# Participants in Groundwater Markets: Who are Sellers?

MI Jian-wei[1], HUANG Ji-kun[1], WANG Jin-xia[1], Aditi Mukherji[2]
(1. Institute of Geographic Sciences and Natural Resources Research, Center for Chinese Agricultural Policy, CAS, Beijing 100101, China; 2. International Water Management Institute, Battaramulla, Sri Lanka)

**Abstract:** Few attention has been paid to the studies of groundwater market in rural China though it was developed rapidly in recent decades. The main objectives of this paper are to describe the main characteristics of participants of rural groundwater market and identify the determinants of selling water. Data used in this research comes from 150 households in two provinces in northern China. Based on our field survey, we find that the farmers with higher wealth, more advantage in agricultural activity, and higher social position are more likely to be the sellers. Transaction costs also have impacts on participants in the groundwater market.

**Key words:** groundwater market; participants; determinants; China
**CLC number:** F062.1 **Document code:** A **Article ID:** 1000-3037(2008)06-0959-11

## 1 Introduction

China, especially north China, has one of the most severe water scarcity issues in the world. On per capita terms, China has only 1/4 of the volume of water resources as compared to rest of the world[1]. The uneven distribution between southern China and northern China makes this problem even worse. North China with 65% of arable land only has 26% of the water resources, a great bulk of which comes from groundwater[1]. North China is also increasingly facing groundwater depletion problems. For example, Wang *et al* [2] found that from 1995 to 2004, the groundwater table has been falling sharply in more than half of the counties in northern China.

Groundwater has played an increasingly important role in northern China in recent decades. In the 1950s and 1960s, local governments made considerable investment on surface irrigation infrastructure. However, since the late 1960s, the role of groundwater in agricultural irrigation has been increasing. According to official statistics, between 1965 and 2003, the number of tubewells increased from 0.2 million to 4.7 million[1,3]. In recent years, groundwater provided 68% of irrigation water for agricultural production in northern China[4].

The ownership pattern of tubewells has also experienced great change in the last three decades. Before the reform in the late 1970s, majority of the tubewells were owned by the village collective. Due to a variety of reasons, including the decline of strength of collective and the declining groundwater tables, private tubewells rose dramatically after the reform in the late 1970s which gave farmers the right of making their own decision on investment, production and claiming for revenue generated[5,6]. The number of private tubewells as a proportion of total tubewells in-

**Received date:** 2008-09-25; **Accepted date:** 2008-10-15.
**Founation item:** International Water Management Institute (PN-42), National Natural Sciences Foundation of China (70733004) and Chinese Academy of Sciences (KSCX-YW-09).
**Biography of the first author:** MI Jian-wei (1974-), Ph.D candidate, main research fields are resource economics, development economics and related policies. E-mail: mijw.05b@igsnrr.ac.cn

creased from almost nothing in the 1970s to nearly 40% by 1990. From 1995 to 2004, the percentage of private ownership rose from 42 to 70[4].

Groundwater markets have spread rapidly in northern China in response to rising of private tubewells and water scarcity[7]. The falling water table has resulted in an expensive investment in tubewell. In order to recover the investment, maintenance and operational costs, well-owners often resort to sell water to the other users and informal groundwater markets emerge. This is especially true in drought areas and areas with deep water table. Using two sets of data collected from six provinces in northern China, Zhang *et al* [7] found that from 1995 to 2004, the villages with groundwater market rose from 9% to 44% and the shares of tubewells selling water rose from 5% to 18%. In 2004, 77% of the water extracted in volumetric terms was sold to satisfy the demand of the water buyers.

Most previous studies on groundwater market have been mainly conducted in South Asia such as India, Bangladesh and Pakistan, but the literature has not resulted in consistent findings on who are the sellers of groundwater. For example, several studies found that those farmers who owned larger area of land are wealthier than other farmers, thus they had higher probability of being a seller[8-15]. While other studies found that medium, small and marginal farmers taken together own as much as 82% of pumps in UP, Bihar and West Bengal in India[16]. Shah *et al* [17] also showed that pump irrigation sellers are more likely the farmers with smaller and fragmented landholding in India, Pakistan, Nepal and Bangladesh.

Despite the significant changes in groundwater management in the largest agricultural country, China, little is known about the nature and determinants of this groundwater market development in. Only paper available is a recent study by Zhang *et al* [7], which found that land area owned by the sellers is slightly more than the buyers. However, whether this difference is statistically significant and what are other major determinants of water market participation are still remained answered. China is an interesting case for study due to several reasons. China has rising water scarcity. Groundwater market has been under rapid development. China is also in a transition period to modernization and non-farm activity emerged as the main source of additional income for a large part of rural households. Moreover, China has the most equal land distribution system in the world under which nearly all farms are small-scale.

Overall goal of this study is to provide empirical evidences of issues raised about. Based on the primary field survey data collected from two provinces in northern China, we identify the determinants of selling water.

The paper is organized as follows. The second section introduces data used in this study. The third section summarizes the main characteristics of the water-sellers and water buyers. The third section examines the determinants of water market participations using econometric analysis. In the last section we present our conclusions and the policy implications.

## 2 Study areas and data

### 2.1 Study areas

The data used in this paper were collected from Hebei and Henan provinces in northern Chi-

na. Hebei Province is a severe drought-affected area. Its groundwater table is very low and falling. Although Henan Province has much higher water table than Hebei, it also often faced rising problem of water scarcity in recent years, especially in some drought years when rainfall was below normal.

Two counties from each of Hebei and Henan provinces were selected for this study. They are Xianxian and Cixian counties in Hebei and Yanjin and Kaifeng counties in Henan. We selected these counties for two major reasons. Firstly, Xianxian belongs to the Haihe River Basin which is one of the drought most frequently occurred areas in northern China. The other three counties belong to the Yellow River Basin which is also a typical water-scarce area in northern China. These two basins form a large part of northern China. Secondly, based on the seriousness of water-scarcity, we classify the above counties into four categories: the most serious drouthy area (Xianxian), moderate drouthy area (Cixian), relatively less drought area with groundwater market (Yanjin) and without groundwater market (Kaifang)①, which basically represent the main characteristics of water-resource and social-economy in northern China.

All the four counties have experienced the decline of water table during the past several decades due to the rising number of tubewells and increasing demand from irrigation, industry and domestic uses. Our survey indicates that in the most seriouss drouthy area, Xianxian, the average water table has declined to 95m under the ground in 2007. In some villages, water table has declined even by 20m within the past three years. In the relatively less drouthy area, Yanjin and Kaifeng, there are still 4 out of 10 villages which we surveyed experienced the decline of water table in the past three years.

As we expected, the costs of sinking a well increased rapidly with the decline of water table. In Xianxian, the average costs of sinking a well in our sample villages reached more than 80000 yuan (Fig. 1), about 4 times of net income of a typical household in 2007. Although the costs were much less in the other three counties than that in Xianxian, they have also increased significantly in recent years. Fig. 1 also shows a clear relationship between water scarcity and costs of sinking a well in our sample counties.

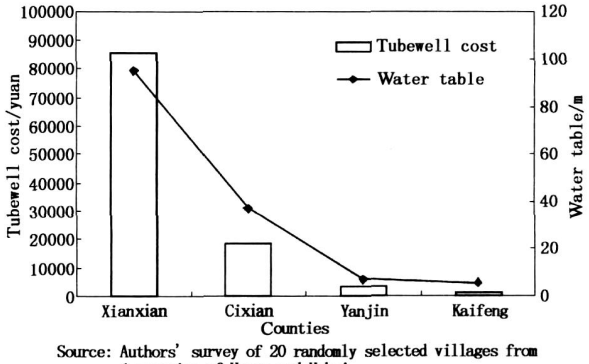


Fig. 1 Costs per tubewell and water table in the sampled counties, 2007

① Kaifeng county has no any groundwater market as water scarcity is not serious there.

### 2.2 Data

Three types of surveys were conducted. They are village leaders, tubewell-owners (or water sellers), and non-tubewell-owners household surveys (or water buyers). For village survey, we randomly selected five villages in each county. The interviewers administered the village questionnaires to the head of village committee and the village accountant. The questions tried to elicit socio-economic situation, irrigation conditions and the status of water resources in the villages. For water sellers and water buyers surveys, we randomly select three tubewell owners and seven non-tubewell owners in each village②. Because we did not find groundwater market in Kaifeng county after we interviewed the village leaders, this study only used data collected from 45 tubewell-owners in 15 villages (3 ×15) and 105 non-tubewell owner households in the same villages (7 ×15). In the tubewell owner survey, we collected the information on tubewell investment, the water pricing and marketing information in addition to the non-tubewell household survey, the late includes general household characteristics and the details of household production, assets and others.

## 3 Descriptive analysis: the main characteristics of the sellers

Groundwater markets have emerged for more than ten years in northern China and developed rapidly in the past decade. As we discussed early, by 2004 the number of villages which reported having groundwater markets rose up to 44% and the average share of water sold was 77%[7]. Similar results also found in our survey. In our sample villages where groundwater market exists, the average land area irrigated by purchased water is about 43% of the total land in the village in 2007. The farmers who are purchasing water from groundwater market are about 54% of the total households. Compared to Zhang *et al*.[7], our survey find a slightly higher average share of water for being sold (79%), which may be partially due to the ongoing development of groundwater market between 2004 and 2007.

Previous studies on groundwater market in South Asia have shown that there is no consensus on the relationship between water sellers and the size of farms, our survey also finds a similar result. Table 1 shows that there is no systematic difference in land endowments between two types of households. Although on the average the water sellers have a slight larger farm size than the buyers (row 1 and 2), the difference is not statistically significant. The average number of plot of sellers is also very close to that of buyers (row 3 and 4). The evenly distributed land endowments in China may reflect that the main purpose of investing on water extraction mechanism (WEMS) is more like earning profit from selling water than satisfying their own demand. This is also found in the other study in Bangladesh when a pump owner invests in a tubewell in a part of the village where he may not have any land. He does so solely for the purpose of selling water. Lewis[18] in his study of groundwater markets in rural Bangladesh has categorized shallow tubewell owners

② Due to the stratified random sampling method, we applied a sample weight in both descriptive and econometric analysis. For a buyer, his weight was generated from the number of households he represented, that is, the number of buyers in that village was divided by 7. For a seller, his weight equaled to the number of sellers in that village was divided by 3.

(STW) as predominantly STW farmers if they invested for own use or STW businessmen if they invested for selling water.

**Table 1 Land endowments (hectare) of buyers and sellers in 2004 and 2007**

| | 2007 | 2004 |
|---|---|---|
| Average land area | | |
| Buyers | 0.61 | 0.59 |
| Sellers | 0.68 | 0.67 |
| Average plot number | | |
| Buyers | 4.14 | 4.19 |
| Sellers | 4.25 | 4.21 |

Source: Author's survey of 150 random selected households from three counties in northern China.

Our survey also reveals that there is a strong linkage between non-farm activity and groundwater-participating, which has never been addressed in the literature. The case of China after economic reform seemed give us a good opportunity to test this relationship. In the past 30 years reform, the increase of agricultural productivity has been accompanied with booming of non-farm activity. By 2000, more than 40% of the rural residents had off-farm employment, about 100 million of them—most of them young and headed for new lives in the city—have left home and moved to urban areas for employment[19]. Those who have comparatively advantage in non-farm activity have allocated large part of their time on other business such as wage-earning and self-employment. As for those farmers who have comparative advantage in farm activity, they have allocated relative more of their time in agricultural activities. Since China has experienced significant dropping of water-level in recent years[2,5], the demand for irrigation especially in drought area has given the water seller the opportunity to earn a profit by providing irrigation service, a situation similar to the findings in South Asia[12,20-22].

Our data shows that non-farm employment is strongly and negatively correlated with the participation of groundwater market. Table 2 summarizes the time allocations of the household's head labor of water sellers and buyers. In 2007, water seller spent about 0.84 months on non-farm activity, about a third of buyer's. This relationship is much more significant in Xianxina and Cixian, where the water tables are even lower than Yanjin. Among the three counties, a typical seller in Xianxian spent the least time on non-farm activity, less than a sixth of buyer's. To further demonstrate this pattern, in Table 3, we summarize the income structure of the sellers and buyers. Again, the sellers have demonstrated obvious advantage in farm activity. The sellers have an average of 22% of income from non-farm income, far less than that of buyers. The later have nearly a half of income from non-farm activities. The difference among the three counties is not significant.

**Table 2 Number of months spent on non-farm activity of water buyers and sellers in 2007**

| County | Water buyer | Water seller |
|---|---|---|
| Xianxian | 2.40 | 0.37 |
| Cixian | 2.59 | 0.82 |
| Yanjin | 2.15 | 0.97 |
| Average | 2.40 | 0.84 |

Source: Author's survey of 150 random selected households from three counties in northern China.

**Table 3 Percentage of non-farm income of water buyers and sellers in 2007**

| County | Share of non-farm income/% | |
|---|---|---|
| | Water buyer | Water seller |
| Xianxian | 46 | 19 |
| Cixian | 53 | 35 |
| Yanjin | 45 | 21 |
| Average | 48 | 22 |

Source: Author's survey of 150 random selected households from three counties in northern China, 2007.

Similar to the findings in the previous literature on groundwater market in South Asia[8-15] and China[7], our survey also indicates that the upper-ladder households seemed more likely to be the sellers. The investment on WEM is certainly a risky and expensive activity. The risks come from not only the competitions from other tubewell owners and collective tubewells, but also weather situations (e.g., variations in rainfalls among season and over years). In water-scarce areas, investment on a tubewell needs a lot of money (Fig. 1). In fact, in our sample, there is 74% of WEMS installed by borrowing from other households or banks. The average rate of debt to total cost of these WEMS is 34%. So, it is reasonable that only those comparatively wealthier households can afford to such large amount of investment in WEMS and have ability to manage the market risk of demand-shock come from weather or other WEMS. Table 4 shows the distribution of buyers and sellers by income quintile. As shown in Table 4, the sellers are distributed more towards the higher income quintiles than that of buyers. On average, 60% of the sellers belong to the first two income quintiles (high income and middle-upper income groups, rows 1 and 2, column 2), whereas the corresponding number for the buyers is much lower (35%, rows 1 and 2, column 1). Only 17% of the sellers come from the lowest and middle-lower income groups (rows 4 and 5, column 2), in contrast to a much larger share of sellers coming from these low income groups (30%, rows 4 and 5, column 1).

**Table 4 Distribution of water buyers and sellers by income level**

| Income category | Percentage of farmers by income category/% | |
|---|---|---|
| | Water buyer | Water seller |
| Highest income (top 20%) | 9 | 18 |
| Middle-upper | 26 | 42 |
| Middle income | 36 | 22 |
| Middle-lower | 22 | 13 |
| Lowest (bottom 20%) | 8 | 4 |

Source: Author's survey of 150 random selected households from three counties in northern China.

There are also several other important factors may contribute to the participation in groundwater-market. A few studies on South Asia analyzed the impacts of transaction costs and social structure to the exchange behavior of groundwater market. For example, using the example of groundwater market in a village of north-east Bihar, India, Wood[23] demonstrated the importance of trust, rules of morality and good relationships in a community. In China, many interviewees had the experience of dispute on the sequence of irrigation in the major seasons and there were even fights cases in some villages before they participated in groundwater market. Our data shows there are

72% of the farmers had experienced the dispute with others before they participated in groundwater market (Table 5, row 3). The percentage of buyers experienced dispute is obviously higher than the sellers' (Table 5, rows 1 and 2, column 1). This indicates that the lower transaction costs may contribute to the investment decision of farmers. The sellers also have wider social network than the buyers. We use the number of guests attending recent ceremony (mainly wedding) as an index of social network. In rural China, farmers normally invite their relatives, friends to attend their ceremony when they or their kids get married. Larger number of guests indicated the farmer has a wilder social network. According to our data set, the social network of a typical seller is about 20% higher than a typical buyer (Table 5, row 1 and 2, column 2).

**Table 5 Transaction costs and social network of groundwater buyers and sellers**

| | Percent of households which experienced disputes before participated in water market/% | Number of guests attended the most recent ceremony |
|---|---|---|
| Buyer | 75 | 103 |
| Seller | 63 | 121 |
| Average | 72 | 109 |

Source: Author's survey of 150 random selected households from three counties in northern China.

Descriptive statistics in this section indicate that those farmers who have relatively less advantage in non-farm activities, more wealth and larger social capital are more likely to become the sellers in the groundwater market. Expectation on transaction costs generated from previous experience may also contribute to the probability of being a groundwater seller. As the decisions to participate in water market are simultaneously determined by several factors, a multivariate regression analysis is needed to identify the impact of each factor.

## 4 Econometric analysis

In this section we conduct econometric analysis on the determinants of groundwater market participation using the household data collected in this study. Based on the discussions above, a general form of water market participation can be specified as:

$$S = f(N, W, T, S, L, O)$$

where, the dependent variable, $S$, represents whether or not a farmer is a groundwater seller. If the household sells water in the market, than $S$ equals to 1, otherwise it equals to 0. $N$ represents the farmer's comparative advantage in non-farm activity, we define it by the share of non-farm income to the household's total income in 2007. $W$ is a series of dummy variables for the categority of household's income (high income, middle-upper income, middle income and middle-lower income, the omitted group is the lowest income) when he/she participated in water market. For example, if a household belongs to the highest income group (or top 20% group) in the village, then the variable 'high income' equals to 1 and other variables equals to zero. $T$ represents the transaction costs faced by a household during the process of irrigation. It is defined by a dummy variable with a value of 1 if the household had experienced any dispute in the process of irrigation

before participated in water market, otherwise it equals to 0. $S$ represents the social capital of the farmer. It is defined by the number of guests who attended the household 's the most recent ceremony. The larger number implicates the household has a wider social network. $L$ represents the land endowments of the farmer. We defined it using the cultivated land area and the number of plots of the household in 2007. $O$ represents the other characteristics, such as age and education of the head labor of the household, which may have impacts on the farmer 's investment decision.

We adopt two econometric methods to estimate four models. Models 1 and 2 are estimated by OLS with and without village dummies. The village dummies are used to control the fixed effect that can 't be observed in our data. Models 3 and 4 are estimated by probit with and without village dummies. The estimated results are shown in Table 6.

All the models have very similar results. This indicates a robust estimation of our models. In models 3 and 4, we provide the marginal effects of each variable rather than coefficients. In the following discussions, we discuss the general results from all models with specifically focus on the results from model 3 as it performs better and has the highest $R^2$.

The variable of comparative advantage in non-farm activity has the expected signs (rows 1 to 2) and large marginal effects in all the four models. Income share of non-farm activity has a large and significantly negative effect on the probability of selling water. For example, according to model 3, a farmer whose income totally comes from farm activity has 12.5% higher probability than the one who has no agricultural income.

Wealth or income category also has large and significant impact on selling water. All the four variables have positive signs in each model. That is to say, compared to the lowest income group, wealthier farmers are more likely to be a water seller. The richer the farmer is, the larger the probability of being a seller is. A typical richest 20% farmer has 58.5% higher probability compared to a typical poorest 20% farmer. The typical middle-upper farmer has a 23.8% higher probability than the poorest farmer. As to middle and middle-lower income farmer, although the effects are positive, they are not significant.

It seemed that land endowments have no significant effects on selling water. The coefficients of land area and plot number are small and insignificant from zero in all the four models estimated (Table 6). This is largely due to equal land distribution policy implemented in China.

It is surprising that the effect of social capital is insignificant though it has the expected sign. This may be due to the high collinearity between number of guests attending ceremony and income category. Actually, after dropped the variable of income category, the coefficient of number of guests attending ceremony becomes significant.

The expectation on transaction costs also has large effects on the probability of being water seller. The farmers who experienced dispute in the process of irrigation have a 12.6% lower probability than those who did not experienced the dispute. The coefficient is highly significant in all four models.

In sum, the above analyses show that the rich farmers and farmers with comparative advantage in agriculture are more likely to be the water sellers. Transaction costs also have significant imapct on the probability to be water seller.

**Table 6 Estimated parameters of determinants of being a water seller**

| | Water seller | | | |
|---|---|---|---|---|
| | OLS(1) | OLS(2) | Probit(3) | Probit(4) |
| Advantage in non-farm activity | | | | |
| Share of non-farm income | - 0.241 | - 0.313 | - 0.125 | - 0.245 |
| | ( - 3.21) *** | ( - 3.56) *** | ( - 3.89) *** | ( - 4.55) *** |
| Income level in the village | | | | |
| High income | 0.316 | 0.274 | 0.585 | 0.468 |
| | (2.28) ** | (1.90) * | (3.29) *** | (2.11) ** |
| Middle-upper income | 0.27 | 0.296 | 0.238 | 0.37 |
| | (2.50) ** | (2.28) ** | (2.98) *** | (2.56) ** |
| Middle income | 0.171 | 0.161 | 0.061 | 0.131 |
| | (1.66) * | 1.37 | 1.47 | 1.31 |
| Middle-lower income | 0.168 | 0.21 | 0.082 | 0.247 |
| | 1.65 | (1.79) * | 1.43 | (1.66) * |
| Land endowments | | | | |
| Land area | - 0.003 | - 0.004 | - 0.004 | - 0.002 |
| | - 1.13 | - 1.33 | - 0.19 | - 1.02 |
| Plot number | 0.001 | - 0.011 | 0.005 | - 0.011 |
| | 0.1 | - 0.74 | 0.05 | 1.01 |
| Social capital | | | | |
| Number of guests in ceremony | 0.000 1 | 0.000 1 | 0.000 1 | 0.000 1 |
| | 0.84 | 0.98 | 0.66 | 1.18 |
| Transaction costs | | | | |
| Previous experience of dispute | - 0.158 | - 0.196 | - 0.126 | - 0.190 |
| | ( - 2.45) ** | ( - 2.82) *** | ( - 3.46) *** | ( - 3.56) *** |
| Other household characteristics | | | | |
| Age of head labor | 0 | - 0.003 | 0.000 4 | - 0.001 |
| | - 0.01 | - 1.19 | 0.5 | - 0.86 |
| Education of head labor | 0 | 0.002 | - 0.001 | - 0.000 3 |
| | - 0.04 | 0.38 | - 0.18 | - 0.05 |
| Village dummy | YES | NO | YES | NO |
| Constant | 0.063 | 0.371 | - 2.449 | - 0.112 |
| | - 0.33 | (2.18) ** | ( - 2.18) ** | - 0.11 |
| Observation | 150 | 150 | 150 | 150 |
| $R^2$ | 0.31 | 0.19 | 0.43 | 0.26 |

Note: Coefficients are marginal effect, absolute value of $t$ (in OLS) and $z$ (in Probit) statistics in parentheses; * significant at 10%; ** significant at 5%; *** significant at 1%.

## 5 Conclusion

This paper seeks to understand the political-economic implications of groundwater market in China. Using primary data at village, household and tubewell owner level, we identified the determinants of participation in groundwater markets in rural China. Combined with previous study on Chinese groundwater market, the paper allows us to understand the characteristics of Chinese

groundwater markets in greater details.

With the rising scarcity of water and booming of private tubewell, the irrigation demand has brought a huge opportunity for farmers to participate the groundwater market. The wealthier households who have significant advantage in agricultural activity are inclined to be the supply side of the market in the form of water sellers. There is weak evidence that the sellers usually have comparatively larger social capital than the other households. Transaction costs may also affect participation of groundwater market. There is no significant evidence that participation in groundwater market is correlated with the land holding of the farmers, so the main purpose of investment in tubewell is profit from water selling rather than for self-use. This is specially true in water scarce counties like Xianxian.

There are some important policy implications of this study: As an important production resource in rural area, water has been transacted between rural households. However, the availability of water is not equal among different farmers. Providing a part of public funds to help the poor in severely water-scarce areas to invest in tubewells and participate in groundwater market, could be a good way of shielding them from production shocks. Lowering entry barrier to groundwater market through easier credit availability may also pull down the water price on account of more competitive market and this will also benefit the poor buyers.

**References:**


[1] Ministry of Water Resources. China Water Resources Bulletin[Z]. 2003.

[2] Wang J, Huang J, Huang Q, Rozelle, S. Privatization of tubewells in North China: Determinants and impacts on irrigated area, productivity and the water table[J]. *Hydrogeology Journal*, 2006, 14: 275 - 285.

[3] Ministry of Water Resources and Nanjing Water Institute. Groundwater Exploitation and Utilization in the Early 21st Century [M]. Beijing: China Water Resources and Hydropower Publishing House, 2004.

[4] Wang J, Huang J, Rozelle S, *et al*. Agriculture and groundwater development in northern China: Trends, institutional responses, and policy options[J]. *Water Policy*, 2007, (Supp. 1): 61 - 74.

[5] Wang J, Huang J, Rozelle S. Evolution of tubewell ownership and production in the North China plain[J]. *Australian Journal of Agricultural and Resource Economics*, 2005, 49(2): 177 - 196.

[6] Sharma P, Sharma R. Groundwater markets across climatic zones: A comparative study of arid and semi-arid zones of Rajasthan[J]. *India Journal of Agricultural Economics*, 2004, 59(1): 138 - 150.

[7] Zhang L, Wang J, Huang J, *et al*. Development of groundwater markets in China: A glimpse into progress[J]. *World Development*, 2008, 36(4): 706 - 726.

[8] Meinzen-Dick R, Sullins M. Water Markets in Pakistan: Participation and Productivity[R]. EPTD Discussion Paper No. 4. IFPRI Washington, D. C., 1994.

[9] Kajisa K, Sakurai T. Efficiency and equity in groundwater markets: The case of Madhya Pradesh, India[J]. *Environment and Development Economics*, 2005, 10: 801 - 819.

[10] Fujita K, Hossain F. Role of the groundwater market in agricultural development and income distribution: A case study in a Northwest Banglandesh Village[J]. *The Developing Economies*, 1995, 33(4): 442 - 463.

[11] Dubash N K. Ecologically and socially embedded exchange: Gujarat model of water markets[J]. *Economic and Political Weekly*, 2000, 35(16): 1376 - 1385.

[12] Jacoby H, Murgai R, Rehman S. Monopoly power and distribution in framented markets: The case of groundwater[J]. *Review of Economic Studies*, 2004, 71: 783 - 808.

[13] Pant N. Control of and access to groundwater in UP[J]. *Economic and Political Weekly*, 2005, 25: 2672 - 2680.

[14] Steinmetz A. Three Essays on Groundwater and Tenancy Contracts in Rural Economies[D]. PhD thesis. Ruprecht Karls

University, Heidelberg, Germany. 2003.

[15] Palmer-Jones R. Irrigation service markets in Bangladesh: Private provision of local public goods and community regulation [R]. Paper presented at Symposium and workshop on: Managing Common Resources-What is the solution? Held at Lund University, Sweden, September, 10 - 11, 2001. http://www.sasnet.lu.se/palmer_jones.pdf

[16] Ballabh V, Choudhary K, Pandey S, *et al* Groundwater development and agricultural production: A comparative study of eastern Uttar Pradesh, Bihar and West Bengal[R]. Paper submitted to IWMI-Tata Water Policy Programme, Anand, Gujarat, 2002.

[17] Shah T, Singh O, Mukherji A. Some aspects of South Asia's groundwater irrigation economy: Analyses from a survey in India, Pakistan, Nepal Terai and Bangladesh[J]. *Hydrogeology Journal*, 2006, 14: 286 - 309.

[18] Lewis D. Technologies and Transactions: A Study of the Interaction Between New Technology and Agrarian Structure in Bangladesh[D]. PhD thesis University of Bath, 1989.

[19] de Brauw A, Huang J, Rozelle S, *et al* China's rural labor markets[J]. *China Business Review*, 2002, March-April: 2 - 8.

[20] Shah T. Groundwater Markets and Irrigation Development: Political Economy and Practical Policy[M]. Oxford University Press, Bombay, 1993.

[21] Meinzen-Dick R. Groundwater markets in Pakistan: Participation and productivity[R]. Research Reports 105, International Food Policy Research Institute, Washington, D. C., 1996.

[22] Mukherji A. Groundwater markets in Ganga-Meghna-Brahmaputra Basin: Theory and evidence[J]. *Economic and Political Weekly*, 2004, 31: 3514 - 3520.

[23] Wood G. Private provision after public neglect: Bending irrigation markets in North Bihar[J]. *Development and Change*, 1999, 30(4): 775 - 794.

# 地下水市场的参与:谁是卖水者?

米建伟[1], 黄季焜[1], 王金霞[1], Aditi Mukherji[2]

(1. 中国科学院 地理科学与资源研究所 农业政策研究中心, 北京 100101;
2. International Water Management Institute, Battaramulla, Sri Lanka)

**摘要**: 尽管中国农村的地下水市场在最近 10多年来得到了快速发展,然而相关的研究文献却凤毛麟角。通过使用来自于中国北方两省 150个农户的微观调查数据,论文描述了中国农村地下水市场参与者的主要特征,并分析了影响农户卖水行为的主要因素。研究发现:那些相对富裕的、在农业活动中具有比较优势的、在本地拥有较高社会地位的农户更有可能成为地下水市场中的卖方,而交易成本的大小也会影响到农户对于地下水市场的参与。

**关键词**: 水资源; 地下水市场; 参与者; 决定因素