Turkish Online Journal of Qualitative Inquiry (TOJQI)
Volume 12, Issue 8, July 2021: 4153 – 4174

Comparative Analysis of Profitability of Rice and Wheat in Different Irrigation Systems across Different Landholding Groups in Haryana: A Case Study of Karnal District

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Abstract
Purpose – To study the comparative analysis of profitability of rice-wheat cultivation in different irrigation systems across different landholdings groups.
Design/methodology/approach – The data of cost of cultivation and net returns are collected by simple random sampling method from 300 sample farming households, drawn from three villages of Karnal district are analyzed and presented in this paper.
Findings – The data indicating that the incurring cost on seeds, fertilizer and micronutrients, insecticides, weedicides, and pesticides are positively related to the size of the landholding, and this is bigger the landholding size greater is the investment in the different inputs. Nevertheless, in the case of hired applications such as irrigation, the incurring cost of irrigation is negatively related to the landholding size; this is bigger the landholding size smaller. The marginal and small farmers incur a lower yield of rice-wheat crops in all irrigation systems than the large and medium farmers. The examination of net returns reveals that the traditional wheat crop shows the highest net returns for all the farm categories. It also shows fewer variations indicating comparable profitability for all farmers' groups irrespective of the operational holding size. The cost of cultivation of rice crop is much greater than wheat crop and this cost increases with the scarcity of water, i.e., cost of cultivation of rice is higher in the groundwater depleted tubewell irrigation village of Kurlan than tubewell irrigation village of Barsat. Nevertheless, it is also seen that not only the cost rises with depletion, the inequality in cost and returns also rises with falling water tables. It was seen that with the advantage of mixed irrigation, farmers in Kheri Man Singh village gained a net return of Rs. 2.79 and Rs. 2.78 on incurring a rupee cost for rice and wheat crop respectively, which was highest compared to the other two irrigation systems under study.
Social implications – The rise in the cost of cultivation and the decline in farmers' net income are significant issues confronting present-day agriculture in Haryana. Degradation of land and depletion of water resources has led to rising discontent among the farming community due to their failure to get aspired farm incomes. The gap in income between small and large farmers is increased day by day. The resource-poor (small) farmers are exploited by resource-rich (large) farmers.
Originality/value – This is the first paper to study the comparative analysis of profitability of rice-wheat cultivation in different irrigation systems across different landholdings groups in Haryana state (Karnal district).

Keywords – Groundwater Depletion, Agriculture Profitability, Irrigation Systems, Land-holdings Groups, Rice-Wheat, Haryana, Karnal
Paper type – Research paper

Introduction

At present time, the issue of shrinking land-holdings and increasing land-fragmentation with depleting groundwater-resources is the most pressing concern among different land-holding groups in Haryana. Agricultural profitability is affected by the ownership of land and water resources. In the study area, the distribution of ownership of land and water resources are not equal but it is done by inheritance, hence, it affects farmer's income. So it is a matter of interest to analyze the agricultural profitability across different landholding categories for major crops (rice and wheat), comparing the cost of cultivation and net returns. The main problem of increasing cost was seen as declining input use efficiency in agriculture across different land-holding groups. The increase in the cost of cultivation is mainly due to over-mechanization, increasing in cost of labor, irrigation costs, land lease-rent, green-revolution inputs like fertilizers, seeds, pesticides, etc.

An irrigation system appropriates the valuable water resources and allocates them according to a certain quantity and timings. There are several alternatives to develop irrigated agriculture using a variety of sources of irrigation. All the different irrigation systems are constrained by some other limiting resources that decide their effectiveness and economic returns. Before deciding which irrigation source is sustainable and profitable, it is essential to make an economic analysis of various irrigation systems.

The empirical study of the Haryana state's irrigation development reiterates that the state is undergoing a significant shift in irrigation sources' composition. While canal irrigation has declined over the years, tubewell irrigation is distinctively on the rise. The farmers have shifted to tubewell irrigation because tubewell irrigated systems enjoy an assured and stable water supply quality, leading to high and stable yields. On the other hand, "canal irrigated areas, particularly in semi-arid regions like Haryana, are generally associated with fluctuations in yield due to uncertain water supply, which is particularly acute in the tail-reach of the canal irrigated areas." Coupled with the structural change in the irrigation system, a shift towards a water-intensive cropping system has also taken place in the state, leading to groundwater depletion, causing primary concern in its agricultural development. Groundwater mining has reached such an alarming level that it threatens the state's tubewell irrigation systems' future sustainability.

The literature on efficiency and sustainability of tubewell irrigation system reiterates the fact that the pioneer phase of groundwater development in Haryana is almost over as the groundwater balance in the state is becoming precarious with time, risings doubts about the technological, economic, social, and ecological sustainability of the tubewell irrigation system. Thus, we contend that tubewell irrigated systems that have been exploited beyond the sustainable limit are expected to experience an increase in yield uncertainties, slowing down production, increased cost of cultivation, and declining net returns. There is an indication that the private cost of installing tubewell and its operation and maintenance is substantially lower than marginal returns to irrigation. In a mixed irrigation system, the conjunctive use of canal water and private tubewells reduces groundwater irrigation pressure by recharging the groundwater. It makes the system cost-efficient and sustainable in the long run, and it also provides more significant equity among farmers by providing an alternative water source for farmers who do not have private sources of irrigation or no longer can afford tubewell irrigation (Shah, 1991).

In light of the above discussions, the study seeks to analyze the comparative performances of the primary sources of irrigation in Haryana's state and capture the relative agricultural profitability of the different irrigation systems across different land-holding groups in the face of depleting groundwater situations. Three different irrigation systems have been selected, which represent a different stage of groundwater development.

The main objective is to compare the economic efficiency of different irrigation systems across different land-holding groups operating under various degrees of water supply flexibility and reliability by analyzing the cost of cultivation, input use pattern, yield, gross output, and net returns. Kheri Man Singh is a village with a mixed irrigation system with conjunctive use of surface and groundwater. Both Barsat and Kurlan have tubewell irrigation systems with complete dependence on groundwater, where the former exhibits comparatively higher groundwater levels and faces fewer problems of groundwater depletion, and the latter experienced problems of groundwater depletion and faces scarcity of groundwater due to excessive groundwater mining with the steady decline in groundwater table each year.

Objectives

1. To study the comparative analysis of profitability of rice-wheat cultivation in different irrigation systems across different landholdings groups.

Study Area

The present study is basically about the state of Haryana and specifically the Karnal district. Karnal district lies between 29˚ 25' 05" to 29˚ 59' 20" North Latitudes and 76˚ 27' 40" to 77˚ 13' 08" East Longitudes, on the western bank of the Yamuna River, which forms its Eastern boundary and separates Haryana state from Uttar Pradesh. It falls in parts of Survey of India Toposheets Nos. 53C and 53G and the total geographical area of the Karnal district is 2,520 square kilometers, i.e., 5.69 percent of the state area. Karnal district is mainly an agricultural-based district with the majority of its population living in rural areas. Agriculture is the single largest source of occupation and livelihood to the population. Kharif and Rabi are the two predominant crop harvests in a year. The principal Kharif crops are Rice, Cotton, Sugarcane, and Maize, and the Rabi crops are Wheat and Barley. Karnal district is a two-crop combination region with Rice-Wheat as the dominant cropping pattern.

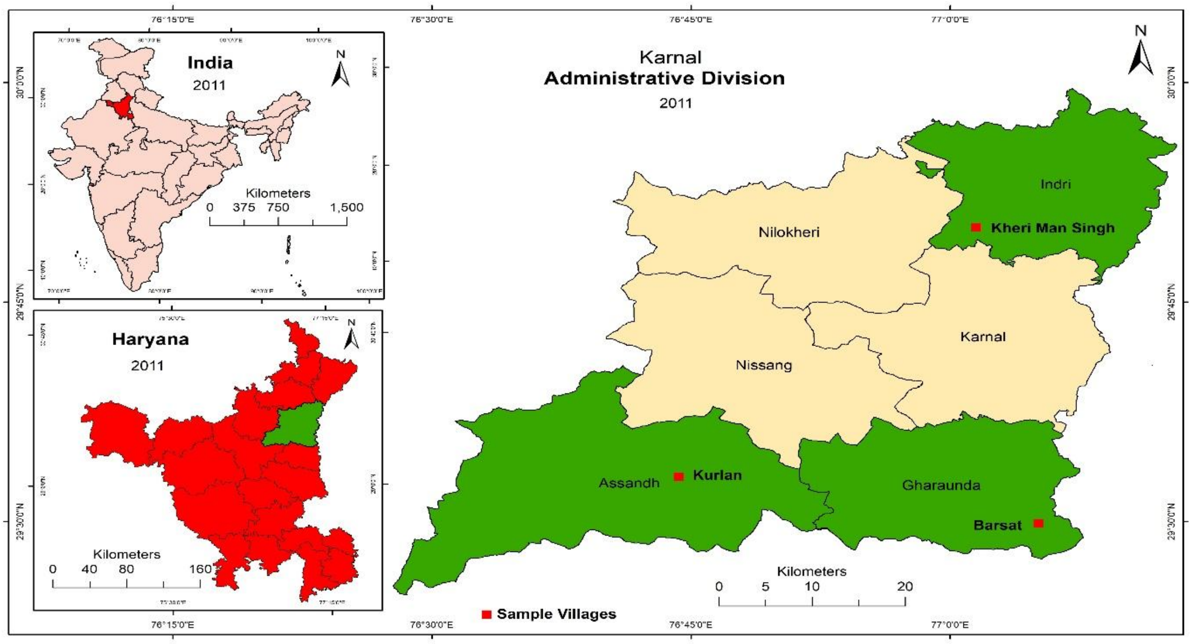


Fig. 1: Location Map of the Study Area

Data Base and Research Methodology

The present study is primarily based on primary data. Three villages, namely Kheri Man Singh, a mixed irrigated village selected from Indri block (safe zone), Barsat, a tubewell irrigated village selected from Gharaunda block (over-exploited condition) and Kurlan, a tubewell irrigated village with problems of groundwater depletion selected from Assandh block (highly over-exploited condition) are surveyed and selected by Purposive Sampling Method. These villages are also having the highest percentage of gross cropped area under irrigation. The 300 households are selected by the Simple Random Sampling method. Primary survey collection methods such as questionnaires, interviews, and focus group discussions are used for data collection. The primary surveyed data has been classified into four categories on the basis of different types of substrata of landholding size i.e. marginal (less than two acres), small (two-four acres), medium (four-ten acres), and large (more than ten acres) households from three villages, 100 households from each village.

Table 1: Selection of sample villages

Villages	Basis for selection
Kheri Man Singh	"Mixed irrigation system (approximately 38 percent irrigated by canal and 62 percent by tubewells). The average depth of water-table is 70 feet and faces least problem of groundwater depletion both because of conjunctive irrigation and also because farmers who do not have tubewells resort to canals for irrigation or exchange water in lieu of farm labour or cash."
Barsat	"Tubewell irrigation system (100 percent irrigated by tubewells). The average depth of water-table is 90 feet and faces lesser problems of groundwater depletion."
Kurlan	"Tubewell irrigation system (100 percent irrigated by tubewells). The average depth of water-table is 150 feet and faces severe constraints to agricultural production due to groundwater depletion as many tubewells have dried up."

Table 2: Profile of sample villages

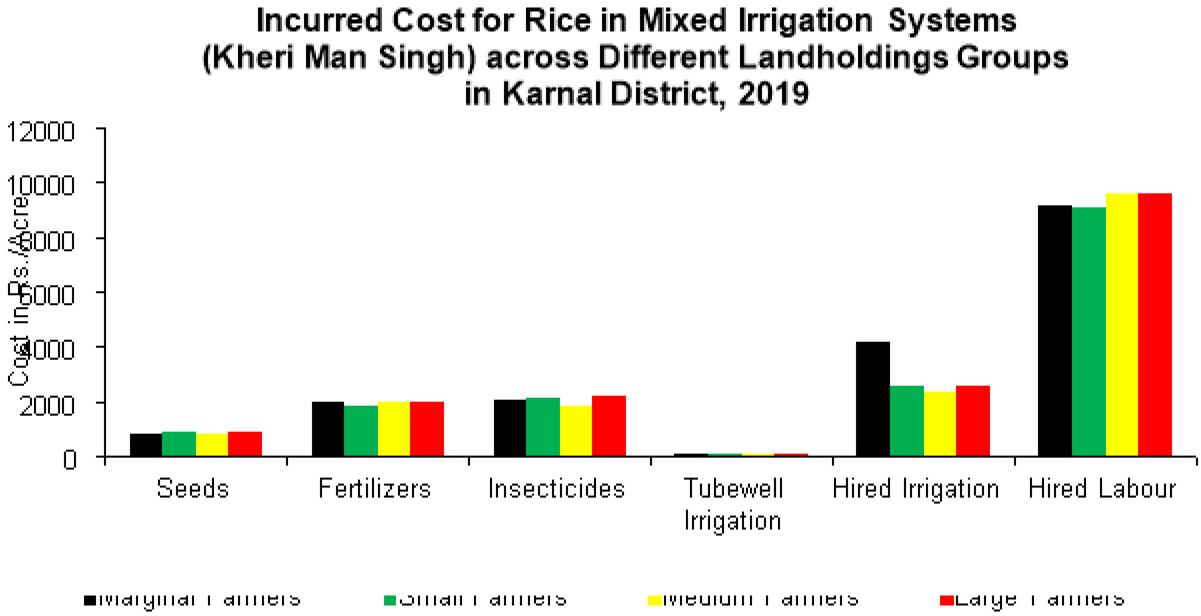
Geographical Characteristics			
Name of Village	**Kheri Man Singh** (Mixed Irrigation Village)	**Barsat** (Tubewell Irrigation Village)	**Kurlan** (Tubewell Irrigation Village With Problems of Groundwater Depletion)

Block	Indri	Gharaunda	Assandh
Geographical Area (Hectare)	647	1202	1738
Slope	Gentle	Gentle	Gentle
Prevalent Soil Type	Alluvial	Alluvial	Alluvial
Demographic and Social Characteristics			
Total Number of Households	560	2057	779
Population of Village	3050	10815	4072
Male Population of the Village	1598	5677	2164
Female Population of the Village	1452	5138	1908
Literacy Rate	67.4	52	73.05
Agricultural Characteristics			
Type of Irrigation	Mixed	Groundwater	Groundwater
Cultivated Area (NSA)	491.1	926.3	539.2
Gross Cropped Area (GCA)	1019.7	1811.6	1065.6
Cropping Intensity (Percentage)	207.6	195.6	197.6
Sources of Irrigation	Canals & Tubewells	Tubewells	Tubewells
Irrigated Area by Source (In Percent)	Canal - 38 % Tubewell - 62 %	Tubewells – 100 %	Tubewells – 100 %
Average Depth of Watertable Below	70 Feet	90 Feet	150 Feet

Result and Discussion

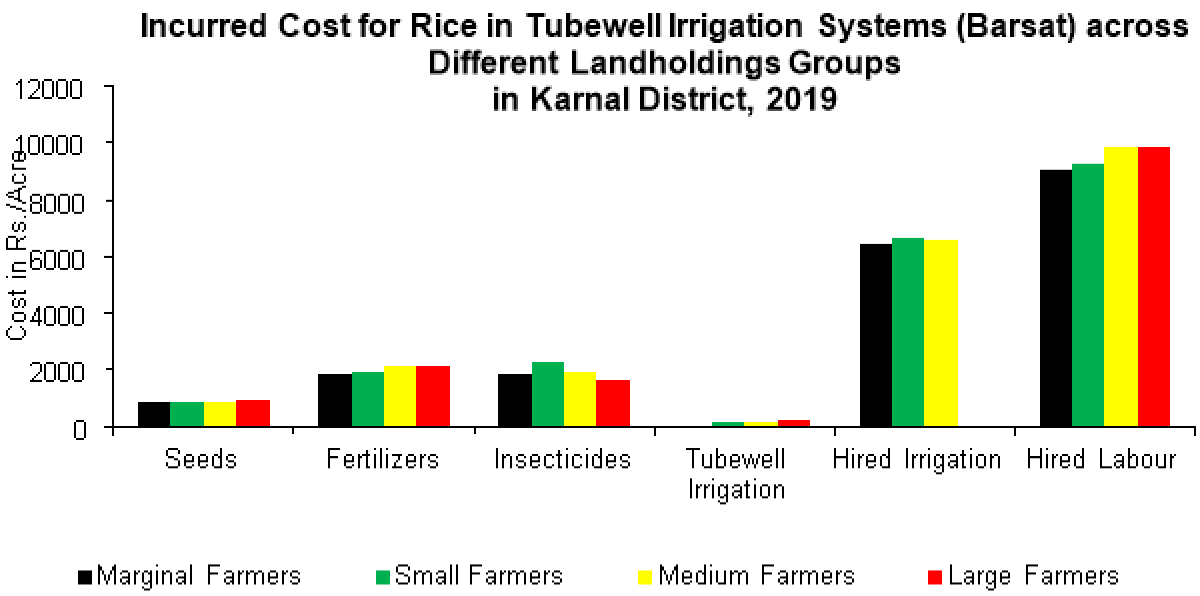
Comparative Analysis of Profitability of Rice and Wheat in Different Irrigation Systems Across Different Landholding Groups

This section analyzes the agricultural profitability across different landholding categories for different crops, comparing the cost of cultivation and net returns. In the case of rice cultivation, the incurring cost on seeds, fertilizer and micronutrient, insecticides, weedicides, and pesticides are positively related to the size of the landholding, and this is bigger the landholding size greater is the investment in the different inputs. Nevertheless, in the case of hired applications such as irrigation, the incurring cost of irrigation is negatively related to the landholding size; this is bigger the landholding size smaller (Figure 2, 3, and 4).



Source: Questionnaire Surveys in Various Villages from May to September 2019

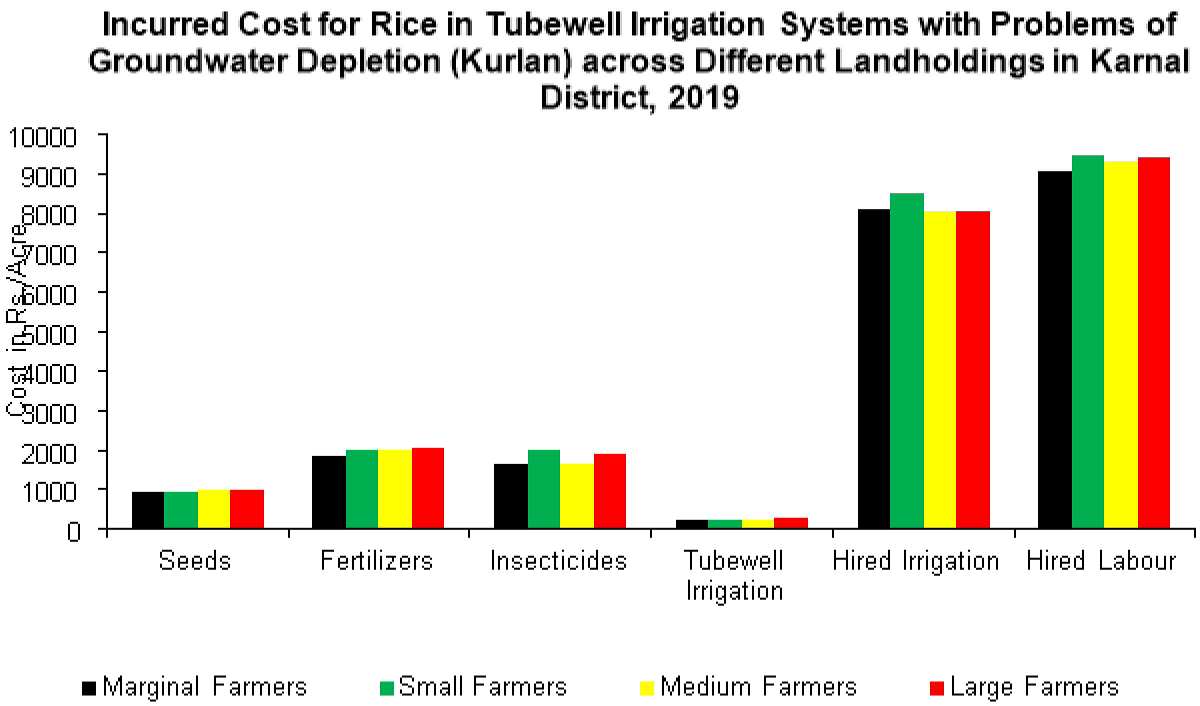
Fig. 2



Source: Questionnaire Surveys in Various Villages from May to September 2019

Fig. 3

The large farmers with more landholdings can save more and spend these savings for further investment in the next cropping season. Thus, capital accumulation is a resultant phenomenon for large farmers. Many scholars have studied that technology being income biased gives better returns to the already better endowed, making them more prosperous. It also leads to an increase in disparity between large and small farmers. The costs of cultivation of Rice and Wheat crop are given in table 3 and 4. The cost of cultivation and net returns are observed for different categories of farmers for the two major crops of Rice and Wheat to analyze the profitability with respect to the landholding sizes in which it is cultivated.



Source: Questionnaire Surveys in Various Villages from May to September 2019

Fig. 4

Table 3: Input Use and Cost of Cultivation of Rice Crop across Different Landholdings Size Groups in Different Irrigation Systems

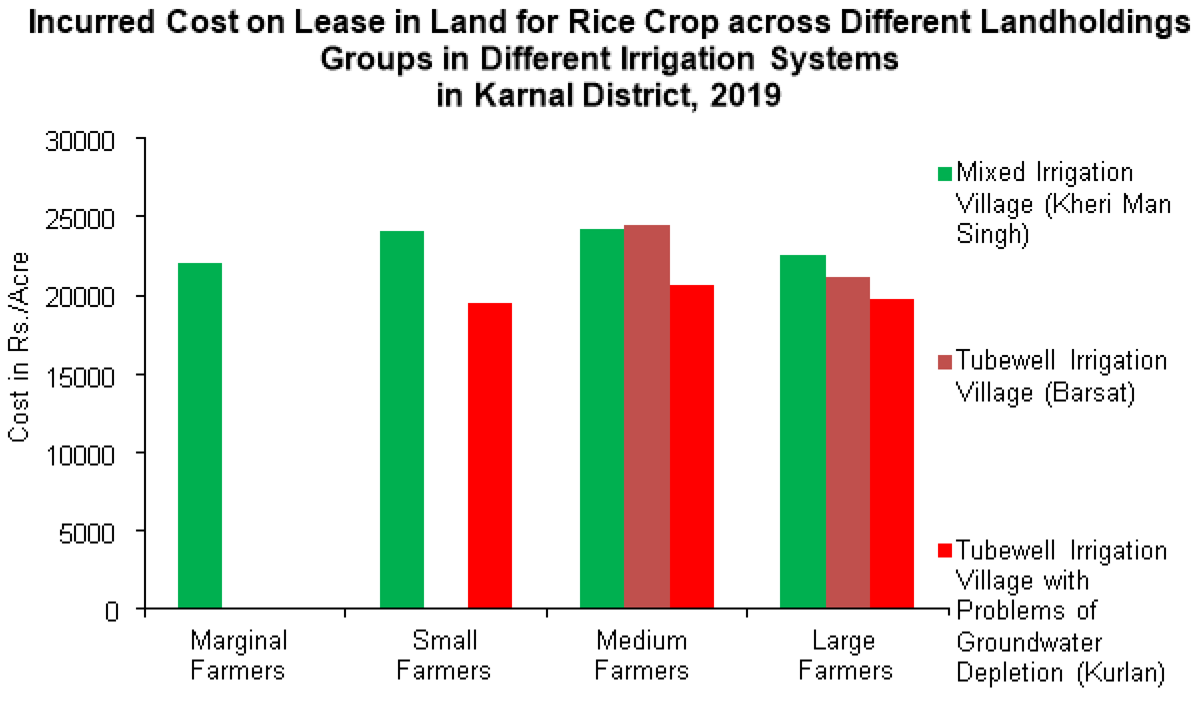
Particulars	Marginal Farmers	Small Farmers	Medium Farmers	Large Farmers	Total Farmers
Mixed Irrigation Village (Kheri Man Singh)					
Inputs					
Seeds (Rs.)	882	908	881	941	899
Fertilizer and Micronutrient (Rs.)	1,999	1,877	2,031	2,040	1,989
Insecticides, Weedicides, and Pesticides (Rs.)	2,110	2,156	1,844	2,270	2,056
Canal Irrigation Cost (Rs.)	100	100	100	100	100
Tubewell Irrigation Cost (Rs.)	110	91	116	122	110
Hired Irrigation Cost (Rs.)	4,200	2,600	2,400	2,600	2,720
Labour (Rs.)	9,156	9,113	9,640	9,638	9,411
Land Rent (Rs.)	22,000	24,083	24,250	22,500	23,260
The imputed cost of Tubewell Irrigation if all pumps were run by Diesel (RCDsl)	15,713	15,401	16,048	16,524	15,912
Cost of Cultivation (Rs.)					
Cost A1	18,557	16,845	17,012	17,711	17,285
Cost A2	40,557	40,928	41,262	40,211	40,545
Cost A2+RCDsl	56,270	56,329	57,310	56,735	56,457
Tubewell Irrigation Village (Barsat)					
Inputs					
Seeds (Rs.)	885	864	889	913	898
Fertilizer and Micronutrient (Rs.)	1,865	1,928	2,161	2,116	2,093
Insecticides, Weedicides, and Pesticides (Rs.)	1,833	2,252	1,942	1,625	1,812
Canal Irrigation Cost (Rs.)	0	0	0	0	0
Tubewell Irrigation Cost (Rs.)	0	127	177	206	191
Hired Irrigation Cost (Rs.)	6,480	6,642	6,570	0	6,570
Labour (Rs.)	9,038	9,300	9,841	9,813	9,709
Land Rent (Rs.)	0	0	24,500	21,214	21,944
The imputed cost of Tubewell Irrigation if all pumps were run by Diesel (RCDsl)	16,065	16,524	17,289	17,136	17,055
Cost of Cultivation (Rs.)					
Cost A1	20,101	21,113	21,580	14,673	21,273
Cost A2	20,101	21,113	46,080	35,887	43,217
Cost A2+RCDsl	36,166	37,637	63,369	53,023	60,270
Tubewell Irrigation Village With Problems of Groundwater Depletion (Kurlan)					
Inputs					
Seeds (Rs.)	938	915	969	995	954
Fertilizer and Micronutrient (Rs.)	1,856	1,984	2,021	2,040	1,981
Insecticides, Weedicides, and Pesticides (Rs.)	1,658	1,995	1,663	1,912	1,776
Canal Irrigation Cost (Rs.)	0	0	0	0	0
Tubewell Irrigation Cost (Rs.)	225	239	247	257	243
Hired Irrigation Cost (Rs.)	8,120	8,516	8,050	8,050	8,120
Labour (Rs.)	9,078	9,477	9,328	9,430	9,378
Land Rent (Rs.)	0	19,500	20,583	19,750	20,115
The imputed cost of Tubewell Irrigation if all pumps were run by Diesel (RCDsl)	20,043	20,543	21,013	22,166	20,802
Cost of Cultivation (Rs.)					
Cost A1	21,875	23,126	22,278	22,684	22,452
Cost A2	21,875	42,626	42,861	42,434	42,567
Cost A2+RCDsl	41,918	63,169	63,874	64,600	63,369
Total of all Sample Villages					
Inputs					
Seeds (Rs.)	898	901	910	936	916
Fertilizer and Micronutrient (Rs.)	1,905	1,920	2,073	2,083	2,022
Insecticides, Weedicides, and Pesticides (Rs.)	1,831	2,126	1,823	1,829	1,883

Canal Irrigation Cost (Rs.)	33	33	33	33	33
Tubewell Irrigation Cost (Rs.)	160	143	172	197	145
Hired Irrigation Cost (Rs.)	6,331	5,255	5,130	4,720	5,542
Labour (Rs.)	9,099	9,262	9,615	9,695	9,502
Land Rent (Rs.)	22,000	23,429	22,714	21,438	22,138
The imputed cost of Tubewell Irrigation if all pumps were run by Diesel (RCDsl)	17,936	17,774	18,597	19,011	18,436
Cost of Cultivation (Rs.)					
Cost A1	20,257	19,640	19,756	19,493	20,043
Cost A2	42,257	43,069	42,470	40,931	42,181
Cost A2+RCDsl	60,193	60,843	61,067	59,942	60,617

Source: Questionnaire Surveys in Various Villages from May to September 2019

Note: Cost A1= All actual expenses in cash and kind incurred in production by owner
Cost A2= Cost A1+Rent paid for leased inland
Cost A2+RCDsl= Cost A2+ imputed cost of tubewell irrigation if all pumps were run by Diesel

In table 3, some vital conclusions can be drawn out by analyzing the cost of cultivation of rice across different landholding groups in different irrigation systems. The large farmers mainly incur the higher costs for seeds, fertilizers, insecticides, and pesticides for the same reason of cyclic accumulation of wealth with greater profits from higher input doses and hence greater savings and more investment in crop inputs in the next crop cycle, increasing the yield further.

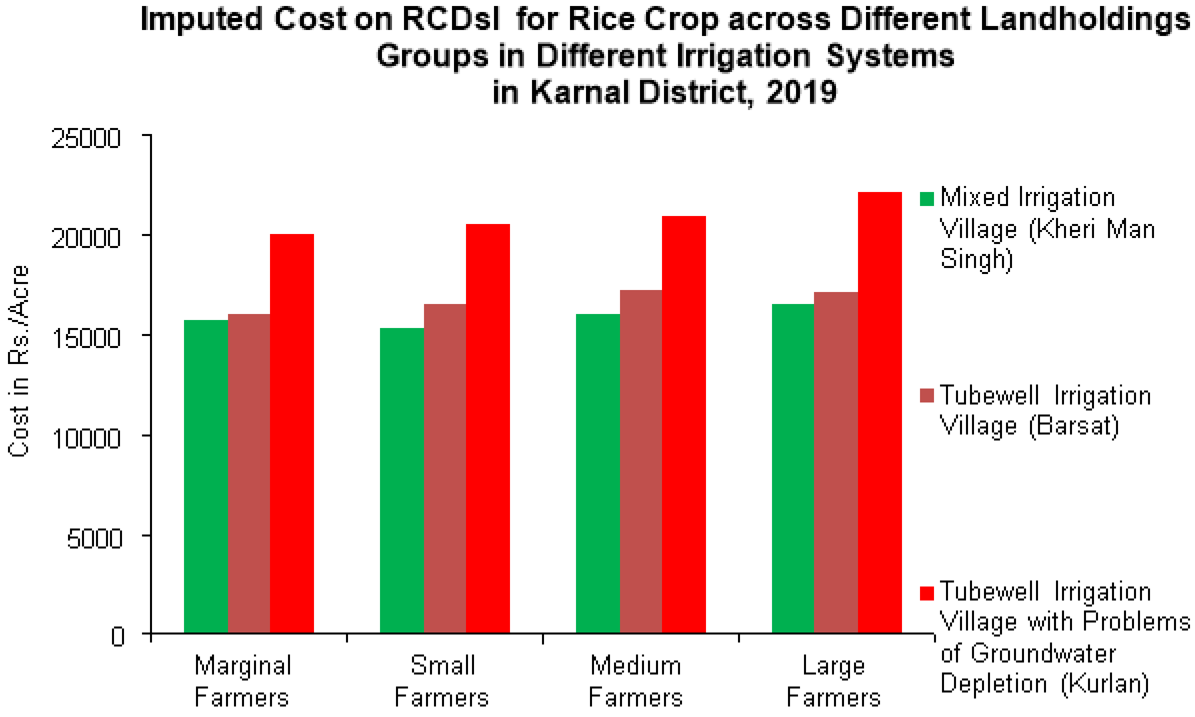


Source: Questionnaire Surveys in Various Villages from May to September 2019

Fig. 5

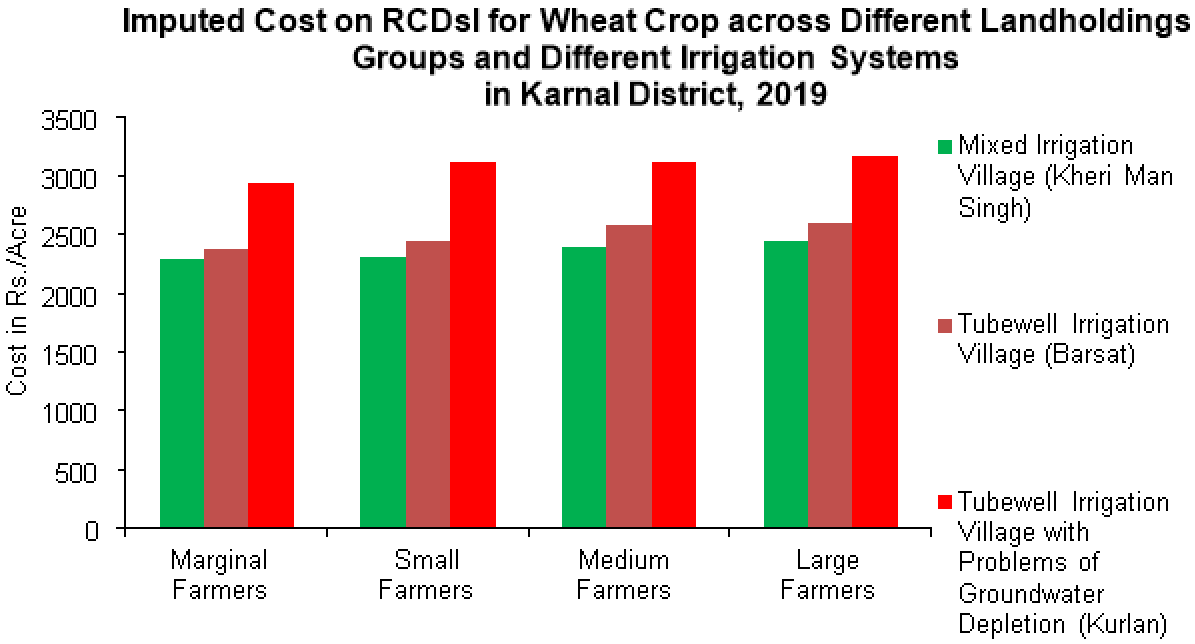
With groundwater depletion, the higher costs incurred by large and medium farmers than the marginal and small farmers in leased in land indicates reverse tenancy where the marginal and small farmers lease out land to the large farmers when they cannot afford the rising cost of cultivation and large farmers equipped with more capital and better technology reaps higher benefits from these leased in the land (Figure 5).

With a lack of capital and resources, the small and marginal farmers cultivate their land with family members' help since they cannot afford hired laborers for every work. Marginal and small farmers do spraying pesticides and insecticides at their own risk because of lacking capital. Across all the sample households, it was noticed that rice transplantation is only done with the hired laborers, which varies from Rs. 3,200.00 to Rs. 3,500.00 from village to village. During the focused group discussions with the farmers of sample villages, the farmers revealed that rice crop being a non-traditional crop in Haryana, the Haryanvi farmers is not experienced enough to work in flooded fields, to transplant rice seedlings in the hot months of June and July. Thus, irrespective of farm size, the cost of hired labor is always more than Rs. 3,000.00 for rice transplantation. Since the running cost of irrigation is meager in Haryana, the electricity cost and diesel cost of running tubewells are included in the comparative analysis of the cost calculation. Like other inputs, the electricity cost and the diesel cost positively correspond to the landholding sizes (Figure 6 and 7).



Source: Questionnaire Surveys in Various Villages from May to September 2019

Fig. 6



Source: Questionnaire Surveys in Various Villages from May to September 2019

Fig. 7

It is apparent as the maximum tubewell ownership also rests with the large landholding groups, and with the low running cost of the pumps, the owners use it to the maximum. It is also noted that these costs are higher for rice than for wheat crops, as the rice needs more water. Another interesting fact is that the cost also increases with the increase in groundwater depletion; that is, the imputed cost of electricity and diesel is higher in Kurlan village, and Barsat and Kheri Man Singh follow it. The lowest cost in Kheri Man Singh village is on account of conjunctive (mixed) irrigation. Nevertheless, in Kurlan, it is higher because depletion has resulted in low yielding or non-functioning of many tubewells.

Table 4: Input Use and Cost of Cultivation of Wheat Crop across Different Landholdings Size Groups in Different Irrigation Systems

Particulars	Marginal Farmers	Small Farmers	Medium Farmers	Large Farmers	Total Farmers
Mixed Irrigation Village (Kheri Man Singh)					
Inputs					
Seeds (Rs.)	1,329	1,363	1,278	1,282	1,310
Fertilizer and Micronutrient (Rs.)	1,905	1,877	1,993	2,011	1,950
Insecticides, Weedicides, and Pesticides (Rs.)	1,080	1,062	995	1,025	1,034
Canal Irrigation Cost (Rs.)	70	70	70	70	70
Tubewell Irrigation Cost (Rs.)	16	14	17	18	16
Hired Irrigation Cost (Rs.)	600	400	400	400	420
Labour (Rs.)	5,915	6,038	6,390	6,421	6,212
Land Rent (Rs.)	18,000	18,083	18,417	15,955	17,220
The imputed cost of Tubewell Irrigation if all pumps were run by Diesel (RCDsl)	2,295	2,320	2,396	2,448	2,368
Cost of Cultivation (Rs.)					
Cost A1	10,915	10,824	11,143	11,227	11,012
Cost A2	28,915	28,907	29,560	27,182	28,232
Cost A2+RCDsl	31,210	31,227	31,956	29,630	30,600
Tubewell Irrigation Village (Barsat)					
Seeds (Rs.)	1,419	1,370	1,334	1,230	1,295
Fertilizer and Micronutrient (Rs.)	1,760	1,844	2,062	1,936	1,956

Insecticides, Weedicides, and Pesticides (Rs.)	953	946	1,071	1,166	1,095
Canal Irrigation Cost (Rs.)	0	0	0	0	0
Tubewell Irrigation Cost (Rs.)	0	19	26	30	28
Hired Irrigation Cost (Rs.)	945	1,080	1,080	0	1,026
Labour (Rs.)	5,889	5,930	6,583	6,632	6,486
Land Rent (Rs.)	0	0	16,500	14,643	15,056
The imputed cost of Tubewell Irrigation if all pumps were run by Diesel (RCDsl)	2,372	2,448	2,587	2,601	2,563
Cost of Cultivation (Rs.)					
Cost A1	10,966	11,189	12,156	10,994	11,886
Cost A2	10,966	11,189	28,656	25,637	26,942
Cost A2+RCDsl	13,338	13,637	31,243	28,238	29,505
Tubewell Irrigation Village With Problems of Groundwater Depletion (Kurlan)					
Inputs					
Seeds (Rs.)	1,370	1,306	1,260	1,250	1,306
Fertilizer and Micronutrient (Rs.)	1,822	1,941	1,919	1,941	1,892
Insecticides, Weedicides, and Pesticides (Rs.)	1,110	1,222	1,186	1,293	1,183
Canal Irrigation Cost (Rs.)	0	0	0	0	0
Tubewell Irrigation Cost (Rs.)	33	35	37	38	36
Hired Irrigation Cost (Rs.)	1,295	1,400	1,225	1,285	1,285
Labour (Rs.)	6,118	6,138	6,137	6,132	6,130
Land Rent (Rs.)	0	15,500	16,500	15,800	16,125
The imputed cost of Tubewell Irrigation if all pumps were run by Diesel (RCDsl)	2,947	3,111	3,122	3,164	3,039
Cost of Cultivation (Rs.)					
Cost A1	11,748	12,042	11,764	11,939	11,832
Cost A2	11,748	27,542	28,264	27,739	27,957
Cost A2+RCDsl	14,695	30,653	31,386	30,903	30,996
Total of all Sample Villages					
Inputs					
Seeds (Rs.)	1,362	1,345	1,292	1,246	1,303
Fertilizer and Micronutrient (Rs.)	1,841	1,892	1,994	1,954	1,932
Insecticides, Weedicides, and Pesticides (Rs.)	1,081	1,092	1,078	1,160	1,104
Canal Irrigation Cost (Rs.)	23	23	23	23	23
Tubewell Irrigation Cost (Rs.)	23	21	26	29	21
Hired Irrigation Cost (Rs.)	980	860	780	773	879
Labour (Rs.)	6,024	6,050	6,380	6,483	6,276
Land Rent (Rs.)	18,000	17,714	17,321	15,522	16,511
The imputed cost of Tubewell Irrigation if all pumps were run by Diesel (RCDsl)	2,636	2,680	2,752	2,833	2,737
Cost of Cultivation (Rs.)					
Cost A1	11,334	11,283	11,573	11,668	11,538
Cost A2	29,334	28,997	28,894	27,190	28,049
Cost A2+RCDsl	31,970	31,677	31,646	30,023	30,786

Source: Questionnaire Surveys in Various Villages from May to September 2019

Note: Cost A1= All actual expenses in cash and kind incurred in production by owner

Cost A2= Cost A1+Rent paid for leased inland

Cost A2+RCDsl= Cost A2+ imputed cost of tubewell irrigation if all pumps were run by Diesel

Table 5: Yield of Rice and Wheat Crop across Different Landholding Groups in Different Irrigation Systems

Particulars	Marginal Farmers	Small Farmers	Medium Farmers	Large Farmers
Rice Yield (Quintal/Acre)				
Mixed Irrigation Village (Kheri Man Singh)	21	22	23	25
Tubewell Irrigation Village (Barsat)	20	21	23	23
Tubewell Irrigation	19	19	20	20

Village with Problems of Groundwater Depletion (Kurlan)				
Wheat Yield (Quintal/Acre)				
Mixed Irrigation Village (Kheri Man Singh)	22	23	23	24
Tubewell Irrigation Village (Barsat)	21	22	22	23
Tubewell Irrigation Village with Problems of Groundwater Depletion (Kurlan)	21	22	22	20

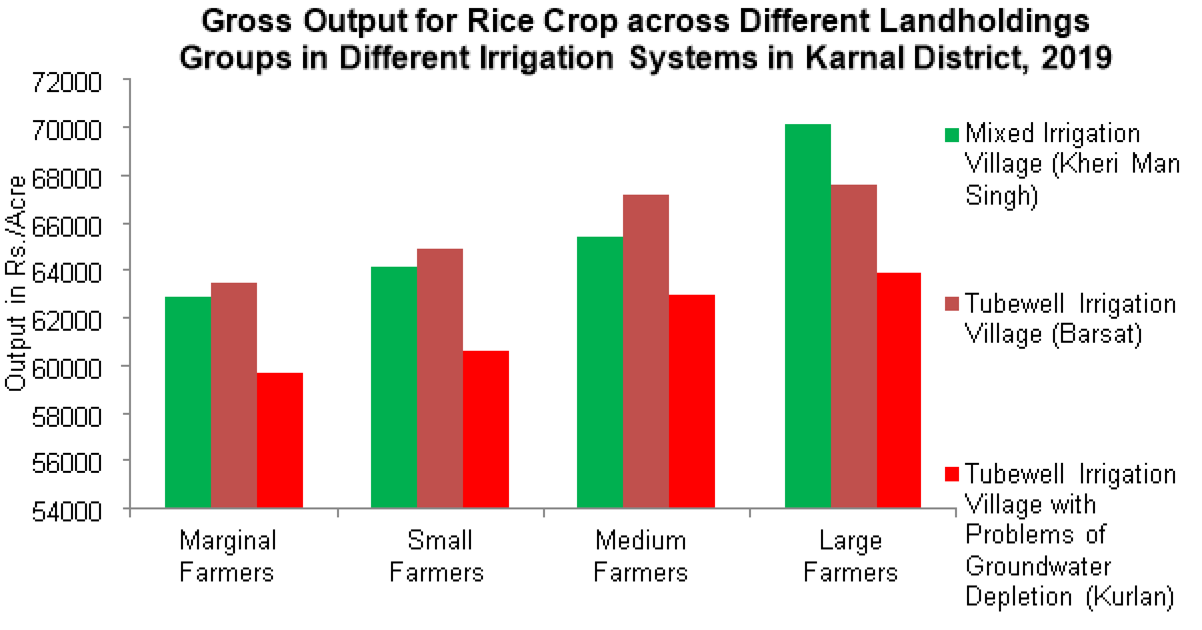
Source: Questionnaire Surveys in Various Villages from May to September 2019

Table 5 shows the yield of rice and wheat crops across different landholding groups in different irrigation systems. The quantity of production is positively related to the number of inputs put in the production cycle. In other words, it is expected that with increased amounts of inputs, the crops are also likely to give higher yields. Rice crop shows greater variability of yield across different irrigation systems than the Wheat crop. Table 5 depicts that marginal and small farmers incur the lower yield of Rice crop in all irrigation systems than the large and medium farmers. Nevertheless, the comparative yield of marginal and small farmers across the three irrigation systems shows that rice yields are much lower in the groundwater depleted village of Kurlan and the Barsat village than in the mixed irrigated village of Kheri Man Singh. The Kheri Man Singh village rice crop's mixed irrigation system shows greater yield variability across different landholding groups. In a mixed irrigation system, “the marginal and small farmers depend much more on canal water than the large and medium farmers who have their own tubewells. Furthermore, canal water being less flexible and reliable, cannot provide quality irrigation to the farmers. Thus, greater dependence of marginal and small farmers on canal water has led to comparatively lower yield than large and medium farmers, respectively. Higher yield levels on large farms may be due to the optimum level of inputs utilized by them along with timely weeding operations, proper selection of varieties of seeds, as compared to other farms.” Also, the yield variation might be due to the different times of sowing and types of land.

In the groundwater-depleted village of Kurlan, small and marginal farmers' lower yields are also associated with irrigation uncertainty. In Kurlan village, the persistent depletion of groundwater has led to a fast decline in water tables. The ability to chase the water table requires substantial capital investments to install submersible pumps and deepen tubewells beyond small and medium farmers' reach due to lack of finances. In such cases, the farmers who do not have tubewells or whose tubewells have low water yields resort to buying water. The sharing of water often depends on social relations between the buyers and sellers, only when there is surplus water. Thus, “the small and marginal farmers who generally do not have tubewells depend on these large farmers for irrigating their land and have to adjust to odd timings of irrigation as they can get water to irrigate their crops only when the tubewell owners are not using it. With fewer electricity supply hours with power cuts, the reliability and quantity of irrigation come down as turns of irrigation of tubewell owners are given greater precedence over the water buyers. While in mixed irrigation systems of Kheri Man Singh village, the constraint to higher yields is water availability; in the groundwater depleted tubewell irrigation systems; the primary constraint is accessibility to irrigation water.”

While rice crop yields show variability across different farm sizes in different irrigation systems, wheat does not show much variation. Unlike rice crops, the wheat crop requires three or four irrigations depending on the winter rains. Moreover, the wheat crop being a Rabi crop is fully irrigated with tubewells avoiding fluctuation in the canal water supply. Furthermore, since all the farmers grow the wheat crop in the Rabi season, irrigation water's total requirement is much less. As a result, water exchange and sharing are not significant problems as there is surplus water. Thus, the yield of the wheat crop is neither constrained by water availability nor by water accessibility.

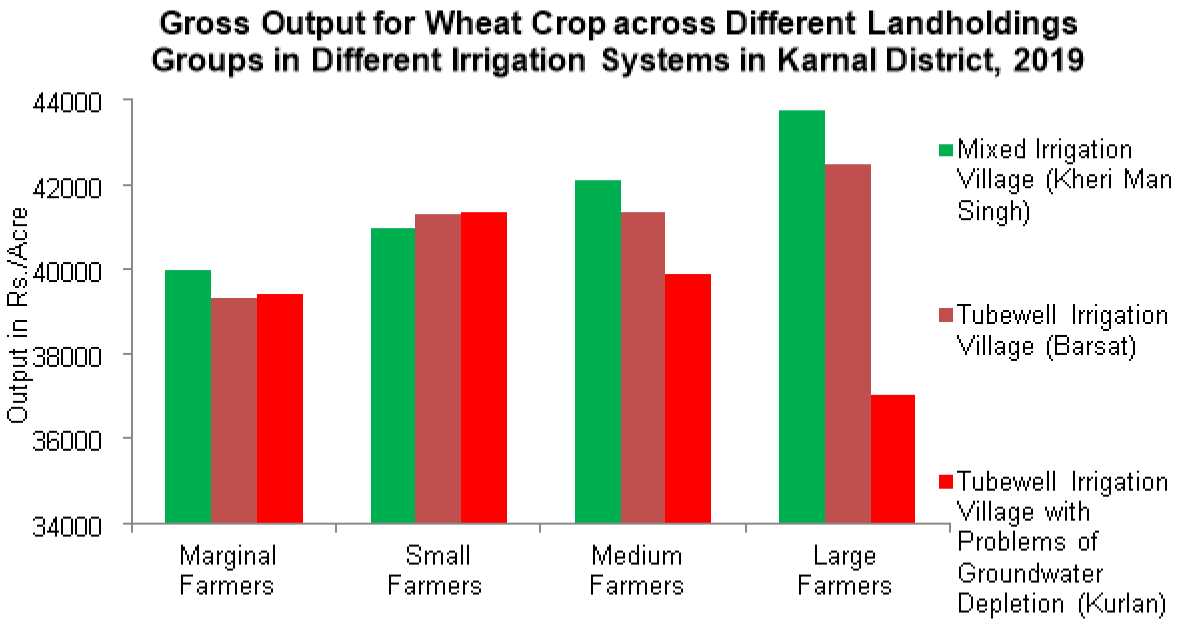
Figure 8 reveals that there has been a continuous increase in gross output for rice crops across different landholdings groups in different irrigation systems. The gross output for rice crops is positively correlated with different landholding sizes in different irrigation systems. Small landholding shows minimum gross output, and large landholdings show maximum gross output for rice crops. It also shows a positive correlation with groundwater depletion because it is noticed here that the gross output for rice crops decreases with the groundwater depletion and increases with the better facilities of irrigation. The mixed irrigation system (Kheri Man Singh) and tubewell irrigation systems (Barsat) show better gross output than the tubewell irrigation system with problems of groundwater depletion (Kurlan) because both village Kheri Man Singh and Barsat having better facilities of irrigation than Kurlan village. In the case of marginal, small, and medium farmers, the tubewell irrigated village of Barsat shows better gross output than the mixed irrigated village of Kheri Man Singh. In the mixed irrigated village of Kheri Man Singh, the marginal and small farmers depend much more on canal water, and canal water being less flexible and reliable than tubewell irrigation, so canal water cannot provide quality irrigation to the farmers. Nevertheless, it is not the same in large farmers because the larger farmers have both facilities of canal irrigation and tubewell irrigation, so they have got maximum gross output than other landholdings.



Source: Questionnaire Surveys in Various Villages from May to September 2019

Fig. 8

While rice crops' gross output shows variability across different farm sizes in different irrigation systems, wheat does not show much variation. Nevertheless, in the case of large landholdings, wheat shows the variation in different irrigation systems (Figure 9). Because large farmers cultivated more rice crops than other landholdings, the large farmers spent much time harvesting rice crops. By this, the land has lost out its moisture by the shortage of water, so farmers have extra needs of irrigation for cultivating wheat crops. Thus, the farmers have also lost out their proper time of sowing the wheat crop, which affects the yields respectively.



Source: Questionnaire Surveys in Various Villages from May to September 2019

Fig. 9

Table 6: Output and Net Returns to Cultivation of Rice Crop across Different Landholdings Groups in Different Irrigation Systems

Particulars	Marginal Farmers	Small Farmers	Medium Farmers	Large Farmers	Total Farmers
Mixed Irrigation Village (Kheri Man Singh)					
Output					
Yield (Quintal/Acre)	21	22	23	25	23
Gross Output (Rs.)	62,896	64,190	65,448	70,177	65,534
Net Returns (Rs.)					
Over Cost A1	44,339	47,345	48,436	52,466	48,249
Over Cost A2	22,339	23,262	24,186	29,966	24,989
Over Cost A2+RCDsl	6,626	7,861	8,138	13,442	9,077
Tubewell Irrigation Village (Barsat)					
Output					
Yield (Quintal/Acre)	20	21	23	23	22
Gross Output (Rs.)	63,475	64,958	67,163	67,637	66,875
Net Returns (Rs.)					
Over Cost A1	43,374	43,845	45,583	52,964	45,602
Over Cost A2	43,374	43,845	21,083	31,750	23,658
Over Cost A2+RCDsl	27,309	27,321	3,794	14,614	6,605
Tubewell Irrigation Village With Problems of Groundwater Depletion (Kurlan)					

Output					
Yield (Quintal/Acre)	19	19	20	20	20
Gross Output (Rs.)	59,721	60,627	62,955	63,944	61,601
Net Returns (Rs.)					
Over Cost A1	37,846	37,501	40,677	41,260	39,149
Over Cost A2	37,846	18,001	20,094	21,510	19,034
Over Cost A2+RCDsl	17,803	-2,542	-919	-656	-1,768
Total of all Sample Villages					
Output					
Yield (Quintal/Acre)	20	21	22	23	22
Gross Output (Rs.)	61,230	63,153	65,283	67,464	64,688
Net Return (Rs.)					
Over Cost A1	40,973	43,513	45,527	47,971	44,645
Over Cost A2	18,973	20,084	22,813	26,533	22,507
Over Cost A2+RCDsl	1,037	2,310	4,216	7,522	4,071

Source: Questionnaire Surveys in Various Villages from May to September 2019

Note: Cost A1= All actual expenses in cash and kind incurred in production by owner
Cost A2= Cost A1+Rent paid for leased inland
Cost A2+RCDsl= Cost A2+ imputed cost of tubewell irrigation if all pumps were run by Diesel

Table 7: Output and Net Returns to Cultivation of Wheat Crop across Different Landholdings Groups in Different Irrigation Systems

Particulars	Marginal Farmers	Small Farmers	Medium Farmers	Large Farmers	Total Farmers
Mixed Irrigation Village (Kheri Man Singh)					
Output					
Yield (Quintal/Acre)	22	23	23	24	23
Gross Output (Rs.)	39,954	40,940	42,075	43,773	41,680
Net Returns (Rs.)					
Over Cost A1	29,039	30,116	30,932	32,546	30,668
Over Cost A2	11,039	12,033	12,515	16,591	13,448
Over Cost A2+RCDsl	8,744	9,713	10,119	14,143	11,080
Tubewell Irrigation Village (Barsat)					
Output					
Yield (Quintal/Acre)	21	22	22	23	23
Gross Output (Rs.)	39,284	41,290	41,346	42,458	41,709
Net Returns (Rs.)					
Over Cost A1	28,318	30,101	29,190	31,464	29,823
Over Cost A2	28,318	30,101	12,690	16,821	14,767
Over Cost A2+RCDsl	25,946	27,653	10,103	14,220	12,204
Tubewell Irrigation Village With Problems of Groundwater Depletion (Kurlan)					
Output					
Yield (Quintal/Acre)	21	22	22	20	21
Gross Output (Rs.)	39,417	41,346	39,867	37,016	39,472
Net Returns (Rs.)					
Over Cost A1	27,669	29,304	28,103	25,077	27,640
Over Cost A2	27,669	13,804	11,603	9,277	11,515
Over Cost A2+RCDsl	24,722	10,693	8,481	6,113	8,476
Total of all Sample Villages					
Output					
Yield (Quintal/Acre)	22	22	22	23	22
Gross Output (Rs.)	39,574	41,144	41,164	41,654	40,954
Net Return (Rs.)					
Over Cost A1	28,240	29,861	29,591	29,986	29,416
Over Cost A2	10,240	12,147	12,270	14,464	12,905
Over Cost A2+RCDsl	7,604	9,467	9,518	11,631	10,168

Source: Questionnaire Surveys in Various Villages from May to September 2019
Note: Cost A1= All actual expenses in cash and kind incurred in production by owner
Cost A2= Cost A1+Rent paid for leased inland
Cost A2+RCDsl= Cost A2+ imputed cost of tubewell irrigation if all pumps were run by Diesel

Table 6 and 7 reveal the output and net returns to rice and wheat crop cultivation across different landholding groups in different irrigation systems. The examination of net returns reveals that the traditional wheat crop shows the highest net returns for all the farm categories. It also shows fewer variations indicating comparable profitability for all farmers' groups irrespective of the operational holding size. It has already been seen in the analysis that the cost of cultivation of rice crop is much greater than wheat crop and this cost increases with the scarcity of water, i.e., cost of cultivation of rice is higher in the groundwater depleted tubewell irrigation village of Kurlan than tubewell irrigation village of Barsat. Nevertheless, it is also seen that not only the cost rises with depletion, the inequality in cost and returns also rises with falling water tables.

In the mixed irrigation system of Kheri Man Singh, there is a problem of flexibility and stability of canal irrigation water for marginal farmers who have not their sole tubewell. A perusal of above table 6 shows that the rice crops the per hectare net returns over Cost A1 are the highest about Rs. 52,446.00 in large farmers and the lowest about Rs. 44,339.00 in marginal farmers. Marginal farmers are totally dependent on hired irrigation, so they have to pay a maximum of Rs. 4,200.00 than other farmers. As a result, the cost of cultivation for marginal farmers is high; thus, the net return over Cost A1 is low than other farmers. Nevertheless, in the case of large farmers, the hired irrigation cost is meager than marginal farmers because these farmers have both irrigation sources, canal and tubewells, so large and medium farmers have got maximum net return over Cost A1 than other farmers. There is no correlation between the cost of cultivation and different landholding size, but in the case of net return over Cost A1, Cost A2, and Cost A2+RCDsl, it is correlated with the different landholding sizes. There has been a continuous increase in net return over Cost A1, Cost A2, and Cost A2+RCDsl for rice crops across different landholding sizes, and it decreases with the landholding size decrease. It is apparent from table 4.7 that per hectare net returns on rice crop over Cost A2 ranged from Rs. 29,966.00 in large farmers to Rs. 22,339.00 in marginal farmers with an average of Rs. 24,989.00 of the mixed irrigation system of Kheri Man Singh. The per hectare net returns over Cost A2+RCDsl ranged from Rs. 13,442.00 in large farmers to Rs. 6,626.00 in marginal farmers with an average of Rs. 9,077.00 of mixed irrigation systems of Kheri Man Singh.

A perusal of above table 7 shows that the per hectare net returns over Cost A1 for the wheat crop are the highest at about Rs. 32,546.00 in large farmers and the lowest about Rs. 29,039.00 in marginal farmers. The net return over Cost A1, Cost A2, and Cost A2+RCDsl are also correlated with the wheat crop case is different landholding sizes. There has been a continuous increase in net return over Cost A1, Cost A2, and Cost A2+RCDsl for wheat crops across different landholding sizes, and it decreases with the landholding size decrease. It is apparent from table 4.8 that per hectare net returns on wheat crop over Cost A2 ranged from Rs. 16,591.00 in large farmers to Rs. 11,039.00 in marginal farmers with an average of Rs. 13,448.00 of the mixed irrigation system of Kheri Man Singh.

The tubewell irrigation systems with regard to the cost of cultivation and net returns give different results. In Barsat village, where there is no problem of groundwater depletion, on the one hand, the cost of cultivation of rice is much lower than that of Kurlan village, which faces problems of groundwater depletion and on the other hand, Barsat village also has very high net returns across all landholdings than that in Kurlan village. There is higher equality among the landholding groups not only in terms of costs incurred but also in terms of net returns in Barsat village. In the case of rice crops, the net return over Cost A1 is correlated with the different landholding sizes. There has been a continuous increase in net return over Cost A1 for rice crops across different landholding sizes, and it decreases with the landholding size decrease. It is apparent from table 6 that per hectare net returns on rice crop over Cost A1 ranged from Rs. 52,964.00 in large farmers to Rs. 43,374.00 in marginal farmers with an average of Rs. 45,602.00 of tubewell irrigation systems of Barsat village. Nevertheless, in the case of net returns over Cost A2, the highest net returns are seen in the marginal and small farmers than large and medium farmers, due to the difference between land lease rent. The large farmers incurred much money for land lease rent, so in this case, the net returns over Cost A2 are lowest than marginal and small farmers. The per hectare net returns on rice crop over Cost A2 ranged from Rs. 43,374.00 in marginal farmers to Rs. 31,750.00 in large farmers with an average of Rs. 23,658.00. It is lowest in medium farmers, about Rs. 21,083.00. The net returns over Cost A2+RCDsl are also affected by the land lease rent. Thus, the net returns over Cost A2+RCDsl are also highest in marginal and small farmers and lowest in medium and large farmers. The per hectare net returns on rice crop over Cost A2+RCDsl ranged from Rs. 27,309.00 in marginal farmers to Rs. 14,614.00 in large farmers with an average of Rs. 6,605.00. It is lowest in medium farmers, about Rs. 3,794.00.

In the wheat crop case, the net returns are the same pattern according to the rice crop, but the ranges are different across different landholding sizes. The per hectare net returns on wheat crop over Cost A1 ranged from Rs. 31,464.00 in large farmers to Rs. 28,318.00 in small farmers with an average of Rs. 29,823.00. The per hectare net returns on wheat crop over Cost A2 ranged from Rs. 28,318.00 to Rs. 16,821.00 in large farmers with an average of Rs. 14,767.00. It is lowest in medium farmers, about Rs. 12,690.00. The per hectare net returns on wheat crop over Cost A2+RCDsl ranged from Rs. 25,946.00 in small farmers to Rs. 14,220.00 in large farmers with an average of Rs. 12,204.00. It is lowest in medium farmers, about Rs. 10,103.00.

The tubewell irrigation systems with problems of groundwater depletion of Kurlan village with regard to the cost of cultivation and net returns give different results. In the case of rice crops, the net return over Cost A1 is correlated with the different landholding sizes. There has been a continuous increase in net return over Cost A1 for rice crops across different landholding sizes, and it decreases with the landholding size decrease. It is apparent from table 6 that per hectare net returns on rice crop over Cost A1 ranged from Rs. 41,260.00 in large farmers to Rs. 37,501.00 in small farmers with an average of Rs. 39,149.00 of tubewell irrigation systems of Kurlan village. The per hectare net returns on rice crop over Cost A2 ranged from Rs. 21,510.00 in large farmers to Rs. 18,001.00 in small farmers with an average of Rs. 19,034.00.

In Kurlan Village, the falling groundwater table has made irrigation very costly despite highly subsidize electricity to agriculture. With the rising cost of cultivation and consecutive lower returns to agriculture, the farmers' investments come down, especially owning lesser landholdings. Thus, there is a disparity in the expenditure of farm inputs among small and large farmers. Moreover, this high cost of cultivation also reflects in the lower net returns indicating a decline in profitability with the decline in groundwater tables. Due to these inequities and the low economic efficiency of rice cultivation in Kurlan, it can be said that the groundwater-depleted tubewell irrigation system is under severe stress.

Thus, in tubewell irrigation systems, it can be seen that the cost of cultivation and net returns to cultivation depend on the availability and accessibility of water resources. For all the sample villages, the hired irrigation cost is decreasing with the increasing landholding size. The highest hired irrigation cost is incurred by the marginal farmers and decreases with the landholding size, respectively.

The marginal and small farmers for all sample villages incurred much money, about Rs. 6,331.00 and Rs. 5,255.00 for hired irrigation, therefore, their cost of cultivation is higher than large farmers, but their net returns are lower than the large farmers. In large farmers' cases, the large farmers incurred fewer amounts on hired irrigation than other landholdings because they have their own Water Extraction Machines. Nevertheless, in the case of land fragmentation, the large farmers incurred Rs. 4,720.00 for as hired irrigation. Thus, the cost of cultivation and net returns to cultivation depends on water resource availability and accessibility.

It is seen that if all the farmers use the same number of irrigations as they are using with highly subsidize electricity to agriculture even with diesel tubewell pumps enormous amount of money would be spent on irrigation giving even negative net returns to small, medium and large categories of farmers in tubewell irrigation systems of Kurlan village for rice cultivation. The imputed cost of diesel is highest in large farmers and lowest in marginal farmers. This comparison refers to the large gap between the marginal and small farmers with large farmers in drafting groundwater. In other words, it also means that the large farmers are more responsible for groundwater depletion as they have the technology to harness water even from greater depths.

Thus, it is observed that electricity subsidy is essential for marginal and small farmers, and its benefits reach all classes of farmers when all of them own Water Extraction Machines (WEMs). Nevertheless, with declining water tables, the gains of electricity are disproportionately borne by the large farmers as they have the capital to change water technology to cope with the groundwater depletion. On the other hand, technological accessibility restricted to a few cultivators leads to regional disparity and ecological degradation.

Input-Output Ratio to Cultivation of Rice and Wheat across Different Landholding Groups in Different Irrigation Systems

"The input-output ratio reflects the criteria for the crop's economic viability based on returns per rupee invested. The input-output ratios were worked out based on different cost concepts, and the same is presented in table 8."

Table 8: Ratio of Cost and Returns to Cultivation of Rice and Wheat across Different Landholdings Classes in Different Irrigation Systems

Particulars	Marginal Farmers	Small Farmers	Medium Farmers	Large Farmers	Total Farmers
Rice					
Mixed Irrigation Village (Kheri Man Singh)					
Return per unit of Cost (Rs.)	2.39	2.81	2.85	2.96	2.79
Return per unit of Cost, including the cost of Land Rent (Rs.)	0.55	0.57	0.59	0.75	0.62
Return per unit of cost, including the cost of Diesel (Rs.)	0.12	0.14	0.14	0.24	0.16
Tubewell Irrigation Village (Barsat)					
Return per unit of Cost (Rs.)	2.16	2.08	2.11	3.61	2.14
Return per unit of Cost, including the cost of Land Rent (Rs.)	2.16	2.08	0.46	0.88	0.55
Return per unit of Cost, including the cost of Diesel (Rs.)	0.76	0.73	0.06	0.28	0.11
Tubewell Irrigation Village With Problems of Groundwater Depletion (Kurlan)					
Return per unit of Cost (Rs.)	1.73	1.62	1.83	1.82	1.74
Return per unit of Cost, including the cost of Land Rent (Rs.)	1.73	0.42	0.47	0.51	0.45
Return per unit of Cost, including the cost of Diesel (Rs.)	0.42	-0.04	-0.01	-0.01	-0.03
Total of all Sample Villages					
Return per unit of Cost (Rs.)	2.02	2.22	2.30	2.46	2.23
Return per unit of Cost, including the cost of Land Rent (Rs.)	0.45	0.47	0.54	0.65	0.53
Return per unit of Cost, including the cost of Diesel (Rs.)	0.02	0.04	0.07	0.13	0.07
Wheat					
Mixed Irrigation Village (Kheri Man Singh)					
Return per unit of Cost (Rs.)	2.66	2.78	2.78	2.90	2.78
Return per unit of Cost, including the cost of Land Rent (Rs.)	0.38	0.42	0.42	0.61	0.48
Return per unit of Cost, including the cost of Diesel (Rs.)	0.28	0.31	0.32	0.48	0.36
Tubewell Irrigation Village (Barsat)					
Return per unit of Cost (Rs.)	2.58	2.69	2.40	2.86	2.51
Return per unit of Cost, including the cost of Land Rent (Rs.)	2.58	2.69	0.44	0.66	0.55
Return per unit of Cost, including the cost of Diesel (Rs.)	1.95	2.03	0.32	0.50	0.41
Tubewell Irrigation Village With Problems of Groundwater Depletion (Kurlan)					
Return per unit of Cost (Rs.)	2.36	2.43	2.39	2.10	2.34
Return per unit of Cost, including the cost of Land Rent (Rs.)	2.36	0.50	0.41	0.33	0.41
Return per unit of Cost, including the cost of Diesel (Rs.)	1.68	0.35	0.27	0.20	0.27
Total of all Sample Villages					
Return per unit of Cost (Rs.)	2.49	2.65	2.56	2.57	2.55
Return per unit of Cost, including the cost of Land Rent (Rs.)	0.35	0.42	0.42	0.53	0.46
Return per unit of Cost, including the cost of	0.24	0.30	0.30	0.39	0.33

Diesel (Rs.)	

Source: Questionnaire Surveys in Various Villages from May to September 2019

To compare the net returns on an incurred cost of rupee one, the ratio of cost and returns were compared for the three irrigation systems across different landholdings groups (table 8). These ratios were calculated by considering the imputed cost of diesel into the cost of cultivation and including the cost of land lease rent. It was seen that with the advantage of mixed irrigation, farmers in Kheri Man Singh village gained a net return of Rs. 2.79 and Rs. 2.78 on incurring a rupee cost for rice and wheat crop respectively, which was highest compared to the other two irrigation systems under study. In mixed irrigation systems of Kheri Man Singh village for rice crops, the input-output ratio was the lowest (1: 2.39) in marginal farmers and the highest (1: 2.96) in large farmers. In all the irrigation systems, the large farmers' highest input-output ratio was seen in tubewell irrigation systems of Barsat village about (1: 3.61) and lowest by small farmers of Kurlan village (1: 1.62). The intensity of the underperformance of returns to rice crop is seen to be maximum in the 'so-called superior' tubewell irrigation systems, and also, the performance further declines with groundwater depletion. When the imputed cost of diesel is considered in the calculation of returns, it was seen that the tubewell irrigation systems of Kurlan village obtained a negative return.

Conclusion

All irrigation systems function under constraints imposed by one or more limiting factors. Every system, therefore, has its own limitations and usefulness. A canal irrigation system lacks the kind of reliability and flexibility generally commanded by the tubewell irrigation system. Inadequate supply of canal water in terms of quantity and time and inefficiency in the management of canal networks led to the exploitation of groundwater for irrigation with the help of private initiative in tubewell technology. The Conjunctive irrigation systems (mixed irrigation systems), canals, and tubewell are the most beneficial for the farmers. At the time of the inadequate supply of canal water, the farmers perform irrigation with their tubewells; therefore, in the present study, the farmers of mixed irrigation systems got the highest net returns than the farmers of other irrigation systems. The most significant advantage of private ownership of tubewells lies in the matter of maintenance and control of waters. At the individual level, private operators are much more efficient even when they operate with low technology. However, erratic power supply, low yields of tubewells, or higher diesel cost, particularly in rice irrigation's peak seasons, often reduce the tubewell irrigation system's reliability and flexibility. Thus, the tubewell irrigation systems with groundwater depletion problems are not much beneficial as other irrigation systems. Therefore, the farmers of tubewell irrigation systems of Kurlan village got the lowest net returns than the farmers of other irrigation systems. The incurring cost on seeds, fertilizer and micronutrients, insecticides, weedicides, and pesticides are positively related to the size of the landholding, and this is bigger the landholding size greater is the investment in the different inputs. Nevertheless, in the case of hired applications such as irrigation, the incurring cost of irrigation is negatively related to the landholding size; this is bigger the landholding size smaller. The marginal and small farmers incur a lower yield of rice-wheat crops in all irrigation systems than the large and medium farmers. Nevertheless, the comparative yield of marginal and small farmers across the three irrigation systems shows that rice yields are much lower in the groundwater depleted village of Kurlan and the Barsat village than in the mixed irrigated village of Kheri Man Singh. The Kheri Man Singh village rice crop's mixed irrigation system shows greater yield variability across different landholding groups. The examination of net returns reveals that the traditional wheat crop shows the highest net returns for all the farm categories. It also shows fewer variations indicating comparable profitability for all farmers' groups irrespective of the operational holding size. It has already been seen in the analysis that the cost of cultivation of rice crop is much greater than wheat crop and this cost increases with the scarcity of water, i.e., cost of cultivation of rice is higher in the groundwater depleted tubewell irrigation village of Kurlan than tubewell irrigation village of Barsat. Nevertheless, it is also seen that not only the cost rises with depletion, the inequality in cost and returns also rises with falling water tables. It was seen that with the advantage of mixed irrigation, farmers in Kheri Man Singh village gained a net return of Rs. 2.79 and Rs. 2.78 on incurring a rupee cost for rice and wheat crop respectively, which was highest compared to the other two irrigation systems under study.

Acknowledgments
The authors sincerely thank Dr. Binu Sangwan, Dr. Nina Singh, and Dr. Parmod Bhardwaj, Professors in department of Geography, M. D. University, Rohtak, for their valuable suggestions, constant encouragement, inspiring suggestions and all meticulous counselling during the investigation and preparation of this manuscript.

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