

Pattern of soil and water Resources Degradation in Haryana: A Study on Agricultural Sustainability

Vijeta Nehra

Research Scholar, Department of Geography
(Shri Jagdishprasad Jhabarmal Tibrewala University,
Jhunjhunu, Rajasthan)

Abstract

The Green Revolution in India has achieved self-sufficiency in food production. However, in the state of Haryana this has resulted in continuous environmental degradation, particularly of soil, vegetation and water resources. Soil organic matter levels are declining and the use of chemical inputs is intensifying. Newly introduced crop varieties have been responsive to inputs but this has necessitated both increased fertiliser application and use of irrigation resulting in water contamination by nitrate and phosphate and changes in the ground water table. With 82% of the geographic area already under cultivation, the scope for increased productivity lies in further intensification which is crucially dependent on more energy-intensive inputs.

Declining nutrient-use efficiency, physical and chemical degradation of soil, and inefficient water use have been limiting crop productivity, whilst the use of monocultures, mechanisation and an excessive reliance on chemical plant protection have reduced crop, plant and animal diversity in recent years. About 60% of the geographical area faces soil degradation (waterlogging, salinity and alkalinity) which threatens the region's food security in the future. Since 1985, the water table has risen more than 1m annually, and patches of salinity have started to appear at the farm level. The situation is worse in higher rainfall areas where waterlogging follows shortly after the rains. Apart from affecting agricultural crops, a high water table causes floods even following slight rains due to the reduced storage capacity of the soil. Such ecological impacts are motivating farmers to reduce fertiliser and pesticides use. This has led to an increased investment in alternative technology and products including an interest in Integrated Pest Management. The paper discusses major physical, hydrological, chemical and biological constraints relating to soil and water resources for ecosystem sustainability

Keywords: Environmental consequences; Agricultural development; Green Revolution

I. INTRODUCTION

Prior to the mid-1960s, increased crop production in India was largely achieved by expansion of cultivated area. To gain self-sufficiency in food grain production, a new agricultural strategy popularly known as the 'Green Revolution' was implemented in the mid-1960s. This strategy involved the use of modern technology, including HYV (high yielding variety) seeds, chemical fertilisers, irrigation facilities, improved farm implements and crop protection measures. It succeeded, and food self-sufficiency was attained.

Food grain production increased from 72 ×106 Mg

in 1965–1966 to 167 × 106 Mg in 1991–1992, 198 × 106 Mg in 1994–1995 and 203 ×106 Mg in 1998–1999. This production increased due to both

Extensification and intensification. The area under cultivation for food grain crops increased from 115:1×106 ha in 1965–1966 to 127:84_106 ha in 1990–1991, and the area under HYV seeds expanded from 1:89 ×106 ha in 1966–1967 to 70:7×106 ha in 1993–1994. The consumption of chemical fertilisers increased from 0:292×106 Mg in 1960–1961 to 12:15 × 106 Mg in 1992–1993, However the major concern for the scientists and policymakers is to sustain the productivity in order to achieve food security to the fast growing population.

In Punjab and Haryana the contribution to total national food grain production increased from 3% before the Green

Revolution to 20% at present, contributing 50 and 85% of government procurement of rice and wheat, respectively. The yield per hectare increased from 0.63Mgha⁻¹ in 1965–1966 to 1.37Mgha⁻¹ in 1991–1992. The total area under irrigation area has almost doubled since 1960–1961.

The increases achieved by the Green Revolution have created several environmental problems, viz. deforestation, waterlogging, salinity, alkalinity, soil erosion and decline and rise of the ground water table linked to brackish water, etc. These environmental problems became evident in the 1980s, and are becoming increasingly prominent through time (Singh, 1997; Kumar and Pasricha, 1999). The study region, Haryana state, where the Green Revolution was implemented during the 1960s, covers a geographical area of 4:374_106 ha of which 82% is cropped. Haryana falls under the Punjab plains which have been developed by the river systems of Ravi, Beas, Sutlej and Yamuna over geological time-scales with the sediments of Shivaliks and Himalayas in the north and Aravalli's brought by the tributaries of the Yamuna. The state has great variation in the range of rainfall from 300 to 1100 mm. The agro-ecosystem is an energy-intensive marketable surplus system which receives little micronutrient input.

The main objective of the paper is to illustrate critical environmental situations and challenges of sustainability in the most intensively cultivated states of India, such as Haryana, in order to report the progress achieved during the Green Revolution and the environmental problems encountered.

II. Land use change: an emerging scenario

After the Green Revolution there has been some extensification in Haryana state. The net sown area was recorded as approximately 78% in 1966–1967 and in excess of 81% in 1990–1991. Intensification has increased with a significant expansion in the area with more than one crop sown per year, during 30 years between 1950–1951 to 1980–1981, this increased from 11 to 42% and again to 53.6% in 1990–1991, this is mainly due to the improvements in irrigation and agricultural technology. As land use intensity has increased, the area of land under irrigation has also increased, from approximately 61% in 1984–1985 to 73% in 1990–1991. The total area under irrigation has increased from 1:29 _ 106 ha in 1965–1966 to 2:66× 106 ha in 1994–1995.

III. Impact of the Green Revolution on cropping systems

There has been a remarkable shift in India in the cropping patterns for both wet season and winter crops since the Green Revolution (Table 1). Rice (*Oryza sativa*) and wheat (*Triticum*) have replaced pulses, bajra (Pearl millet), jowar/sorghum (*Syricum*), as dominant food crops, while cotton (*Gossypium*spp.) is the key cash crop. The main wet season crops in 1965–1966 comprised bajra (46%), rice (13%) and sorghum (12%); however in 1995–1996 rice (34%) was the major crop followed by bajra (27%) and cotton (24%). For winter crops wheat has increased in production as major crop from 43% in 1965–1966 to 64% in 1995–1996. In Haryana, the yields of rice and wheat have increased considerably (Table 2). Gurgaon district recorded highest compound growth rate of 5.22% for wheat crops during 1986–1995.

Table 1 Changing cropping pattern (Indian Council of Agricultural Research, 1998.)

Crops	1965-1966(%)	1995-1996(%)
Rainy Season (Kharif)		
Bajra	46	27
Rice	13	34
Sorghum or Jowar	12	5
Cotton	11	24
Sugarcane	8	6
Malze	6	1
Winter Season (Rabif)		
Wheat	43	64
Chickpea	42	14
Barley	7	2
Oilseeds	6	19
Pulses	2	1

Cropping patterns have changed as a result of the new agricultural technologies including irrigation facilities, improved seed varieties, pesticides, insecticides and new methods of farming. Recently, however, the two dominant crops, rice and wheat, have been facing severe constraints and challenges for sustainable productivity (Sharma and Mukhopadhyay, 1999)

IV. Environmental consequences of agricultural development

Increasing pressure of the population on the land dictates the need for potential utilisation of all available land. However, large parts of the land are degraded by desertification, soil salinity, waterlogging, floods, and droughts, due to inefficient agricultural practices, and deforestation has caused excessive soil erosion (Gill, 1992; Randhawa, 1992). The increasing demand for food, fodder, fibre and fuel can only be met through bringing more of these degraded areas into cultivation and forestry. Sensing the gravity of the problem, the Government of India has set up a National Wastelands Development Board (NWDB) with the objective of bringing all the wastelands under productive use in the country through a massive programme of afforestation.

Based on national classification of the different types and categories of wastelands, two major types have been considered in this study: cultivable wasteland, and non-cultivable wasteland. Haryana has about 7.54% of land under these categories in total.

The largest area comprises sandy stretches in Sirsa, Table 3 Constraints and challenges before crop production in Haryana

Crop	Constrain
Rice	<p>Inadequate irrigation due to decline in water table and poor discharge of tube wells. Canal water supply is also not sufficient. In some parts the quality of ground water is not good</p> <p>Increasing problems of salinity and alkalinity</p> <p>Declining soil fertility due to depletion of major and micronutrients (N, P and Zn) due to continuous rice–wheat cropping system</p> <p>Deterioration of physico-chemical soil conditions because of heavy tillage and puddling.</p> <p>Imbalanced use of fertilisers</p> <p>Delayed and prolonged transplanting of rice</p>

	<p>Excessive cultivation of basmati rice, susceptible to diseases and insect pests but produced to get a good price</p> <p>Heavy losses due to diseases and insect pests such as bacterial leaf blight blast, stem-rot, false smut, leaf folder and stem-borer</p>
Wheat	<p>Late planting of wheat (10–15% up to 25 December, 40% after 25 December)</p> <p>Weeds are a serious problem. Phalaris is minor from 2000 to 6000 plants per m²</p> <p>Reduced soil fertility, both major and micro-nutrients and soil organic matter</p> <p>Increase in soil salinity/alkalinity particularly in western districts</p> <p>Increasing problem of disease in popular varieties such as HD2329 and HD2285. Besides rusts, now heavy incidence of leaf blight is also seen</p>

Hissar and Bhiwani which encompasses 3.76% of cultivable wasteland. Salt affected areas, mainly alkaline in nature, and waterlogged and marshy areas, comprise approximately 1.6 and 0.6% of cultivable wasteland respectively. The main concentration of both the categories is found in Ambala, Karnal, Jind, Sonapat and Hissar. Wastelands related to undulating landforms are mainly found in Faridabad, Gurgaon, Mahendragarh, Bhiwani and Hissar comprise about 0.3% of land. Barren land has spread over Faridabad, Gurgaon and Mahendragarh covers about 1.4% of land.

4.1. Improved land use and nutrient management

There is a marked change in soil fertility caused by changes in agricultural practices during the Green Revolution (Table 4). To exemplify, 3% of soil in 1980 had a low P content and by 1995 a low P content was found in 73% of soil, whilst the area of soil with a low N content only increased from 89 to 91%. Soils with a high K content have decreased from 91% in 1980 to 61% in 1995. The wheat–rice rotation is disturbing the balance of available nutrients in the soil and also causing a deficiency of micronutrients, particularly zinc and copper (Gill, 1992). To improve production specific soil–water–fertiliser–crop management practices need to be evolved based upon comprehensive soil resource

information. Research of various aspects of pollution of soil, water and environment, fertilisers, salinity, insecticides, pesticides and industrial effluents should be intensified. Some critical environmental issues including soil erosion, generation of dust, and soil compaction due to heavy machinery have also emerged.

Table 4 Changes in N, P and K status in Haryana soilsa

Available Material	Nutrient Status	Distribution of N,P and K	
		1980 (%)	1995 (%)
Nitrogen	Low	89.3 %	91.5
	Medium	9.6	7.9
Phosphorus	Low	3.3	73.0
	Medium	95.3	25.4
	High	1.4	1.6
Pottasium	Low	-	5.3
	Medium	8.1	33.2
	High	91.1	61.5

The cultivation of wheat and rice in rotation has been accepted by the farmers as the best combination for getting maximum benefit from cultivation.

Thus, the success of diversification and implications of the ecological imbalance of the wheat–rice rotation should be understood. To ease the wheat–rice stress on natural resources, some farmers have diversified to other crops like soybean (*Glycine max*) and sunflower (*Helianthus spp.*). A greater area could be diverted to sugarcane (*Saccharum officinarum*), cotton, oilseeds, and soybean. Even fishery and dairy enterprises have proved very promising for economic returns. To increase diversification more emphasis needs to be given to multipurpose plant species including grass and legumes (Singh, 1999).

Land with 30% or more slope in northern hilly part of the state should be exclusively reserved for forest. Other types of waste materials obtainable from poultry, duckery, fishery and bee-keeping should be incorporated.

Medicinal plants, oil plants and horticultural species should also be added. In recent years, organic chemicals and biotechniques such as tissue culture technology are also being used to develop plants with resistance/tolerance and reduce the use of pesticides.

4.2. Ground water use and declining water table

Approximately 95–98% of the area under rice wheat is irrigated. Irrigation from ground water accounts for 60–65% of the total irrigation requirement and the remaining 35–40% is met through canals.

This intensive exploitation has caused the ground water problems. While in many areas the ground water table is rising (as discussed earlier). Many districts in the rice–wheat growing area of Haryana show a water table decline in the range 3–10 m. These districts are Kurukshetra (10 m), Ambala (3 m), Yamunanagar (3 m), Kaithal (3 m), Karnal (5 m), Panipat (5 m). An integrated use of ground water and surface water resources should be the basis for future planned irrigation on which sustainable crop production depends.

4.3. Impact on ground water quality

The use of agro-chemicals in Haryana is the highest in India. Fertiliser consumption has increased from 3 to 130 kg ha⁻¹ in the last 30 years. Fertiliser use for rice and wheat is 160 and 170 kg ha⁻¹, respectively. There is an imbalance in the N, P and K consumption ratio in rice–wheat crops. The use of K is also low in this region. There is a definite trend in accumulation of nitrates to toxic levels in the ground water.

V. Need for land and water conservation

The monitoring of land and water detects significant changes in the soil characteristics that directly or indirectly affect the quality of the land and its ability to produce the basic needs of food, fibre and timber.

An integrated assessment of the status and risk of soil degradation will produce one of the essential data sets for national understanding (Singh, 1997). The objectives for producing a soil degradation map are to identify the dangers resulting from inappropriate land and soil management; to improve the capability in regional and national institutions; and to deliver accurate information for agricultural planning purposes.

Other states and centre funded work includes reclamation of salt and alkaline affected lands, field channel and water channels (warabandi) construction work (Alexander, 1985).

Soil reclamation and land leveling are prominent in the annual plan for Haryana. The Planning Commission has allocated funds for the development of culturable as well as

non-culturable wasteland and various chemical inputs have been allocated for the land. Land

Reclamation and Development Boards are engaged in this task and also provide subsidies for agricultural inputs in Haryana.

The districts of Hissar, Rohtak and Gurgaon have been largely reclaimed through different developmental programmes initiated by the Government of Haryana. The committee on Natural Resources, Planning Commission, New Delhi's study on wastelands, including saline, alkaline and waterlogged land and their reclamation measures has estimated that about 6000, 4000 and 2000 ha of land affected by salinity and alkalinity were reclaimed in the Hissar, Rohtak and Gurgaon districts, respectively. As general characteristics the alkali soils of Haryana have a high pH value of average 9.3, with a higher proportion of sodium bicarbonate in the upper 1m depth and negligible infiltration rates. On an average depth of 1.5m the soils have a calcic horizon, thus signifying the presence of pedogenic calcium carbonate. The task of desalinisation in such soil is quite formidable. The low percolation also leads to rapid waterlogging.

Various agencies are taking stock of the salinization and various remedial measures are being planned to regenerate the wastelands. Studies are being carried out by the Ministries of Environment and Forest, Agriculture, the Planning Commission, National Commission on Agriculture, Ministry of Agriculture, Universities and various other agencies on wasteland development. There is an urgent need to create awareness among people for prudent use of land resources by implementing action-oriented projects and to reclaim Waste lands. Policies can be formed to shift land use from traditional to modern technical use. An attempt should be made not only to increase production but also to sustain the increased production for wheat and rice without further degradation of our natural resources. The reclamation measures required to be taken up for restoration of physical health of soils and its productivity are outlined below.

5.1. *Re-enrichment of inherent fertility and agroforestry*

The re-enrichment of inherent fertility approach is based upon the regeneration of internal resources to sustain land productivity. This is to be achieved by growing different crops together, mixing or rotating with legumes, planting trees and shrubs, whose roots draw nutrients from

deep layers to help translocation of the nutrients and water to the root zone thus increasing operative soil depths. Agroforestry may be evolved along with compatible livestock management both of land and water and integrated land and water development plan for various biomass production, regeneration of land resource base and increase in employment and income. Agroforestry develops on natural principles through crop-tree combination and integrated fertility management (Gordon and Bentley, 1990; Singh, 1999).

5.2. *Management of water resources*

The extensive micro measures for conservation and augmentation of scarce moisture play the most critical role as well as being the best motivation to achieve participation from local people. The systems include in situ moisture conservation and a network of small water harvesting structures that promote recurrent recharge of the soil profile as well as ground water. Many governmental and non-governmental initiatives are being taken in this direction (Gill, 1992).

These include narrowing down the gap between supply and demand for water resources; recharging of ground water reservoirs in areas with declining water table; recharging of excess water through the existing drainage channels by putting bunds at appropriate places; recharging by diverting run-off from adjoining wasteland area; recharging through empty/injection wells; recharging by diverting excess canal water during the rainy season to paddy fields; watershed development and massive reforestation of hilly areas; installation of skimming wells to tap good quality water; installation of deep tube wells along with rivers to enhance the irrigation supply; revision of water allowance, capacity factors and rotational system of irrigation keeping in view the shifting of cropping system; efficient on-farm water management including adoption of optimum irrigation schedule of crops; encouraging low water consumption crops in place of paddy, particularly, in light textured soils (crops such as soybean, cotton, maize, barley and oats). All these measures have great potentials with regard to conjunctive use of poor quality ground water and canal water.

The soil conservation planning of the area should be on macro-watershed basis rather than micro-watershed basis. Thus, physical planning of watersheds, the socio-economic

details would come from target group village/community (Singh, 1998).

VI. Conclusions

In the Haryana state much progress was made in agricultural productivity, but at the cost of land and water degradation. Intensive agriculture during the Green Revolution has brought significant land and water problems relating to soil degradation over exploitation of ground water and soil pollution due to the uses of high doses of fertilisers and pesticides. Land and water conservation is an important concern not only to the farmers and the rural communities in Haryana but also to the country as a whole. Conservation of these resources is essential for sustainable agricultural development. The future food grain requirement

of India in 2010 will show an increase amounting to 269×10^6 Mg over 211×10^6 Mg in 2000.

An attempt should be made not only to increase the production but also to sustain the increased production without further degradation of the natural resources.

Possible reclamation measures are required to be taken up for restoration of physical health of soils and its productivity. By analysing the shift in cropped area and cropping pattern, it is quite evident that monocultures are the dominant systems as the shift has taken place from jowar, bajra, to rice during Kharif (summer cropping) season and wheat has replaced crops such as barley and gram during Rabi (winter cropping) season due to an expansion of irrigation facilities in these states. People prefer high yielding and more remunerative crops like wheat and rice, although barley and gram are still grown in rainfed areas. Although some diversification, and the productivity and profitability of crop husbandry continues to be an integral part of the existing cropping pattern, wheat and rice with highest growth yields per hectare, and high economic returns, will continue to be dominant. In the light of this, incentives for checking environmental degradation (soil, water and biodiversity, etc.) caused by the growth of these crops should be encouraged through incentive packages.

Diversification of agriculture to increase the percentage area under agroforestry, oilseeds and pulses is being encouraged. Sunflower is becoming a prominent crop among the oilseeds; its water requirement is quite high.

Although the sugarcane area has been substantially

increased, it has not reduced pressure on ground water. The region has been achieving regeneration of wastelands by improving irrigation facilities with a degree of success mainly on plain areas. Technologies for managing soil problems and suitability of poor quality ground water for different crops and cropping system need to be refined. To optimise results from the reclamation of degraded areas, there is a need to create awareness of soil degradation and the importance of soil development. The integrated and sustainable monitoring and management of agriculture and forestry requires a focus on the issues such as collection and effective utilisation of land and water inventory data for land use planning, nutrient management, increased biomass productivity and need for diversification, re-enrichment of inherent fertility and agroforestry, moisture conservation and water harvesting, the recharging of ground water reservoirs in areas of water table decline, and agro-industrial watershed based planning. In this way, understanding of environmental consequences of agricultural development helps to illustrate the nature and complexity of forces driving the change and now these imply the concerns for food security of the region.

References

- [1] Alexander, T.M., 1985. Soils of India and Their Management. The Fertiliser Association of India, New Delhi.
- [2] Gill, J.S., 1992. Land use, conservation, management and development of land resources of Punjab. In: Report of Department of Soil Conservation and Engineering, Chandigarh, Punjab.
- [3] Gordon, J.C., Bentley, W.R., 1990. A Handbook on the Management of Agroforestry Research. Winrock Institute, New Delhi. Government of Punjab, 1992. Report of Department of Soil Conservation and Engineering, Chandigarh, Punjab., Indian Council of Agricultural Research, 1998.
- [4] Decline in Crop Productivity in Haryana and Punjab: Myth or Reality, New Delhi.
- [5] Kumar, R., Pasricha, N.S., 1999. Land use and land cover changes in the Indus plains of Punjab in the post Green Revolution period 1965–1995. In: Proceedings of the International Seminar on Historical Perspectives of Land-use/Land-cover Change in South Asia for the

- Study of Global Change, April 11–13, 1999. NPL, New Delhi.
- [6] Randhawa, N.S., 1992. Concerns about sustainability of Punjab agriculture on land use, conservation and development of land resources in Punjab. In: Report of Department of Soil Conservation and Engineering, Punjab, Chandigarh.
- [7] Sharma, B.D., Mukhopadhyay, S.S., 1999. Land cover and land use: Punjab perspectives. In: Proceedings of the International Seminar on Historical Perspectives of Land-use Land-cover Change in South Asia for the Study of Global Change, April 11–13, 1999. NPL, New Delhi.
- [8] Singh, R.B., 1997. Impact of agriculture and land use/cover change on soil and water resources and ecosystem sustainability: a case study of Punjab. In: Epps, R. (Ed.), Sustainability of Rural System in the Context of Global Change. University of New England, Armidale.
- [9] Singh, R.B., 1998. Understanding high mountain land use towards sustainable environmental management in Jammu and Kashmir. In: Haigh, M.J., et al. (Eds.), Headwaters: Water Resources and Soil Conservation. Oxford and IBH Publishing Co., New Delhi.
- [10] Singh, R.B., 1999. Land use change, diversification of agriculture and agro-forestry in northwest India. In: Haque, T (Ed.), Land Use Planning in India. National Centre for Agricultural Economics and Policy Research, New Delhi .

