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DEVELOPMENT AND ACCESSIBILITY OF GROUNDWATER RESOURCES IN HARYANA

Doctoral Dissertation Abstract (2019)

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Groundwater has emerged as a key resource input in India's agriculture and food security in recent years. Over the past three decades, it has become the main factor of growth in irrigated areas. At present tubewells account for over 60 per cent irrigated area in India. With the advent of Green Revolution technology in farming followed by the adoption of modern water extraction mechanisms, there has been a spurt in the rate of extraction of groundwater to meet agricultural needs. However, such rapid development of the resource along with lack of well-defined property rights has made it vulnerable to overexploitation. The state of Haryana has also passed through similar experiences. It is mostly a semi-arid region with limited rainfall ranging from 300 mm in the south-west to 1100 mm in the north-east. Currently, about 85 per cent of total cultivated area in the state is irrigated. The rapid expansion of groundwater use has been a major factor contributing to the increase in irrigated area. The ready availability of this irrigation source continued to enhance the intensive cultivation of water intensive crops on an extensive scale notwithstanding the hydro-geological thresholds of this resource. Intensification of groundwater exploitation and fall of water tables have reduced access to groundwater irrigation to a large number of small and marginal farmers who can neither use traditional techniques nor are able to use new technology so as to pump out water economically. Despite its huge significance and importance, groundwater irrigation is heading for a crisis and needs urgent attention and understanding.

The present study covers various aspects of groundwater resources in Haryana ranging from its availability to accessibility and utilization for irrigation. The study also examines issues related to groundwater depletion and its quality for agricultural usages in different regimes of groundwater availability. Further, the study provides insight into inequality in groundwater access across the regimes as well as land holding size of farmers. Lastly, the study evaluates the structure and role of groundwater markets in accessibility of groundwater resources in different groundwater availability regimes.

Database and Methodology

The study utilizes both primary and secondary sources of data. Primary data have been derived through survey of selected households from different groundwater availability regimes in Haryana. To begin with the state is divided into three groundwater availability regimes. Secondary data have been

collected from Central Ground Water Board, northwestern region, Chandigarh and Statistical Abstracts of Haryana on various parameters related to groundwater. Trend graph and choropleth technique have been used to depict the temporal and spatial variations in level of irrigation and groundwater development. The spatial and temporal variation in groundwater table depth and change in depth have been portrayed using interpolation mapping technique. Various indices have been utilized to show the dynamics of groundwater in Haryana. The suitability of groundwater for irrigation purposes have been analyzed across different regimes of groundwater availability with the help of electrical conductivity, sodium absorption ratio (SAR), percent sodium, residual of sodium carbonate, permeability index. Salinity and alkalinity hazards of groundwater have been depicted with the help of US salinity hazard diagrams. Wilcox diagram has been prepared to see the suitability of groundwater for irrigation purposes. Piper diagram has been constructed to plot the parameters of physico-chemical data of groundwater and for depicting different hydro-geochemical facies. Gibbs diagram has been prepared to depict controlling mechanism of groundwater chemistry. Physical and economic accessibility of groundwater has been evaluated to measure inequity in access to groundwater across the farm size classes and different regimes of groundwater availability. To analyze the influence of various parameters on physical and economic accessibility of groundwater, stepwise regression analysis has been carried out. Agricultural efficiency of groundwater irrigation has been measured in terms of land productivity and water productivity. Breadth and depth of groundwater markets have been calculated across different regimes of groundwater availability to evaluate the role of groundwater markets for reducing the inequality in access of groundwater.

Major Findings of the Study

It has been noted that the state has experienced a phenomenal rise in area under irrigation since inception of Green Revolution. But since 2000, there has been no significant horizontal expansion in area under irrigation. Northeastern part of the state is almost fully irrigated. On the other hand in some southwestern districts like Bhiwani and Mahendergarh, there have been decline in proportion of irrigated area. The level of irrigation tends to be higher in the regimes of better groundwater availability. HGAR (High Groundwater Availability Regime) has highest proportion of irrigated area followed by MGAR (Moderate Groundwater Availability Regime) and LGAR (Low Groundwater Availability Regime). HGAR has also recorded highest increase in level of irrigation over the time period of 1990-93 to 2012-15. During first one and a half decade of 21st century, there has been a tremendous increase in vertical expansion of irrigated area. Most of the districts in the state have high intensity of irrigation. There is very high intensity of irrigation recorded in norteastern parts of the state along with Jind district in northcentral parts and Faridabad district in extreme southeastern parts. It reveals that by and large the irrigation sources in the state are being harnessed very intensively.

Canal and tubewells are two dominant sources of irrigation in Haryana. From mid-1980 to the end of 20th century both sources of irrigation have had almost equal share in irrigated area. However, since the beginning of 21st century, tubewell have emerged as a dominant source of irrigation and the share of canal irrigation has continuously declined. It may be attributed to increasing physical and economic accessibility of groundwater to the farmers.

Groundwater irrigation has played a vital role in agricultural development of Haryana. But it has led to overexploitation of groundwater resources at a very large scale. This is despite the fact that over the period of 1995 to 2013, the groundwater availability in the state has increased by 35 per cent. Alluvial plain in the state particularly in northeastern part is rich in terms of groundwater endowment. However, Aravalli region in south and southwestern region has had poor availability of groundwater. Interestingly, over the last two decades since mid-1990s gross draft of water has increased at a faster rate in low tubewell intensity areas in western Haryana. The intensity of groundwater draft is already very high in intensively tubewell irrigated area in northeastern plain. There is a widespread overexploitation of groundwater in the state as in 86 per cent of area; water draft exceeds the annual recharge. Persistent overexploitation of groundwater resources has culminated in depletion of this precious resource in large parts of the state. About 53 per cent area of the state has experienced decline in water table. On the other hand in about two-fifth area of the state, particularly in the belt running from Rohtak-Bahadurgarh-Gohana area to Hisar and Sirsa, water table has come up resulting in twin environmental problem of waterlogging and soil salinity. The rise in the water table in the mid belt may be attributed to poor horizontal and vertical drainage, intensive canal irrigation and inability of the farmers to go for conjunctive irrigation due to saline and poor quality of groundwater.

Groundwater depletion and deterioration of its quality are the major environmental issues in tubewell irrigated areas. The intensification of cropping and expansion of rice-wheat crop combination have led to excessive mining of groundwater and deterioration of groundwater quality. The study brings out that groundwater quality in the state is largely controlled by evaporation processes in LGAR and MGAR, while it is controlled by lithology in HGAR. There has been an improvement in EC (salinity condition) of groundwater in MGAR and HGAR. But LGAR, which is marred by scarcity of groundwater has experienced deterioration in groundwater quality during last two decades. Chloride concentration has improved in regions with better groundwater regimes and deteriorated in LGAR. RSC based unsuitability of groundwater has increased sharply. The unsuitability of groundwater in terms of RSC has increased in HGAR which means that RSC has increased in purely tubewell irrigated areas. However, in MGAR conjunctive use of canal and groundwater may have prevented deterioration of groundwater quality. The soil permeability seems to have slightly declined over two decades in MGAR and HGAR due to excessive irrigation as well as clay loamy soils. Overall, over last two decades in the state there has been a slight decline in percentage of observation wells having good quality irrigation water. But groundwater quality in the state has deteriorated, particularly in groundwater scarcity regime (LGAR).

Depletion in groundwater resources have led to unequal access to groundwater. Inequity in access to groundwater is a great concern as it affects farmers' income. In India, shrinkage of landholding size and inequality in land distribution are big factors in access to groundwater resources as water rights are tied to landownership and Haryana is no exception. Inequality in the tubewell ownership is strongly influenced by the size of landholding of farmers and availability of groundwater resources. Groundwater extraction ratio is higher in the areas having better availability of groundwater. It is about four times higher in HGAR than LGAR.

There is a huge difference in physical accessibility of groundwater across the groundwater availability regimes. The farmers in HGAR on an average access about 6 times more water than LGAR. Regression analysis reveals that cost of irrigation, depth to water level and fragmentation of land holdings have negative influence but farm size has positive influence on physical access to groundwater. There is a gross inequality in economic access to groundwater both across groundwater availability regimes and class size of farms. Economic accessibility of groundwater by an average farmer in HGAR is about 27 times more than that of in LGAR. Such a difference in economic accessibility of groundwater may cause gross societal and regional disparity. There is a huge gap in level of agricultural productivity between high and low groundwater availability regimes in Haryana. Decline in land productivity from HGAR to LGAR indicates that availability of groundwater is directly related to land productivity. Water productivity (agricultural output per unit volume of irrigation water) is highest in water scarcity zone LGAR followed by MGAR and least in HGAR. The farmers of LGAR experienced three times more per water drop fall in agricultural productivity than the farmers of HGAR.

The institution of groundwater markets has stepped in to mitigate growing inequalities in groundwater accessibility, particularly in soil moisture deficit areas. It is evident that about two-fifth farmers in the state participate in groundwater markets. The size of groundwater markets is largest in LGAR and it decreases with the increasing availability of groundwater. The proportion of self-user farmers is higher in area having better availability of groundwater. The participation of farmers in groundwater markets decreases with increase in landholding size. A small proportion of large and middle farmers buy water and it occurs due to fragmented landholdings. It is only about 13 per cent irrigated area of all sample farmers that is irrigated by groundwater markets. As expected, LGAR has most extensive groundwater markets followed by MGAR and HGAR. But the depth of purchased water is highest in HGAR followed by MGAR and LGAR. In case of non-tubewell owners too, the main reason for participation in water markets is fragmentation of land holdings followed by incapability for installation of tubewell. Crop share contract is found to be most common mechanism of water transaction in groundwater markets followed by hourly cash contract. In water scarce regime (LGAR), most of transactions in groundwater, markets are done in the form of crop sharing contracts. This is similar mechanism of risk transfer as in the case of crop-sharing tenancy. In MGAR where there is no scarcity of groundwater all transactions for getting water are done on hourly cash contract basis. In areas of HGAR where there is ample availability of groundwater, most of the farmers have their own tubewells, hence there is no water market as such. However, water requirements at different locations in case of fragmented land holdings are met by mutual exchange of ground water between the farmers.

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