

GROUNDWATER IRRIGATION ECONOMY OF HARYANA: A GLIMPSE INTO SPREAD, EXTENT AND ISSUES

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ABSTRACT

Since the inception of Green Revolution in India, Haryana has emerged as one of the major users of groundwater in irrigation sector. Irrigation supplied by groundwater played a vital role in agricultural transformation, food security and livelihoods of the country in general and of the State in particular. However, very limited research on groundwater irrigation economy of Haryana has been conducted till now. Therefore, the present study based on both primary and secondary data has been conducted to highlight the various facets of groundwater economy in agriculture dominated State of Haryana. The obtained results indicate that the density of tube wells per thousand hectares and number has increased by more than 250 and 300 per cent, respectively, during 1975 to 2013. The area under hired irrigation through tube wells is also increasing. In spite of remarkable increase in number of commercial and cooperative banks in the State, they account for only about 15 per cent of the total loans disbursed for tube well installation. Bulk of tube wells (70 per cent) are owned by small farmers and it is contrary to the belief that the benefit of electricity subsidy goes only to large farmers who are most likely to have large number of own electric tube wells. Finally, the findings of the study reflect that the groundwater irrigation economy in Haryana is in growth phase and it is important to understand fully the dynamics of this economy before the managers and policy makers may begin to think about effectively managing it.

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Introduction

Groundwater is generally considered to be the most productive irrigation source due to its reliability of supply and availability on demand. The use of groundwater for irrigated agriculture in rural India has a long history. However, the area of irrigated crop land using groundwater has expanded rapidly with diffusion of Green Revolution technology in India. Irrigation from groundwater grew by a factor of over four during 1960-1999 period and currently represents over half of the country's irrigated area (Dubash, 2000; Scott and Sharma, 2009). Introduction of modern drilling techniques, electric operated pumping systems, availability of electricity at nominal or no price and absence of effective groundwater legislation had promoted uncontrolled use of groundwater in the country (Patle et al., 2015). Furthermore, there are about 82 million farm households in India, out of which 21 million households have their own water extraction mechanisms (WEMs), while another 24 million employed hiring of irrigation services from others (Mukherji, 2007). Apart from this, rapid development of groundwater resources is becoming a major concern in the western Indus-Ganges Basin (Pakistan and the Indian States of Punjab, Haryana and Uttar Pradesh), as it has led to decline in groundwater levels. This decline in groundwater levels has, in turn, led to drying up of dug wells and increasing well failures causing higher costs of installing new tube wells, deepening of existing wells and maintenance activities (Moench, 1992). Competitive deepening of wells makes the distribution of access to groundwater increasingly skewed in

favour of large and resource-rich farmers, leaving the resource out of reach for the poor farmers (Shah, 1993; Saleth, 1996). Under this scenario, groundwater markets have emerged as an alternative water management strategy for making equitable and efficient use of scarce water resources (Shah, 1993).

Since the emergence of pumped groundwater irrigation, localised informal sale and purchase of groundwater, extracted through WEMs, has evolved as agrarian institution globally, particularly in India (Mukherji, 2007; 2008). This informal sale and purchase of groundwater, extracted through WEMs, is henceforth referred as "groundwater markets" for the sake of brevity and convenience. However, informal groundwater markets in India are quite different from the formal groundwater markets found in parts of USA, Australia and Chile (Bjornlund and McKay, 2002). Recently, such informal trading in groundwater has also started to emerge in China, as a result of privatisation of erstwhile village community-owned wells and tube wells (Zhang et al., 2008). A large body of literature both in water-scarce regions as well as in water-abundant areas exists that discusses various dimensions of groundwater markets, such as their informal, localised and fragmented nature, on the one hand and their spread, extent, mode of functioning and the impact they have on agrarian economy, on the other hand (Shah, 1993; Shah and Ballabh, 1997; Singh, 2002; Sharma and Sharma, 2004; Prakash, 2005; Mukherji, 2006, 2007, 2008; Shah et al., 2006; Dubey and Rai, 2008; Scott and Sharma, 2009). These studies have a limited spatial coverage, covering a few

villages and hence fail to generate a macro picture of spread and extent of the groundwater markets at regional, national and global scale.

Among the Indian States, Haryana, located in north-western part of the country, is basically an agricultural State and groundwater plays an important role in the economic development and ecological balance of the State. Therefore, the State has seen tremendous increase in groundwater use for agriculture in the past few decades (Bhalla, 2007; Hira, 2009). Haryana State with only 1.4 per cent of the total geographical area of the country is contributing about 7 per cent of the India's food production. Irrigation supplied by groundwater, played a vital role in agricultural transformation of the State. Net irrigated area in Haryana increased from 1.2 million ha in 1966-67 to 3.1 million ha in 2012-13 of which the share of groundwater has increased from 0.6 million ha to 1.7 million ha. During the same time period, area under surface water irrigation (canals) increased from 0.9 million ha to 1.3 million ha. In fact, over the years, area under groundwater irrigation has grown steadily, while the area under surface water irrigation has either stagnated or even declined (Figure 1). Similarly, the share of tube well irrigated area to the total irrigated area increased

from 38.9 per cent in 1975-76 to 61.2 per cent in 2011-12 (Singh and Amrita, 2015) leading to more agricultural output than that from all other sources of irrigation put together in the State. Apart from this, the number of tube wells in the State has increased from 0.02 million in 1966 to 0.73 million in 2012. This expansion of groundwater for irrigational use at such an alarming level led to sharp depletion of the resource and compels the farmers to shift their shallow tube wells into deep tube wells (Chawla et al., 2010). However, many farmers are not able to invest for the installation of deep tube wells as it necessitates big investment and, therefore, buy water from other farmers. This kind of informal groundwater markets have become a feature of State's agriculture economy. In spite of various insightful studies on groundwater markets globally as well as in India, very limited research on groundwater irrigation economy in Haryana has been conducted until now. Therefore, to fill the research gap, the present study has been undertaken to highlight the various characteristics of groundwater economy in agriculture dominated State of Haryana for a better understanding of sustainability of groundwater resources, leading to food security of the country in general and of the State of Haryana in particular.

Figure 1: Growth of Net Irrigated Area in Haryana During 1966-67 and 2012-13

Study Area

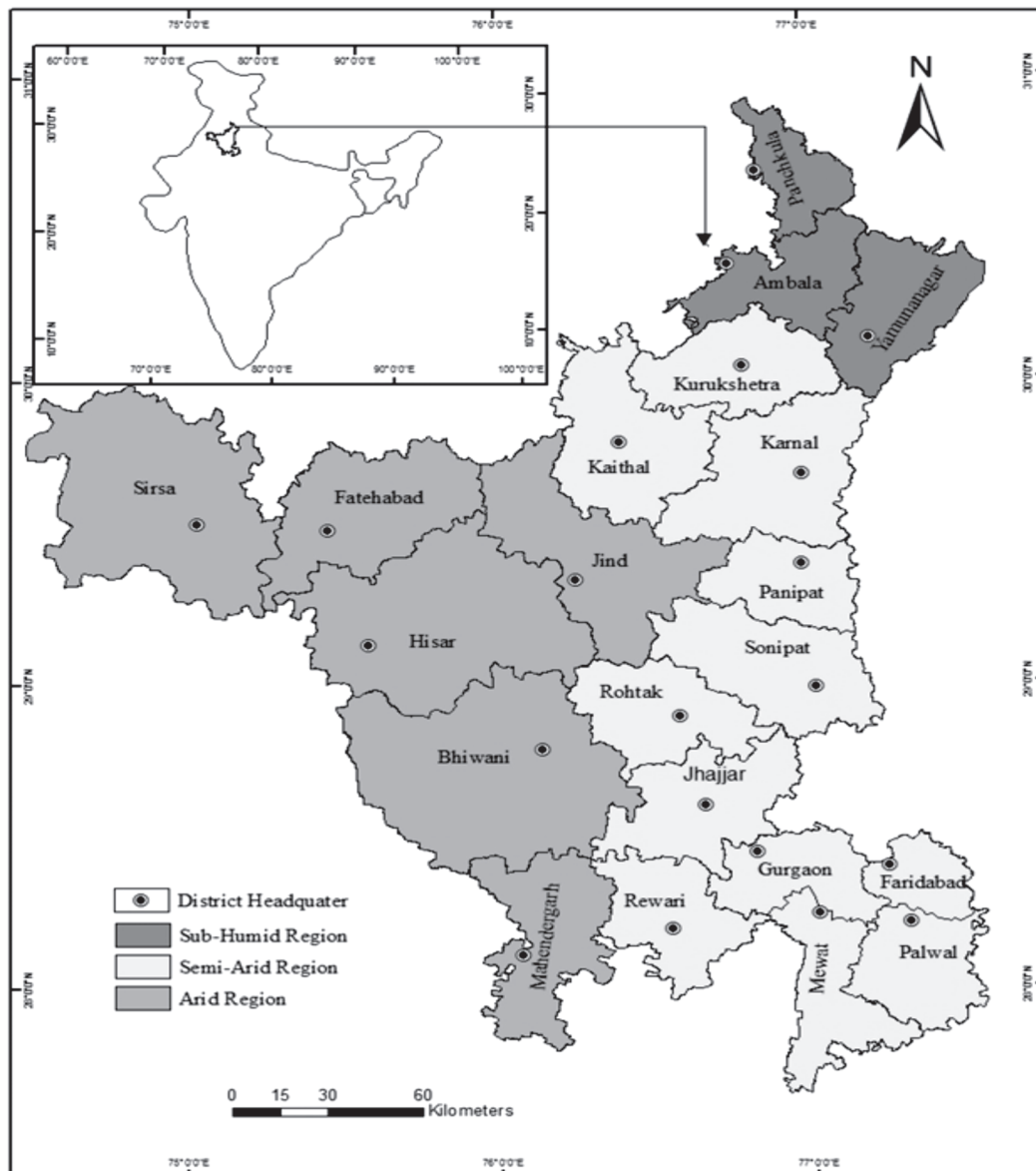
The study area is the State of Haryana in north-western India, which extends between latitudes $27^{\circ}39'$ and $30^{\circ}55'$ N and longitudes $74^{\circ}28'$ and $77^{\circ}36'$ E (Figure 2). The State covers a geographical area of about 44212 km² accounting about 1.4 per cent of the total area of the country. Administratively, it comprises 21 districts and 118 Community Development (CD) blocks. Physically, the State falls into three broad divisions namely, the Sub-Himalayan Tract, Indo-Gangetic Plain and Out-liers of Aravali Hills. The

general slope of the ground is from north to south but the slopes become reverse further south and south-west due to presence of subdued ranges of the Aravalis. The soil texture of the State comprised 55 per cent sandy loam, 30 per cent loamy sand, 10 per cent loamy and 5 per cent sandy, which are generally favourable for a variety of crops such as rice, maize, jowar and sugarcane during kharif and wheat, barley and mustard during the rabi seasons. The climate is arid to semi-arid with an annual average rainfall of 455 mm. Around 80 per cent of rainfall is received

during June to September, while the remaining is received during winter period from December to February. The western Yamuna canal and Bhakra canal system are the main surface

irrigation systems, providing irrigation to crops. Apart from this, the State has an extensive minor irrigation system in the form of tube wells exploiting large quantities of groundwater.

Figure 2: The Geographic Location of the Study Area with Districts and Climatic Zones



Methodology

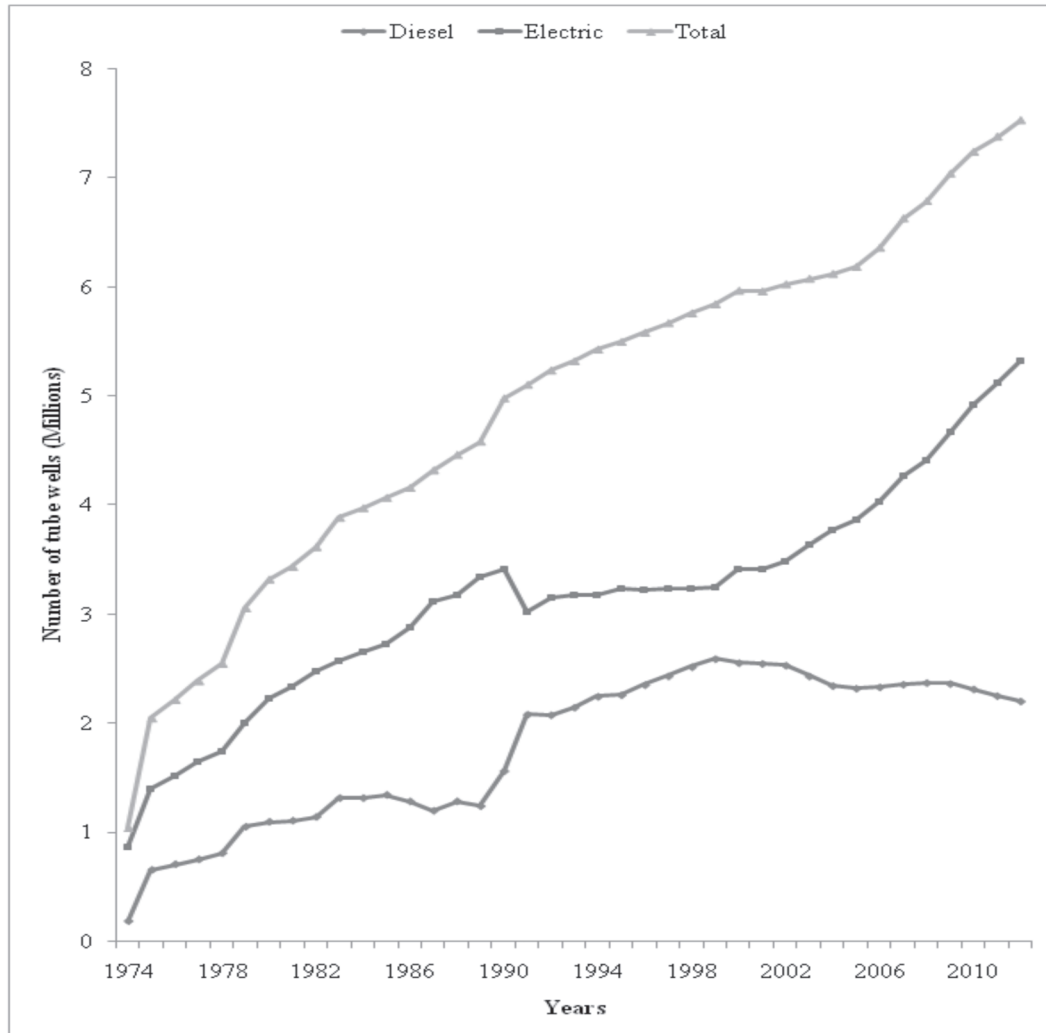
The present study is based on both primary and secondary data. The primary data were collected through a questionnaire survey of randomly selected 360 farmers across Haryana to get the details about different sources of financing used for the installation of their tube wells. The secondary data for the study were collected from various published reports of government and non-government organisations and the records of the Directorate of Economics and Statistics, Ministry of Agriculture, New Delhi and Department of Economic and Statistical Analysis, Haryana. These records highlight the cost of crop cultivation including irrigation for different crops grown, yield of crops, number of tube well owners, etc. These data are the only reliable official sources pertaining to groundwater economy for the State of Haryana. The data, thus, generated were analysed by means of standard mathematical and statistical tools. Furthermore, number and density of tube wells, area under hired and owned irrigation, farmers with owned and hired irrigation, different crops grown and their yield through owned and hired irrigation were made for every district, region and category of farmers classified according to the size of their landholdings. Farmers were classified as small (up to 2 hectares), medium (2-4 hectares) and large (4 hectares or more) (Singh and Singh, 2015). For computing regional variations, the 21 districts of Haryana have been divided into three regions such as sub-humid (Ambala, Panchkula and Yamunanagar), semi-arid (Faridabad, Gurgaon, Jhajjar, Kaithal, Karnal, Kurukshetra, Mewat, Palwal, Panipat, Rewari, Rohtak and Sonipat), and arid

(Bhiwani, Fatehabad, Hisar, Jind, Mahendergarh and Sirsa) (Raju et al., 2013).

Results and Discussion

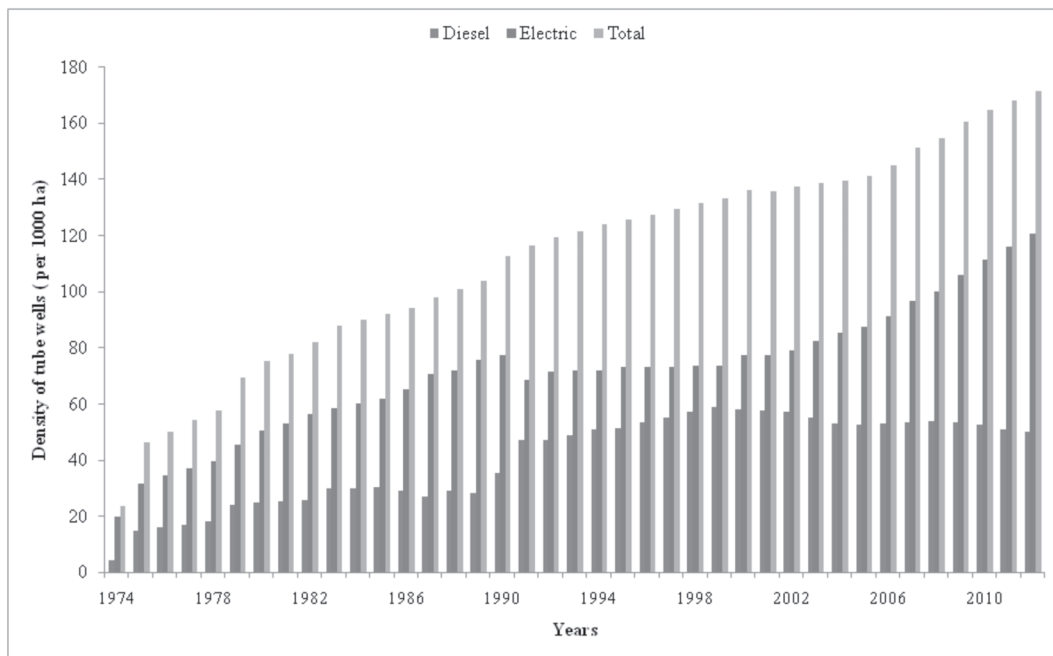
Historical Development of Tube Well Irrigation:

The utilisation of groundwater for irrigation has a long history in Haryana. The first phase covers the period up to 1970, when the traditional sources of irrigation continued to be significant. Groundwater withdrawal by means of Persian wheels from the dug wells accounted for about 25 per cent of the net irrigated area. Next phase includes the period of 1970-90, when dependency on dug wells declined rapidly and the area irrigated through tube wells has increased from 34 to 48 per cent, registering a growth of 132.4 per cent. This tremendous growth in tube well irrigated area in the State can be attributed to declining discharges in canals, on the one hand and increasing demand for timely and adequate amount of water due to introduction of package technology and greater productivity of crops, on the other hand. This compelled farmers to install their own tube wells during this phase. By the turn of century, tube well irrigated area toppled the canal irrigated area, dominant mode of irrigation till 2000 (Figure 1). Apart from this, policy of the government such as cost-effectiveness of electric tube wells, free boring scheme and flat tariff rates encouraged the rapid growth of tube wells in the State (Figure 3). Further, installation cost of tube wells encouraged the farmers to operate their tube wells at a high level of capacity utilisation by supplying irrigation water to other farmers. Thus arose a new institution of tube well irrigation markets or groundwater markets in the State.

Figure 3: Growth of Tube Wells in the State of Haryana During 1974-75 and 2012-13

Number and Density of Tube Wells: The number of tube wells (electric and diesel) has increased by more than 300 per cent during the period 1974-75 to 2012-13, while the density per thousand hectares during the same period has increased from 46 to 170 (Figure 4). This tremendous growth in tube well number and density clearly demonstrates the increasing

role of groundwater in the development of irrigated agriculture. Apart from this, the density of electric-operated tube wells in the State has increased continuously as a result of higher demand. Indeed, this reflects the impact of State government's concerted efforts such as flat tariff rates of electricity after economic liberalisation.

Figure 4: Density of Tube Wells in Haryana During 1974-75 and 2012-13

Amongst the three regions, semi-arid region had the highest tube well density including diesel and electric tube wells (Table 1). Interestingly, though the overall density of tube wells in the State has increased, the density of diesel-operated tube wells has decreased on account of high operation and maintenance cost except in the groundwater scarce arid region. An increase in the density of diesel tube wells in groundwater scarce arid region of the State can be attributed to installation of these tube wells

along the canals on account of fresh water availability at shallow depths. Besides, the cropping pattern of the region (bajra, jawar, cotton, mustard) demands less water and electric tube wells are considered to be more expensive to install as compared to diesel tube wells. These results show a clear paradoxical divide that water abundant regions in the country are saddled with diesel tube wells, while water scarce regions are well endowed with electric tube wells (Shah et al., 2006; Mukherji, 2007, 2008).

Table 1: Density of Diesel and Electric Tube Wells (Per thousand hectares) in Haryana During 2008-09 and 2012-13

District	2008-09			2012-13		
	Diesel	Electric	Total	Diesel	Electric	Total
	Sub-Humid Region					
Ambala	30.5	120.2	150.6	31.0	145.6	176.6
Panchkula	13.5	32.1	45.6	13.6	40.5	54.2
Yamunanagar	48.8	127.4	176.3	32.8	151.5	184.3
Sub-humid region	34.5	104.5	139.1	28.1	125.8	153.9
	Semi-Arid Region					
Faridabad	38.2	94.2	132.4	31.3	111.3	142.6
Gurgaon	5.9	176.5	182.4	4.7	205.9	210.6
Jhajjar	185.7	35.2	220.9	115.7	41.4	157.1
Kaithal	90.9	155.9	246.8	81.7	190.8	272.5
Karnal	38.0	229.6	267.6	0.7	172.3	173.0
Kurukshetra	1.3	244.2	245.5	58.3	442.0	500.3
Mewat	43.0	45.2	88.1	50.7	54.8	105.4
Palwal	119.9	59.9	179.7	109.3	75.9	185.3
Panipat	29.3	211.7	241.0	22.8	246.4	269.2
Rewari	18.7	162.2	180.8	32.9	190.1	223.0
Rohtak	97.1	17.8	114.9	90.4	21.1	111.6
Sonapat	105.2	95.4	200.6	98.1	114.2	212.2
Semi-arid region	69.3	130.3	199.6	60.3	154.1	214.4
	Arid Region					
Bhiwani	25.3	50.8	76.1	46.9	62.5	109.4
Fatehabad	37.4	98.5	135.9	34.5	122.8	157.3
Hisar	52.7	20.6	73.3	49.1	28.7	77.8
Jind	74.8	94.5	169.3	69.7	121.7	191.4
Mahendergarh	0.8	134.1	134.9	0.7	155.3	156.0
Sirsa	52.1	71.2	123.3	44.6	91.5	136.1
Arid region	42.2	68.8	111.1	44.0	86.2	130.2
Haryana	53.6	99.8	153.4	49.8	120.4	170.2

Source: Compiled by authors.

District-wise analysis revealed that Kurukshetra district in semi-arid region and Bhiwani district in arid region have witnessed the largest percentage increase in density of tube wells with Kurukshetra recording over 80 per cent increase in electric tube wells and Bhiwani with an increase of more than 40 per cent in diesel tube wells during 2008-09 and 2012-13. Growth

rates in density of tube wells have, however, declined in Karnal, Jhajjar and Rohtak districts. Negative growth in Karnal district can be attributed to shifting of shallow tube wells to deep tube wells (submersible tube wells), while in Rohtak and Jhajjar, the same may be ascribed to poor quality of groundwater. Kurukshetra district has maintained its lead in the State with the most

number of tube wells since 1974-75. The number of tube wells here has grown the fastest with no sign of slowing down and as of today, the district farmers have about 10 per cent of all tube wells in Haryana.

Source of Financing of Tube Wells: Tube well installation depends upon the income source of farmers. Haryana's rural credit markets are characterised by co-existence of formal, semi-formal and informal lenders like any other part of the country. Table 2 shows that about 20-35 per cent of farmers use their own funds for installation of tube wells. Financial institutions such as

commercial and co-operative banks have emerged as the most important sources of finance for farmers in Haryana. However, it is indeed a matter of concern that in spite of all the efforts made for their development, institutional finance accounts for about 15 per cent of the total loans disbursed for tube well installation. Meanwhile, commission agents, moneylenders and traders are still contributing for more than 50 per cent of the total credit for tube well installations (Table 2). Other non-institutional sources such as friends and relatives account for about 10 per cent of the credit providers for installation of tube wells in the State.

Table 2: Sources of Financing for Tube Wells in Haryana

Farmer Class	Own Saving (%)	Commercial and Co-operative Banks (%)	Commission Agents and Moneylenders (%)	Relatives, Friends and Others (%)
Small	19.9	5.2	61.8	13.1
Medium	30.5	15.3	49.6	4.5
Large	33.8	15.7	40.8	9.8

Source: Field survey by authors.

Groundwater Irrigation-Energy Nexus: Groundwater irrigation uses high capacity electric and diesel tube wells. Therefore, energy subsidies are another key area in groundwater economy of Haryana. Agricultural tube well users have to pay only a small fraction of actual tariff, resulting in large quantum of subsidies, thousands to crores of rupees, for irrigation sector. Therefore, farmers are turning more and more towards installation of electric tube wells (Figure 3). A direct consequence of this surge in electric tube wells has been mounting perpetual loss and poor financial health to the State. The gross subsidy

provided to tube well users and subsequently normalised by using the State's gross cropped area in recent years has been highlighted in Table 3. Meanwhile, electricity subsidies to electric tube wells have led to indiscriminate use of groundwater for irrigation, resulting in severe depletion of groundwater levels. During the year 2012-13, more than two-thirds of groundwater depth monitoring wells reported depths greater than five metres and about 62.5 per cent of wells recorded a fall in groundwater levels from the previous year (CGWB, 2013).

Table 3: Electricity Subsidies to Tube Well Users in Haryana

Year	Aggregate Subsidy to Tube Well Users (Billion ₹)	Normalised Electricity Subsidies to Tube Well Users (₹/ha)	Subsidies to Tube Well Users (Percentage of the total subsidies available to farmers)
2010-11	34.35	5373	45
2011-12	34.21	5366	43
2012-13	39.74	6234	44
2013-14	48.53	7613	51

Source: Sharma et al., 2015.

Spread of Hired and Own Irrigated Area through

Tube Wells: Spread of hired and own irrigated area through tube wells in the State of Haryana has been presented in Table 4. About 6.9 per cent area was irrigated through hired tube wells during 2008-09, whereas it has increased to 7.3 per cent during the year 2012-13, thus indicating that area under hired irrigation through tube wells is increasing. However, area irrigated through hired tube wells in the State is comparatively low. The net irrigated area from all sources in the State was about 2.8 million

ha during the year 2008-09, out of this 1.2 million ha was irrigated through surface water (canal), while the rest 1.6 million ha was irrigated by utilising the groundwater resources. During the year 2012-13, net irrigated area in the State was observed to be 3.0 million ha, out of which 1.3 million ha was irrigated through surface water and 1.7 million ha through groundwater resource. It shows a growth of 10 per cent in utilisation of groundwater for irrigation from 2008-09 to 2012-13.

Table 4: Net Area Irrigated through Hired Tube Wells, Own Tube Wells and Percentage of Households Reporting Irrigation from Hired Tube Wells in Haryana During 2008-09 and 2012-13

District	2008-09			2012-13		
	Net Area Irrigated through Hired Tube Wells (%)	Net Area Irrigated through Own Tube Wells (%)	Households Reporting Irrigation through Hired Tube Wells (%)	Net Area Irrigated through Hired Tube Wells (%)	Net Area Irrigated through Own Tube Wells (%)	Households Reporting Irrigation through Hired Tube Wells (%)
1	2	3	4	5	6	7
Sub-Humid Region						
Ambala	11.5	88.5	30.6	17.6	82.4	37.1
Panchkula	NA	NA	NA	NA	NA	NA
Yamunanagar	2.5	97.5	15.0	0.0	100.0	0.0

(Contd.....)

Table 4 (Contd.....)

1	2	3	4	5	6	7
Sub-humid region	8.6	91.4	27.2	7.9	92.1	17.1
		Semi-Arid Region				
Faridabad	0.0	100.0	0.0	7.2	92.8	16.7
Gurgaon	2.2	97.8	0.0	12.3	87.7	13.2
Jhajjar	0.0	100.0	0.0	8.8	91.2	7.1
Kaithal	0.0	100.0	0.0	0.0	100.0	0.0
Karnal	0.0	100.0	0.0	0.0	100.0	0.0
Kurukshetra	0.0	100.0	0.0	0.0	100.0	0.0
Mewat	NA	NA	NA	NA	NA	NA
Palwal	NA	NA	NA	NA	NA	NA
Panipat	0.0	100.0	0.0	0.0	100.0	0.0
Rohtak	16.4	83.6	7.0	0.0	100.0	0.0
Rewari	8.0	92.0	10.5	10.5	89.5	11.5
Sonipat	1.7	98.3	0.0	0.0	100.0	0.0
Semi-arid region	2.2	97.8	2.4	2.5	97.5	4.6
		Arid Region				
Bhiwani	5.1	94.9	6.3	7.0	93.0	9.4
Fatehabad	15.1	84.9	25.7	14.0	86.0	20.0
Hisar	15.1	84.9	13.4	19.3	80.7	21.9
Jind	4.4	95.6	11.8	10.5	89.5	11.1
Mahendergarh	0.0	100.0	0.0	NA	NA	NA
Sirsa	18.6	81.4	32.7	22.3	77.7	31.8
Arid region	11.7	88.3	15.2	13.9	86.1	17.5
Haryana	6.9	93.1	10.6	7.3	92.7	10.8

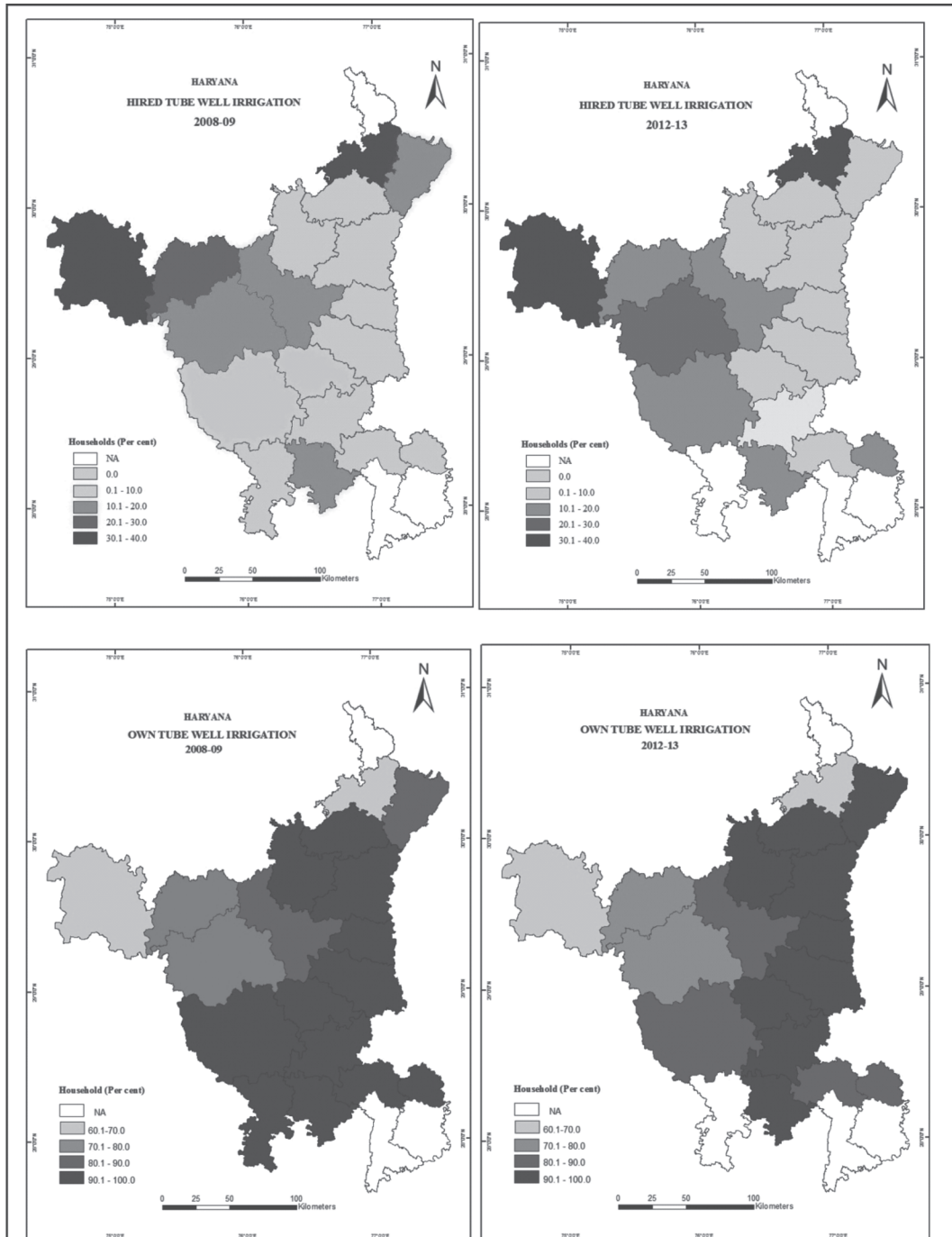
Source: Compiled by authors.

NA: Data not available.

There are marked inter-regional differences in area and percentage of households irrigating their fields through hired tube wells (Table 4, Figure 5). Arid region has the highest area under hired tube well irrigation, while the semi-arid region exhibited underdeveloped groundwater markets in spite of fresh water availability and large number of tube wells. Both high water demand and economic returns from the cultivation of rice crop compelled the farmers

to invest in their own tube wells. Apart from this, about 11 per cent of households in the State are dependent on hired irrigation through tube wells, highest being in sub-humid region followed by arid. Higher dependence on hired irrigation through tube wells in sub-humid region can be attributed to larger proportion of fragmented land holdings and farmers cannot afford installation of tube wells.

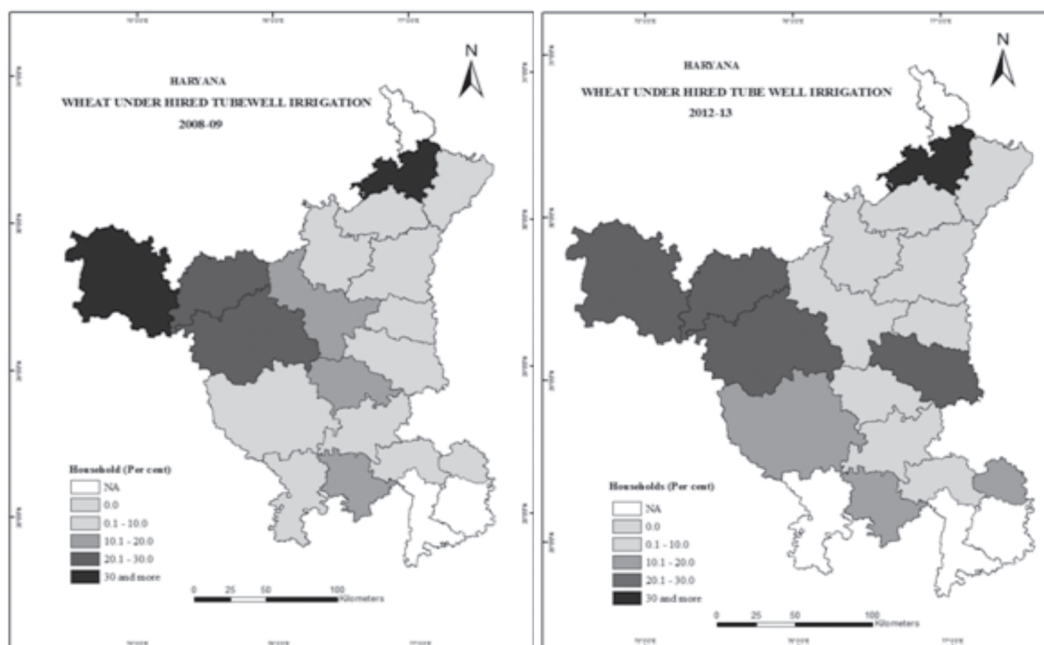
Figure 5: Percentage of Households Reported Irrigation from Hired and Own Tube Wells During 2008-09 and 2012-13



Hired and Own Irrigated Area through Tube Wells during Rabi and Kharif Seasons: Wheat, mustard (rabi), rice and cotton (kharif) are the major irrigated crops in Haryana and optimise the economic returns of cultivators. During the study period, hired irrigated area through tube wells has increased under mustard and cotton crops, while it has decreased under wheat and rice crops across the State (Tables 5 and 6). Higher irrigated area through groundwater markets under mustard and cotton crops can be anomalously attributed to remunerative prices of these crops during the study period. Moreover, percentage of households reporting wheat and cotton irrigation through hired tube wells has increased, whereas the same has decreased under mustard and rice crops. A decrease in

percentage of households reporting rice irrigation through hired tube wells can be attributed to higher water demand of the crop which compelled the farmers to install their own tube wells, whereas this decrease under cotton crop is beyond understanding. Amongst the regions, arid region registered an increase of hired irrigated area through tube wells under all crops except the mustard. Meanwhile, percentage of households reporting irrigation through hired tube wells under all crops peaked in Ambala district of the State (Figure 6) whereas, Kaithal, Karnal and Kurukshetra districts had not witnessed hired irrigation through tube wells under all crops, supporting the fact that these districts have consistently maintained a very high tube well density in the State (Table 1).

Figure 6: Percentage of Households Reported Irrigation in Wheat Crop from Hired and Own Tube Wells During 2008-09 and 2012-13



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Figure 6 (Contd.....)

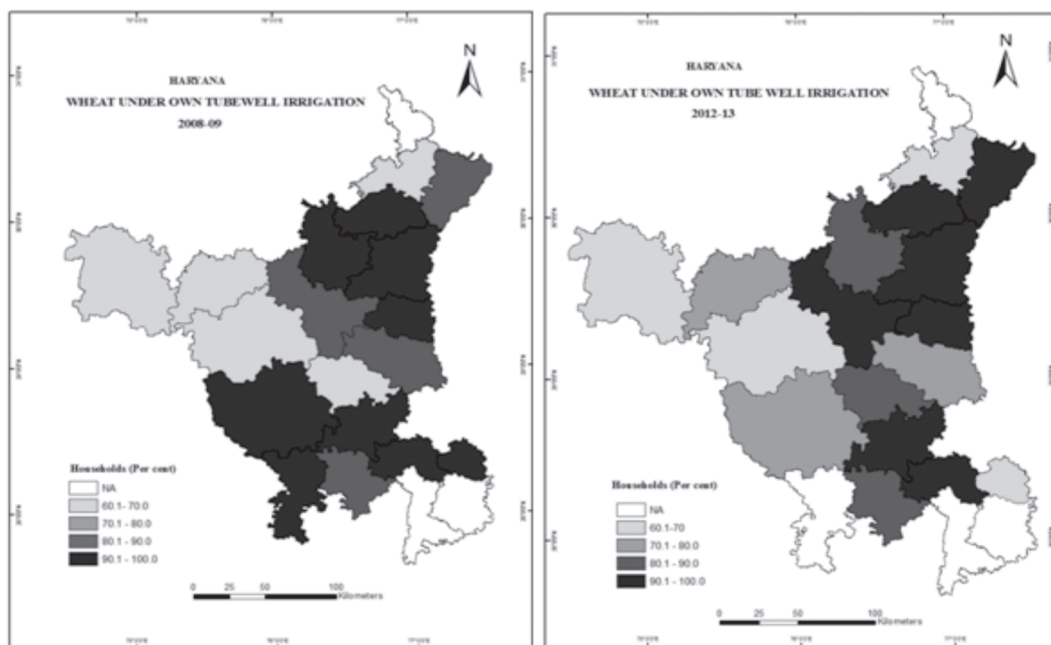


Table 5: Net Area Irrigated through Hired Tube Wells, Own Tube Wells and Percentage of Households Reporting Irrigation from Hired Tube Wells in Haryana under Wheat and Mustard Crops During Rabi Season for the Period 2008-09 and 2012-13

District	2008-09			2012-13		
	Net Area Irrigated through Hired Tube Wells (%)	Net Area Irrigated through Own Tube Wells (%)	Households Reporting Irrigation through Hired Tube Wells (%)	Net area Irrigated through Hired Tube Wells (%)	Net Area Irrigated through Own Tube Wells (%)	Households Reporting Irrigation through Hired Tube Wells (%)
1	2	3	4	5	6	7
Wheat Crop						
Sub-Humid Region						
Ambala	15.1	84.9	34.4	22.0	78.0	47.1
Panchkula	NA	NA	NA	NA	NA	NA
Yamunanagar	1.1	98.9	10.0	0.0	100.0	0.0
Sub-humid region	9.9	90.1	28.6	11.5	88.5	27.6
Semi-Arid Region						
Faridabad	0.0	100.0	0.0	8.2	91.8	18.5
Gurgaon	0.0	100.0	0.0	6.1	93.9	11.8

(Contd.....)

Table 5 (Contd.....)

1	2	3	4	5	6	7
Jhajjar	0.0	100.0	0.0	0.0	100.0	0.0
Kaithal	0.0	100.0	0.0	0.0	100.0	0.0
Karnal	0.0	100.0	0.0	0.0	100.0	0.0
Kurukshetra	0.0	100.0	0.0	0.0	100.0	0.0
Mewat	NA	NA	NA	NA	NA	NA
Palwal	NA	NA	NA	NA	NA	NA
Panipat	4.8	95.2	0.0	0.0	100.0	0.0
Rewari	20.5	79.5	16.0	7.6	92.4	15.8
Rohtak	14.3	85.7	16.7	0.0	100.0	0.0
Sonipat	3.9	96.1	3.0	0.0	100.0	0.0
Semi-arid region	4.8	95.2	3.3	1.3	98.7	4.6
Arid Region						
Bhiwani	1.7	98.3	5.3	6.3	93.7	18.5
Fatehabad	13.7	86.3	26.3	18.3	81.7	28.5
Hisar	13.9	86.1	27.6	23.1	76.9	13.6
Jind	6.0	94.0	16.7	3.0	97.0	6.7
Mahendergarh	0.0	100.0	0.0	NA	NA	NA
Sirsa	19.5	80.5	37.0	26.8	73.2	14.3
Arid region	11.5	88.5	20.8	14.3	85.7	18.3
Haryana	7.4	92.6	12.6	6.9	93.1	17.6
Mustard Crop						
Semi-Arid Region						
Gurgaon	9.8	90.2	27.3	20.8	79.2	36.4
Jhajjar	0.0	100.0	0.0	17.3	82.7	17.2
Rewari	10.7	89.3	16.0	11.8	88.2	16.7
Rohtak	27.6	72.4	14.3	0.0	100.0	0.0
Sonipat	0.0	0.0	0.0	0.0	100.0	0.0
Semi-arid region	11.4	88.6	16.7	14.4	85.6	16.1
Arid Region						
Bhiwani	18.8	81.3	18.5	8.4	91.6	15.4
Fatehabad	100.0	0.0	66.7	0.0	100.0	0.0
Hisar	10.5	89.5	13.6	18.3	81.7	21.9
Jind	0.0	0.0	0.0	0.0	100.0	27.3
Mahendergarh	0.0	100.0	0.0	NA	NA	NA
Sirsa	0.0	100.0	14.3	0.0	100.0	0.0
Arid region	13.3	86.7	18.3	11.4	88.6	18.7
Haryana	12.4	87.6	17.6	12.9	87.1	17.0

Source: Compiled by authors.

NA: Data not available.

Table 6: Net Area Irrigated through Hired Tube Wells, Own Tube Wells and Percentage of Households Reporting Irrigation from Hired Tube Wells in Haryana under Rice and Cotton Crops During Kharif Season for the Period 2008-09 and 2012-13

District	2008-09			2012-13		
	Net Area Irrigated through Hired Tube Wells (%)	Net Area Irrigated through Own Tube Wells (%)	Households Reporting Irrigation through Hired Tube Wells (%)	Net Area Irrigated through Hired Tube Wells (%)	Net Area Irrigated through Own Tube Wells (%)	Households Reporting Irrigation through Hired Tube Wells (%)
1	2	3	4	5	6	7
Rice Crop						
Sub-Humid Region						
Ambala	8.0	92.0	32.3	10.8	89.2	25.0
Yamunanagar	4.2	95.8	20.0	0.0	100.0	0.0
Sub-humid region	6.8	93.2	29.3	5.0	95.0	11.5
Semi-Arid Region						
Faridabad	0.0	100.0	0.0	11.8	88.2	22.2
Gurgaon	0.0	100.0	0.0	0.0	100.0	0.0
Jhajjar	0.0	100.0	0.0	0.0	100.0	0.0
Kaithal	0.0	100.0	0.0	0.0	100.0	0.0
Karnal	0.0	100.0	0.0	0.0	100.0	0.0
Kurukshetra	0.0	100.0	0.0	0.0	100.0	0.0
Panipat	0.0	100.0	0.0	0.0	100.0	0.0
Rewari	0.0	0.0	0.0	0.0	100.0	0.0
Rohtak	0.0	100.0	0.0	0.0	100.0	0.0
Sonipat	2.7	97.3	8.3	0.0	100.0	0.0
Semi-arid region	0.4	99.6	0.9	0.3	99.7	1.6
Arid Region						
Bhiwani	0.0	100.0	0.0	0.0	100.0	0.0
Fatehabad	3.1	96.9	4.3	3.0	97.0	8.3
Hisar	0.0	100.0	0.0	0.0	100.0	0.0
Jind	1.8	98.2	10.0	6.5	93.5	8.7
Sirsa	0.0	0.0	0.0	0.0	100.0	0.0
Arid region	2.5	97.5	5.3	5.1	94.9	8.3
Haryana	2.3	97.7	7.9	1.7	98.3	5.4
Cotton Crop						
Arid Region						
Bhiwani	4.0	96.0	6.7	6.4	93.6	12.0
Fatehabad	24.7	75.3	38.5	22.3	77.7	27.8
Hisar	20.9	79.1	17.4	15.8	84.2	20.4
Jind	10.5	89.5	20.0	23.3	76.7	15.4
Sirsa	17.9	82.1	28.6	22.4	77.6	40.0
Arid region	17.7	82.3	21.9	17.8	82.2	20.3
Haryana	16.9	83.1	20.0	17.8	82.2	20.3

Source: Compiled by authors.

NA: Data not available.

Yield of Hired and Own Irrigated Crops through

Tube Wells: Irrigation is an essential demand of crop on which the yield depends and it is expected that with increased number of irrigations, the crops are also likely to give higher yields. However, yield of crops is dependent on several other factors such as, quantity of inputs applied in the production cycle (high-yielding variety seeds, fertilisers, etc.) including the institutional framework, soil and climatic conditions, cropping patterns and water conveyance infrastructure (Bjornlund et al., 2007). Apart from these, farmers who own tube wells can supply water at requirement of the crop, whereas the buyer relies upon the seller for availability of water, resulting in more yields for a particular crop to those farmers who own a tube well. It can be witnessed from Tables 7 and 8 that yield of wheat and rice crops was more in the State of Haryana through the irrigation of own tube wells as they applied more amount of water than the farmers irrigating these crops through hired tube wells. However, such results in the case of mustard crop yield could not be observed, while a noticeable higher yield was observed in cotton crop for the farmers irrigating through

hired tube wells. The high yield in the case of hired irrigation under cotton crop could be due to the fact that the farmers irrigating cotton through hired tube wells apply less amount of water as compared to the farmers irrigating through own tube wells, since root system of the cotton crop is very sensitive to the excess irrigation. Also, more than 80 per cent farmers having their own tube wells in the State preferred cotton crop on account of higher productivity, yields and subsequently, the net returns in relation to other crops. Likewise, marked inter-regional differences in yield of different crops were noticed. Sub-humid region recorded highest yield in rice crop followed by arid and semi-arid regions, while highest wheat yield was noticed in semi-arid region followed by arid region. Furthermore, Fatehabad district recorded highest yield in rice crop followed by Ambala and Sirsa districts. Yamunanagar district witnessed the highest yield of wheat crop followed by Gurgaon and Kaithal districts. In addition, Gurgaon district recorded highest yield of mustard crop, while Bhiwani district experienced highest yield of cotton crop during 2008-09 and 2012-13 (Tables 7 and 8).

Table 7: Yield of Rabi Crops (tonnes/ha) Irrigated through Own and Hired Tube Wells in Haryana During 2008-09 and 2012-13

District	2008-09		2012-13	
	Own Tube wells	Hired Tube Wells	Own Tube Wells	Hired Tube Wells
Wheat Crop				
Sub-Humid Region				
Ambala	2.8	2.6	3.5	3.4
Panchkula	NA	NA	NA	NA
Yamunanagar	4.7	4.5	5.1	0.0
Sub-humid region	3.7	3.5	4.3	3.4

(Contd.....)

Table 7 (Contd.....)

	Own Tube Wells	Hired Tube Wells	Own Tube Wells	Hired Tube Wells
Semi-Arid Region				
Faridabad	4.6	0.0	4.7	4.7
Gurgaon	5.0	0.0	4.9	5.5
Jhajjar	4.7	0.0	3.6	0.0
Kaithal	5.0	0.0	4.6	0.0
Karnal	4.7	0.0	4.8	0.0
Kurukshetra	4.4	0.0	4.8	0.0
Mewat	NA	NA	NA	NA
Palwal	NA	NA	NA	NA
Panipat	4.8	0.0	4.8	0.0
Rewari	3.9	3.7	4.5	4.6
Rohtak	4.6	4.4	3.6	0.0
Sonipat	4.8	5.0	3.5	0.0
Semi-arid region	4.7	4.4	4.4	4.9
Arid Region				
Bhiwani	4.3	4.1	3.8	3.8
Fatehabad	4.7	4.2	4.3	4.2
Hisar	4.6	3.9	3.9	3.9
Jind	4.8	4.5	4.4	4.7
Mahendergarh	4.9	0.0	NA	NA
Sirsa	4.3	4.6	4.6	4.7
Arid region	4.6	4.3	4.2	4.2
Haryana	4.3	4.0	4.3	4.2
Mustard Crop				
Semi-Arid Region				
Gurgaon	2.0	2.1	2.1	2.0
Jhajjar	1.6	0.0	1.4	1.2
Rewari	1.9	1.5	2.0	2.0
Rohtak	1.7	1.8	1.4	0.0
Sonipat	0.0	0.0	1.7	0.0
Semi-arid	1.8	1.8	1.7	1.7
Arid Region				
Bhiwani	1.9	1.8	1.8	1.7
Fatehabad	1.8	1.7	1.8	0.0
Hisar	1.9	1.9	1.6	1.5
Jind	0.0	0.0	1.7	0.0
Mahendergarh	1.9	0.0	0.0	0.0
Sirsa	1.6	1.5	1.5	0.0
Arid	1.8	1.7	1.7	1.6
Haryana	1.8	1.8	1.7	1.6

Source: Compiled by authors.

NA: Data not available.

Table 8: Yield of Kharif Crops (tonnes/ha) Irrigated through Own and Hired Tube Wells in Haryana During 2008-09 and 2012-13

District	2008-09		2012-13	
	Own Tube Wells	Hired Tube Wells	Own Tube Wells	Hired Tube Wells
Rice Crop				
Sub-Humid Region				
Ambala	5.4	4.8	6.1	5.2
Yamunanagar	4.8	3.7	5.0	0.0
Sub-humid region	5.1	4.2	5.5	5.2
Semi-Arid Region				
Faridabad	3.9	0.0	2.9	3.0
Gurgaon	3.4	0.0	5.0	0.0
Jhajjar	2.4	0.0	0.0	0.0
Kaithal	3.5	0.0	6.0	0.0
Karnal	3.3	0.0	5.4	0.0
Kurukshetra	4.0	0.0	6.6	0.0
Panipat	2.5	0.0	4.2	0.0
Rewari	0.0	0.0	2.5	0.0
Rohtak	4.6	0.0	3.7	0.0
Sonipat	2.0	2.0	3.4	0.0
Semi-arid region	3.3	2.0	4.4	3.0
Arid Region				
Bhiwani	4.1	0.0	0.0	0.0
Fatehabad	6.4	5.5	5.7	4.6
Hisar	3.3	0.0	2.5	0.0
Jind	3.5	3.0	6.0	5.4
Sirsa	0.0	0.0	6.1	0.0
Arid region	4.3	4.2	5.1	5.0
Haryana	4.2	3.5	5.0	4.4
Cotton Crop Arid Region				
Bhiwani	2.1	3.0	1.9	2.6
Fatehabad	2.0	2.2	2.1	2.1
Hisar	2.1	1.4	1.8	1.6
Jind	1.6	2.0	1.9	2.1
Sirsa	2.2	1.8	2.0	2.5
Arid region	2.0	2.1	1.9	2.2

Source: Compiled by authors.

NA: Data not available.

Who Owns a Tube Well and Who Hires Groundwater?: Table 9 shows the distribution of tube well ownership among different landholding sizes of farmers in Haryana during

2008-09 and 2012-13. This shows that the bulk of tube wells are owned by small farmers followed by medium and large farmers. Tube well ownership pattern in the State has increased

among small farmers, whereas it has decreased among large farmers and remained stagnant in medium farmers. Apart from this, there are inter-regional and inter-district variations in tube well ownership, but on the whole this pattern of small and marginal farmers overwhelmingly persisted across climatic regions and districts. Additionally, about 10 per cent farmers have relied on hired irrigation in Haryana through tube wells, out of which 90 per cent are small farmers (Tables 4 and 10). These results reveal that as the landholding size increases, more and more farmers depend on their own tube wells for irrigation.

Table 9: Distribution of Tube Well Ownership Among Farmers According to Operational Landholding Size Classes in Haryana During 2008-09 and 2012-13

District	2008-09			2012-13		
	Small	Medium	Large	Small	Medium	Large
	Sub-Humid Region					
Ambala	60.0	24.0	16.0	59.1	40.9	0
Panchkula	NA	NA	NA	NA	NA	NA
Yamunanagar	36.8	26.3	36.8	70.7	24.4	4.9
Sub-humid	53.6	24.6	21.7	66.7	30.1	3.2
	Semi-Arid Region					
Faridabad	53.3	40.0	6.7	76.2	19.0	4.8
Gurgaon	79.4	20.6	0.0	91.7	4.2	4.2
Jhajjar	89.5	10.5	0.0	83.6	9.8	6.6
Kaithal	71.4	25.7	2.9	28.6	19.0	52.4
Karnal	45.5	29.5	25.0	68.0	24.0	8.0
Kurukshetra	41.7	33.3	25.0	51.9	30.8	17.3
Mewat	NA	NA	NA	NA	NA	NA
Palwal	NA	NA	NA	NA	NA	NA
Panipat	71.4	28.6	0.0	39.1	47.8	13.0
Rewari	88.1	11.9	0.0	71.8	25.6	2.6
Rohtak	70.0	15.0	15.0	84.5	15.5	0.0
Sonipat	57.8	37.8	4.4	66.7	28.3	5.0
Semi-arid	69.1	24.2	6.7	69.4	21.8	8.8
	Arid Region					
Bhiwani	90.7	9.3	0.0	76.9	15.4	7.7
Fatehabad	54.1	23.0	23.0	64.7	25.5	9.8
Hisar	70.0	22.5	7.5	69.6	28.3	2.2
Jind	65.5	20.7	13.8	70.3	20.3	9.4
Mahendergarh	68.4	31.6	0.0	NA	NA	NA
Sirsa	51.5	42.4	6.1	50.0	31.3	18.8
Arid	71.0	20.8	8.2	69.8	22.9	7.3
Haryana	68.3	22.9	8.8	69.3	22.9	7.8

Source: Compiled by authors.

NA: Data not available.

Table 10: Number and Percentage of Households Hiring Irrigation from Tube Wells in Haryana During 2008-09 and 2012-13

Farmer Class	2008-09		2012-13	
	Number of Households within the Operational Landholding Category Who Reported Hiring Irrigation from Tube Wells	Percentage Distribution of Households within the Operational Landholding Category Who Reported Hiring Irrigation from Tube Wells	Number of Households within the Operational Landholding Category Who Reported Hiring Irrigation from Tube Wells	Percentage Distribution of Households within the Operational Landholding Category Who Reported Hiring Irrigation from Tube Wells
Small	102	90.7	91	85.8
Medium	11	9.3	13	11.4
Large	-	-	3	2.8
All	113	100	106	100

Source: Compiled by authors.

Conclusions

Haryana has experienced an absolute boom in groundwater irrigation economy over the last four decades. The findings of the study reveal that the density of tube wells per thousand hectares and number have increased by more than 250 and 300 per cent, respectively, during 1975 to 2013. This tremendous growth clearly demonstrates the increasing role of groundwater in the development of irrigated agriculture. Cost effectiveness of electric tube wells and flat tariff rates are some of the common causes for this rapid growth. A direct consequence of this surge in electric tube wells has been mounting perpetual loss and poor financial health to the State as the gross subsidy provided to electric tube wells is about 45 per cent of the total subsidies available to the farmers. Electricity subsidies to electric tube wells and their resulting expansion are taking a heavy toll on groundwater levels. During the year 2012-13, more than two-

thirds of groundwater depth monitoring wells reported depths greater than five metres and about 62.5 per cent of wells recorded a fall in water levels from the previous year. Surprisingly, in spite of remarkable development in commercial and cooperative banks, these institutions account for about 15 per cent of the total loans disbursed for tube well installation. Meanwhile, commission agents, moneylenders and traders are still contributing for more than 50 per cent of the total credit for tube well installations in Haryana.

The study also discloses that the area under hired irrigation through tube wells in the State is increasing, which is comparatively low (30 per cent farmers buy groundwater for irrigation at national level), therefore, leaving much of the land unirrigated and may cause economic losses to farmers, further affecting the economy of the State. Besides, about 70 per cent

of the tube wells are owned by small farmers followed by medium and large farmers. This finding from the study is contrary to the earlier belief that the benefit of electricity subsidy goes only to large farmers who are most likely to have large number of own electric-tube wells. This belief is very much missing in much of the Haryana State policy discourses and analyses, which has several policy implications. The findings of the study also drive home the point that groundwater markets are no longer a

localised small-scale phenomenon found in sporadic pockets here and there in the State, but are indeed an all-pervasive feature in State's agricultural landscape and hence demand more attention than hitherto given. Finally, it is concluded that the groundwater irrigation economy in Haryana is in growth phase and it is important to understand fully the dynamics of this economy before managers and policy makers can begin to think about effectively managing it.

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