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Sustainability of Existing Farming System in Punjab and Haryana - Some Issues on Groundwater Use

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Intensive use of renewable and non-renewable resources along with the modern technology since 1966 has substantially increased the agricultural production in the Punjab and Haryana. It was true particularly with rice and wheat. However, there were rippling effects on other crops as well. Doubts are now being raised about the sustainability of the present model of agricultural development.

It is suspected that existing high level of production may severely deplete the natural resources and adversely affect agricultural production in the long run. The words of Professor Schultz (1987) that the economic consequences of the short view in economic policy carry a high price, may become true in the most productive region of India if due attention is not given. The present study examines the sustainability of existing farming system in the Punjab and Haryana and also proposes some measures to maintain the sustainability of agriculture.

The study intends to look at the issue of sustainability during the green revolution period (1972-73 to 1979-80), the post-green revolution period (1980-81 to 1987-88), and the prospects in the long run. Depending upon the quality of groundwater, two categories of districts from Punjab and Haryana, one with good quality water and the other with poor quality, were selected. This has been done keeping in view the fact that management and environmental problems vary with water quality. The areas endowed with good quality groundwater are being over-exploited without maintaining the water level at a reasonable depth. On the other hand, regions with poor quality groundwater are not being extracted, therefore leading to rise in the water table. Both the situations are undesirable for the sustainability of agriculture.

The districts endowed with good groundwater quality selected for this study include Karnal, Kurukshetra and parts of Jind in Haryana and Ludhiana, Amritsar, Ropar, Kapurthala and Jalandhar in the Punjab. The districts with poor quality groundwater for this study include parts of Jind, Hisar and Rohtak in Haryana and Ferozepur and Sangrur in the Punjab. Four major crops, *viz.*, rice, wheat, cotton and sugarcane, were selected. Rice-wheat rotation is generally being followed in good water quality zones, whereas cotton-wheat is being practised in most of the poor quality areas. Sugarcane is a common crop in both the situations.

The study computed the compound growth rates of area, production and yield during the green revolution and post-green revolution periods to project the performance of selected crops. The exploitation of groundwater in good and poor quality regions is discussed with the help of secondary information. The consequences of over- and under-exploitation of groundwater and factors determining its extraction are elaborated with help of regression analysis. At the end, some measures are suggested to maintain the sustainability of agriculture in the Punjab and Haryana.

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TABLE I. COMPOUND GROWTH RATES OF PRODUCTION, AREA AND YIELD OF RICE AND WHEAT

(per cent per annum)

Districts	Rice						Wheat					
	1972-73 to 1979-80			1980-81 to 1986-87			1972-73 to 1979-80			1980-81 to 1986-87		
	Production	Area	Yield	Production	Area	Yield	Production	Area	Yield	Production	Area	Yield
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Haryana												
Karnal	16.17	8.14	7.41	3.84	4.52	-0.69 NS	6.09	2.38	3.62	7.93	0.13	7.79
Kurukshetra	14.03	7.26	6.31	1.14 NS	2.87	-1.69	9.42	3.71	5.51	7.18	1.49	5.60
Jind	24.76	18.23	5.52	5.65	6.48	-0.79 NS	7.36	2.19	5.05	8.18	5.11	2.91
Hisar	7.38	1.07	6.26	12.36	10.32	1.85 NS	1.49	-6.01	7.99	10.55	5.42	4.86
Rohtak	22.60	28.57	-4.63	17.86	11.57	5.63 NS	8.04	3.71	4.19	5.49	1.55	3.87
Punjab												
Ludhiana	39.95	36.67	2.40 NS	12.95	12.54	0.38 NS	3.56	1.08	2.46	2.85	0.18	2.66
Jalandhar	23.65	17.34	5.38	10.44	7.27	2.95	1.34	1.49	-0.14	5.60	0.74	4.81
Ferozepur	15.00	14.29	0.62 NS	8.18	5.34	2.70	9.22	4.82	4.18	4.44	2.48	1.91
Amritsar	13.00	9.99	2.74	12.10	3.85	7.94	5.94	2.65	3.20	4.08	2.14	1.89
Kapurthala	14.98	12.86	1.88	6.81	6.15	0.61 NS	6.66	5.50	1.50	4.27	1.84	2.37
Patiala	21.01	13.66	6.47	6.01	4.47	1.48	9.09	2.84	6.06	6.95	1.51	5.36
Sangrur	43.32	31.90	8.65	16.85	17.96	-0.95 NS	6.46	2.46	3.70	4.78	2.04	2.68
Ropar	18.47	12.96	4.86	10.57	6.51	3.80	8.18	1.10	7.07	9.29	5.83	3.25

NS = Non-significant.

TABLE II. COMPOUND GROWTH RATES OF PRODUCTION, AREA AND YIELD OF COTTON AND SUGARCANE

(per cent per annum)

Districts	Cotton						Sugarcane					
	1972-73 to 1979-80			1980-81 to 1986-87			1972-73 to 1979-80			1980-81 to 1986-87		
	Production	Area	Yield	Production	Area	Yield	Production	Area	Yield	Production	Area	Yield
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Haryana												
Karnal	6.77	1.11	5.59	-10.34	-12.10	2.00^{NS}	-3.88	-4.45	0.59^{NS}	-3.09	-6.55	3.70
Kurukshetra	-4.19	-9.73	6.94	-21.33	-16.82	5.42^{NS}	-1.11	-0.27^{NS}	-0.85	9.92	3.95	5.76
Jind	3.59	0.82	2.75	0.79^{NS}	1.80^{NS}	1.00^{NS}	-2.83^{NS}	-3.97	-6.69	5.01	-4.52	9.99
Hisar	-5.49	-6.97	1.59	2.72^{NS}	1.15^{NS}	1.55^{NS}	1.36	0.28^{NS}	-6.62	-1.35	-9.15	8.59
Rohtak	1.98	0.51	1.46	-3.72^{NS}	-4.93	1.28^{NS}	-4.16	3.53^{NS}	-7.43	-0.47	-5.94	5.81
Punjab												
Ludhiana	-9.53	-4.13	-5.53	-25.98	-26.69	0.97	-5.82	-6.34	0.55^{NS}	3.90	-0.30^{NS}	4.23
Jalandhar	-3.02	-1.74	-1.30	-18.08	-19.46	1.71	-0.37^{NS}	-0.85^{NS}	0.48^{NS}	1.79^{NS}	1.89	-1.09^{NS}
Ferozepur	-1.42	-0.50	-1.92	1.89	-2.18	4.16^{NS}	-6.74^{NS}	-13.04	7.24	18.27	15.63	2.29^{NS}
Amritsar	-15.09	-6.89	-8.87	-37.04	-28.19	12.32	-0.87^{NS}	-0.22^{NS}	-0.66^{NS}	-8.89	-8.01	-0.96^{NS}
Kapurthala	-	-	-	-	-	-	1.74^{NS}	-2.50^{NS}	4.35^{NS}	0.89^{NS}	0.00^{NS}	0.89^{NS}
Patiala	-9.45	-5.11	-4.65	-25.76	-27.59	2.52^{NS}	-4.67^{NS}	-3.43^{NS}	-1.28^{NS}	3.46^{NS}	-0.48^{NS}	3.96
Sangrur	-0.20	-0.33	-0.50	-6.12	-6.34	0.24	-3.43	-4.10	0.28^{NS}	-3.93	-6.15	2.36
Ropar	-	-	-	-	-11.64	11.64	9.92	3.59	6.10	3.73	1.03	2.66

NS = Non-significant.

CHANGES IN PRODUCTION

Compound growth rates of production, area and yield of rice, wheat, cotton and sugarcane are computed for the selected districts of Punjab and Haryana for the green revolution period (1972-73 to 1979-80) and the post-green revolution period (1980-81 to 1986-87). The results are presented in Tables I and II.

For the majority of the districts, the growth rate of production has slowed down during the post-green revolution period. Interestingly, acreage expansion became an important source of increasing production of rice and wheat during the post-green revolution period. It was yield that was a dominating source of increasing production of rice and wheat during the green revolution period. The rate of change in yields of rice and wheat during the post-green revolution period has either become stagnant or negative or non-significant. The crop substitution and reclamation of degraded soils have contributed to the increase in the production of rice and wheat during the post-green revolution period. But their contribution was rather slow and has not been adequate to compensate the fall in the growth rate achieved during the green revolution period.

Production of cotton has sharply declined in all the districts under study. It is one of the several crops grown during *kharif* that was replaced by rice. Since rice is a relatively more profitable and stable crop than cotton, therefore, farmers preferred its cultivation.

The case of sugarcane is quite different. The impact of the green revolution is not reflected in this crop. The fact is that there was no technological breakthrough in sugarcane; therefore, production and acreage are largely determined by prices and profitability. However, the components of rice and wheat production technology, like application of fertiliser and irrigation management, have contributed to the increase in the crop yields of sugarcane.

On the basis of the facts, it is inferred that despite the relative advantage of improved technology, the production and profitability of rice and wheat are shrinking during the post-green revolution period in the Punjab and Haryana. The acreage of cotton is declining and sugarcane does not show any encouraging results.

The key constraints in the production system are: deteriorating soil health and stagnation of new technology since 1966. Although fertiliser consumption has increased and irrigated area expanded, the rates of growth of yields have slowed down. If such a trend continued over the years, the agricultural production of these states will be severely affected. In fact another green revolution is very much warranted to sustain the agricultural production of Punjab and Haryana.

IRRIGATION DEVELOPMENT

(i) Cropwise Irrigated Area

The irrigated area under rice and wheat has dramatically increased in different districts of Punjab and Haryana. High private profitability of rice with existing incentives on inputs and better output support prices are responsible for acreage gains in the Punjab and Haryana. The irrigation requirement of rice for this region is about 130 cm/ha. Rice accounts for about 53 per cent of the total irrigation water requirement in the Punjab. The corresponding figure for Haryana is 35 per cent. The irrigation water requirement of wheat in both the states is about four times less than that of rice.

The irrigation requirement of sugarcane is about 140 cm/ha, which is considered higher than other crops (Table III). The irrigated area under sugarcane is declining in all the districts, except Jalandhar and Ropar. The irrigated area of cotton is declining in a majority of the districts. An area of about 2.9 ha cotton can be irrigated with an equivalent irrigation water requirement of rice. Although cotton is not a very high water requirement crop, irrigation is leading to a rise in the water table in poor quality groundwater areas in the absence of appropriate sub-surface drainage measures.

TABLE III. IRRIGATION WATER REQUIREMENT OF IMPORTANT CROPS IN PUNJAB AND HARYANA REGION

(cm/ha)

Crops (1)	Irrigation water requirement (2)	IWR_r/IWR_i (3)
Rice	130	1.00
Wheat	40	3.25
Cotton	45	2.89
Sugarcane	140	0.93
Bajra	20	6.50
Mustard	12	10.83

Note:- IWR_i is irrigation water requirement of ith crop; and IWR_r is irrigation water requirement of rice.

(ii) Sourcewise Irrigated Area

Karnal and Kurukshetra in Haryana and all districts in Punjab, except Amritsar and Ferozepur, are dominated by tubewell irrigation (Table IV). Over time the area under tubewell has increased in all the selected districts. Jind, Hisar and Rohtak in Haryana have poor quality of groundwater and, therefore, canal is a dominant source of irrigation. Although Ferozepur and Sangrur also have water quality problem, a fairly large area is under tubewell irrigation. This shows that marginal quality of water wherever possible to develop has been exploited.

The number of tubewells phenomenally increased in all the districts, except that there was some decline in Ferozepur. Kapurthala is one district which witnessed tremendous increase in the number of tubewells which rose from a low level of about 2,000 in 1970-71 to a high level of about 26,000 in 1986-87. This is an indication that the private cost of installing tubewell and its operation and maintenance is substantially lower than marginal returns to irrigation. It is reported that the Punjab farmer gets a subsidy of Rs. 5.90 on electricity to produce one quintal of rice, Rs. 3.95 for cotton and Rs. 1.46 for wheat (Gulati, 1990). Such an encouraging incentive has resulted in the installation of a large number of tubewells, and consequently in the over-exploitation of the groundwater to maximise short-run private profit.

MAGNITUDE OF THE PROBLEM

Over-exploitation of groundwater was observed in all the districts of Punjab and in Karnal and Kurukshetra in Haryana (Table IV). The net result is a negative balance of groundwater. Thanks to the canal seepage in these districts that recharges groundwater, otherwise the water table would have fallen at a faster rate. The water table in Karnal district fell from 4.8 metres in 1974 to 7.7 metres 1989. The corresponding figures for district Kurukshetra were 7 metres and 10.7 metres respectively (HSMITC, 1990). A study in the fresh water belt of

Sudhar block in district Ludhiana reported phenomenal increase in the number of tubewells from 2,000 in 1965 to 65,000 in 1980, resulting in a fall in the water table from 3 to 11 metres (Khepar and Kaushal, 1991). Singh and Joshi (1989) reported that the water table in the Punjab is receding at a rate of 0.3 to 0.5 metre per year. Such a continuous depletion of groundwater may be undesirable as it may lead to desertification.

TABLE IV. PROGRESS OF TUBEWELL AND WATER EXTRACTION IN DIFFERENT DISTRICTS OF PUNJAB AND HARYANA

Districts	1970-71		1985-86		Usable discharge (mcm)	Draft 1989-90 (mcm)	Balance 1989-90 (mcm)
	ha/TW	TW/000ha	ha/TW	TW/000ha			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Haryana							
Karnal	11	90	10	97	1,089	1,499	-410
Kurukshetra	7	134	8	123	658	1,307	-654
Jind	26	38	22	45	453	201	252
Hisar	76	13	53	19	1,190	420	469
Rohtak	26	38	18	56	514	219	301
Punjab							
Ludhiana	13	74	8	111	1,264	1,954	-690
Jalandhar	24	41	25	39	703	1,491	-788
Ferozepur	68	15	53	19	N.A.	N.A.	-
Amritsar	49	20	22	45	1,631	1,647	-16
Kapurthala	47	21	5	200	334	668	-334
Patiala	17	58	7	150	1,161	2,76	-1,215
Sangrur	28	35	14	70	1,285	2,190	-905
Ropar	10	94	8	125	N.A.	N.A.	N.A.

Note:- ha/TW = Area in ha covered by one tubewell.
TW/000 ha = Number of tubewells in thousand ha of irrigated area. N.A. = Not available.

On the other hand, the situation in the poor quality water region is facing the problem of rise in the water table and is leading to soil salinity and waterlogging. It has been estimated that the rate of rise in the water table in the poor quality areas of Haryana is of the order of 0.15-1.0 metre per year (FAO, 1985). It has also been reported that areas with high groundwater levels already account for 0.4 million hectares in Haryana. It is apprehended that upto 1.5 to 2.0 million hectares may be affected by high water levels, waterlogging and, in the long run, by soil salinisation in Haryana (Gangwar and Toorn, 1987). The saline water belt of Punjab also shows similar trends. For example, in Muktsar block of Faridkot district, the water table rose from 17 to 2 metres (Khepar and Kaushal, 1991). The number of tubewells increased marginally from 1,000 in 1970 to 2,500 in 1980.

CONSEQUENCES OF THE PROBLEM

(i) Cost

One of the consequences of decline in the water table is reduction in tubewell discharge, which affects the command area of a tubewell and hence the cost of irrigation. While the command area is positively related with the discharge rate, the cost is negatively related. The estimated costs of groundwater for 1980 and 1990 are presented in Table V. This shows a substantial increase in the extraction cost. This is never reflected in the private cost of irrigation because farmers are paying flat rates for electricity to operate tubewells and their marginal cost of extracting groundwater is zero (Dhawan, 1986). Therefore, the private cost is unaffected while the social cost will rise with progressive pumping. Nonetheless, the lower discharge rate will affect the overall irrigation efficiency in the farm with additional time to irrigate the same area. Till the flat rates are continued, the society will bear the burden of additional cost of decline in the water table. As soon as the actual charges are effected from the users, the private cost will rise and may induce judicious use of groundwater.

Unlike over-extraction of groundwater in good water quality areas, the poor quality groundwater areas are witnessing continuous rise in the water table. The problem is taking a serious turn in terms of loss in production and decline in farm income. Gangwar and Toorn (1987) estimated a loss of Rs. 26.8 crores due to rise in poor quality water in Haryana during 1982 and predicted the loss to rise to a high level of Rs. 71.9 crores in 2,000. Depending on some specific assumptions, they estimated the investment requirement ranging from Rs. 450 crores to Rs. 530 crores to reclaim and prevent the losses due to the problem.

TABLE V. COST OF EXTRACTING GROUNDWATER THROUGH SHALLOW TUBEWELLS IN HARYANA DURING 1980 AND 1990

Item (1)	1980 (2)	1990 (3)
Total capital cost (Rs.)	7,500	18,500
Pumping period (hrs/year)	1,600	1,600
Fixed cost (Rs./year)	1,800	4,440
Fixed cost (Rs./hr)	1.125	2.775
Variable cost (Rs./hr)	1.025	1.50
Average tubewell discharge (m^3/hr)	36	27
Total cost (Rs./hr)	2.150	4.275
Cost of water (Rs./10^3m^3)	59.72	158.33

(ii) Equity

Continuous decline in the water table in many parts of these two states has resulted in a decline in water discharge over the years. It is expected that in the absence of suitable measures, a stage will soon be reached when shallow tubewells will be ineffective. Eventually, to harvest the groundwater farmers will have to go for deep tubewells. The deep tubewell technology is costly and beyond the reach of a small farmer. The installation cost of a deep tubewell is about 2 lakhs with a discharge rate of 45 litres per second. The cost of installing a shallow tubewell is about Rs. 18,500. Unlike shallow tubewell, the deep tubewell technology is uneconomic for smaller areas. It is feared that with continuous decline in the water table, the small and less resource endowed farmers will be deprived of the groundwater. The large and better resource endowed farmers will be in a position to install deep tubewell and dictate the terms for irrigation water to small farmers. Consequently, the small farmers will have to pay much higher irrigation charges and adjust agricultural operations according to the availability of water. Surely it will increase the cost and severely affect the small farmers and production in the long run.

(iii) Loss of Life

With decline of water table, the general practice amongst farmers is to lower the pump. There are reports available from Punjab and Haryana that with the onset of monsoon lethal gases are formed in deep pits of tubewells. Whenever a farmer goes down the deep pits to rectify some problem, he becomes a victim of lethal gases and dies of asphyxia. There are reports that since 1985, about 63 persons have lost their lives due to asphyxia in deep pits of tubewells. Of this, 40 in Haryana and 8 in Punjab died during 1988 (Taneja *et al.*, 1988).

FACTORS RESPONSIBLE FOR MINING

It has been postulated that increase in the draft of groundwater is determined by rainfall, rice acreage and the number of tubewells. Cross-district regression equations were estimated with the help of Ordinary Least Squares technique. Linear, double-log and semi-log equations were estimated to arrive at the best-fit for explaining the results. Depending upon the value of R^2 and significance of variables, the linear and semi-log equations were selected. The results are presented as follows:

Linear:

$$ND_t = \underset{}{162.06} \underset{(0.39)}{- 0.20\, R_t} \underset{(1.36)}{+ 7.94\, RA_t} \underset{(8.12)}{+ 8.43\, TW_t} \qquad R^2 = 0.89$$

Semi-log:

$$Ln\, ND_t = 882.06 \underset{(629.01)}{- 379.17\, R_t} \underset{(138.07)}{+ 318.01\, RA_t} \underset{(284.72)}{+ 495.33\, TW_t} \qquad R^2 = 0.76$$

Figures in parentheses are standard errors of the estimates.

where ND is the net groundwater draft in million cubic metres (mcm); R is rainfall (cm); RA is rice acreage (000 ha); and TW is number of tubewells (per 000 ha irrigated area); t is time and our estimates represent 1986-87.

Semi-log and linear models respectively explain 76 to 93 per cent of the variation in the net draft of groundwater. In both the models, all the explanatory variables appeared with expected signs. Rice acreage and number of tubewells have positive relation with the net draft, while rainfall has negative relation. In the case of linear model, rice acreage was significant at 1 per cent probability level. On the other hand, rice acreage and number of tubewells were significant at 5 and 20 per cent probability levels respectively in semi-log model. It is surprising that rainfall was non-significant in both the models.

The regression coefficient of semi-log model explains that with one per cent increase in rice acreage, the net draft will increase by 318 mcm. One per cent increase in the number of tubewells will extract 495 mcm additional volume of groundwater. It may be mentioned that rice acreage is increasing in the Punjab and Haryana. This is rather an undesirable situation in an area of depleting groundwater.

REMEDIAL MEASURES

Huge subsidy on irrigation, both surface and groundwater, has been extended to the farmers. To utilise groundwater, subsidy on electricity in Indian agriculture rose from Rs. 3.53 billion in 1980-81 to Rs. 14.57 billion in 1986-87 (Gulati, 1989). This electricity subsidy has a very high social cost. It has been reported that for the State of Punjab, the per unit cost of production of electricity is around Re 0.54, yet to the farmers the charges work out to be not more than Re 0.13 per unit. Thus for every unit of electricity consumed in the agricultural sector, the state incurs a subsidy cost of Re 0.40, amounting between Rs. 100 crores and Rs. 120 crores of the total expenditure every year (Johl, 1984). A similar situation prevails in Haryana. The staggering subsidy is reducing the private cost but over-exploiting the groundwater without visualising the future threat to agriculture and ecology. Farmers should be charged the actual cost of extracting groundwater for its judicious use. Further, it would be more appropriate to extend subsidy on irrigation water saving devices rather than on water extracting mechanisms. These devices may be better land leveling, sprinkler and drip irrigation systems. Experiences reveal that these devices not only save water but significantly improve irrigation efficiency and increase productivity. In poor water quality areas, the additional advantage of these devices will be helpful in postponing the problem of soil salinity and waterlogging.

High water requirement crops, particularly rice, in good water quality regions is preferred because of higher profit. To replace rice, the production technology of competing crops will have to be upgraded. In order to compete with rice, the yield of maize should be increased by 70 per cent, that of *moong* by 130 per cent, *arhar* by 169 per cent, cotton and groundnut by 47 per cent (Johl, 1984). Cotton, groundnut and maize should receive high research priority to increase the yield potential for realising higher profits. As large as five hectares of maize can be irrigated by an equivalent amount of water required by one hectare of rice. The corresponding figures for groundnut and cotton are 5 and 2.9 ha respectively.

The water table in poor quality regions should be deep enough to cut the capillary rise. Since groundwater use is negligible in these areas, the water table is rising and affecting crop growth and production. The research findings revealed that the groundwater ranging from 4.5 to 12 mmhos/cm electrical conductivity can be used safely in *moong* and mustard respectively, with pre-sowing irrigation by good quality canal water (Minhas and Gupta, 1990). Therefore, installation of shallow tubewell should be encouraged in areas where electrical conductivity of groundwater is upto 12 mmhos/cm and at least one pre-sowing canal irrigation is available. Poor quality water can also be used in conjunction with canal water to increase production and lower water table. Alternatively, horizontal sub-surface drainage should be provided in high poor quality water table areas. Per hectare cost of installing sub-surface drainage varied from Rs. 7,047 to Rs. 10,365 at 1981-82 prices (Datta *et al.*, 1990).

CONCLUSION

The above facts clearly demonstrate that the rate of change in production and crop yields of important crops, *viz.*, rice, wheat, cotton and sugarcane, has slowed down in the Punjab and Haryana. In good water quality regions the existing production levels are maintained by over-exploitation of groundwater. Contrary to this, the poor quality water regions are under-utilising groundwater and deteriorating the soil health by salinity and waterlogging.

Both the phenomena are undesirable and threaten the production and ecological sustainability. Appropriate technological, institutional and price policies should be initiated to save land and water resources for the next generation.

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