Evaluation Study on 'Optimisation of Agriculture Power Subsidy and Irrigation Water Intensity' in Haryana

A

Report

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By

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Introduction

I.1: Background

The agriculture sector is a key to the economic development of Haryana as more than 60 per cent population depends, directly or indirectly, on agriculture. Irrigation water is one of the critical components in agriculture. The natural source of irrigation is rainfall which is unreliable and unpredictable in terms of quantity, incidence and duration in the present scenario. In order to over the problem of irrigation water deficiency, dependence on artificial sources of irrigation water has increased over the period. Irrigation water comes mainly from two sources i.e., surface water and ground water. Surface water is provided by the flowing water of rivers or the still water of tanks, ponds, lakes, and artificial reservoirs. The surface water is carried to the fields by canals, distributaries, and channels. Ground water has been extracted by electric tube wells and diesel pump sets. The improvement in agricultural production & productivity depends primarily on the expansion of irrigation facilities. Irrigation has also led to an increase in cropping intensity. A significant proportion of net irrigated area in Haryana has been dependent on tube well irrigations. Apart from tube well irrigations, a segment of the farmers depend on canal irrigation also. Farmers generally prefer groundwater for irrigation because of its reliability and flexibility.

Agrarian transformation in Punjab & Haryana under the Green Revolution strategy generated tremendous demand for power in agriculture sector. Despite that Haryana being close to Delhi, the national capital, industrialisation and urbanisation spread in areas located in the national capital region at relatively faster pace. Punjab & Haryana is based on peasant proprietorship and therefore, increase in production and productivity in agriculture has enhanced the purchasing power of almost all the sections of the society which gave a boost to the commercial activities in the State. The accelerated growth in the wide range of economic activities was made possible by a very high growth in energy consumption by various categories of consumers.

The power sector exerts a critical influence on the performance of the agriculture sector as it affects farmer access to and use of electricity for a variety of irrigation operations, particularly pumping ground water for irrigation. Electricity is the most versatile form of energy that is used as an input in agriculture production.

Electricity as infrastructure is of key importance to accelerate the process of economic development and it was realised that power should be made available at a reasonable price. Until the early 1970s, the state electricity utilities in India levied charges on electric tube wells based on metered consumption. Thereafter, under the strategy of green revolution state governments have adopted a policy of providing free or subsidized power to farmers to increase agricultural productivity to ensure food security in the country. Consequently, the number of electric tube wells has increased over the period of time. In order to reduce transaction costs, the utilities removed meters and introduced flat tariffs for electricity supply to agriculture sector. Many states shifted to free and unmetered supply to agriculture which has underscored system of energy accounting and internal accountability in power utilities. Lack of adequate/ proper energy accounting system motivates the utilities to hide operational inefficiency and theft of electricity by non-agricultural consumers. It may be argued that in the absence of adequate accounting system, reliable estimation of actual electricity consumption by the agricultural consumers and the amount of subsidy cannot be precisely estimated. Free or highly subsidised power supply leads to deteriorate financial position of the power utilities. Poor financial performance of the power utilities has contributed to the financial crisis in the state power utilities in terms of reducing its ability to undertake required investments to respond to rising local demand and to maintain a smooth and reliable service. For the agriculture sector, the supply of electricity has been characterized by rationing, frequent power interruptions, and voltage fluctuations that raise the real cost of electricity to farmers and affect their production activities in several ways. Taking into account this situation, the following two aspects of power supply are likely to be important from the farmers' perspective. First, the total number of hours of actual availability of quality power supply per day (both during scheduled and unscheduled period) during each season. This aspect may be referred as the "availability" of power supply. The second aspect relates to the "unreliability" of actual supply and will be defined as the total duration of power cuts during the scheduled hours of power supply to the agriculture sector. An important reason for power cuts during scheduled periods of power supply is frequent transformer burnouts. Poor quality increases farmers' costs for three reasons. First, low voltage implies that water delivered by the pump per unit of time is reduced, other things remaining the same. Second, poor quality also leads to motor burnouts. Apart from the costs of getting the motor rewound, production activities need to be readjusted and there is potential loss of output in the time period it takes to get the motor reinstalled. Poor quality of supply may also cause the electricity transformer to fail, further interrupting the supply of power until the time it takes to repair it. Thirdly, poor quality of power supply motivates the farmers to select local motors that consumes relatively higher amount of electricity (World Bank 2001).

It may be pointed out that the two major policies, the subsidised supply at a flat rate and unmetered supply played havoc with financial management and administration of the power sector. The political leadership indulged in competitive populism and announced to provide highly subsidized or free supply of electricity to the farmers. The major share of benefits has been cornered by the big landlords and the farmers who were highly influential and controlled the rural vote banks.

The electricity subsidy for agriculture was a small amount to begin with but assumed perceptible proportion over time as its consumption increased. The number of electric tube wells has increased. The area under paddy cultivation has also gone up. Consequently, requirement of irrigation water has increased but over extraction of ground water tended to deplete water table over the period of time. It indicates that more power is required to extract the same quantity of water and consequently the cost of electricity supply has tended to increase.

In the present scenario, the major issues leading to agrarian crisis in India as well as states are consistent rising inputs costs, inadequate infrastructure for produce marketing, lack of alternative region wise crops and lack of ensured minimum support prices (MSP) for less water intensive crops.

Since, power is cheap or free, farmers have no incentive to use energy and groundwater efficiently. Groundwater overexploitation has reached near-crisis level in many of the Indian states. It may be highlighted that subsidised supply of electricity motivates people to utilise the scarce resources, particularly ground water and electricity, in an inefficient manner. Consequently, the crisis for sustainable development of agriculture as well as power sector becomes inevitable.

I.2: Objectives of the Study

With the above mentioned background, we would broadly focus on optimisation of agriculture power subsidy and irrigation water intensity.

The main objectives of the study are:

- To find out desirable cropping pattern for source wise irrigation.
- To assess efficiency in water utilisation for source wise irrigation.

- To compare agricultural production and productivity per acre for source wise irrigation in Rabi and Kharif seasons.
- To assess implications of source wise irrigation for sustainable growth in the agriculture sector and power sector.

I.3: Research Methodology and Data Base

Haryana Kisan Aayog has divided the state, based on ecology and cropping pattern, into three agro-eco regions: Region 1 consists of 8 districts, namely Panchkula, Ambala, Kurukshetra, Yamunanagar, Karnal, Kaithal, Panipat and Sonipat. This Zone forms nearly 32 percent of the total area of the State; Region II consists of 7 districts, namely Sirsa, Fatehabad, Hisar, Jind, Rohtak, Faridabad and Palwal. This Zone accounts for nearly 39 percent of the total area of the State; and Region III consists of 6 districts, namely Bhiwani, Mahendergarh, Rewari, Jhajjar, Gurgaon and Mewat. It covers nearly 29 per cent of the total area of the State.

In this study multi-stage random sampling technique has been adopted to select the ultimate household. Initially, we have selected six districts, namely Kurukshetra & Sonipat from region I, Hisar & Palwal from region II and Jhajjar and Mahindergarh from region III on the basis of certain relevant indicators.

Table 1: Some Relevant Indicators

Regions	District	Net Area Irrigated as per cent of Net Sown Area (per cent)	Share of Canal Irrigation in Net Sown Area (per cent)	Share of Tubewell Irrigation in Net Sown Area (per cent)	Per Capita Land Holdings (in hectare)	No. of Diesel Pump sets per 000 hectare Net Sown Area	No. of Electric Tube wells per 000 hectare Net Sown Area	Total Pump sets per 000 hectare Net Sown Area
Region-I	Kurukshetra	100	3	97	2.67	58	438	496
	Sonipat	90	54	36	1.35	121	152	272
Region-II	Hisar	80	61	18	3.25	58	41	99
	Palwal	96	34	62	1.67	134	101	234
Region-III	Jhajjar	93	57	36	2.09	155	64	219
	Mahindergarh	40	25	14	1.82	1	198	199

Source: Author's calculations on the basis of data available in Statistical Abstract of Haryana, 2013-14.

We have also collected the required information on the above mentioned indicators at sub-divisions level. Thereafter, we chose 24 villages, consisting four villages from each selected district. The selected villages are Jyotisar, Kirmach, Barna and Hathira from Tehsil Thanesar of district Kurukshetra; Jauli, Gamri, Anwali and Bhainswal from Tehsil Gohana of district Sonipat; Kaimri, Rawalwas Kalan, Kalwas and Dhansu from Tehsil Hisar of district Hisar; Baroli, Dhatir, Alwapur and Solra from Tehsil Palwal; Jahangirpur, Patauda, Luhari and Dadritoye from Tehsil Jhajjar of district Jhajjar and; Mandhana, Dharson, Patikara and Raghunath Pura from Tehsil Narnaul of district Mahendergarh. Our total sample size is 960 households, consisting households from different categories, classified on the basis of their dependence on sources of irrigations. However, one household has been dropped due to inconsistency in data. So, effective sample size for analysis is 959 households.

Objective wise Methodology

To meet the objective of desirable cropping pattern in Rabi and Kharif seasons, we collected information regarding perceptions of the households about their existing cropping pattern from all the four categories, classified on the basis of their dependence on canal, electric tube wells, diesel pump sets and other sources of irrigations. To examine desirable cropping pattern for source wise irrigations, we tried to highlight how source of irrigation influences cropping pattern.

To assess the efficiency in irrigation water utilisation, we compared the optimum number of times a crop is required to be irrigated with the actual number of times, it is irrigated by the categories of irrigation source wise households. The optimum number of times a crop is required to be irrigated depends on many factors. We considered a normal year for the purpose. We have also attempted to estimate wasteful consumption of groundwater and electricity taking into account the optimum number of irrigations for important crops as recommended in the package of practices issued by Ch. Charan Singh Haryana Agricultural University (HAU) Hisar and notified by the Department of Agriculture, Government of Haryana.

To examine agricultural production and productivity per acre for source wise irrigations, we compared crop wise production and productivity per acre in relation to sources of irrigations during Rabi and Kharif seasons for the sampled households.

To assess implications of source wise irrigation, we attempted to capture the perceptions of the sampled households in terms of change in cropping pattern, level of water table, soil degradation, groundwater de-gradation, salinity problems, etc. In the existing cropping pattern (wheat-rice rotation), excessive use of pesticides and chemical fertilisers took place that is reflected in terms of its impact on human/ animal's health. In other words, such practices promote various kinds of diseases for human beings as well as animals. To assess source wise irrigations and agricultural sustainability, we analysed how source of irrigations affects the issues related to the land degradation, water table depletion, deterioration in the quality of ground water, soil salinity, water logging etc.

In this study, we used primary as well as secondary data. The primary data was collected from a survey with the help of well designed perception questionnaire while the secondary data was obtained from the relevant government departments/ offices.

In this study, we have classified farm households in four categories on the basis of sources of irrigation i.e., canal irrigations, electric tubewell irrigations, diesel pumpsets irrigations and other sources which include mix sources of irrigations.

The study has been organised into five chapters. The Chapter one deals with introduction including objectives and research methodology of the study. The Chapter two focuses on perceptions of households regarding cropping pattern, crop wise production & productivity during Kharif & Rabi seasons. The Chapter three examines source wise irrigations pattern and its implications for agricultural sustainability. In Chapter four, we have attempted to estimate optimum amount of agriculture power subsidy and irrigation water. The Chapter five highlights the major findings, conclusion and policy recommendations.

Chapter II

Perceptions of the Households regarding Cropping Pattern, Production and Productivity

In this chapter, we attempted to capture perceptions of the households regarding cropping pattern, crop wise production & productivity during Kharif & Rabi seasons.

II.1: Classification of the Households

To analyse perceptions, we divided the households in different categories on the basis of irrigation source wise.

Table 2: Classification of Farm Households on the basis of Irrigation Source wise Land Holdings

Particulars	Canal Irrigation	Electric Tubewell Irrigation	Diesel Pumpset Irrigation	Others Sources	Total
Marginal	12 **(6.63)** (38.71)	94 **(51.93)** (18.91)	37 **(20.44)** (17.62)	38 **(20.99)** (17.19)	181 **(100)** (18.37)
Small	11 **(3.85)** (35.48)	147 **(51.40)** (29.58)	77 **(26.92)** (36.67)	51 **(17.83)** (23.08)	286 **(100)** (29.54)
Semi- Medium	8 **(2.94)** (25.81)	146 **(53.68)** (29.38)	57 **(20.96)** (27.14)	61 **(22.43)** (27.60)	272 **(100)** (27.87)
Medium	0 **(0.00)** (0.00)	80 **(49.69)** (16.10)	31 **(19.25)** (14.76)	50 **(31.06)** (22.62)	161 **(100)** (17.43)
Large	0 **(0.00)** (0.00)	30 **(50.85)** (6.04)	8 **(13.56)** (3.81)	21 **(35.59)** (9.50)	59 **(100)** (6.78)
Total	31 **(3.23)** (100)	497 **(51.82)** (100)	210 **(21.90)** (100)	221 **(23.04)** (100)	959 **(100)** (100)

Note: 1. Figures in brackets indicate per cent to total

2. Other sources includes mixed sources of irrigation i.e., canal and electric tube wells; canal and diesel pump sets; electric tube wells and diesel pump sets; and canal, electric tube wells and diesel pump sets.

Source: Field Survey, 2015-16

The Table 2 presents the classification of the sampled households on the basis of irrigation source wise & land holdings wise. In our total sample size of 959 households, there are 18.37 per cent marginal famers (having operational land holdings up to 2.5 acres). The share of small farmers (having land holdings 2.51 to 5.0 acres) in the total households is 29.54 per cent. The representation of semi- medium (5.1 to 10.0 acres), medium (10.1 to

25.0 acres) and large (above 25 acres) farmers in total households is 27.87 per cent, 17.43 per cent and 6.78 per cent respectively. Irrigation source wise classification reflects that the highest share (51.82 per cent) of households belong to the category of households who depend on electric tube wells for irrigations. The share of households depending on canal and diesel pumpsets irrigations is 3.23 per cent and 21.90 per cent respectively. It may be noted that 23.04 per cent households depend on mix sources of irrigations. It is interesting to highlight that no medium and large farm households depends purely on canal irrigation in our sample.

II.2: Cropping Pattern in Haryana

Cropping pattern depends mainly on quality & availability of irrigation water. Broadly, there are two sources of irrigation apart from rainfall in Haryana i.e., canal irrigation and tubewell irrigation. Presently, about 70 per cent of irrigated area depends on tubewell irrigations in the state of Haryana (Statistical Abstract of Haryana 2014-15).

The Table 3 shows the cropping pattern during Kharif season for the sampled households. The major crops in Kharif season were paddy, bajra, gawar, cotton and fodder. Fodder was used only for domestic purposes by most of the households. Some households were also growing vegetables like onion, carrot, ladyfingers etc.

Table 3: Irrigation Source wise Cropping Pattern in Kharif Season (in acre)

Particulars	**Canal Irrigation**	**Electric Tubewell**	**Diesel Pump sets**	**Other Sources**	**Total**
Bajra	35	635	247	213.5	1130.5
Gawar	48	456.5	185	326	1015.5
Paddy	15	1918	647.5	1016.5	3597
Cotton	8.5	139.5	147	383.5	678.5
Onion	-	45	13.5	7	65.5
Moong	-	-	-	27	27
Total	106.5	3194	1240	1973.5	6514

Source: Field Survey 2015-16

It needs to be noted that paddy cultivation is most preferred crop in kharif season across the sources of irrigations, except canal irrigation. The households who mainly depend on canal irrigation and their land holdings lies near the bank of canal have also shown interest in paddy cultivation. Second most preferred kharif crop is bajra.

The Table 4 shows the cropping pattern during Rabi season for the sampled households. The major crops were wheat, oilseeds, barley, sugarcane and fodder in Rabi season.

Table 4: Irrigation Source wise Cropping Pattern in Rabi Season (in acre)

Particulars	Canal Irrigation	Electric Tubewell	Diesel Pump sets	Other Sources	Total
Wheat	64.5	3511	1215.5	1705	6496
Mustard	42.5	649.5	286	372	1350
Barley	-	45	2	9.5	56.5
Sugarcane	-	29	17	51	97
Vegetables	-	9	2	-	11
Total	107	4243.5	1522.5	2137.5	8010.5

Source: Field Survey 2015-16

It may be noted that wheat and mustards are the major crops across the sources of irrigations. It becomes pertinent to highlight that wheat paddy rotation is prominently prevailing in most of the Haryana, except southern districts.

It has also been observed that most of the households stick to their existing cropping pattern mainly due to non availability of suitable alternative crops on the one hand and lack of adequate cold storage and assured markets to sell agricultural produce on the other. There is an urgent need to motivate the farmers to break mono cropping culture with suitable alternatives crops keeping in view assured market and minimum support price for sustainable agricultural growth in the state.

II.3: Irrigation Source wise Production and Productivity

With the extension of irrigation facilities, the utilisation of High Yielding Varieties (HYVs) seeds, pesticides and chemical fertilisers have led to a significant growth in productivity of the crops over the period of time. The irrigation water supply becomes a critical input in the agricultural production process. Timely available irrigation water motivates the farmers to invest in other inputs like HYV seeds, fertilizers etc., all of which are helpful to increase crops productivity. In other word, crops productivity mainly depends on the reliability and quality of irrigation water applied. Improved reliability of irrigation water may ensure better timing of irrigation for crops' growth. Non availability of irrigation water at critical stages of growth can significantly reduce the crop growth and yield.

The Table 5 presents irrigation source wise production and productivity of major crops in Kharif season. The data shows that the productivity of bajra was found more than 6.5 quintals per acre across the sources of irrigations. The productivity of gawar was more than

3.50 quintals per acre under all the different sources of irrigations, except the category of diesel pump sets irrigations.

Table 5: Irrigation Source wise Production & Productivity of Major Crops in Kharif Season

Particulars	Canal Irrigation			Electric Tube well Irrigation			Diesel Pump Sets			Other Sources		
	Area (Acre)	TP (Qtls)	Prod (Qtls)	Area (Acre)	TP (Qtls)	Prod (Qtls)	Area (Acre)	TP (Qtls)	Prod (Qtls)	Area (Acre)	TP (Qtls)	Prod (Qtls)
Bajra	35	228	6.51	635	4395	6.92	247	1734	7.02	213.5	1398	6.54
Gawar	48	168	3.50	457	1602	3.51	185	550	2.97	326	1064	3.26
Paddy	15	278	18.53	1918	35951	18.74	648	9174	14.16	1017	18530	18.22
Cotton	8.5	32	3.76	140	468	3.34	147	538	3.66	383.5	1563	4.08
Onion	-	-	-	45	1440	32.00	14	415	29.64	7	230	32.86
Mung	-	-	-	-	-		-	-	-	27	100	3.70

Source: Field Survey 2015-16
Note: Qtls- Quintals; TP- Total Production; Prod: Productivity

The data further indicates that irrigation source wise productivity of paddy was 18.53 quintals for canal irrigations, 18.74 quintals for electric tube wells, 14.17 quintals for diesel pump sets and 18.23 quintals per acre for other sources of irrigations. Similarly, the productivity of cotton also varied from 3.35 quintals to 4.08 quintals per acre across the sources of irrigations.

It has been observed that the productivity per acre of main Kharif crops under canal irrigations was comparable with the productivity under remaining sources of irrigations. It is also pertinent to note that the households whose land holding lies on the bank of canal generally prefer paddy cultivation in Kharif season in the category of canal irrigations.

The Table 6 shows irrigation source wise production and productivity of major crops during Rabi season.

Table 6: Irrigation Source wise Crop wise Productivity in Rabi Season

Particulars	Canal Irrigation			Electric Tube well Irrigation			Diesel Pump Sets			Other Sources		
	Area (Acre)	TP (Qtls)	Prod (Qtls)	Area (Acre)	TP (Qtls)	Prod (Qtls)	Area (Acre)	TP (Qtls)	Prod (Qtls)	Area (Acre)	TP (Qtls)	Prod (Qtls)
Wheat	65	1032	15.88	3511	55045	15.68	1216	19463	16.01	1705	27673	16.23
Mustard	43	279	6.49	650	4139	6.37	286	1883	6.58	372	2420	6.51
Barley	-	-	-	45	675	14.96	2	30	15	10	174	17.40
Vegetables	-	-	-	9	106	11.78	2	18	9	-	-	-
Sugarcane	-	-	-	29	7930	273.45	17	4900	288.23	51	15550	304.90

Source: Field Survey 2015-16
Note: Qtls- Quintals; TP- Total Production; Prod: Productivity

The data reveals that the productivity per acre of wheat was 15.88 quintals under canal irrigations relatively higher than 15.68 quintals under electric tube well irrigations. The productivity of wheat was 16.01 quintals and 16.23 quintals per acre under diesel pump sets and other sources of irrigations respectively. The productivity of mustard, second major crop in Rabi season, was found 6.49 quintals, 6.37 quintals, 6.58 quintals and 6.51 quintals per acre under canal, electric tube wells, diesel pump sets and other sources of irrigations respectively. Per acre productivity of barley was 14.96 quintals under electric tube well irrigations, 14.17 quintals under diesel pump sets and 17.40 quintals under other sources of irrigations. Similarly, per acre productivity of sugarcane was found 273.44 quintals under electric tube well irrigations, 288.23 quintals under diesel pump set irrigations and 304.90 quintals under other sources of irrigations. Some households have also shown interest in growing seasonal vegetables like onion, carrot, ladyfingers etc. Per acre productivity of vegetables was found 11.78 quintals and 9 quintals under electric tube wells and diesel pump sets irrigations respectively.

It has been observed that per acre productivity of wheat and mustard under canal irrigations was marginally higher than that of electric pump set irrigations. It may be noted that the crop diversification has been influenced from extension of irrigation facilities. Moreover, the quality & reliability of irrigation water affects the cropping pattern wherein the farmers select crops that give them a higher return from each unit of land they cultivate.

It may be argued that wheat and paddy crops have played a major role in pushing up the agricultural production in the state but excess utilisation of ground water and electricity consumption led to agricultural un-sustainability. The area under paddy cultivation needs to be brought down on priority basis due to irrigation water shortages. It should also be noted that paddy is not the staple diet of Haryana.

Chapter III

Source wise Irrigation Pattern and Its Implications for Sustainable Agricultural Growth

III.1: Source wise Irrigation Pattern

Ideal irrigation pattern depends on optimum water requirement by a crop to grow and availability of source wise irrigations. The comparison between optimum number of times a crop required to be irrigated with actual number of times of irrigations helps us to estimate wasteful consumption of irrigation water and electricity, if the pump is operated by electricity. It is pertinent to reveal that depth and number of irrigations depends on many factors such as weather conditions, especially the intensity and frequency of rainfall during the crop season, type of soil (sandy, clay, sandy loan etc.), irrigation methods to be adopted (flood, sprinkle etc.) and other management practices being followed.

Table 7: Source wise Crop wise Irrigation Pattern in Kharif Season

Particulars	Optimum No. of Irrigations Required*	Actual No. of Irrigations			
		Canal	Electric Tube wells	Diesel Pump sets	Other Sources
Bajra	1-2	1.33	2.84	2.04	1.83
Gawar	1-2	1	1.82	1.82	1.65
Paddy	15-20	18.33	46.31	36.70	39.51
Cotton	3-4	2.33	4.27	3.87	3.53
Fodder	3-4	4	4.33	4.17	4.33

Note- *: Optimum No. of Irrigation is recommended by agricultural experts and notified by the Department of Agriculture, Government of Haryana
Source: Field Survey, 2015-16

The Table 7 presents the comparison of crop wise optimum number of times of irrigations required and number of times of actual irrigations per acre with different sources of irrigations during Kharif season. The data clearly shows that average number of times of actual irrigations is significantly higher than optimum number of times of irrigations was required in most of the Kharif crops across the sources of irrigations, except canal irrigation. In case of paddy, being a highly water intensive crop in Kharif season, the recommended optimum number of times of irrigations is between 15-20 per acre but actual average number of times of irrigation through canal, electric tube well, diesel pumpsets and other sources of irrigations was 18.33, 46.31 , 36.70 and 39.51 respectively. It is pertinent to note that average actual number of irrigations (46) with electric tube wells in paddy cultivation is more than double the optimum number of irrigations (15-20) required. Interestingly, actual average number of times of irrigations through electric tube wells is much higher than rest of the sources of irrigations in most of the Kharif crops. It clearly indicates towards over utilisation of ground water through electric tube wells.

Table 8: Source wise Crop wise Irrigation Pattern in Rabi Season

Particulars	Optimum No. of Irrigations Required*	Actual No. of Irrigations			
		Canal	Electric Tube wells	Diesel Pump sets	Other Sources
Wheat	5-6	3.43	5.52	4.62	4.70
Mustard	2	2.00	2.54	2.26	2.10
Barley	4-5	-	5.25	4.00	3.50
Sugarcane	12-14	-	22.00	15.00	14.00
Fodder	6-8	-	6.91	6.07	6.00

Note- *: Optimum No. of Irrigation is recommended by agricultural experts and notified by the Department of Agriculture, Government of Haryana
Source: Field Survey, 2015-16

The Table 8 presents crop wise optimum number of irrigations required and source wise actual number of irrigations in Rabi season. The data reveals that source wise average number of times of actual irrigations for most of the Rabi crops was within the specified range of optimum number of times of irrigations, except sugarcane & barley in the category of electric tube wells irrigations. It was observed that the average actual number of times of irrigations for sugarcane (22) through electric tube wells was perceptibly higher than the optimum number of times of irrigations required (12-14).

It has also been observed that per acre actual irrigations through electric tube wells was relatively high than that of rest of the sources of irrigations in most of the Kharif & Rabi crops. It may be due to a perceptible proportion of the electricity supply to agricultural pumpsets is unmetered and is provided at highly subsidised rates in Haryana and consequently the farmers are motivated to utilise groundwater as well as electricity inefficiently. Due to unmetered supply to agriculture, energy accounting system became ineffective and in fact collapsed. In such a state of affairs when more than half of the electricity supply was not metered, it was impossible to estimate the actual technical and distribution (T&D) losses and the pilferage of power. Obviously, the beneficiaries of the unmetered supply had developed a vested interest in the system to remain unaccountable. Canal irrigation is regulated due to non availability of sufficient flow of irrigation water whereas irrigation through diesel pump sets put direct financial burden on the farmers which forced them to think about efficient usage of irrigation water to some extent as they utilise diesel pump sets only whenever it is required.

There were hardly any efforts from the state government to motivate farmers for efficient utilisation of electricity and ground water. There is an urgent need to ensure metered supply at consumer ends, particularly the agriculture connections, on priority basis to ensure accountability. It will promote efficiency and add to viability in the power supply.

Unmetered power supply promotes inefficiency in electricity consumption as well as utilisation of ground water. The power utilities claimed 100 per cent metering at agriculture feeders but it has a significant amount of load of non-agriculture sector, particularly domestic. In the absence of proper metering at consumer ends, the precise estimation of actual electricity consumption by agricultural consumers and the amount of power subsidy is not possible.

III.2: Status of Soil Quality

Quality of soil is one of the main ingredients to determine agriculture production and productivity. Broadly soil quality is measured in terms of soil fertility/ productivity. We have classified quality of soil in three categories i.e., good, bad and average to seek perceptions of the households. In case of good quality of soil, the production as well as productivity is expected to be high. During field survey deterioration in quality of soil was observed which occurred mainly on account of continuous excess use chemical fertiliser, pesticides and ground water for irrigations. The households pointed out that canal irrigation is relatively more conducive for cultivation as compared to ground water.

Table 9: Perception of the Households regarding Irrigation Source wise Quality of Soil

Particular	Canal	Electric Tube wells	Diesel Pump sets	Other Sources	Total
Good	30 (96.77)	238 (47.89)	104 (49.52)	98 (44.34)	470 (49.00)
Bad	1 (3.23)	152 (30.58)	69 (32.86)	76 (34.39)	298 (31.07)
Average	0 (0.00)	107 (21.53)	37 (17.62)	47 (21.27)	191 (19.92)
Total	31 (100)	497 (100)	210 (100)	221 (100)	959 (100)

Note: Figures in brackets indicate per cent to total
Source: Field Survey 2015-16

The Table 9 shows perception of the households regarding irrigation source wise quality of soil in terms of productivity of crops per acre. The data highlights that majority of the households reported for good quality of soil across sources of irrigations. About one thirds of the households reported bad quality of soil whereas about 20 per cent households reported average quality of soil.

The Table 10 presents the perception of the households regarding irrigation source wise degradation in the quality of soil. The data reveals that a majority of the households particularly from the categories of electric tube wells & diesel pump sets irrigations reported soil degradation over the period. The households in the category of canal irrigation reported very marginal deterioration in the quality of soil mainly due to dumping of industrial waste in the canal particularly in district Palwal.

Table 10: Perception of the Households regarding Irrigation Source wise Degradation in the Quality of Soil over the Period

Particular	Canal	Electric Tube wells	Diesel Pump sets	Other Sources	Total
Yes	2 (6.45)	305 (61.37)	149 (70.95)	87 (39.37)	543 (56.62)
No	25 (80.65)	142 (28.57)	43 (20.48)	110 (49.77)	320 (33.37)
Can't Say	4 (12.90)	50 (10.06)	18 (8.57)	24 (10.86)	96 (10.01)
Total	31 (100)	497 (100)	210 (100)	221 (100)	959 (100)

Note: Figures in brackets indicate per cent to total
Source: Field Survey 2015-16

It clearly indicates that excess utilisation of ground water for irrigation purposes leads to deteriorate soil quality which may reflect in terms of low productivity of soil on the one hand and poor quality of produce on the other.

It has been observed irrespective of sources of irrigations that soil degradation was one of major problems associated with excessive utilisation of tube-wells to extract ground water. The households argued that to maintain and/ or increase productivity of the crops during the cropping seasons, Kharif and Rabi, higher amount/doses of chemical fertilisers and pesticides are required. Excess utilisation of chemical fertilisers and pesticides also led to deteriorate fertility of land over the period. Gradually, the soil fertility is affected by irrigations with high total dissolved solids (TDS) ground water and consequently several traditional crops have been disappeared in the study area.

III.3: Status of Subsoil Water Quality

The quality of ground water is pre requisite for agricultural development.

Table 11: Perception of the Households regarding Irrigation Source wise Status of the Quality of Subsoil/ Ground Water

Particular	Canal	Electric Tube wells	Diesel Pump sets	Other Sources	Total
Good	16 (51.61)	215 (43.26)	57 (27.14)	74 (33.48)	362 (37.75)
Bad	12 (38.71)	239 (48.09)	106 (50.48)	96 (43.44)	453 (47.24)
Average	3 (9.68)	43 (8.65)	47 (22.38)	51 (23.08)	144 (15.01)
Total	31 (100)	497 (100)	210 (100)	221 (100)	959 (100)

Note: Figures in brackets indicate per cent to total
Source: Field Survey 2015-16

To seek the perceptions of the households about the quality of ground water/ subsoil water, we have classified it into three categories i.e., good, bad and average. The Table 11 presents the perception of the households regarding irrigation source wise quality of ground water. Majority of the households (47.24 per cent) reported bad quality of groundwater. Good and average quality of ground water was reported by 37.75 per cent and 15.01 per cent households respectively. It may be noted that quality of ground water tended to deteriorate with excess extraction of ground water on the one hand and excess use of chemical fertilisers, pesticides etc. on the other.

Table 12: Perception of the Households regarding Irrigation Source wise Decrease in Groundwater Table

Particular	Canal	Electric Tube wells	Diesel Pump sets	Other Sources	Total
Yes	20 (64.52)	327 (65.79)	148 (70.48)	122 (55.20)	617 (64.33)
No	5 (16.13)	140 (28.17)	34 (16.19)	80 (36.20)	259 (27.01)
Can't Say	6 (19.35)	30 (6.04)	28 (13.33)	19 (8.60)	83 (8.66)
Total	31 (100)	497 (100)	210 (100)	221 (100)	959 (100)

Note: Figures in brackets indicate per cent to total
Source: Field Survey 2015-16

The Table 12 presents the perception of the households regarding decrease in groundwater table. The data shows that more than 64 per cent households reported decrease in ground water table in their fields whereas 27.0 per cent households rejected this proposition. It may also be noted that 8.66 per cent households did not have any knowledge about the decrease in ground water table. Irrigation source wise households who reported decrease in ground water were 64.52 per cent from canal irrigations, 65.79 per cent from electric tube wells, 70.48 per cent from diesel pumpsets and 55.20 per cent from other sources of irrigations. It needs to be highlighted that the highest share of the households reporting decrease in ground water table was in the category of diesel pump sets. These households are relatively more aware about decline in ground water table mainly because diesel pump sets extract water from upper layers of the soil and the households are forced to insert more pipes in the ground more frequently. Electric tube wells are used for submersible pump sets. Deeper the levels of ground water higher the capacity of electric motor (measured in Horsepower) would be required, which have to consume higher amount of electricity. It implies that water table depletion forced the household to adopt expensive deep-water equipments, which further worsened the crisis in terms of additional financial burden on the households.

III.4: Problem of Soil Salinity

The problem of soil salinity is also observed mainly due to salt content in soil and/ or ground water. It needs to be highlighted that the problem of salinity appeared in the areas where ground water is used for irrigations rampantly. The problem of salinity is not severe under canal irrigations. Gradually, the soil fertility is affected by irrigations with high total dissolve solids (TDS) groundwater and consequently, several traditional crops have been disappeared. By extracting excess ground water evaporation and evapotranspiration tend to increase salt concentration. Direct evaporation from the soil surface causes a rapid accumulation of salt in the top layers. When a significant amount of ground water is provided for irrigation without adequate provisions for leaching of salt, the soils rapidly become salty and unproductive. In case of intense evaporation ground water storage in the reservoirs tends to increase salt concentration. It may be argued that over extraction of ground water leads to deplete the ground water table on the one hand and deterioration of the quality of ground water due to saline water intrusion and/ or the upward diffusion of deeper saline water on the other. Using saline ground water for irrigation may increase soil salinity.

The Table 13 presents the perception of the households regarding increase in soil salinity.

Table 13: Perception of the Households regarding Irrigation Source wise Increase in Soil Salinity

Particular	Canal	Electric Tube wells	Diesel Pump sets	Other Sources	Total
Yes	8 (25.81)	374 (75.25)	128 (60.65)	89 (40.27)	599 (62.46)
No	18 (58.06)	117 (23.54)	67 (31.90)	122 (55.20)	324 (33.79)
Can't Say	5 (16.13)	6 (1.21)	15 (07.14)	10 (4.53)	36 (3.75)
Total	31 (100)	497 (100)	210 (100)	221 (100)	959 (100)

Note: Figures in brackets indicate per cent to total
Source: Field Survey 2015-16

The data clearly reveals that 62.46 per cent of the sampled households reported increase in the problem of soil salinity in their areas particularly in the categories of electric tube wells and diesel pump sets. The households pointed out that the problem of salinity may be controlled to some extent by applying ground water mixed with canal water for irrigations.

Consistent use of ground water for irrigation has accumulated the problem of soil salinity in the sampled area. There is an urgent need to deal with the growing problem of soil salinity on priority basis.

III.5: Awareness among Households regarding Electricity Supply and Water Harvesting Techniques

It has been observed that adequate awareness among various stakeholders regarding electricity saving and water harvesting techniques may be very helpful to reduce the pressure electricity and ground water.

The Table 14 presents the perception of the households regarding the status of electricity supply to their tube wells. The data reveals that 79.48 per cent of households highlighted the issue of inadequacy of power supply to meet irrigation requirements in the existing cropping pattern. Only 20.52 per cent households reported that power supply to their electric tube wells is adequate to meet irrigation requirements in the existing cropping pattern.

Table 14: Status of Electric Supply for Tubewells during Kharif & Rabi Seasons

Particulars		Farmers Category					
		Marginal	**Small**	**Semi-Medium**	**Medium**	**Large**	**Total**
Is supply of electricity adequate for existing cropping pattern?	**Yes**	28 (29.79)	29 (19.73)	20 (13.70)	17 (21.25)	8 (26.67)	102 (20.52)
	No/ No Response	66 (70.21)	118 (80.27)	126 (86.30)	63 (78.75)	22 (73.33)	395 (79.48)
	Total	94 (100)	147 (100)	146 (100)	80 (100)	30 (100)	497 (100)
Status about Quality of Electricity Supply	**Regular**	15 (15.96)	22 (14.97)	23 (15.75)	11 (13.75)	6 (20.00)	77 (15.49)
	Irregular/ No Response	79 (84.04)	125 (85.03)	123 (84.25)	69 (86.25)	24 (80.00)	420 (84.51)
	Total	94 (100)	147 (100)	146 (100)	80 (100)	30 (100)	497 (100)
Do you want to avail adequate paid electric supply?	**Yes**	53 (56.38)	82 (55.78)	53 (36.30)	34 (42.50)	10 (33.33)	232 (46.68)
	No/ No Response	41 (43.62)	65 (44.22)	93 (63.70)	46 (57.50)	20 (66.67)	265 (53.32)
	Total	94 (100)	147 (100)	146 (100)	80 (100)	30 (100)	497 (100)

Note: Figures in brackets indicate per cent to total.
Source: Field Survey 2015-16.

The data further shows that a perceptible proportion of the sampled households (84.51 per cent) reported the problem of irregular supply to their tube wells. The households highlighted that the state government has fixed duration of 8 hours per day for power supply to agriculture sector. However, the supply remained interrupted and irregular during most of the period. The time schedule has also been changed frequently and at some occasion the duration of 8 hours was divided in different quarters. Such type of activities has led to inefficiency and wastage of ground water as well as electricity. It puts negative impacts on agriculture production & productivity. It may be argued that irregular power supply and depleting ground water table have emerged as a great threat for agriculture sustainability in the study areas. Therefore, power supply to agriculture sector should be regular on the one hand and crop diversification in favour of less water intensive crops on the other to ensure sustainability in agriculture. It has been pertinent to highlight that inability to rationalise agriculture tariff and deteriorating financial position may force the power utilities to cut power supply to the rural area.

The data further highlights that a majority of the marginal & small farm households were interested in metered supply and they were also ready to pay for assured quality supply. But most of big farmers were not interested in paid supply. They were interested in the existing system of subsidised power supply.

It may be argued on the basis of available data/ information that big farm households were the major beneficiaries of power supply at subsidised rates mainly because of low power consumption by a significant proportion of marginal and small farmers. Therefore, there is an urgent need to ensure power supply at subsidised rates to the targeted households. Big farmers, being in a better financial position, may be charged full cost of supply so that the burden of agriculture power subsidy can be reduced on the one hand and the environmental impacts may be controlled/ reduced to some extent on the other. It was also observed that 46.68 per cent households were ready to pay higher tariffs provided the regular and sufficient power supply to their tube-wells. The state government should take initiatives to make the farmers aware about the benefits of metered power supply and ensure metering at consumer ends particularly for agricultural consumes on priority basis. It will help to estimate precisely electricity consumption by the agricultural households on the one hand and the amount of power subsidy on the other.

The Table 15 shows the level of awareness among irrigation source wise households regarding water harvesting techniques. The data reveals that more than 80 per cent households do not have awareness regarding water harvesting techniques. Only 12.41 per cent households reported to have some information about the techniques, whereas about 7 per cent households opted the option 'can't say'. It implies that a significant proportion of the households had hardly any information regarding water harvesting techniques.

Table 15: Level of Awareness among Irrigation Source wise Households regarding Water Harvesting Techniques

Particular	Canal	Electric Tube wells	Diesel Pump sets	Other Sources	Total
Yes	6 (19.35)	56 (11.27)	16 (07.62)	41 (18.55)	119 (12.41)
No	24 (74.42)	389 (78.27)	185 (88.10)	174 (78.74)	772 (80.50)
Can't Say	1 (03.22)	52 (10.46)	9 (04.28)	6 (02.71)	68 (07.09)
Total	31 (100)	497 (100)	210 (100)	221 (100)	959 (100)

Note: Figures in brackets indicate per cent to total
Source: Field Survey 2015-16.

It may be argued that there is an urgent need to generate awareness among the farm households regarding energy saving and water harvesting techniques on priority basis to ensure sustainable agricultural development in the state. Some households have also suggested repairing the canals system regularly so that they may use canal water to meet irrigation requirements to some extent.

Chapter IV

Estimation of Over Utilisation of Electricity and Ground Water

Efficiency in agriculture power subsidies implies maximum agricultural production/ output with minimum power subsidy which may help to reduce pressure on finances of the state government on the one hand and ground water extraction on the other. To attain efficiency, we made attempts to calculate possible reduction in the amount of power subsidy per acre without using any sophisticated statistical tools/ techniques. It has been observed from the available data that households with electric tube wells have been using ground water inefficiently particularly in terms of excess number of irrigations as against optimum number of irrigations required for the growth of a crop. There is hardly any control over the utilisation/ extraction of ground water for irrigation purposes by the government agencies. The number of times actual irrigations per acre took place through electric tube wells is relatively higher than that of optimum number of times a crop is required to be irrigated in the sampled households during Kharif as well as Rabi seasons. During Kharif & Rabi seasons some crops like paddy & sugarcane are very water intensive. The households from the category of electric tube wells utilised the ground water and electricity to meet irrigation requirements of these crops in a very inefficient manner. It may happen due to supply of electricity to the agriculture sector at highly subsidised rates in Haryana which motivates the households to misutilise electricity as well as ground water.

IV.1: Estimation of Over Utilisation of Electricity

It has also been observed that actual capacity of the electric motors, measured in terms of Horse Power (HP), was much higher than that of sanctioned load of the electric tube well connections. We have made attempts to calculate the amount of power subsidy for excess electricity consumption under paddy cultivation for the sampled households. The required capacity of the electric motor, measured in terms of horsepower, depends on the depth of the ground water to extract.

One horsepower of electric motor is equal to 0.745 kWh. It means one horsepower motor consumes 0.745 units (kWh) of electricity per hour. Average capacity of electric motors of the sampled households works out to be 11.69 HP. Average time taken to irrigate one acre with electric tube wells happens to be 3 hours. Per acre electricity consumption for single irrigation will be 26.12 (11.69x0.745x3) units. As per tariff order for the year 2015-16, average cost of supply to agriculture sector works out to be Rs. **7.34**. Per acre cost of supply for single irrigation comes out to be Rs. **191.72** (26.12x7.34). Average number of times actual irrigation took place in excess of optimum number of times a crop (**paddy**) required to be irrigated is **26**. Total cost of supply for excess consumption of electricity in one acre of paddy cultivation comes out to be Rs. **4984.72** (191.72x26). Total cost of supply for excess consumption of electricity for the sampled households works out to be Rs. **95.61 lakh** (4984.72x1918). Total area sown under paddy cultivation for the year 2014-15 was 12,87,000 hectare in Haryana. Due to non availability of irrigation source wise area sown under paddy cultivation, we divided it in the proportion of irrigation source wise area sown under paddy cultivation in total sampled households. The area sown under paddy cultivation and irrigated by electric tube wells comes out to be 686000 (53.32 per cent) hectares. The area under paddy cultivation may be converted in acres which happens to be 1694 000 (686000x 2.47) acres. Per acre cost of supply for excess consumption of electricity for paddy cultivation works out to be Rs. **4984.72**. **<u>Therefore, the total amount of agricultural power subsidy for excess electricity consumption under only paddy cultivation in the state as a whole turns out to be Rs. 844.41 (1694000x 4984.72) crore, which a very perceptible amount. This amount accounts for 2.85 per cent of state's own revenue receipts and 2.31 per cent of development revenue expenditure for the year 2014-15.</u>**

IV.2: Estimation of Over Utilisation of Ground Water

We have also tried to calculate the amount of water extracted with electric tube wells to meet excess number of irrigations for paddy cultivation. The irrigation water is measured in terms of acre centimetres. It implies a volume of water required to cover an area of one acre surface to a depth of one centimetre. Average depth of irrigation for paddy cultivation is required **5 centimetres**. The volume of ground water extracted per acre with electric tube wells for excess number of actual irrigations (26 irrigations) happens to be **130** (5x26) centimetres. The volume of irrigation water may also be converted in terms of acre feet. One acre foot is equal to 30.48 centimetres. So, the volume of excess irrigation water per acre comes out to be **4.267** (130/30.48) acre feet. The total volume of excess irrigation water extracted with electric tube wells to irrigate paddy cultivation for the sampled households comes out to be **8184.106** (4.267x1918) acre feet. The total area under paddy cultivation and irrigated by electric tube wells in Haryana during the year 2014-15 was 16,94,000 acres. **<u>Therefore, the total volume of irrigation water extracted, by electric tube wells, to meet excess irrigations for paddy cultivation in the state as a whole works out to be 7.23 (4.267x1694000) million acre feet (MAF).</u>**

It becomes pertinent to highlight that a huge volume of ground water has been extracted and utilised in very inefficient manner by the electric tube wells households. It indicates towards a serious irrigation ground water crisis in near future. The problem of irrigation water deficiency may be resolved to some extent if the excess volume of irrigation water is to be regulated properly. The state government should make serious efforts to motivate the farmers for proper utilisation of irrigation ground water on the one hand and to give incentives for adopting less water intensive crops on the other.

The productivity of the irrigation water may also be measured in terms of water required in litre per kilogram of crop production (litre/kg) per acre. Average depth of irrigation for paddy cultivation is recommended by the agricultural experts in Haryana at 5 cm. One acre centimetre is equal to 40.485 cubic meters. One cubic meter is equal to one kilo litres (1000 litres). So, the volume of ground water required for 20 irrigations at 5 cm depth, optimum number of irrigations & depth, for per acre paddy cultivation in Haryana comes out to be 4048.5 (202.425x20) cubic meter or 40,48,500 litres. The volume of excess water extraction by electric tube wells has been found as 5263.05 (202.425x26) cubic meters or 52, 63,050 litres per acre. Per acre average production of paddy under electric tube well irrigations in the sampled households is 18.74 quintals (1874 kg). In the category of electric tube well irrigations, per acre average optimum irrigation water requirement under paddy cultivation for the sampled households comes out to be 2160 (4048500/ 1874) litres per kilogram. Per acre average volume of excess ground water extracted by electric tube wells for paddy turns out to be 2808 (5263050/1874) litres per kilogram. It means the amount of excess water extraction by electric tube wells is much high as compared to the optimum irrigation water required to produce one kilogram of paddy for the sampled households. It may happen due to irrational behaviour of the households on account of highly subsidised power supply to the agriculture sector.

On the basis of the available information, it may be inferred that a significant amount being paid in terms of agricultural power subsidy on account of inefficient electricity consumption along with ground water extraction could be saved, if the state government motivates the households to utilise electricity and ground water in an efficient manner. It is also pertinent to note that per acre productivity of paddy under canal & other sources of irrigations is more or less equal to the productivity of paddy under electric tube wells irrigations. Therefore, it may be argued that excess consumption of electricity and ground water could be regulated without putting adverse impact on production & productivity of the crops.

In order to utilise ground water efficiently the farmers may be motivated to adopt drip or sprinkle irrigations. It has been observed that most of the sampled households are using flood irrigation, which may also lead to inefficient management of ground water. Available literature also suggests that the water crisis can be partly solved by increasing water use efficiency (WUE), and there is considerable scope for improving efficiency of water use through managing irrigation systems efficiently.

IV.3: Conclusion

The practices of excess extraction of ground water by farmers under electric tube well irrigations have probably happened on account of power supply to the agriculture sector at flat rate, which is also very nominal in Haryana. Flat rate system has also motivated the farmers to install in-efficient pump sets that consumed excessive electricity and led to wastage of electricity and ground water. The households argued that the state government has fixed duration of 8 hours per day for power supply to agriculture sector. However, the supply remained interrupted and irregular during most of the period. The time schedule has also been changed frequently and at some occasion the duration of 8 hours was divided in different quarters. Such types of activities have also led to inefficiency and wastage of ground water as well as electricity. It puts negative impacts on agriculture production & productivity. There should be regularity in power supply to agriculture sector. Moreover, it has also been observed that farmers generally prefer local branded motor as it was relatively cheaper and extract more ground water. It is pertinent to note that use of local inefficient electric motors particularly on account of flat rate system also led to over utilisation of ground water and excess consumption of electricity, which has its implications for sustainable agricultural growth and financial viability of the power utilities.

It may be pointed out that wheat paddy still dominates the cropping pattern in the state of Haryana and there has not been any perceptible shift towards other crops. The farmers too have focussed only on wheat paddy mono cropping pattern mainly due to assured returns and stable markets. The changes in the cropping pattern have not been observed in the state despite so many recommendations being suggested to combat the agricultural crisis in the state.

At this juncture, the best course of action may be to transform the existing unmetered flat tariff policy into a rational metered consumption based tariff. This proposition may be helpful to motivate the farm households to utilise electricity and ground water efficiently which may in turns ensure optimal utilisation of electricity and irrigation water. Further, the agricultural power subsidy should be targeted. In order to ensure efficiency and transparency, the mechanism for direct payment of subsidy to the beneficiaries may also be explored.

Chapter V

Summary, Concluding Remarks and Policy Recommendations

The agriculture sector is a key to the economic development of Haryana as more than 60 per cent population depends, directly or indirectly, on agriculture. Irrigation water is one of the critical components in agriculture. The natural source of irrigation is rainfall which is unreliable and unpredictable in terms of quantity, incidence and duration in the present scenario. Irrigation water comes mainly from two sources i.e., surface water and ground water. Surface water is provided by the flowing water of rivers or the still water of tanks, ponds, lakes, and artificial reservoirs. The surface water is carried to the fields by canals, distributaries, and channels. Ground water has been extracted by electric tube wells and diesel pump sets. The improvement in agricultural production & productivity depends primarily on the expansion of irrigation facilities. A significant proportion of net irrigated area in Haryana has been dependent on tube well irrigations. Apart from tube well irrigations, a segment of the farmers depend on canal irrigation also. Farmers generally prefer groundwater for irrigation because of its reliability and flexibility.

The power sector exerts a critical influence on the performance of agriculture sector as it affects farmer access to and use of electricity for a variety of irrigation operations, particularly pumping ground water for irrigation. Agrarian transformation in Punjab & Haryana under the Green Revolution strategy generated tremendous demand for power in agriculture sector. Until the early 1970s, the state electricity utilities in India levied charges on electric tube wells based on metered consumption. Thereafter, under the strategy of green revolution state governments have adopted a policy of providing free or subsidized power to farmers to increase agricultural productivity to ensure food security in the country. Consequently, the number of electric tube wells has increased over the period of time. In order to reduce transaction costs, the utilities removed meters and introduced flat tariffs for electricity supply to agriculture sector. Many states shifted to free and unmetered supply to agriculture which has underscored system of energy accounting and internal accountability in power utilities. Lack of adequate/ proper energy accounting system motivates the utilities to hide operational inefficiency and theft of electricity by non-agricultural consumers. It may be argued that in the absence of adequate accounting system, reliable estimation of actual electricity consumption by the agricultural consumers and the amount of subsidy cannot be precisely estimated.

It has also been observed that subsidised supply of electricity motivates people to utilise the scarce resources, particularly ground water and electricity, in an inefficient manner. Consequently, the crisis for sustainable development of agriculture as well as power sector becomes inevitable.

With this background, we broadly focussed on optimisation of agriculture power subsidy and irrigation water intensity.

The main objectives of the study are:

- To find out desirable cropping pattern for source wise irrigation.
- To assess efficiency in source wise irrigation water utilisation.
- To compare agricultural production and productivity per acre for source wise irrigation in Rabi and Kharif seasons.
- To assess implications of source wise irrigation for sustainable growth in the agriculture sector and power sector.
-

Research Methodology and Data Base

Haryana Kisan Aayog has divided the state, based on ecology and cropping pattern, into three agro-eco regions: Region 1 consists of 8 districts, namely Panchkula, Ambala, Kurukshetra, Yamunanagar, Karnal, Kaithal, Panipat and Sonipat. This Zone forms nearly 32 percent of the total area of the State; Region II consists of 7 districts, namely Sirsa, Fatehabad, Hisar, Jind, Rohtak, Faridabad and Palwal. This Zone accounts for nearly 39 percent of the total area of the State; and Region III consists of 6 districts, namely Bhiwani, Mahendergarh, Rewari, Jhajjar, Gurgaon and Mewat. It covers nearly 29 per cent of the total area of the State.

In this study multi-stage random sampling technique has been adopted to select the ultimate household. Initially, we have selected six districts, namely Kurukshetra & Sonipat from region I, Hisar & Palwal from region II and Jhajjar and Mahindergarh from region III on the basis of certain relevant indicators.

Thereafter, we selected 24 villages, consisting four villages from each selected district. Our total sample size is 960 households, consisting households from different categories, classified on the basis of their dependence on sources of irrigations. However, one household has been dropped due to inconsistency in data. So, effective sample size for analysis is 959 households.

Objective wise Methodology

To meet the objective of desirable cropping pattern in Rabi and Kharif seasons, we collected information regarding perceptions of the households about their existing cropping pattern from all the four categories, classified on the basis of their dependence on canal, electric tube wells, diesel pump sets and other sources of irrigations. To examine desirable cropping pattern for source wise irrigations, we tried to highlight how source of irrigation influences cropping pattern.

To assess the efficiency in irrigation water utilisation, we compared the optimum number of times a crop is required to be irrigated with the actual number of times, it is irrigated by the categories of irrigation source wise households. The optimum number of times a crop is required to be irrigated depends on many factors. We considered a normal year for the purpose. We have also attempted to estimate wasteful consumption of groundwater and electricity taking into account the optimum number of irrigations for important crops as recommended in the package of practices issued by Ch. Charan Singh Haryana Agricultural University (HAU) Hisar and notified by the Department of Agriculture, Government of Haryana.

To examine agricultural production and productivity per acre for source wise irrigations, we compared crop wise production and productivity per acre in relation to sources of irrigations during Rabi and Kharif seasons for the sampled households.

To assess implications of source wise irrigation, we attempted to capture the perceptions of the sampled households in terms of change in cropping pattern, level of water table, soil degradation, groundwater de-gradation, salinity problems, etc. In the existing cropping pattern (wheat-rice rotation), excessive use of pesticides and chemical fertilisers took place that is reflected in terms of its impact on human/ animal's health. In other words, such practices promote various kinds of diseases for human beings as well as animals. To assess source wise irrigations and agricultural sustainability, we analysed how source of irrigations affects the issues related to the land degradation, water table depletion, deterioration in the quality of ground water, soil salinity, water logging etc.

In this study, we used primary as well as secondary data. The primary data was collected from a survey with the help of well designed perception questionnaire while the secondary data was obtained from the relevant government departments/ offices.

In this study, we have classified farm households in four categories on the basis of sources of irrigation i.e., canal irrigations, electric tubewell irrigations, diesel pumpsets irrigations and other sources which include mix sources of irrigations.

Total sample size was selected 960 households but one household was dropped due to inconsistency in the data. Therefore, our analysis has been based on 959 households. In our total sample size of 959 households, there are 18.37 per cent marginal famers (having operational land holdings up to 2.5 acres). The share of small farmers (having land holdings 2.51 to 5.0 acres) in total households is 29.54 per cent. The representation of semi- medium (5.1 to 10.0 acres), medium (10.1 to 25.0 acres) and large (above 25 acres) farmers in total households is 27.87 per cent, 17.43 per cent and 6.78 per cent respectively. Irrigation source wise classification reflects that the highest share (51.82 per cent) of households belong to the category of households who depends on electric tube wells for irrigations. It is interesting to highlight that no medium and large farm households depends purely on canal irrigation in our sample.

The major crops in Kharif season were paddy, bajra, gawar, cotton and fodder. Paddy cultivation is most preferred crop in kharif season across the sources of irrigations, except canal irrigation in the sampled area. The households who mainly depend on canal irrigation and their land holdings lies near the bank of canal have also shown interest in paddy cultivation. In the Rabi season the major crops are wheat, oilseeds, barley, sugarcane and fodder. Wheat and mustards are the major crops across the sources of irrigations.

It becomes pertinent to highlight that wheat paddy rotation is prominently prevailing in most of the Haryana, except southern districts.

Interestingly most of the households stick to their existing cropping pattern mainly due to non availability of suitable alternate crop on the one hand and lack of adequate cold storage and assured markets to sale agricultural produce on the other. There is an urgent need to motivate the farmers to break mono cropping culture with suitable alternatives crop keeping in view assured market and minimum support price for sustainable agricultural growth in the state.

Crops productivity mainly depends on the reliability and quality of irrigation water applied. Improved reliability of irrigation water may ensure better timing of irrigation for crops' growth. Non availability of irrigation water at critical stages of growth can significantly reduce the crop growth and yield.

It has been observed that the productivity per acre of main Kharif and Rabi crops under canal irrigations was comparable with the productivity under remaining sources of irrigations. Some households have also shown interest in growing seasonal vegetables like onion, carrot, ladyfingers etc.

It may be noted that the crop diversification has been influenced from extension of irrigation facilities. Moreover, the quality & reliability of irrigation water affects the cropping pattern wherein the farmers select crops that give them a higher return from each unit of land they cultivate.

It may be argued that wheat and paddy crops have played a major role in pushing up the agricultural production in the state but excess utilisation of ground water and electricity consumption led to agricultural un-sustainability. The area under paddy cultivation needs to be brought down on priority basis due to irrigation water shortages. It should also be noted that paddy is not the staple diet of Haryana.

Ideal irrigation pattern depends on optimum water requirement by a crop to grow and availability of source wise irrigations. The comparison between optimum number of times a crop required to be irrigated with actual number of times of irrigation helps us to estimate wasteful consumption of irrigation water and electricity, if the pump is operated by electricity. It is pertinent to reveal that depth and number of irrigations depends on many factors such as weather conditions, especially the intensity and frequency of rainfall during the crop season, type of soil (sandy, clay, sandy loan etc.), irrigation methods to be adopted (flood, sprinkle etc.) and other management practices being followed.

The data clearly shows that average number of times of actual irrigations is significantly higher than optimum number of times of irrigations was required in most of the Kharif crops across the sources of irrigations, except canal irrigations. Interestingly, actual average number of times of irrigations through electric tube wells is much higher than rest of the sources of irrigations in most of the Kharif crops. It is pertinent to note that average actual number of irrigations (46) with electric tube wells in paddy cultivation is more than double as against the optimum number of irrigations (15-20) required. It clearly indicates towards over utilisation of ground water through electric tube wells.

The data reveals that source wise average number of times of actual irrigations for most of the Rabi crops was within the specified range of optimum number of times of irrigations, except sugarcane & barley in the category of electric tube wells irrigations.

It has also been observed that per acre actual irrigations through electric tube wells was relatively higher than that of rest of the sources of irrigations in most of the Kharif &

Rabi crops. It may be due to a perceptible proportion of the electricity supply to agricultural pumpsets is unmetered and is provided at highly subsidised rates in Haryana and consequently the farmers are motivated to utilise groundwater as well as electricity inefficiently. Due to unmetered supply to agriculture, energy accounting system became ineffective and in fact collapsed.

There were hardly any efforts from the state government to motivate farmers for efficient utilisation of electricity and ground water. Unmetered power supply promotes inefficiency in electricity consumption as well as utilisation of ground water. In the absence of proper metering at consumer ends, the precise estimation of actual electricity consumption by agricultural consumers and the amount of power subsidy is not possible. There is an urgent need to ensure metered supply at consumer ends, particularly the agriculture connections, on priority basis to ensure accountability and transparency. It will promote efficiency in electricity and ground water utilisation and add to viability in the power supply.

During field survey deterioration in quality of soil was observed which occurred mainly on account of continuous excess use of chemical fertiliser, pesticides and ground water for irrigations. The households pointed out that canal irrigation is relatively more conducive for cultivation as compared to ground water irrigation.

The data reveals that a majority of the households particularly from the categories of electric tube wells & diesel pump sets irrigations reported soil degradation over the period.

It has been observed irrespective of sources of irrigations that soil degradation was one of major problems associated with excessive utilisation of tube-wells to extract ground water in the study areas. The households argued that to maintain and/ or increase productivity of the crops during the cropping seasons, Kharif and Rabi, higher amount/doses of chemical fertilisers and pesticides are required. Excess utilisation of chemical fertilisers and pesticides also led to deteriorate fertility of land over the period. Gradually, the soil fertility is affected by irrigations with high total dissolved solids (TDS) ground water and consequently several traditional crops have been disappeared in the study area.

Majority of the households (47.24 per cent) reported bad quality of groundwater. It may be noted that quality of ground water tended to deteriorate with excess extraction of ground water on the one hand and excess use of chemical fertilisers, pesticides etc. on the other.

More than 64 per cent of the sampled households reported decrease in ground water table in their fields. It needs to be highlighted that the highest share of the households reporting decrease in ground water table was in the category of diesel pump sets. These households are relatively more aware about decline in ground water table mainly because diesel pump sets extract water from upper layers of the soil and the households are forced to insert more pipes in the ground more frequently. The households with electric tube wells are using submersible pump sets and electric motors with higher capacity are required to extract deep ground water, which consumes more electricity. It implies that water tables depletion forced the households to adopt expensive deep-water equipments, which further worsened the crisis in terms of additional financial burden on the households.

It needs to be highlighted that the problem of salinity appeared in the areas where ground water is used for irrigations rampantly. The problem of salinity is not severe under canal irrigations. The data clearly reveals that 62.46 per cent of the sampled households reported increase in the problem of soil salinity in their areas particularly in the categories of electric tube wells and diesel pump sets irrigations. The households pointed out that the problem of salinity may be controlled to some extent by applying ground water mixed with canal water for irrigations.

In the category of electric tube wells irrigations 79.48 per cent of households highlighted the issue of inadequacy of power supply to meet irrigation requirements in the existing cropping pattern. A perceptible proportion of the sampled households (84.51 per cent) reported the problem of irregular supply to their tube wells. It may be argued that irregular power supply and depleting ground water table have emerged as a great threat for agriculture sustainability in the study areas. Therefore, power supply to agriculture sector should be regular on the one hand and crop diversification in favour of less water intensive crops on the other to ensure agriculture sustainability in Haryana.

It was observed that a majority of the marginal & small farm households were interested in metered supply and even they were ready to pay for assured quality supply. But most of big farmers were not interested in paid supply. They were interested in the existing system of subsidised power supply.

It may be argued on the basis of available data/ information that big farm households were the major beneficiaries of power supply at subsidised rates mainly because of low power consumption by a significant proportion of marginal and small farmers. Therefore, there is an urgent need to ensure power supply at subsidised rates to the targeted households. Big farmers, being in a better financial position, may be charged full cost of supply so that the burden of agriculture power subsidy can be reduced on the one hand and the environmental impacts may be controlled/ reduced to some extent on the other.

It was found that more than 80 per cent households do not have awareness regarding water harvesting techniques in the sampled areas. Therefore, there is an urgent need to generate awareness among the farm households regarding energy saving and water harvesting techniques on priority basis to ensure sustainable agricultural development in the state.

Efficiency in agriculture power subsidies implies maximum agricultural production/ output with minimum power subsidy which may help to reduce pressure on finances of the state government on the one hand and on ground water extraction on the other. It has been observed from the available data that households with electric tube wells have been using ground water inefficiently particularly in terms of excess number of irrigations as against optimum number of irrigations required for the growth of a crop. The number of times actual irrigations per acre took place through electric tube wells is relatively higher than that of optimum number of times a crop is required to be irrigated in the sampled households during Kharif as well as Rabi seasons.

We have made attempts to calculate the amount of power subsidy for excess electricity consumption under paddy cultivation for the sampled households. The required capacity of the electric motor, measured in terms of horsepower, depends on the depth of the ground water to extract.

Average capacity of electric motors of the sampled households works out to be 11.69 HP. Average time taken to irrigate one acre with electric tube wells happens to be 3 hours. Per acre electricity consumption for single irrigation comes out to be 26.12 units. Per acre cost of supply for single irrigation works out to be Rs. **191.72** (@ Rs.7.34 per unit). Total cost of supply for excess consumption of electricity in one acre of paddy cultivation comes out to be Rs. **4984.72** (191.72x26). Total cost of supply for excess consumption of electricity for the sampled households works out to be Rs. **95.61 lakh** (4984.72x1918).

The area sown under paddy cultivation and irrigated by electric tube wells in the state comes out to be 686000 (53.32 per cent) hectares which turns out to be 16, 94,000 (686000x2.47) acres. Per acre cost of supply for excess consumption of electricity for paddy cultivation works out to be Rs. **4984.72**. **Therefore, the total amount of agricultural power subsidy for excess electricity consumption under only paddy cultivation in the state as a**

whole turns out to be Rs. 844.41 (1694000x 4984.72) crore, which a very perceptible amount. This amount accounts for 2.85 per cent of state's own revenue receipts and 2.31 per cent of development revenue expenditure for the year 2014-15.

The irrigation water is measured in terms of acre centimetres. It implies a volume of water required to cover an area of one acre surface to a depth of one centimetre. Average depth of irrigation for paddy cultivation is required 5 centimetres. The volume of ground water extracted per acre with electric tube wells for excess number of actual irrigations (26 irrigations) happens to be 130 (5x26) centimetres. The volume of excess irrigation water per acre comes out to be 4.267 (130/30.48) acre feet. The total volume of excess irrigation water extracted with electric tube wells to irrigate paddy cultivation for the sampled households comes out to be 8184.106 (4.267x1918) acre feet. **The total volume of irrigation water extracted by electric tube wells to meet excess irrigations for paddy cultivations in the state of Haryana comes out to be 7.23 (4.267x1647000) million acre feet (MAF).**

It may be inferred that a significant amount being paid in terms of agricultural power subsidy on account of inefficient electricity consumption along with ground water extraction could be saved, if the state government motivates the households to utilise electricity and ground water in an efficient manner. It is also pertinent to be noted that per acre productivity of paddy under canal & other sources of irrigations is more or less equal to the productivity of paddy under electric tube wells irrigations. Therefore, it may be argued that excess consumption of electricity and ground water could be regulated without putting adverse impact on production & productivity of the crops.

The practices of excess extraction of ground water by farmers under electric tube well irrigations have probably happened on account of power supply to the agriculture sector at flat rate, which is also very nominal in Haryana. Flat rate system has also motivated the farmers to install in-efficient pump sets that consumed excessive electricity and led to wastage of electricity and ground water.

It has also been observed that farmers generally prefer local branded motor as it was relatively cheaper and extract more ground water. It is pertinent to note that use of local inefficient motors particularly on account of flat rate system led to over utilisation of ground water and excess consumption of electricity, which has its implications for sustainable agricultural growth and financial viability of the power utilities.

At this juncture, the best course of action may be to transform the existing unmetered flat tariff policy into a rational metered consumption based tariff. This proposition may be helpful to motivate the farm households to utilise electricity and ground water efficiently which may in turns ensure optimal utilisation of electricity and irrigation water.

Policy Recommendations

- The farmers should be motivated by the government as well as non government agencies to break down rice-wheat mono cropping pattern and to shift towards horticulture/ floriculture. No doubt, wheat and paddy crops have played a major role in pushing up the agricultural production in the state but excess utilisation of ground water and electricity consumption led to agricultural un-sustainability.
- Excess utilisation of ground water and electricity consumption led to un-sustainability in agriculture as well as power sector. The area under paddy cultivation needs to be brought down on priority basis due to irrigation water shortages. It should also be noted that paddy is not the staple diet of Haryana.
- The state government must emphasis on development of region wise suitable less water intensive crops on priority basis.
- Due to lack of adequate infrastructure like cold storage, assured markets & minimum support price the households are stick to the existing cropping pattern.
- Canal water pollution is an emerging problem on account of releasing industrial wastes particular in district Palwal. Appropriate policy should be design to control the release of industrial wastes in canal water.
- To save water, practice of flood irrigations must be discouraged and incentives in terms of capital subsidy for adoption of micro-irrigation practices like may be ensured.
- The state government should focus on awareness generation programmes among the rural households so that the households may be motivated to use water saving techniques/ practices like direct seeded rice, alternate furrow irrigation, laser land leveling, etc. in order to reduce pressure on ground water extraction and electricity consumption. The state government can seek help from the institutions who are working in these critical areas.
- The state government must focus on development of water ponds, construction of recharge bore wells at appropriate locations, pumping of seepage water near canal banks for increasing canal water supply.

- The state government must ensure 100 per cent metering at consumer ends on priority basis to estimate precisely actual electricity consumption and amount of subsidy and to make system transparent and accountable.
- Subsidised power supply should be targeted to marginal and small farmers. Blind subsidy is a matter of serious concern. Subsidy to big farmers must be slowly phased out, at least it should be made transparent to begin with.
- To regulate excess use of ground water and electricity for paddy cultivation crop diversification in favour of less water intensive crops may be promoted through ensuring minimum support price and assured markets.
- The policy of Direct Benefit Transfers (DBT) may be explored in power subsidy which will require proper metering at consumer ends.

Selected Bibliography

Bhalla, G. S. (1964), “Economic Theory and Public Enterprise Pricing”, *The Indian Economic Journal*, Vol. 12, No.2, Oct-Dec, pp. 156-66.

CEA (2000), 16th Electric Power Survey of India, Central Electricity Authority, New Delhi

CEA (2001), *Report of the Inter-Disciplinary Group Appointed By Ministry of Power on Reduction on the Cost of Power & Transparency in Bidding Process*, Central Electricity Authority, New Delhi.

Gulati, Mohinder and Sanjay Pahula (2015), “Direct Delivery of Power Subsidies to Manage Energy- groundwater Agriculture Nexus”, Aquatic Procedia, No. 5, pp. 22-30 (www.sciencedirect.com).

Garg, B. R. & K. K. Jain (1998), “Impact of Electricity Subsidy for Irrigation in Punjab Agriculture”, *Indian Journal of Agriculture Economics*, Vol.53, No.3,pp. 309-311.

Ghose, Nilabja (1998), “Electricity Use in Indian Agriculture”, Indian Journal of Agriculture Economics, Vol.53, No.3, pp.304-308.

GOH, *Statistical Abstract of Haryana* (various issue), Planning Department, Govt. of Haryana, Chandigarh.

GOI, *Five Year Plan Documents*, Planning Commission, Govt. of India, New Delhi.

Gill, S.S. (2005), “Economic Stress and Suicides in Rural Punjab”, JPS, Vol. 12, No. 2, pp. 219-237.

HERC, *Tariff Orders on Annual Revenue Requirement* (various years), Haryana Electricity Regulatory Commission, Panchkula.

IIPA (2006), *Study on Impact of Restructuring of SEBs, Report of Expert Group*, Indian Institute of Public Administration, New Delhi

MoP (2006), *Performance Report of Power Sector*, Ministry of Power, Govt. of India

Kumar, Surinder (2002), “Lest the Regulators Be Regulated: Power Sector Reforms in Haryana, *Indian Journal of Power and River Valley Development*, (May-June), Vol 5&6, Culcutta, pp 87-89.

Kumar, Surinder (2004), ‘*Electricity Theft: Empowering People and Reforming Power Sector’*, Manohar Publication, Delhi & Institute for Development and Communication, Chandigarh.

MOP (2001), *Memorandum of Understanding (MoU) Between the Ministry of Power, Government of India and Government of Haryana Regarding Power Sector Reforms*, Ministry of Power, Government of India, (www.powermin.nic.in).

MOP (2001), *Report of the Expert Group on the Settlement of SEBs Dues*, Ministry of Power, Government of India, (www.powermin.nic.in).

MOP (2002), *Expert Committee Report on Sector Specific Reforms (Power Sector)*, Ministry of Power, Government of India, (www.powermin.nic.in).

Nehra, Kulwant (2016): “Implications of Subsidised Power Supply for Sustainable Agriculture in Haryana”, Man and Development, Vol. 38, No. 1, pp. 51-70.

Nivedita and S.P. Singh (2013), “Agricultural Diversification and Contract Farming in Punjab”, Journal of Economic and Social Development, Vol. IX, No. 1, pp. 38-51.

Rajagopalan, Meera & Harvey Demaine (1994), “Issues in Energy Subsidies for Irrigation Pumping”, *Energy Policy*, Vol.22, No.1, pp.89-95.

Rao, S. L. (2002), “The Political Economy of Power”, *Economic and Political Weekly*, Vol. 37, No. 33, pp. 3433-3444

World Bank (2001), *India Power Supply to Agriculture*, Vol. 1 to 4, Report No 22171-IN, World Bank Document Centre, New Delhi.

Joydeb, Sasmal (2014), “*Foodgrains Production in India- How Serious is the Shortage of Water Supply for Future Growth*”, Indian Journal of Agriculture Economics, Vol.69, No.2, April-June, pp.229-242

Singh, Kulwant (2016): "Agricultural Sustainability and Subsidised Power Supply: Reflections from Haryana", Agricultural Situation in India, Vol. LXXIII, No. 6, September, pp. 23-30.

Singh, O. P., Rakesh Singh and Manish Kumar Singh (2014): "Impact of Farm Sector Electricity Subsidy on Water Use Efficiency and Water Productivity in India", Indian Journal of Agriculture Economics, Vol. 69, No.3, July-Sept., pp.404-413.

Singh, S.P. and B. Sahoo (2007), "Diversification of Agricultural Economy towards Horticulture and Livestock: Regional Variations, Convergence and Determinants", Indian Journal of Labour Economics, Vol. 50, pp. 658-672.

Dhindwal, A.S., V.K. Phogat and M.S. Dahiya (2009): *Report on Efficient Management of Irrigation Water in Haryana*, CCS Haryana Agriculture University, Hisar.