ABUNDANCE TO SCARICITY: A CONSEQUENCE OF OVEREXPLOITION OF GROUND WATER IN PUNJAB STATE (INDIA)

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Abstract

Punjab is principally an agricultural state with 70 of the population depending on agriculture. During the last four decades there have been major achievements in this direction since all the energies of Center and State Governments were directed towards this sector. This included increasing water resources (surface and groundwater), improvement in seeds and application of higher quantity of fertilizers, pesticides and insecticides. As a result total area under cultivation, irrigated area and ultimately the food grain production increased tremendously. It rose from 2.0 metric tons in 1950-51 to about 25.21 metric tons in 1999-2000. As the canal water supply was limite, the grater reliance was placed on groundwater by installing uncontrolled number of tube wells. The situation got further aggravated by the often

1 INTRODUCTION:

Punjab as the name denotes in local language was the land of five rivers. After partition of India in 1947, the State of Punjab within Indian Unions left with only three rivers viz. Ravi, Beas and Satluj. Jhelum & Chenab the mighty rivers are new under the control of Pakistan.

Till the end of nineteenth century, the rivers have been the main source of Irrigate through inundation canals what were non-perennial. However with the construction of dams on rivers and diverting the river water into per canals widespread surface Irrigation was introduced which changed the Irrigation from protection to production. The present scenario is such that surface Irrigation Potential of the state stands fully harnessed & there is no further of its further exploitation. This was however, not sufficient to meet the increased Irrigation demand during the green revolution of 1960's which ushered a new era in the history of Indian agriculture. To make the country self sufficient in food grains it was planned to tap all the available land and waterresources in the State. Apart from high yielding variety of seeds (HYV), the paddy was introduced as second major crop in then State taking toll of cropping intensity from 120% (1960-61) to about 185% (1999-2000). Now more and more area was brought under cultivation and use of chemical fertilizers was increased as a result net sown area increased 3757 million hectare (MHa) in 1960-61 to 4237 MHa in the year 1999-2000.

As the surface water potential was limited, irrigation thrust that commensurated with the green revolution was born by the ground water (minor irrigation). An un controlled exploitation of ground water resource was started by installing a large number of tube wells. It can be judged from the fact that the number of tube wells in this tiny state rose from about 50, 000 in 1960's to 9,25,000 in 1999-2000. The area irrigated by tube wells increased from 829 thousand hectare (ThHa) in 1960-61 to 2982 ThHa in 1999-2000 which about 60% of the net sown area. Today the utilization of minor irrigation potential (ground water) of the State is more than the major irrigation (surface irrigation). The minor has thus become major. Apart from supplementing irrigation in canal-irrigated tracts, about 50% of the cultivated area exclusively depends for irrigation on ground water. There has been thus complete metamorphosis in the irrigation system changing it from productive to intensive. The small state with only 4.2 MHa of net sown area out of total geographical area of 5.036 MHa which forms only 1.5 percent of the geographical area of the country produces more than 22%(12.7million metric tones) of India's wheat, 9% (6.8million metric tones) and 24% of cotton (0.3 million metric tones). It contributes 60-70% of wheat and 40-50% of rice to the central pool. The average yield is 3347 kg/Ha for

rice and 4696 kg/Ha for wheat. The State has thus rightly been termed as the food bowl of the country, which has changed deficit into surplus.

According to estimate total normative irrigation requirement of the State is about 5.92 million hectare meter (MHam). Considering 1.73 MHam as the net recoverable recharge to the ground water, the State is still deficit about 1.54 MHam of water (Prehar et al., 1993). Surface irrigation resources being limited, the excess irrigation requirement is being met through the over drawl of ground water resources. This has set in the declining trend in the ground water levels , which is dangerous situation. Optimum utilization of water resources for sustainable agriculture is the need of the hour. Efforts have been made in this paper to analyze the post and present scenario regarding the ground water. The remedial measure that needs to be adopted to avoid the situation from further worsening has been discussed.

2 GENERAL DESCRIPTION OF STUDY AREA:

Located in the North West India around 35^0 latitudes and 74 degree longitude, Punjab has an area of 50362 sq.kms. comprising mostly of plane and fertile lands. It forms a part of the vast alluvial expense popularly known as the Indo-Gangetic plain.

Topographically the area presents a gentle slope except for the shiwalik hills flanking the North East boundary. The elevation of hills varies between 70-100 m. A narrow strip of about 10 km. Width consisting of piedoment deposits occur in the immediate vicinity of hills and is locally called kandi belt.

Climatologically the area is located in the sub tropical belt. A noticeable climatic change from North East (NE) to South West (SW) is observed. In summer, the maximum temperature may touch 48^0C and in winter the minimum temperature occasionally falls below 0^0C.

The precipitation occurs mostly due to South Western Monsoons (Water laden winds originating from Indian Ocean) during the period from middle June to end of September. About 80 percent of rainfall occurs during this period. The rainfall decreases from North East to South West. Average annual rainfall varies from 92 cm in NE to less than 35 cm in the SW. Long dry spells are often enperienced in winter as well as in summer.

2.1 Ground Water regime in Punjab

The major part of the state consists of thick pile of quarternary alluvium. The north and north eastern parts of the state alongthe stare of Himachal Pardesh are occupied by hills comprising of shiwalik formation and piedomont deposits and can be grouped in following hydrogeological units.

1. Sub Himalayan Zone
    (a) Shiwalik formations
    (b) Intermontane Valleys
2. Piedomont deposits (Kandi Zone)
3. Sirowal Zone
4. Indus Plain

The water bearing formations in these four different units don't seem to have similarity. The intermontane valleys are aligned with river terracesflwal fans and collwal deposits and form

poor aquifers. While in Shiwalik sand stone, silt stone, clay stone and boulder beds predominate. Springs of low discharge occur on hill slopes. These springs are confined at the bedding contacts where argillaoeons beds are underlying arenaceous beds.

In Kandi area alluvial fans comprising of poorly sorted sediments like boulders, cobbles, pebbles, sand and clay. Ground water occurs under unconfined conditions due to predominance of coarser sediments. In between kandi and Indus flood plains these exist a zone characterized by dominantly fine sediments consisting of clay and silt with well sorted granular material comprising gravel and sand. This zone is known as 'Sirowal' vast alluvial tracts formed due to older and newer alluvium of quaternary age comprise of another unit known as Indus plain which occupy 95% of the total area of the state. The ground water potential of various hydrological units is summarized in table-I.

Table-I: Ground water potential of hydrological units

Sr.No.	Unit	Depth Range (m)	Yield Prospect (m^3/hr)
1.	Sub-Himalyan Zone	70-200	50-125 (Heavy Drawdown)
2.	Kandi Zone	150-300	50-150 (Heavy Drawdown)
3.	Sirowal	50-150	20-75 (Moderate Drawdown)
4.	Indus Plain	40-300	75-250 (Less Drawdown)

3 BEHAVIOUR OF GROUND WATERTABLE

Groundwater observations are of vital importance in irrigated agriculture from manifold considerations such as for, ascertaining the latest conditions regarding watertable depth in an area, determining the trends in groundwater levels and assessing groundwater resources for utilization.

In Punjab, irrigation department as far back as in 1892 initiated a regular periodic measurement of groundwater levels using open wells. These observations are recorded twice a year, once in the month of June i.e. before the setting in of Monsoon when water table is supposed to be at its lowest ebb so for as the seasonal fluctuations are concerned and again in the month of October when the water table is highest for a particular year after the Monsoons. The behaviour of groundwater as indicated by these observations in respect of various canal tracts or the irrigation boundaries of the state viz: Upper Bari Doab Canal (UBDC) tract, Bist Doab Tract, Sirhind Canal Circle Zone A, Sirhind Canal Circle Zone B and Eastern Division Ferozepur Circle from the period 1930 to 2001 and that in the various Districts of the state for the period 1998 to 2001 has been reported and analyzed.

3.1 Analysis of Data

For analysis of data, the whole period of 71 years has been divided into three smaller periods.

Period I 1930 - 1941

Period II 1941 - 1962

Period III 1962 - 2001

The results obtained for each period have been discussed and analyzed.

3.2 Behaviour of water table depth during the period 1930 - 1941 and 1941 - 1962

The results of water table depth in various tracts of Punjab for these periods have been reported and discussed as under:

From the above results it is clear that in case of UBDC & Bist Doab Tract, where the water table was falling at a very slow rate during the period 1930 - 1941, a substantial rise occurred during the period 1941 - 1962, this rise can be attributed to the wet period of 1947 - 1962 in which Punjab experienced high rainfalls, serious cloudburst and unprecedented heavy floods with an intensity of 100 to 300 percent (Table 1). As observed in case of Sirhind Canal Zone A and Zone B and Eastern Division Ferozepur, the groundwater level showed a continuously rising trend. However the rise was more steep in the period 1941 to 1962 (Table 1). This can again be due to the wet period of 1947 - 1962, absence of proper drainage measures and lesser use of ground water for irrigation purposes.

3.3 Water table behaviour during the period 1962-2001

In this period, successive years of extreme drought occurred. Rainfall failed in whole of the country in 1966-1968. After 1962 a cycle of generally dry years started. The drainage works that were completed in this period had also their effect in quickly dispensing of the run-off of the rainfall. All the rivers and major choes i.e. the flashy streams in Punjab had been canalized and provided with protection embankments and there was no flooding from the rivers. Withdrawal of groundwater for irrigation by means of tube wells was taken up as on large scale to meet the irrigation needs of the paddy and high yielding varieties introduced in this period. It is clear from the fact that the number of tube wells in Punjab rose from 0.05 million in 1966 to about 0.925 million in 1999-2000. Summing up, the prevention of flooding from rivers and choes, canalizing and deepening the rivers, construction of drainage channels, efficient disposal of run-off of rainfall and withdrawal of a large quantity of groundwater for irrigation and other purposes caused a continuous decline in water levels in whole of Punjab except only in the Sirhind Canal Zone B.

Table 1: Behavior of water table in various tracts of Punjab State from 1930 to 2001

Tract	**Area (000 Ha)**	**Water Table Depth (m)**				**Average Rise ® /Fall (F)/year (cm)**		
		1930	**1941**	**1962**	**2001**	**1930-41**	**1941-62**	**1962-01**
Upper Bari Doab	865.8	5.67	6.04	3.22	8.58	3.4F	13.4R	14.1F
Bist Doab	884.4	11.70	12.71	5.43	10.46	9.2F	34.7R	13.2F
Sirhind Canal Circle Zone A	1791.3	5.43	5.21	2.96	10.23	2.0R	10.7R	19.1F
Sirhind Canal Circle Zone B	963.1	27.22	26.03	18.38	5.40	10.8R	36.4R	34.2R
Eastern Division Ferozepur Circle	531.6	5.43	4.79	2.38	6.10	5.8R	11.5R	9.8F

3.4 Existing Water Resources Development

The irrigation is one of most important input for increasing agriculture production and cropping intensity. The development of irrigation potential the irrigation projects has received high

priority. The Punjab State tops in percentage of area irrigated in the country. Which are about 93.8% of the area under agricultural activities.

In the state of Punjab history of canal irrigation dates back to 1356 when Firozshah Tuglak thought of utilizing Yamuna waters. At present around 14,500 km. Long net work of about 1100 canals/branches and about 100,000 km of water courses provides assured irrigation over an area of 15.6 lac hectares. Six head works namely Nangal, Ropar, Harike, Hussaini Wala, Shah Nehar and Madhopur serve the present irrigation system. These works are on six main canal system viz. Bhakra, Sirhind, Bist-Doab, Sirhind feeder, Upper Bari Doab, Shah Nehar and Kandi, out of the total irrigation channels only about 6000 km (40%) channels are lined thus providing large scope for seepage. In year 1961. 31% of the irrigated area was the groundwater wells whereas by the end of 1994 it increased to 55% (Table-2) and Table-3 and Fig-2 shows the district wise area irrigated by surface and ground water

Table-2 Net area irrigated in Punjab by different sources.

Year	Net Area Sown	Net Area (thousand hectare) irrigated				Percentage of net area sown	Percentage of net irrigated area by tube wells
		Canals	Tube wells	Other sources	Total		
1960-61	3757	1180	829	110	2119	56	39
1965-66	3803	1294	921	440	2655	70	35
1970-71	4053	1292	1591	50	2933	72	54
1975-76	4158	1370	1742	70	3182	77	55
1980-81	4191	1430	1939	126	3495	83	55
1985-86	4197	1412	2274	42	3728	89	61
1990-91	4218	1669	2233	70	3972	94	56
1995-96	4136	1561	2283	30	3874	94	55
1999-2000	4237	977	2982	18	3977	94	70

Table 3: Area under different water table depths (Below NSL) for the period June 2001

S.No.	District	District Area (000 Ha)	Area (000 Ha)& Percentage Area with Water Table Depth Between			
			0m-3m	3m –5m	5m – 10m	Above 10m
1	Amritsar	508.8	Nil	Nil	269.4 (53%)	239.4 (47%)
2	Bathinda	340.1	Nil	Nil	242.9 (71%)	97.2 (29%)
3	Fatehgarh Sahib	117.7	Nil	Nil	94.2 (80%)	23.5 (20%)
4	Faridkot	147.2	Nil	83.7 (50%)	83.7 (50%)	Nil
5	Ferozepur	531.6	Nil	132.9 (25%)	398.7 (75%)	Nil
6	Gurdaspur	357.0	23.8 (6.7%)	119.0 (33.3%)	142.8 (40%)	71.4 (20%)
7	Hoshiarpur	331.0	Nil	132.4 (40%)	99.3 (30%)	99.3 (30%)
8	Jalandhar	264.3	Nil	26.4 (10%)	105.7 (40%)	132.2 (50%)
9	Kapurthala	163.3	Nil	32.7 (20%)	65.3 (40%)	65.3 (40%)
10	Ludhiana	376.2	Nil	75.2 (20%)	150.5 (40%)	150.5 (40%)
11	Mansa	215.0	Nil	107.5 (50%)	107.5 (50%)	Nil
12	Moga	220.9	Nil	Nil	55.2 (25%)	165.7 (75%)
13	Mukatsar	260.8	156.5 (60%)	104.3 (40%)	Nil	Nil
14	Nawan Shehar	125.8	Nil	Nil	75.5 (60%)	50.3 (40%)
15	Patiala	362.7	Nil	Nil	Nil	362.7 (100%)
16	Ropar	211.7	Nil	121.0 (57%)	60.5 (29%)	30.2 (14%)
17	Sangrur	502.1	Nil	Nil	77.2 (15%)	424.9 (85%)
	Total for State	**5036.2**	**180.3 (3.6%)**	**935.1 (18.6%)**	**2008.6 (39.8%)**	**1912.2 (38%)**

Table 5: District wise area of rise and fall of water table in Punjab during 1999-2001.

S. No.	District	District Area (000 Ha)	Area (000 Ha) and percentage area with rise ® and Fall (F) between		
			0m – 0.5m	0.5m –1.0m	Above 1.0 m
1	Amritsar	508.8	149.6 (29%) F	299.3 (59%)F	59.9 (12%)F
2	Bathinda	340.1	145.8 (42%) F 97.2 (29%) R	97.2 (29%) F	Nil
3	Fatehgarh Sahib	117.7	47.1 (40%) F	70.6 (60%) F	Nil
4	Faridkot	147.2	147.2 (100%)F	Nil	Nil
5	Ferozepur	531.6	398.7 (75%)F	88.6 (16%)F 44.3 (9%)R	Nil
6	Gurdaspur	357.0	229.5 (64%)F	51.0 (14%)F	76.5 (22%)F
7	Hoshiarpur	331.0	110.3 (34%)F 36.8 (11%)R	73.6 (22%)F	73.6 (22%)F 36.8 (11%)R
8	Jalandhar	264.3	71.4 (27%)F 7.9 (3%)R	153.3 (58%)F 5.3 (2%)R	26.4 (10%)F
9	Kapurthala	163.3	40.8 (25%)F	40.8 (25%)F	81.7 (50%)F
10	Ludhiana	376.2	273.6 (73%)F	102.6 (27%)F	Nil
11	Mansa	215.0	107.5 (50%)R	107.5 (50%)F	Nil
12	Moga	220.9	220.9 (100%)F	Nil	Nil
13	Mukatsar	260.8	208.6 (80%)F	52.2 (20%)R	Nil
14	Nawan Shehar	125.8	75.5 (60%)F 50.3 (40%)R	Nil	Nil
15	Patiala	362.7	317.4 (88%)F	45.3 (12%)F	Nil
16	Ropar	211.7	151.2 (71%)F	60.5 (29%)F	Nil
17	Sangrur	502.1	386.2 (77%)F	115.9 (23%)F	Nil
	Total for State	**5036.2**	**2973.8 (59%)F** **299.7 (6%)R**	**1306.2 (26%)F** **101.8 (2%)R**	**317.6 (6%)F** **36.8 (1%)R**