12.50)	40 (100.00)
Medium Farmer	03 (07.14)	01 (02.38)	05 (11.90)	04 (09.52)	29 (69.05)	00 (00.00)	42 (100.00)
Large Farmer	04 (21.05)	03 (15.79)	05 (26.32)	00 (00.00)	07 (36.84)	00 (00.00)	19 (100.00)
Very Large Farmer	06 (46.15)	00 (00.00)	06 (46.15)	00 (00.00)	01 (07.69)	00 (00.00)	13 (100.00)
Total	**15 (10.00)**	**13 (08.67)**	**18 (12.00)**	**16 (10.66)**	**76 (50.67)**	**12 (08.00)**	**150 (100.00)**
High Groundwater Availability Regime (HGAR)							
Marginal Farmer	00 (00.00)	00 (00.00)	04 (11.76)	00 (00.00)	30 (88.24)	00 (00.00)	34 (100.00)
Small Farmer	00 (00.00)	00 (00.00)	02 (03.64)	00 (00.00)	53 (96.36)	00 (00.00)	55 (100.00)
Medium Farmer	02 (05.88)	00 (00.00)	00 (00.00)	00 (00.00)	32 (94.12)	00 (00.00)	34 (100.00)
Large Farmer	03 (17.65)	00 (00.00)	00 (00.00)	00 (00.00)	14 (82.35)	00 (00.00)	17 (100.00)
Very Large Farmer	00 (00.00)	00 (00.00)	00 (00.00)	00 (00.00)	10 (100.0)	00 (00.00)	10 (100.00)
Total	**05 (03.33)**	**00 (00.00)**	**06 (04.00)**	**00 (00.00)**	**139 (92.67)**	**00 (00.00)**	**150 (100.00)**
State Average							
Marginal Farmer	03 (02.36)	14 (11.02)	18 (14.17)	26 (20.47)	55 (43.31)	11 (08.66)	127 (100.00)
Small Farmer	08 (05.48)	09 (06.16)	19 (13.01)	07 (04.79)	97 (66.44)	06 (04.11)	146 (100.00)
Medium Farmer	07 (07.00)	04 (04.00)	11 (11.00)	06 (06.00)	68 (68.00)	04 (04.00)	100 (100.00)
Large Farmer	09 (16.67)	03 (05.56)	08 (14.81)	00 (00.00)	34 (62.96)	00 (00.00)	54 (100.00)
Very Large Farmer	06 (26.09)	00 (00.00)	06 (26.09)	00 (00.00)	11 (47.83)	00 (00.00)	23 (100.00)
Total	**33 (07.33)**	**30 (06.67)**	**62 (13.78)**	**39 (08.67)**	**265 (58.89)**	**21 (04.67)**	**450 (100.00)**

Source: Compiled by Author. Figures in parentheses indicate the percentage to total.

installed tubewells due to low tubewell installation cost in these regimes. However, in LGAR, marginal and small farmers mostly buy groundwater from the tubewells owned by large and medium farmers.

Breadth of Groundwater Markets

The proportion of total irrigated area by purchased groundwater has been considered as the breadth of groundwater market. Table 2 shows that groundwater markets irrigate about

Table 2

Haryana: Breadth and Depth of Groundwater Markets across Landholding Classes and Groundwater Availability Regimes

Particulars	Landholding Size(ha)					
	Marginal Farmer	Small Farmer	Medium Farmer	Large Farmer	Very Large Farmer	Total
Low Groundwater Availability Regime (LGAR)						
Net Area Irrigated (ha)	28.54	59.51	51.01	76.92	0.00	215.98
Area Irrigated by Water Markets (ha)	21.05	30.36	26.32	12.75	0.00	90.49
Total Groundwater Hired (ha-cm)	541.00	457.00	372.00	236.00	0.00	1606.00
Breadth of Water Markets (per cent)	73.76	51.02	51.60	16.58	0.00	41.90
Depth of Water Markets (cm/ha per year)	25.70	15.05	14.13	18.51	0.00	17.75
Sold Water (ha-cm)	230.00	338.00	190.00	150.00	0.00	908.00
Moderate Groundwater Availability Regime (MGAR)						
Net Area Irrigated (ha)	19.76	50.60	121.05	108.90	147.36	447.66
Area Irrigated by Water Markets (ha)	06.88	06.07	11.74	06.88	08.50	40.08
Total Groundwater Hired (ha-cm)	345.00	391.00	660.00	466.00	572.00	4225.00
Breadth of Water Markets (per cent)	34.82	12.00	09.70	06.32	05.77	08.95
Depth of Water Markets (cm/ha per year)	50.15	64.42	56.22	67.73	67.29	60.73
Sold Water (ha-cm)	125.00	137.00	154.00	135.00	205.00	756.00
High Groundwater Availability Regime (HGAR)						
Net Area Irrigated (ha)	22.48	86.84	100.81	94.33	135.63	440.09
Area Irrigated by Water Markets (ha)	05.75	02.90	00.00	00.00	00.00	08.65
Total Groundwater Hired (ha-cm)	375.00	160.00	00.00	00.00	00.00	535.00
Breadth of Water Markets (per cent)	25.57	03.33	00.00	00.00	00.00	01.96
Depth of Water Markets (cm/ha per year)	65.21	55.17	00.00	00.00	00.00	76.42
Sold Water (ha-cm)	00.00	350.00	400.00	390.00	00.00	1140.00
State Average						
Net Area Irrigated (ha)	70.78	196.95	272.87	280.15	282.99	1103.73
Area Irrigated by Water Markets (ha)	33.68	39.33	38.06	19.63	08.50	139.22
Total Groundwater Hired (ha-cm)	1261.00	1008.00	1032.00	702.00	572.00	6366.00
Breadth of Water Markets (per cent)	47.58	19.96	13.94	07.00	03.00	12.61
Depth of Water Markets (cm/ha per year)	37.44	25.63	27.12	35.76	67.29	45.73
Sold Water (ha-cm)	355.00	825.00	744.00	675.00	205.00	2804.00

Source: Compiled by Author.

13 per cent of the total irrigated area of all farmers. There is a massive difference in the breadth of the groundwater market across the landholding size as about half of the land of marginal farmers and about one-fifth of that of small farmers is irrigated by purchased water. The breadth of the groundwater markets has been observed as most prominent in LGAR as about 42 per cent area is irrigated by purchased groundwater. The breadth of groundwater markets in this zone has been detected most extensive in the case of marginal farmers (74 per cent), followed by small and medium farmers (about half of irrigated land). Only

very small proportion (about 17 per cent) of the area is irrigated from purchased groundwater by large farmers in this regime. Apart from the size of landholding, fragmentation of landholdings also contributes towards enlarging groundwater markets in LGAR. In MGAR, there is only about 9 per cent of land irrigated through groundwater markets. In this regime, about 35 per cent land of the marginal farmers is irrigated by groundwater markets. However, in this case, the breadth of groundwater markets also decreases with the increase in size of landholdings. In HGAR, groundwater markets irrigate only 2 per cent of cultivated land. About one-fourth land of marginal farmers and 3 per cent of small farmers is irrigated through groundwater markets in HGAR.

Depth of Groundwater Markets

It refers to the depth in cm/hectare/year of purchased groundwater from the groundwater market by farmers. It also shows the intensity of groundwater used by the buyers. The average depth of groundwater application in the state has been observed to the tune of 46 cm/hectare/year. It is highest in HGAR (76 cm/hectare/year), followed by MGAR (61 cm/hectare/year) and LGAR (18 cm/hectare/year). However, there is not a discernible pattern in the depth of groundwater markets across the class size of farmers.

Reasons for Participation in Groundwater Markets

Table 3 records the farmers' responses concerning their participation and non-participation in groundwater markets. Land fragmentation has been reported to be the most significant reason for the participation of tubewell owners (48 per cent), followed by the profit-earning motive (23 per cent). About 18 per cent of tubewell owners participate in groundwater market due to the growing water demand, and another 10 per cent have recorded surplus groundwater as the reason for sale. However, in the groundwater scarcity zone (LGAR), increasing groundwater demand for irrigation has been the main factor in participation in groundwater markets, followed by fragmentation of landholding and profit earning.

The non-tubewell owners participate in groundwater markets as buyers only. The main reason for their participation is also fragmentation of landholdings (51 per cent), followed by their unaffordability to install tubewell (39 per cent) and failure of tubewell (10 per cent). In MGAR, fragmentation of landholding has been observed as the major reason for the participation of non-tubewell owners in groundwater markets than in LGAR. Table 3 shows that the main reason for non-participation by tubewell owners in groundwater markets is the non-availability of groundwater buyers (71 per cent), followed by a lack of surplus groundwater (29 per cent). However, the reasons vary across the groundwater availability regimes. Non-availability of surplus groundwater for sale has been the sole reason for non-participation of farmers in the groundwater market in HGAR. Most of the non-tubewell owners do not participate in groundwater markets as they carry out rainfed agriculture (73 per cent), and another 27 per cent prefer canal irrigation over tubewell irrigation. However, in LGAR, farmers with tubewells do not have sufficient groundwater to sell; hence non-tubewell owners mostly do rainfed farming. However, in MGAR canal has been observed as an alternative source of irrigation for non-tubewell owners.

Table 3

Haryana: Reasons for Participation and Non-Participation in Water Markets across Different Groundwater Availability Regimes

Reason	Groundwater Availability Regimes (Number of Farmers)			
	LGAR	MGAR	HGAR	Average
Participation of Tubewell Owners				
Surplus Water	00 (00.00)	09 (18.00)	00 (00.00)	09 (10.00)
Profit Earning	06 (20.68)	15 (30.00)	00 (00.00)	21 (23.33)
Growing Demand of Water	12 (41.37)	00 (00.00)	05 (45.45)	17 (18.18)
Fragmented Landholding	11 (37.93)	26 (52.00)	06 (54.54)	43 (47.77)
Total	**29 (100.00)**	**50 (100.00)**	**11 (100.00)**	**90 (100.00)**
Non-Participation of Tubewell Owners				
No Surplus Water	22 (100.00)	46 (64.78)	00 (00.00)	68 (29.31)
No Buyer	00 (00.00)	25 (35.21)	139 (100.00)	164 (70.68)
Total	**22 (100.00)**	**71 (100.00)**	**139 (100.00)**	**232 (100.00)**
Participation of Non-Tubewell Owners				
Tubewell Failure	08 (12.50)	00 (00.00)	00 (00.00)	08 (10.00)
Can't Afford Installation of a Tubewell	26 (40.62)	05 (31.25)	00 (00.00)	31 (38.75)
Fragmented Landholding	30 (46.87)	11 (68.75)	00 (00.00)	41 (51.25)
Total	**64 (100.00)**	**16 (100.00)**	**00 (00.00)**	**80 (100.00)**
Non-Participation of Non-Tubewell Owners				
Prefer Canal Irrigation	00 (00.00)	13 (100.00)	00 (00.00)	13 (27.08)
Prefer Rainfed Agriculture	35 (100.00)	00 (00.00)	00 (00.00)	35 (72.91)
Total	**35 (100.00)**	**13 (100.00)**	**00 (00.00)**	**48 (100.00)**

Source: Compiled by Author. Figures in parentheses indicate the percentage of the total.

Transaction Mechanism in Groundwater Markets

There are various types of groundwater transaction mechanisms observed in India's groundwater markets. Mukherji (2004) has identified two main types of groundwater transactions. One is the outright sale of groundwater (against cash, kind, or a mix) either at hourly or seasonal rates. The second one involves a tenancy arrangement, where the groundwater seller leases in or leases out land to other landowners either for a fixed cash amount or sharing the produce. In some instances, the buyers remit cash to sellers on the basis of hourly utilization of groundwater.

The groundwater markets in Haryana work as an informal system. There are three main types of transactions used in the groundwater markets. These are cash contract, crop share contract, and groundwater exchange contract. There are two sub-types of transactions in a cash contract, such as, hourly and seasonal cash contract. In hourly cash contracts, buyers pay the price of groundwater to the seller on the basis of per hour use of water. Under a seasonal cash contract, buyers pay a fixed price per unit area or output at the end of the crop season. In a crop share contract, the groundwater buyers share a part of their crop output as a groundwater price to the seller.

Table 4
Haryana: Groundwater Transaction Mechanism across Different Groundwater Availability Regimes

Transactions Type	Groundwater Availability Regimes (Number of Farmers)			
	LGAR	MGAR	HGAR	Average
Hourly Cash Contract	06 (06.45)	66 (100.00)	00 (00.00)	72 (42.35)
Seasonal Cash Contract	01 (01.07)	00 (00.00)	00 (00.00)	01 (00.58)
Crop Share Contract	86 (92.47)	00 (00.00)	00 (00.00)	86 (50.58)
Water Exchange Contract	00 (00.00)	00 (00.00)	11 (100.00)	11 (06.47)
Total	**93 (100.00)**	**66 (100.00)**	**11 (100.00)**	**170 (100.00)**

Source: Compiled by Author. Figures in parentheses indicate the percentage of the total.

Farmers exchange groundwater for groundwater at different locations in a water exchange contract.

Table 4 shows that about half of the groundwater transactions in the state take place on a crop-sharing basis. In another 42 per cent of cases, groundwater sellers charge cash on hourly basis. In only 6 per cent of cases, there is an exchange of groundwater contract whereby the seller gets the same amount of groundwater from the buyer at another location (field). There are vast variations in groundwater transaction mechanisms across groundwater availability regimes. In LGAR, about 92 per cent of groundwater transactions have been carried out through crop share contracts. This has been mainly done to cover the risk vulnerability in production. In MGAR, all the groundwater transactions have been done on cash basis. In HGAR, where the size of the groundwater market is relatively small, all the transactions have been carried out through groundwater exchange contract.

Conclusions

The present study has assessed groundwater markets' structure, breadth, depth, and associated factors across different groundwater availability regimes in Haryana. About two-fifths of sample farmers have participated in groundwater markets. The participation of farmers in groundwater markets (mostly as buyers) has been observed higher among marginal and small farmers, whereas it has declined with an increase in landholding size. The proportion of self-user farmers is higher in HGAR and MGAR, as the area has better groundwater availability.

Groundwater markets have irrigated about 13 per cent irrigated area of all sample farmers. The breadth of groundwater markets has been detected most extensive in LGAR (62 per cent), and it has decreased in MGAR (44 per cent) and HGAR (2 per cent). A massive difference has been observed in the breadth of groundwater markets across the landholding size. About half of the land of marginal farmers and about one-fourth of that of small farmers has been found irrigated through groundwater markets. The proportion of such farmers has declined with an increase in landholding size. However, the depth of purchased groundwater use in HGAR (76 ha-cm/year) has been found to be four times higher than in the LGAR (18

ha-cm/year).

Overall, fragmentation of landholding has been observed as the main reason for the participation of tubewell owners in groundwater markets, followed by the profit-earning motive. However, in LGAR, increasing groundwater demand for irrigation has been the main factor for groundwater marketing. In the case of non-tubewell owners, the main reason for participation in groundwater markets is the fragmentation of landholdings, followed by the incapability to install tubewell and the failure of tubewells.

A crop sharing contract has been witnessed as the most common groundwater market transaction mechanism, followed by an hourly cash contract. In LGAR, crop sharing system has been mostly used for payments. In MGAR, where there is no risk of crop failure, all groundwater transactions have been made through hourly cash contract basis. In HGAR, where all the farmers are tubewell owners, the groundwater transactions have been done as a mutual water exchange at different locations.

References

Central Ground Water Board (CGWB). 2013. *Dynamic Ground Water Resources of India.* Central Ground Water Board, Faridabad (Haryana): 58-96.

Dubash, N. K. 2002. *Tubewell Capitalism, Groundwater Development and Agrarian Change in Gujarat.* Oxford University Press, New Delhi: 1-287.

Mukherji, A. 2004. Groundwater markets in Ganga-Meghna-Brahmaputra basin: theory and evidence. *Economic and Political Weekly,* 39 (31): 3514 - 3520.

Mukherji, A. 2007. Implications of alternative institutional arrangements in groundwater sharing: evidence from West Bengal. *Economic and Political Weekly,* 42 (26): 2543-2564.

Mukherji, A. 2008. Spatio-temporal analysis of markets for groundwater irrigation services in India. *Hydrogeology Journal,* 16: 1077-1087.

Mukherjee, S. and Biswas, D. 2016. An enquiry into equity impact of groundwater markets in the context of subsidized energy pricing: a case study. *Indian Institute of Management Kozhikode Society and Management Review,* 5 (1) 63-73.

Shah, T. and Ballabh, V. 1997. Water markets in north Bihar: six village studies in Muzaffarpur district. *Economic and Political Weekly,* 32 (52): A183 - A190.

Sharma, P. and Sharma, R. C. 2004. Groundwater markets across climatic zones: a comparative study of arid and semi-arid zones of Rajasthan. *Indian Journal of Agricultural Economics,* 59 (1): 138-150.

Singh, D. 2002. Groundwater markets in fragile environments: key issues in sustainability. *Indian Journal of Agricultural Economics,* 57 (2): 180-196.

Singh, D. 2007. Who gains and who loses in the game of groundwater markets in water-scarce regions. *Agricultural Economics Research Review,* 20: 345-360.

Dr. Jitender Kumar, Assistant Professor
E mail: jitender@nbgsmc.ac.in
Department of Geography
N.B.G.S.M. College,
Sohna, Gurugram (Haryana).

punjab geographer