DEVELOPMENT OF IRRIGATION AND DEGRADATION OF SOIL RESOURCES

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Abstract

Punjab model of irrigation is characterized by excess demand for water for irrigation coupled with unconstructive mining of groundwater for meeting the food bowl requirement of the country. While irrigation is an ancient practice thought to have originated in Mesopotamia 6000 years ago, the amount of agricultural land under million hectares in 1900. By 1998 more than 271 million hectares were irrigated, with much of the increased occurring after 1960. Much of the agricultural productivity, although consisting about 17 per cent of all crop land produces approximately 40 per cent of the world food. In post independence period there are many major developments in irrigation have been recognised. The area under irrigation acreage has been increased in Punjab. Moreover, sources and techniques of irrigation also improve in terms of efficiency and reliability. Due to the excessive use of groundwater its negative impacts seen on the soil resources. These are depletion of micro and macro nutrients of soil, water logging, problem of salinity etc.

Keywords: Irrigation, efficiency, micro and macro nutrients of soil, water logging and salinity.

Introduction

Irrigation denotes the supply of water by manmade means to regulate the growth of plants. The use of irrigation in arid and semi-arid regions of the world can be traced back to the "dawn of Neolithic agricultural revolution". However its extensive use for agricultural development all over the world stated in 19th century. Only with sufficient progress in engineering techniques, making it possible to dam sizeable rivers and to erect other structures, perennial canal irrigation to cover large alluvial basins become feasible. Similarly, advances in water pumping technology made it possible to exploit the water for irrigation on a large scale. These developments have made large scale agricultural developments feasible in certain water short basins such as Gangetic Basin and Indus Basin (Kumar, 2007).

Thus surface flows and drainage from irrigated agricultural lands carry salts, fertilizers, pesticides and other pollutants into surface water, causing harm to fish and wildlife and impairing water for human uses (Lutz Ernst, 1998). Therefore greater the percentage of irrigation water applied to high yielding varieties of seeds, compared with indigenous seeds, the less amount of water and lower risk of adverse environmental effects. It is necessary to clearly define the hierarchy of the technical efficiency of different irrigation systems. It is also important to take into account the share of irrigated area to the total agricultural area, the larger the potential of irrigation, greater the environmental impacts. The major environmental problems due to extent of irrigation are water logging, salinity, water pollution, ground water depletion, soil degradation, air pollution, noise pollution etc.

Study Area

Punjab is situated in north-western part of India. It comprises of 1.53 per cent of total geographical area of the country. Its latitudinal extent is from 29^{0}33' N to 32^0 32' N and longitudinal extent is from 73^{0}54' E to 76^{0}50' E. Punjab is land locked state but holds a great strategic significance as it is bounded by Pakistan in the West. The river Ravi forms a part of its western boundary with Pakistan. It is further bounded by Jammu and Kashmir in the north, Himachal Pradesh in the east, Haryana and Rajasthan in the south-east and south. High diversity is found in its physical environment, i.e. north and north-east parts having hills and rough topography while southern parts are

having frequent occurrences of sand dunes. Whereas flood plains run along the river Ravi, Beas, Satluj and Ghaggar subjected to floods every year.

Purpose and Methodology

Present study is intended to evaluate the major impacts of irrigation on environment on 2016-17. For the present study the adopted methodology is consonance with selected objectives. It includes processing, analysis and synthesizing of relevant data from secondary sources. District has been taken as unit of study. Four time periods have been taken i.e. beginning of year of green revolution (1965-66), post green revolution (1985-86), 2005-06 and the recent 2016-17 for showing the spatial pattern of extent of irrigation and environmental degradation. Statistical techniques are used for deriving the results.

Development of Irrigation

With the advent of new agricultural technology, especially its bio chemical component of irrigation as a key element in agricultural development has further increased. Irrigation is an important component of the new technology package and promotes the use of other inputs in the package like fertilizers, insecticides, pesticides, weedicides and H.Y.V of seeds.

Table 1

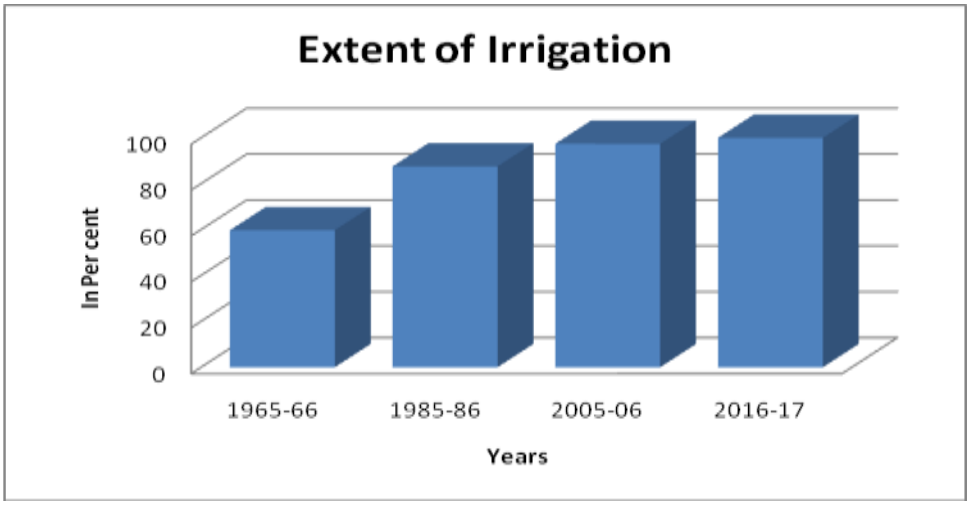
Development of Irrigation in Punjab during 1965-66 to 2016-17

Year	Net Irrigated Area (Ha.)	Gross Irrigated Area (Ha.)	Extent of Irrigation (Per cent)
1965-66	2567.1	3516.6	59.72
1985-86	3749.3	6628.6	87.55
2005-06	4060.0	7679.7	97.4
2016-17	4126.0	7795.0	100.0

Source: Economic and Statistical Organization of Punjab, Chandigarh.

As a result drastic changes have been recorded in irrigation. Punjab has significant strides in the extent of irrigation since 1965-66 which is clearly indicated that area under net irrigation from all sources was 2567.1 hectares in 1965-66. It has increased to 4126 hectares in 2016-17 and registered positive volume of change of 1558.9 hectares, which looks quite impressive. But in respect of gross irrigated area it has increased 3516.6 hectares in 1965-66 to 7795 hectares in 2016-17 and this way positive increase of 4278 hectares is recorded during study period. But overall extent of irrigation has increased from 59.72 per cent in 1965-66 to 100 per cent

Figure: 1



Source: Economic and Statistical Organization of Punjab, Chandigarh.

in 2016-17. Thus there is no net sown area remain unirrigated. The major causes of high extent of irrigation in Punjab rapid increase of tubewell irrigation, introduction of pivot of green revolution technology such as use of chemical fertilizers, H.Y. V. of seeds, insecticides, pesticides, weedicides, etc. thus the extent of irrigation has made feasible the transformation of Punjab agriculture. Environmental impacts of irrigation are also noted on study area. These are water logging, salinity, water pollution, ground water depletion, soil degradation, air pollution, noise pollution, etc.

Degradation of Soil Resources

(i) Soil degradation

Land degradation results from mismanagement, which primarily leads to degradation of other natural resources. The term land degradation is generally used to signify loss or reduction of land productivity as a result of natural and human activity. It encompasses degradation of soil and vegetation cover may be affected by anthropogenic pressure including deforestation, overgrazing, unsuitable agricultural practices and industrial practices. Thus the degradation process is related to the interaction of two systems i.e. the natural ecosystem and the human social system which determines the success or failure of resource management programmes (Chanda and Swaminathan, 2006). Soil degradation in Punjab is discussed under following heads;

Macro and Micro Nutrients

Soil resources of the study region are also affected due to extension of irrigation facilities. The texture, structure, macro and micro nutrients of the soil have been affected. Table 2 shows the depletion of both macro-micro nutrients in Punjab. It further reveals that in whole of Punjab, no deficiency of nitrogen is noted which shows that Punjab soils have sufficient amount of nitrogen. But

Table 2

Status of Major Nutrients in Different Districts of Punjab, 2016-17

(in per cent)

	Nitrogen			Phosphorus			Potassium		
Districts	L	M	H	L	M	H	L	M	H
Gurdaspur	100	0	0	3	10	87	50	50	0
Amritsar	100	0	0	3	20	77	5	51	44
Ludhiana	100	0	0	2	10	88	15	64	21
Hoshiarpur	100	0	0	5	17	78	50	44	6
Patiala	100	0	0	23	29	48	3	36	61
Moga	100	0	0	48	28	23	-	48	52
Muktsar	100	0	0	24	44	32	0	16	84
Mansa	100	0	0	45	17	38	3	52	45

L= Low, M= Medium, H= High range of avaibility

Source; Department of Soil and Water Conservation, Punjab, Chandigarh.

in case of Phosphorous deficiency, which is high in the districts of Gurdaspur, Amritsar, Hoshiarpur and Ludhiana. Whereas in other parts of the state Phosphorous deficiency is recorded low. Though, Potassium deficiency is found throughout the study region, yet high deficiency of potassium is recorded in Muktsar, Patiala, Moga and Firozpur districts whereas low deficiency is found in rest of the state.

Micro nutrients like Zinc, Copper, Iron and Magnesee deficiency have also recorded in the study region. High deficiency in Zinc is noted in the districts of Gurdaspur, Amritsar, Muktsar and Moga with 42 per cent, 36 per cent, 39 per cent and 37 per cent respectively. Whereas, lowest zinc deficiency of 7.0 per cent is noted in Ludhiana district. While the districts of Jalandhar, Patiala, Sangrur, Kapurthala and Hoshiarpur are also deficient in Zinc. But Iron deficiency is noted highest in Muktsar district with 34 per cent followed by Hoshiarpur district with 23 per cent. While between 10 to 15 per cent Iron deficiency is found in the districts of Jalandhar, Sangrur and Moga. Whereas in all other districts, it is recorded less than 10 per cent. Similarly in case of Magnesee deficiency, Sangrur district has the highest magnesee deficiency of 32 per cent followed by Jalandhar and Moga districts with 23 per cent and 26 per cent respectively. In all other parts of the study region low deficiency i.e. less than 20 per cent is recorded. On the other hand Copper deficiency is found very low in all parts of the study region.

Table 3

Status of Micro Nutrients in Different Districts of Punjab, 2016-17

(in per cent)

	Zinc		**Copper**		**Iron**		**Magnesee**	
Districts	D	S	D	S	D	S	D	S
Gurdaspur	42	58	1	99	1	99	5	95
Amritsar	36	64	1	99	4	96	2	98
Kapurthala	13	87	0	100	5	95	2	98
Hoahiarpur	18	82	2	98	23	77	5	95
Ludhiana	7	93	2	98	7	93	11	89
Jalandhar	11	89	1	99	13	87	23	77
Patiala	11	89	1	99	5	95	4	96
Muktsar	39	61	7	93	34	66	8	92
Sangrur	13	87	2	98	16	84	32	68
Moga	37	63	0	100	13	87	26	74

D= Deficient, S= Sufficient

Source; Department of Soil and Water Conservation, Punjab, Chandigarh.

(ii) Sub-soil Water – Irrigation has also affected the aquifers of sub soil water. Increased crop intensity and wheat rice crop rotation have highly pressurized on sub soil water, because wheat and rice crop require frequent watering. The increased demand of water has met by sinking of large number of tubewells. Thus the exploitation of the sub-soil water was so heavy that recharge could not keep pace with the rate at which it was pumped out and as a result, the water table has declined upto 100 feet in central parts of Punjab. Whereas development of irrigation in Punjab made possible the use of chemical fertilizers, insecticides, pesticides, etc. on large scale and has polluted sub-soil water. The excessive canal irrigation in the south-western parts of the state where sub-soil water is saline and alkaline has come up to the surface and caused water logging conditions which again affect the soils.

(iii) Water Logging- Water logging is the condition when the soil is saturated with water and has inadequate aeration for crop growth. Clayton defined a land to be water logged when water table within ± 150 cm of the natural surface. A committee constituted by the central water and power commission (India) defined an area as water logged, when either water stagnates on the land surface, or the water table rises to an extent that soil pores in the crop root zone become saturated, resulting in the restrictions in normal circulation of air, decline in the level of oxygen and increase in the level of carbon dioxide . When water logging reaches the root zone of the plants, yields diminish significantly because the roots need a soil-air-water environment to grow and cannot survive in free water. There are four principal causes of water leakage from canals, wastage from distribution networks, over-irrigation and lack of suitable drainage facilities. All these lead to water logging. Following the water logging process, saline conditions generally develop on the surface. (Chanda and Swaminathan 2006). Table 4 reveals that there are 9222.95 hectares area under water logging. Gurdaspur district has the largest area of 3543.28 hectares under water logging followed by Kapurthala, Muktsar, Firozpur and Mansa districts with 1476.73 hectares, 1349.87 hectares, 1107.16 hectares and 1085.65 hectares respectively. Due to water logging in these districts most of land become redundant. Districts like Faridkot, Hoshiarpur, Sangrur, Patiala, Jalandhar, Tarn Taran and Amritsar are least affected because in all these districts tubewell irrigation is predominant. Low water logging is recorded in case of Nawanshehar, Rupnagar, S.A.S Nagar, Fatehgarh Sahib, Ludhiana, Moga and Bathinda districts. Thus, irrigation is the main reason for water logging which is consider as first environment irrigational problem in the state.

Table 4

Districts	Water Logging (in Hect.)	Salt Affected Land
Gurdaspur	3543.28	261.40
Amritsar	3.07	309.38
Tarn Taran	38.27	277.86
Kapurthala	1476.73	450.51
Jalandhar	8.64	42.97
Nawanshehar	-	-
Hoshiarpur	259.29	-
Rupnagar	-	-
S.A.S. Nagar	-	999.73
Ludhiana	-	14.87
Firozpur	1107.16	1323.46
Faridkot	301.56	137.74
Muktsar	1349.87	1829.66
Moga	-	118.18
Bathinda	-	-
Mansa	1085.65	802.95
Sangrur	18.7	464.84
Patiala	30.67	37.48
Fatehgarh Sahib	-	-
Punjab	9222.95	7071.03

Source; Department of Soil and Water Conservation, Punjab.

(iv)Salt Affected Areas: All irrigation water contains salts and the salt concentrations in soils tend to increase as water evaporates from the surface or is transpired by plants. In order to maintain a favourable root-zone salt balance, more water (called the 'leaching requirement') must be applied to the soil than is used by the evapo-transpiration process. The excess water drains to the groundwater table, and in the absence of drainage it contributes to the development of water-logging conditions. Salts accumulate in the upper soil profile as evaporation and transpiration remove water, and highway saline or alkaline conditions develop as more and more water moves upward from the water table by capillary action. This salinization of the upper soil profile increases continuously and when it reaches intolerable levels, the land goes out of production. A total 7071.3 hectares are salt affected areas in Punjab, except the districts of Hoshiarpur, Nawanshehar, Rupnagar, Fatehgarh Sahib and Bathinda. All other districts are having salt affected lands which is the result of excessive irrigation particularly canal irrigation. The most salt affected areas owing to excessive canal irrigation in Muktsar followed by Firozpur, S.A.S Nagar and Mansa with 1323.46 hect., 999.73 hect. and 802.95 hect. respectively. The salt affected land varies between 100 to 500 hect. in case of

Gurdaspur, Amritsar, Tarn Taran, Kapurthala, Sangrur and Faridkot districts. While the least salt affected areas are the districts of Jalandhar, Patiala, Nawanshehar, Rupnagar, Fatehgarh Sahib and Bathinda. It is noted that Muktsar, Mansa and Firozpur districts are highly affected by canal irrigation which resulted into the existence of salt affected lands.

Conclusion and Suggestions From the preceding discussion it is observed that the extension of irrigation facilities in the study region has affected the soil resources. Sub soil Water table has declined at an alarming rate of about 70 cm/year by pumping out more water for irrigation purposes and secondly it is contaminated by high doses of agro-chemicals. Whereas soils have depleted in macro and micro nutrients by intensive agriculture and contaminated by overdoses of agro-chemicals. Therefore for further development of agriculture, it becomes imperative to make some suggestions such as;

1. The excessive use of pumping sets should be discouraged for the future growth of agriculture by using efficient techniques like sprinkle irrigation, drip irrigation and development of underground water components.
2. Farmers should be educated and encouraged to grow water resistant crops i.e. maize, basmati rice, oilseeds, pulses, etc.
3. Sprinkle and drip irrigation should be encouraged along Shiwaliks and in south-western parts of Punjab.

4. Considerable areas about 30 per cent should be diverted to other crops like maize, fodder, oilseeds, pulses, etc. from wheat- rice crop rotation.

5. Minimum price should be fixed for crops like maize, vegetables, oilseeds, pulses, fruits, etc. which will certainly encourage the farmers to bring more area under these crops.

If all these suggestions are taken into account in the study region than Punjab agriculture can be made environmentally and economically viable that will help for making Punjab Agriculture Sustainable.

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