

## ECO-DEGRADATION OF PRODUCTIVE LIFE SUPPORT ENVIRONMENT AS CORRELATED TO AGRICULTURAL DEVELOPMENT IN PUADH REGION, PUNJAB

YADVINDER SINGH, Patiala

**ABSTRACT** : Ground water regimes for the period 1967-1968 to 1990-91 are monitored for Productive Life Support Environment (PDLSE) or Domesticated Agro Ecosystem (DAE) in Puadh region of Punjab when the state was undergoing Green Revolution. The area assessed is 3266.50 sq km falling in four tehsils, namely, Fatehgarh Sahib (701.50 sq km), Rajpura (1,138 sq km), Ropar (335 sq km) and Kharar(692 sq km) constituting the south eastern fringe of the Punjab.

The development of agriculture in study area is directly connected with introduction of HYVs particularly of wheat and paddy or rice. The area under these crops increased by 76.93% and 249.93% respectively and cropping showed a trend towards specialization in favour of wheat and rice rotation putting increasing demands for crop irrigation. Net irrigated area increased by 141.11% and gross irrigated area increased by 147.82% during 1967-68 to 1990-91; from just 32.11% of net sown area in 1967-68 the net irrigated area increased to 78.8% in 1990-91 while the gross irrigated area as the per cent of total cropped area increased from 39.08. in 1967-68 to 79.95% in 1990-91.

Irrigation mainly through tube wells has been the main-stay of increasing food production in PDLSE or DAE of four tehsils. The area under ground water irrigation increased from 64,452 ha in 1967-68 to 179,500 ha in 1990-91 and commensurate with it was steady increase in number of tubewells from just 3,413 in 1967-68 to 39,830 in 1990-91. The major ecological implication of increased irrigation by tubewells is that it has led to fall in depth of ground water table by varying degrees depending upon hydrological and geological regimes. Maximum decline of water level is noticed in NE of Ghanaur (Rajpura).

Over exploitative water based agriculture has resulted in water logging, salinization, soil degradation alongwith ground water depletion and ground water pollution. The changes in patterns and modes of water utilization for irrigation result in ecodegradation of PDLSE (DAE) with fast changing hydrological cycle.

### INTRODUCTION

Productive Life Support Environment (PDLSE) or the Domesticated Agro-Ecosystem (DAE) as it is usually termed is a 'man-made' physical habitat constantly under overburdening stresses and strains in order to cope with increasing food demands consequential to growth of human and animal populations.

Amongst various ecosystems, human impact is the most widespread and is the greatest on PDLSE (DAE) in Punjab especially because of Green Revolution. Since this ecosystem is always managed with the sole objective of maximising output, the impact is the most marked on crop production with dominant components being crops and animals. Water availability in the form of irrigation facilities

in the DAE plays a decisive role in achieving the objectives of higher yields especially when High Yielding Varieties (HYV's) are under cultivation.

Presently, the ground water regimes are monitored for the period 1967-68 to 1990-91 when DAE was undergoing Green Revolution in Punjab. Assessment is made for four tehsils namely, Fatehgarh Sahib 701.50 sq km (Fatehgarh Sahib District), Rajpura 1,138 sq km (Patiala District), Ropar (Roopnagar) 735 sq km and Kharar 692 sq km (both Ropar District). These constitute the south eastern fringe of Punjab with a total area of 3,266.50 sq km and this region in Punjab is termed as Puadh (Figures 1 - 2).

#### LANDSCAPE :

The agricultural land forms part of (i) piedmount plain with NE to SW slopes having an average gradient of about 10m/km towards upland plains and (ii) flat featureless upland and flood plains with gradient of only 1m/km and constituting the major part of study area of DAE. The piedmont and upland plains are well drained diffusing into flood plains. Ground water flow regime for Punjab Puadh region is

reflected in figure 3. Sandy loam and compact alluvial soils of upland and flood plains provide excellent conditions for cultivation.

#### DEVELOPMENT OF AGRICULTURE

Agricultural development in the study area is directly correlated with the introduction of HYV s particularly of wheat and paddy or rice. This is consequential to marked increase in population during 1967-68 to 1990-91 period. Data reflected in Table 1 explicitly show that while there is no marked increase in the number of towns (from 9-11) and villages (from 1,367-1,383) the population increased by strides i.e. (i) 22.32% increase during 1967-68 to 1977-78 period (population density/sq km. increased by 22.16% ), ( ii ) 31.15% increase during 1977-1978 to 1987-88 period with population density/sq km increasing by 31.27%, and (iii) 29.35% increase during 1987-88 to 1990-91 period with population density/sq km increasing by 29.41%.

The cropping pattern showed a trend towards specialization in favour of wheat and rice rotation and the area under these crops increased by 76.29% and 249.93% respectively thus putting demands for crop irrigation.

Table 1 :

DAE in Puadh Region of Punjab : Number of Inhabitations and Population  
1967-68 to 1990-91.

Peroid	Total Number of Inhabitations		Total Population	Population Density (Persons / sq km.)
	Villages	Towns		
1967-68	1,367	9	6,92,744	212
1977-78	1,380	9	8,47,370	259
1987-88	1,383	11	11,11,367	340
1990-91*	1,383	11	14,37,554	440

+ Based on respective Census Figures of the years 1961, 1971, 1981 and 1991 available from District Statistical Abstracts.

\* Provisional Figures

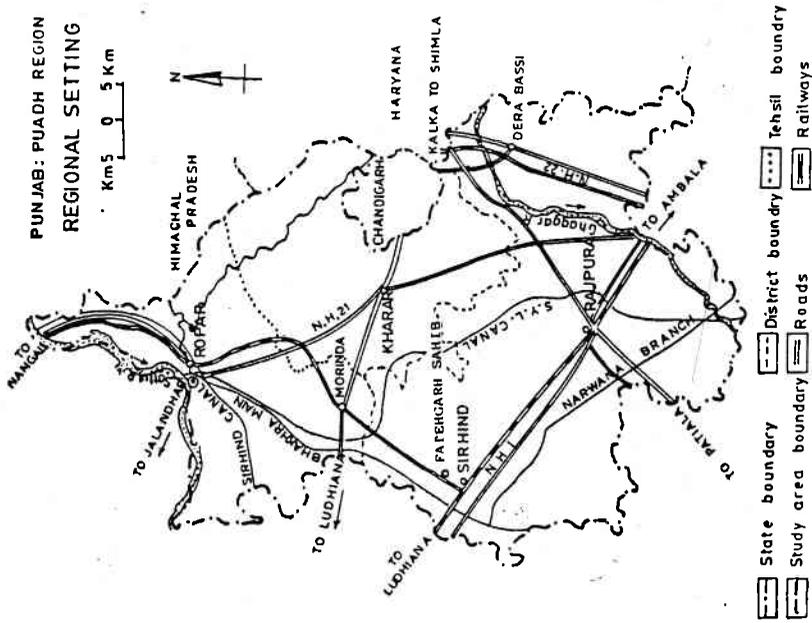


Fig. 1 : Punjab - Puadh region Regional setting

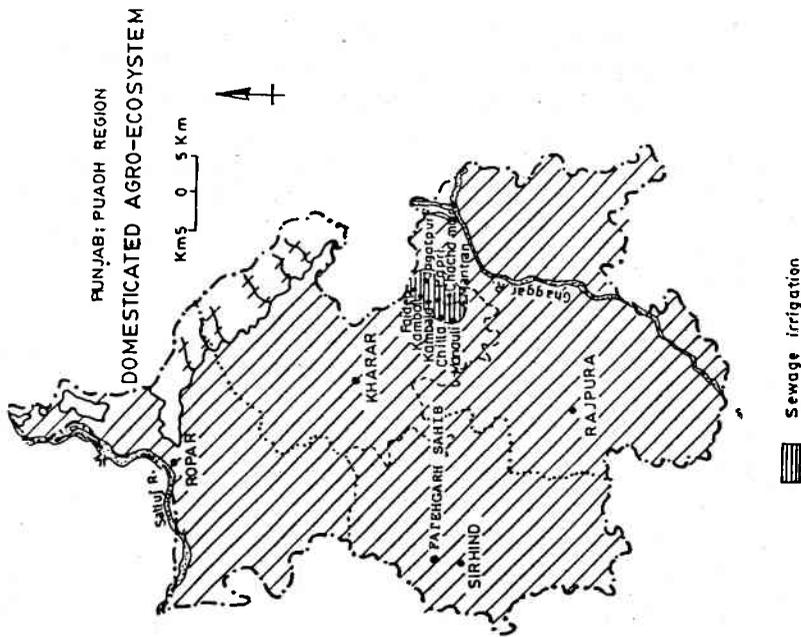
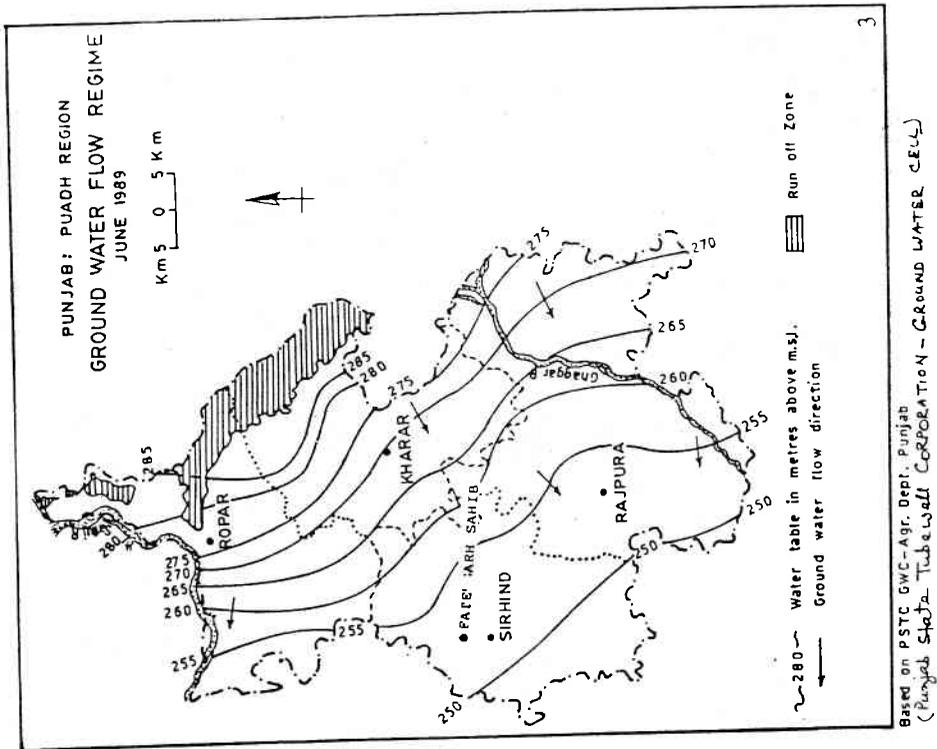


Fig. 2 : Punjab-Puadh region - Domesticated Agro-Ecosystem

**Fig. 3 : Punjab-Puadh Region - Ground Water Flow Regime**



**(a) Agricultural Land Use Classification :**

There have been marked changes in the agricultural land use in the study area during the review period. Forests constitute the most vital class of agricultural land use. Area under forests in DAE has undergone a marked change. Table 2 shows that during 1967-68 to 1972-73 it increased by 115.79%, decreased by 14.66% between 1972-73 to 1977-78 but gradually increased by 13.52, 3.47% & 7.00% during 1977-78 to 1982-83, 1982-83 to 1987-88 and 1987-88 to 1990-91 respectively. Further, data on land-use classification in Table 2 indicate the following trends.

- (i) **Land Not Available for Cultivation:** From being 40,001 ha in 1967-68, it was just the same i.e. 40,200 ha in 1990-91 (increase of 0.5%) but in the intervening periods it showed a decrease by 19.31% during 1967-68 to 1972-73, an increase by 11.2% during 1972-73 to 1977-78, a decrease by 0.66% during 1977-78 to 1982-83 and again an increase by 3.08% during 1982-83 to 1987-88. Land put to non-agricultural use showed a gradual increase amounting to 85.2% during 1967-68 to 1990-91. The increase in land used for non-agricultural purposes has mainly been due to the upcoming of satellite town of SAS Nagar as well as construction of Satluj-Yumna Link (SYL) canal.
- (ii) The barren and uncultivable land decreased from 20,617 ha in 1967-68 to 4,300 ha in 1990-91 showing a decline of 79.14%.
- (iii) Over the assessment period, fallow land kept on decreasing between 1967-68 to 1982-83 to 33.60% of the original but increased by 80% in 1987-88 and another 40.12% increase in 1990-91.

Table 2

## DAE of Puadh\* : Agricultural Land-Use classification 1967-68 to 1990-91

(Area in - 00 Hectares)

S. NO.	Indicators	Year					
		1967-68	1972-73	1977-78	1982-83	1987-88	1990-91**
1.	Forests	123.90	267.37	228.15	259.00	268.00	287.00
2.	Land Not Available for cultivation	400.01	322.73	358.89	356.50	367.50	402.00
	(i) Land put to non-Agricultural uses	193.84	242.20	263.50	294.50	322.50	359.00
	(ii) Barren and uncultivable Land	206.17	80.53	95.39	62.00	45.00	43.00
3.	Fallowland	133.89	91.38	57.50	45.00	81.00	113.50
4.	Culturable Waste	159.88	65.63	70.00	58.00	46.00	58.00
5.	Net Sown Area	2,448.82	2,519.39	2,551.96	2,548.00	2,504.00	2,406.00
6.	Area Sown More Than Once	1,014.82	1,167.52	1,424.97	1,459.00	1,678.00	1,790.00
7.	Total Cropped Area	3,463.64	3,686.91	3,976.93	4,007.00	4,182.00	4,196.00

\* Total area according to Village Records: 3,266.5 sq.km. (3,26,650 ha).

\*\* Figures for 1990-91 are Provisional.

Source : Dist . Statistical Abstracts.

- (iv) Culturable waste almost gradually decreased between 1967-68 and 1990-91 when it was just 36.27% of the original. Through the use of fertilizers and water, barren lands, culturable waste as well as fallow lands have been brought under cultivation.
- (v) Net sown area did not change much over the years, slightly increasing between 1967-68 and 1987-88 but slightly decreased by 1.74% in 1990-91.
- (iv) Area sown more than once had a rapid increase by 76.38% in 1990-91 over the figures in 1967-68.
- (vii) Total cropped Area also showed a gradual increase over the years from 3,46,364 ha in 1967-68 to 4,19,600 ha in 1990-91, an increase of 21.14%.
- (b) Irrigation : The data presented in Tables 3-4 clearly indicate that:
- (i) Canal irrigated area has been almost continuously on the decline largely due to exploitation of ground water for irrigation. It was 13,534 ha in 1967-68, increased by 16.74% in 1972-73 but dropped by 47.53% in 1990-91. Rajpura, Fatehgarh Sahib and Ropar tehsils get water from Sirhind Canal and Bhakra Main Line. There is no canal irrigated area in Kharar Tehsil.
- (ii) Irrigation mainly through tube-wells and ordinary wells has been the main-stay of increasing food production in DAE four tehsils. The area under ground water irrigation has shown a steady increase from 64,452 ha in 1967-68 to 1,79,500 ha

Table 3

## DAE of Puadh Region: Irrigation 1976-68 to 1990-91

(Area in 100 hectares)

S. NO.	Indicators	Year					
		1967-68	1972-73	1977-78	1982-83	1987-88	1990-91*
1.	Area Irrigated By:						
	a. Canals	135.34	158.00	125.00	114.00	93.00	71.00
	b. Tube-Wells and	644.52	1123.00	1365.00	1439.00	1660.00	1795.00
	c. Other Sources	6.48	5.00	27.00	23.00	25.00	30.00
2.	Net Irrigated Area	786.34	1286.00	1517.00	1576.00	1778.00	1896.00
3.	Net Irrigated Area as Per cent of Net Sown Area	32.11	51.04	59.44	61.85	71.00	78.80
4.	Gross Irrigated Area	1353.79	2,117.07	2,314.90	2,815.00	3,214.00	3,355.00
5.	Gross Irrigated Area as Per cent of Total Cropped Area	39.08	57.42	58.20	70.25	76.85	79.95
6.	Total Waterlogged Area	449.00	128.00	110.00	492.00	242.00	242.00
7.	Total Saline Area	510.00	441.00	211.00	38.00	23.00	34.00

\* Figures for 1990-91 are Provisional.

Source: District Statistical Abstract.

Table 4

## DAE of Puadh Region: Major Agricultural Inputs, 1967-68 to 1990-91

S. NO.	Indicators	Year					
		1967-68	1972-73	1977-78	1982-83	1987-88	1990-91*
1.	Total Fertilizer Consumption (Tons)	49,731	86,988	86,729	93,427	1,03,554	1,09,986
	a. Consumption Per ha of Net Sown Area (kg)	203.08	345.27	339.85	366.66	413.55	457.13
	b. Consumption Per ha of Total Cropped Area (kg)	143.58	235.93	218.08	233.16	247.61	262.12
2.	Total Number of Tube-well and Pumping Sets	3,413	20,882	22,564	36,548	35,774	39,830
3.	Total Number of Tractors	589	2,418	3,938	4,133	4,942	5,703
4.	Total Agricultural Machinery (Implements)	81,848	66,052	63,830	62,848	63,012	63,176

\* Figures are Provisional.

Source: District Statistical Abstracts.

in 1990-91. Commensurate with it was steady increase in total number of tube wells and pumping sets from just 3,413 in 1967-68 to 39,830 in 1990-91.

- (iii) Irrigation from other sources cover 648 ha in 1967-68, dropped to 500 ha in 1972-73 but suddenly increased to 2,700 ha in 1977-78 and 3,000 ha in 1990-91 but was little less in 1982-83 (2,300ha) and 1987-88 (2,500 ha). These include sewage waters supplied either from Chandigarh Sewage Treatment Plant (for over roughly 500 ha) or lifted by pumping sets from streams carrying sewage and industrial waste waters (Figures 2). Due to heavy application of sewage waters for rice cultivation in some villages (Faida, Jagatpur, Kambala, Papri, Chilla, Mantran of Kharar tehsil) that are situated adjoining Chandigarh and SAS, Nagar, the water table is almost up to the ground level. The end result of such irrigation is low yield (lands being densely infested with weeds since their seeds are carried by sewage and industrial waste waters), poor quality grains and harmful effects on agricultural labour (cf. Srivastava & Panday 1986).

- (iv) Net irrigated area increased by 141.11% and gross irrigated area increased by 147.82% during 1967-68 to 1990-91. From just 32.11% of net sown area in 1967-68, the net irrigated area increased to 78.8% in 1990-91 while the gross irrigated area as the per cent of total cropped area increased from 39.08 in 1967-68 to 79.95% in 1990-91. In fact, irrigation has been a prerequisite to enhanced agricultural production.

(c) **Agricultural Inputs** : For enhancing agricultural production apart from use of HYVs and utilization of irrigation facilities the other inputs are in the form of farm machinery and

fertilizers. In four tehsils of study area in Puadh region in Punjab total fertilizers consumption was 49,731 tons in 1967-68 and it increased by about 74% during 1972-73 and 1977-78 but the increase was fantastic during 1982-83 (87.86%), 1987-88 (108.22%) and 1990-91 (121.16%) with 1967-68 as base year. Per hectare consumption of fertilizers during 1967-68 and 1990-91 also increased markedly as calculated in terms of Net Sown Area or total cropped area as is evident from the data given in Table 4.

As far as, farm machinery is concerned (cf. Table 4), the total number of tractors markedly increased from just 589 in 1967-68 to 5,703 in 1990-91, indicating 9.68 times increase. But the number of agricultural implements suffered a gradual decline in use over the years i. e. 22.81% decrease when figures for 1967-68 and 1990-91 are compared (Table 4).

(d) **Agricultural Production** : Information about the area under cultivation and total production of Principal crops as food grains (Wheat, rice) and Pulses, Oil seeds, cash crops, etc. For a period of 1967-68 to 1990-91 at almost 5 year intervals is given in Table 5. For food grains the area and production gradually increased between 1967-68 to 1990-91 period, final increase being 77% and 283.34% respectively. As far as cultivation of wheat and rice is concerned, during 1967-68 to 1990-91, the area under these crops in four tehsils increased by 76.29% and 249.93% respectively. Specifically, production increased by 219.25% for wheat and by 964.92% for rice, thereby indicating that area increase and production increase ratio is 1:2.87 in case of wheat and 1:3.80 in case of rice. Cultivation of pulses, oil seeds and cash crops suffered a serious set back both for area under cultivation and production over the assessment period (for details see Table 5). As a matter of fact the

Table 5

**DAE of Puadh Region : Area and Production of Principal Crops, 1967-68 to 1990-91**  
(Area in 100 Hectares ; Production in 100 Tons)

S. NO.	Indicators	Year					
		1967-68	1972-73	1977-78	1982-83	1987-88	1990-91*
1.	Food Grains						
	a) Area	1,899.57	2,348.37	2,543.05	2,973.00	3,192.00	3,363.00
	b) Production	2,857.46	4,118.68	6,158.80	8,227.41	10,119.00	10,954.00
2.	Wheat						
	a) Area	1,048.25	1,407.97	1,405.56	1,633.00	1,732.00	1,848.00
	b) Production	1,868.10	2,734.80	3,586.25	4,786.90	5,560.00	5,964.00
3.	Rice						
	a) Areas	348.35	437.58	663.83	927.00	1,183.00	1,219.00
	b) Production	422.80	790.09	2,031.21	2,929.48	3,965.00	4,494.00
4.	Pulses, Oil Seeds & Cash Crops						
	a) Area	1,063.51	842.34	872.37	485.00	416.60	368.23
	b) Production	2,330.81	1,792.99	2,292.81	1,797.19	1,195.84	1,766.31

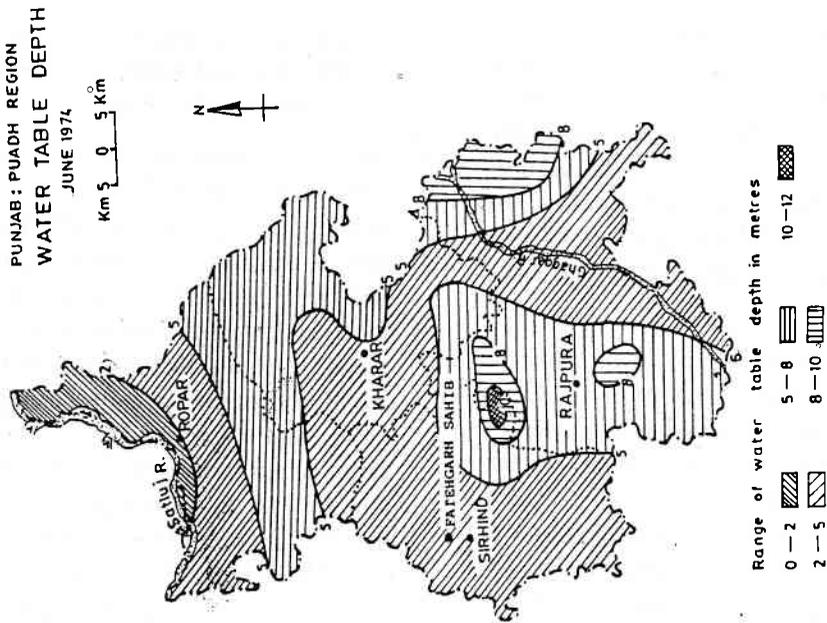
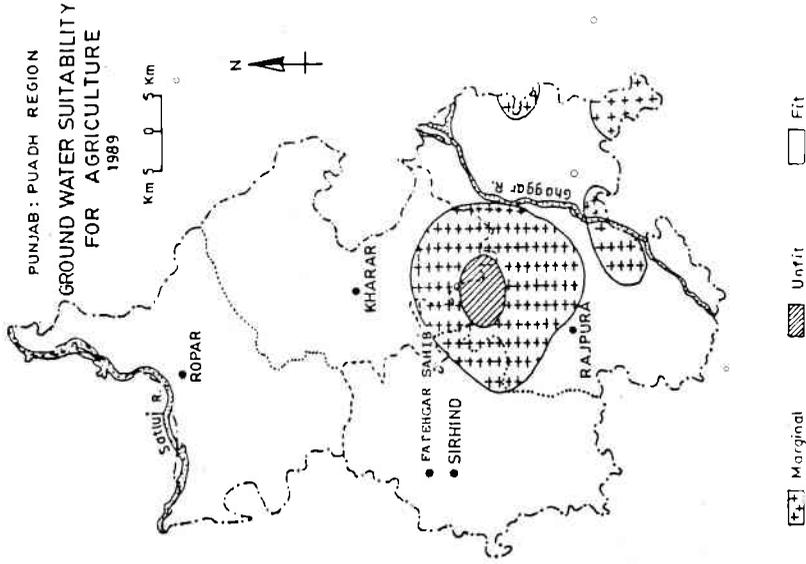
\*Source: District Statistical Abstracts.

production of wheat and rice increased much because of diversion of more area for these crops as well as due to improved agronomic technology. The cultivation of kharif crops other than rice suffered a great set-back because of diversion of area for rice.

#### ECOLOGICAL IMPLICATIONS

- (i) **Decrease in Disease Resistance:** Traditional varieties of wheat and rice co-existed with local ecosystems and were less prone to diseases but HYVs are more prone to local diseases since their genetic base is narrow. They do not have desired long term disease immunity. HYVs become easily susceptible to new races and biotypes of diseases and they need to be improved continuously.
- (ii) **Waterlogging and Salinization :** The extension of irrigation through Sirhind

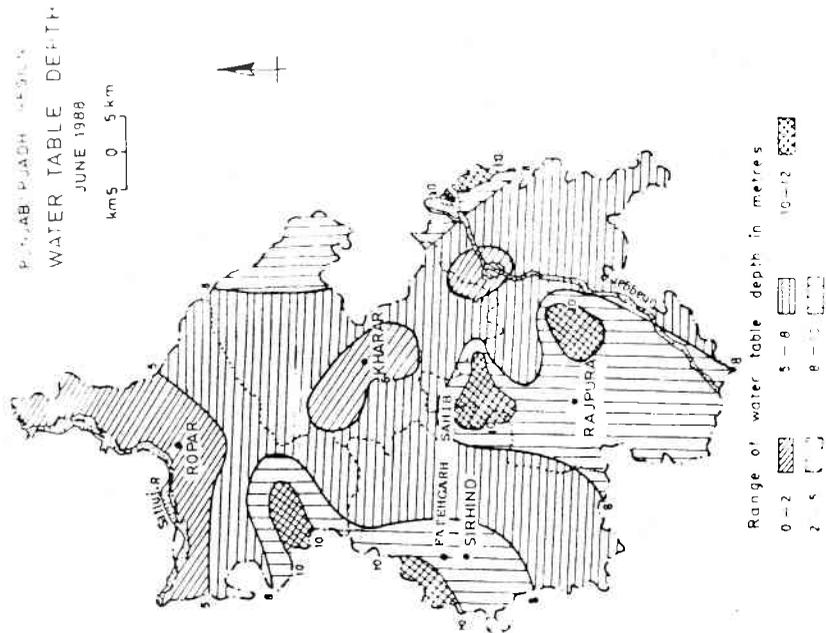
Canal and Bhakra Main Line Canal brought perceptible changes in ground water regimes of Puadh DAE. There is an overall rise in water table in canal irrigated areas (Uppal & Mangat 1982) and consequently this has led to water logging and salinization. In 1967-68 the water logged and saline areas constituted 27.68% of total areas under survey (water logged 12.96% and saline 14.72%). With pumping out of ground water through tube well irrigation and reduction in canal irrigated area as referred to earlier, these areas have been greatly reduced (see Table 3). The proportion of saline land and waterlogged areas came down greatly when 1967-68 and 1990-91 figures are compared. There have been some fluctuations in waterlogged area over the years and these are attributable to the construction of Satluj



**Fig. 4 :** Punjab-Puadh Region - Ground Water Suitability for Agriculture

**Fig. 5 :** Punjab-Puadh Region - Water Table Depth - June 1974

Fig. 6 : Punjab-Puadh Region - Water Table Depth - June 1988



Yumna Link (SYL) canal obstructing the natural flow of seasonal water streams carrying rain water leading to frequent inundation of low lying areas and flooding of agricultural tracts. The resultant ecological distortions like waterlogging and salinity conditions have certainly led to definite replenishment of ground water resources.

Sizeable areas of waste water farming in Kharar tehsil of Puadh DAE are becoming waterlogged because of (i) annual flow of partially treated sewage in the irrigation channel has provided ample irrigation to agricultural land and (ii) perennial flow of untreated or partially treated waste waters in seasonal Attawa and Kanthala choes accentuated the situation leading to raising of water table. Likewise some waterlogged pockets of

agricultural land also exist in the vicinity of Patiali Rao and Sukhna choe which also carry urban waste waters.

- (iii) **Soil Degradation:** In spite of the fact that urban waste water is often rich in nutrients and may have a favourable affect on plant growth, often the soils where irrigation is done with urban waste water emit foul smell resulting in environmental pollution. In case of clay soils, fats, oils and grease (component of sewage and industrial waste water) clog soil voids and this obstructs the irrigation process resulting in the emission of foul smell and also effects soil fertility (Grewal 1993). Studies made by CBFP & CWP (1985-86) on waste water irrigated area of Chandigarh region indicated that (i) the accumulation of heavy metals (lead, chromium, cadmium, nickel zinc, coper) in sewage irrigated soils was

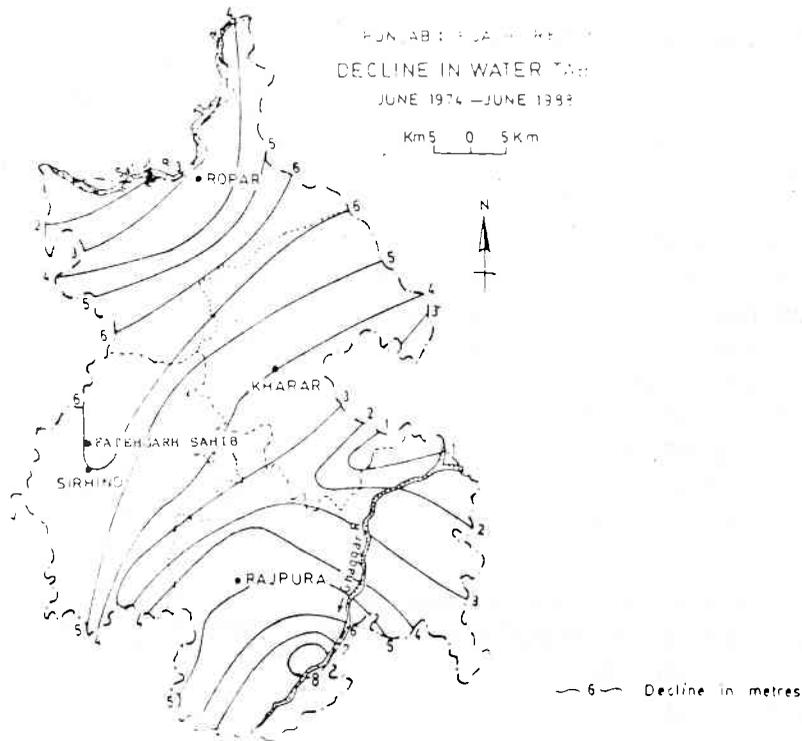


Fig. 7 : Punjab-Puadh Region - Decline in Water Table

high as compared to soils under tube well irrigation, ( ii ) untreated industrial waste water irrigated areas show phytotoxicity, ( iii ) plant uptake of heavy metals was abnormally high in 45 day old paddy plants as compared to tube well irrigation and ( iv ) total nitrogen content in soils of raw sewage irrigated area was of medium level and for better plant growth these soils required to be supplemented with nitrogen.

( iv ) **Ground Water Pollution:** In the Kharar tehsil areas of urban waste water irrigation near Chandigarh, the ground water is the only source of drinking water. The contamination of ground water in sewage water farming area of Puadh region lying in the vicinity of Chandigarh is upheld by the fact that ( i ) bacteriological contam-

ination (total faecal coliform count) of ground water even in deeper zone has been observed mainly in raw sewage irrigated area of village Faida and partially treated sewage irrigated zone of village Manauli and ( ii ) ground water was contaminated with heavy metals in Faida, Papri, Manauli and Mantran where raw or almost raw water is used for irrigation (CBFP & CWP 1985-86).

Contamination of ground water would also be caused due to drainage of sewage and industrial waste waters of Chandigarh into Kanthala and Attawa choes which flow in parts of Puadh DAE.

### GROUND WATER DEPLETION

The major ecological implication of increase in irrigation particularly by tube wells or pumping

sets for furthering Green Revolution is that by and large, it has led to the fall in depth of ground water table in the study area by varying degrees depending upon the hydrological and geological set up of the areas. The tremendous increase in paddy/rice area during eighties (Table 5) has increased draft from the tube wells during Kharif season (summer/monsoon months). This has resulted in over-burdening of ground water regime. The ground water of large parts of Rajpura tehsil and some part of neighbouring Sirhind and kharar are marginally fit or unfit for irrigation. By and large, ground water of DAE is suitable for crop irrigation (Figure 4).

Map of progressive changes in ground water table of the study area during 1974-88 period distinctly exhibits depletion of water table in most parts except near or around Satluj river (Figures 5,6). Noticeable fall of 6m (0.44/yr) in water table during this period is observed around Morinda, Bassi Pathana, Kurali, Rajpura, Sailba Majri. Maximum decline of water level of more than 8 m is noticed in NE of Ghanaur (Rajpura). While in Chamaur Sahib-Sirhind area the decline is of more than 6 m (see Figure 6). Because of lining of canals and distributories in Punjab during 1974-80 with World Bank Aid water seepage was greatly reduced and this resulted in lesser replenishment of ground water. Figure 7 clearly depicts that due to ground water irrigation there is decline in water table in Punjab Puadh region during 1974-88, the most prominent being in parts of Ropar, Fatehgarh Sahib and Rajpura (5-6 m) tehsils where canal water facilities do not exist.

Decline in water table in *bet* area of Satluj river is low due to recharge during floods in the river. Recharging is also noticeable in Sirhind canal zone since the canal is unlined. Drought in 1987 followed by heavy floods

in 1988 have offset several predictions about water level behaviour that ought to have been during normal rain fall years. It is to be noted that rainfall is a key factor in controlling the water level behaviour. Ground water is recharged by (a) seepage from surface irrigation, 34.23%; (b) rains, 41%; and (c) canals, 24.77% (Singh 1992).

## CONCLUDING REMARKS

Agricultural Development in Puadh region of Punjab under Green Revolution is moving towards creating more culturable wasteland through soil and land degradation (waterlogging, salinization) as well as water pollution. The continuous cultivation of HYVs of wheat and rice has reduced the supply of fodder and organic manure that used to be a boon to agriculture in the recent past (about 3-4 decades ago).

Over exploitative water based agriculture has resulted in ground water depletion. In nutshell, it may be stated that the changes in patterns and modes of water utilization for irrigation has resulted in eco-degradation of PDLSE(DAE) with fast changing hydrological cycle.

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## ADDRESS OF THE AUTHOR

**Dr. Yadviner Singh**  
Lecturer in Geography,  
Punjabi University,  
Patiala-147002. India.