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Economic benefits and ecological cost of Green Revolution: A case study of Haryana, India

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Abstract: The Green Revolution in Haryana has achieved much progress in agricultural productivity but at the cost of land and water degradation. Intensive agriculture during the Green Revolution period has brought continuous environmental degradation, particularly of soil, vegetation and water resources due to the use of high doses of fertilisers and pesticides. The adaptation of various modern agricultural techniques has further strengthened the role of agricultural sector in the economic development and employment generation of Haryana. The cropping intensity in Haryana is one of the highest among the Indian States; and the production and productivity of major crops increased several times due to the advent of Green Revolution. But the adaptation of new cultivation strategy has restricted the state to have only two crops, i.e., wheat and paddy. Further it has resulted in diseased soil, pest infested crops, overexploited groundwater and water logging deserts.

Keywords: Economic benefits; Ecological cost; Green Revolution.

Introduction

The term 'economic development' was rarely used before 1940s. Before its formation in 1966, the Haryana territory was agriculturally a less developed part of the former Punjab. Its net area irrigated was 35.54 per cent against 58.48 per cent in Punjab. Its compound annual growth rate of agriculture in the ratio 1:2 with Punjab. One may recall the formation of the state coincide with the here that the formation of the state coincide with the beginning of the Green Revolution in parts of India including the Haryana territory. The advent of the Borlaug seed fertiliser based technology heralded a new era in agricultural transformation in mid-sixties. Green revolution was a technology innovation. This event provided a stimulus to the extension of irrigation which was its single most important prerequisite. But this advancement in agriculture caused scarcity of fresh water, deforestation and soil erosion on the Shiwalik hills and the Aravalli outliers; water logging in canal irrigated and low-lying areas in the east-central region and along the streams; a critical fall in water table in the tubewell irrigated area in the north-east (Singh, 1998:176-182).

In the age of Green Revolution, Haryana achieved fastly growth of the productivity by the use of HYV, fertilisers, pesticides etc. But this picture of development is not beautiful as it seen. The pressure of land and water resources is increasing by the use of fertilisers and pesticides and also caused land degradation and extent of saline areas and waterlogging areas. Water depletion is also occurred due to the excessive use of water for irrigation (Haryana Encyclopaedia, 2008).

The history of mankind has witnessed some significant agricultural revolutions. A notable agricultural change on political lines took place in the post-1917 revolution of Soviet Union. Agricultural land was nationalized and organized into collective or State farms. The same socialistic spirit guided the formation of communes in China. Around the middle of the present century, the world saw another major agricultural revolution associated with the cultivation of high-yielding varieties of wheat and paddy famously named as Green Revolution (Brar, 1999). The credit to develop this new technology went to Norman Borlaug who innovated the new varieties of dwarf wheat for which he was awarded the Nobel Peace Prize.

The new seeds were introduced in the third world countries during the period 1965-70. The per capita production in the developing countries was increased quite sharply due to the introduction of new seeds. The Green Revolution in Asia doubled the cereals production between 1970 and 1995 (World Development Report, 2008). India, which had just avoided a severe famine in 1967, produced enough grains within five years to support its population. Even after 1979 drought, grains imports were not necessary. India became self-sufficient in wheat and rice, tripling its production between 1961 and 1980. Such has been the success story of the Green Revolution propagated by its proponents in the mass media. Despite its obvious success, however, the Green Revolution came under severe criticism during the 1970s for ecological and socio-economic reasons. The main criticism directed against the success of Green Revolution was the high yield which could not be obtained under certain optimum conditions: optimal irrigation, intensive use of

fertilizers, monoculture (for the rational use of machinery and agricultural equipments), and pest control with chemical pesticides (Glaeser, 1987).

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 are 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 introduction of this new technology has completely replaced the old mode of production in Haryana's agriculture. Traditional agriculture was progressively given way to modern and commercial agriculture and sooner Haryana became the role model for the other States in the country. No doubt, the new technology has provided numerous economic gains to the State and the country in the form of increase in production and productivity, and irrigation coverage up to 95 per cent of the total cropped area in Haryana. But Haryana has been suffering a lot from the ecological point of view. Due to the new agricultural technology the demand for water, chemical fertilizers, insecticides and pesticides increased very sharply in the State, which gave birth to the problem of water depletion and water logging, soil degradation and health problems. So, it becomes all the more important to study the economic gains and ecological cost of the Green Revolution.

Objectives of the study

- **i.** To identify the pattern of regional variations in intensity of the Green Revolution in Haryana.
- **ii.** To examine the growth of agricultural activities and the consequent environmental problems in Haryana.
- **iii.** To examine the degree of spatial correspondence between the economic benefits and the degree of degradation of soil, water and unsustainable cropping pattern.
- **iv.** To provide overall linkages between the Green Revolution and environment with empirical findings from Haryana

Database and Methodology

This paper was based on the secondary data, collected from the different issues of the statistical abstract of Haryana, published by the Economic and Statistical advisor, planning department, Government of Haryana, Haryana Agricultural University Hisar, Department of Water Resources and Department of Agriculture, Haryana. The methodology of this chapter addresses itself to the objectives of the study enunciated in the introductory part of this paper. Since the purpose is to examine the economic benefits and ecological cost of the Green Revolution and to identify the elements of economy and ecology which would bear the impact of Green Revolution, to examine the present scenario in regional variations in the spread and intensity of the cropping of the Green Revolution. Intensity of cropping of the Green Revolution has been calculated by the formula:

$$\text{Intensity of Cropping} = \frac{\text{Total Cropped Area} * 100}{\text{Net Sown Area}}$$

So, the main objective of the paper is to illustrate economic benefits and ecological cost of green revolution 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. For this purpose, the paper is divided into two sections. The first section examines the major economic benefits of the Green Revolution in Haryana. The ecological cost has been analyzed in the second section.

Section-I

1. Economic benefits of the Green Revolution

Economically, the agriculture in the state of Haryana has made spectacular progress after its independence in 1966. After being a new state, the Haryana experienced a new advancement in the field of agriculture. The state's economy recorded an annual growth rate of 5.60 during 1966-1985 against 5.18 for Punjab and 4.05 for the country as a whole (Singh,1998:36). The State of Haryana was known as the 'Bread Basket' of India due to its agricultural performance in since 1970s. The food surpluses from Haryana have been the backbone of the national food system. Although, Haryana encompasses only 1.34 per cent of the total geographical area of the country, it produces 3.4 million tonnes rice and

11.8 million tonnes wheat in India. In the total food grains production Haryana stands third, followed by Utter Pradesh and Punjab. The major economic gains of Green Revolution have been examined by focusing on the following points.

1.1 GSDP and Employment

The production structure of Haryana is heavily dominated by primary sector activities. Due to the advent of modern methods of cultivation, the agriculture sector of Haryana becomes the leader in economic development. In the case of Haryana, agriculture is the mainstay of economy. It absorbed 60.79 percent of the working force in 1981, as cultivators and agricultural laborers. No less than about 86 percent of its total area is under plough. The all India figure is 46.31 per cent. About 60 per cent of the net area sown is irrigated in comparison to about 30 per cent in India. Agriculture contributed about 44.48 per cent of the state's domestic product in 1985-86 as compared with 27.30 per cent in India at current prices (Singh, 1998:36-37).

Haryana's agriculture sector constituted 46 per cent in GSDP in 1980-81 which slowly came down to 28.47 per cent in 2001-02 and 19.03 per cent in 2013-14. On the other hand agriculture consisted of 95.23 per cent of the primary activities income in 1980-81 and at present it consists of 93.19 per cent of total output of the primary activity. But if we compare the share of agriculture sector with the share of industrial or dynamic sector it is still an important part for the state's economy. It is pertinent to note that despite rapid mechanization of agricultural activities in Haryana since the early sixties the agriculture sector is still playing an important part in employment generation. In 1971, out of the total workforce 62.67 per cent was working in the agriculture sector and after one decades period it decreased to 60.79 per cent in 1981. The share of agriculture sector in employment is still high. After the period of four decades of the advent of Green Revolution and capital intensive techniques of production in rural economy of Haryana a substantial proportion of workforce still depend on the agriculture sector for their livelihood. So, it is the agriculture sector which has not only the growth driver of the GSDP of the State but also a major source of income for a large proportion of the total population.

1.2 Shifts in Land Utilization

The quantity and quality of land resources in a particular region played an important role in the agricultural development. Haryana is essentially a plain area: 94 per cent below 300 metres. The plain spreads between the hilly tract in the northeast and the sand dune sprinkled desert topography in the south and southwest. The outliers of the Aravallis make their appearance in the southern part of the state. As such, Haryana assumes the shape of a saucer with its depression in the tract around Rohtak. Haryana has traditionally been the part of the old Punjab and is essentially in the nature of divide between the Ganga and the Indus river systems. It is transitional to the Rajasthan desert and the Ganga plain. In the last century, the State's geographical boundaries have been shifted twice – the violent partition of India in 1947 and the administrative division of Punjab in 1966 into present day Haryana and Himachal Pradesh. Now, Haryana encompasses total geographical area of 4421 thousand hectares, which constitutes about 1.34 per cent of total geographical area of the country. The land utilization pattern of the State showed that out of the total geographical area about 80 per cent is the net sown area (Table 1).

Table 1, Land Utilization Pattern in Haryana
(Area in thousand hectares)

Items	1966-67	1970-71	1980-81	1990-91	2000-01	2011-12
Geographical area	4421	4421	4421	4421	4421	4421
Area under forest	91	99	132	169	115	39
Uncultivated and barren land	232	181	65	97	102	106
Land put to non agricultural use	257	309	369	320	368	500
Uncultivated land excluding Fallow land	137	98	60	48	59	64
Fallow land	259	150	177	169	232	149
Net sown area	3423	3565	3602	3575	3526	3513
Cropped area	4599	4957	5462	5919	6115	6489
Cropping intensity in(percentage)	134	139	151	165	173	185

Source: Statistical abstract of Haryana, Director of land records, Haryana

Due to the introduction of new technology and commercialization of production relations the uncultivated and barren land is continuously declining since 1966-67 to 1990-91but increase a little in 1990s to onwards. It was 232 thousand hectares in 1966- 67 and declined to almost 130 thousand hectares in 2011-12. Similarly, the new mode of production in Haryana's agriculture also brought more and more area of fallow land under cultivation. The fallow land declined from 259 thousand hectares in 1966-67 to 177 thousand hectares in 1980-81; and it further declined to 149 thousand hectares in 2011-12.

The table also shows that due to new techniques of production the net sown area has also increased from 3423 thousand hectares in 1966-67 to 3602 thousand hectares in 1980-81; and it marginally declined to 3513 thousand hectares in 2011-12. The decline in net sown area has been due to the rapid growth of urban area in different parts of the State. Also, due to western vision of life-style the Haryanvi's are continuously moving towards better inhabitants. The cropped area has also progressed from 4599 thousand hectare to 6489 thousand hectares between 1966-66 and 2011-12. The cropping intensity has also progressed from 134 in 1966-67 to 185 in 2011-12. It is apparent that the introduction of modern methods of cultivation not only helped to increase the area under cultivation but it also played a positive role in the transformation of traditional methods of cultivation.

1.3. Production and Productivity Trends

The agriculture in Haryana made rapid strides since independence. Some of the factors which contributed towards early progress include the peasant proprietor dominated agrarian structure, early completion of consolidation of holdings, extension of irrigation facilities, strengthening the co-operative credit structure, building a transport, marketing and storage, infrastructure, agriculture research and hard working peasants. After the reorganization of the State in 1966, which incidentally also coincided with the advent of new agricultural technology accelerated the growth process in the State. At the initial stage, Green Revolution in Haryana was confined to wheat only because traditionally Haryana has never a rice growing area. But after a few years, new varieties of rice also became popular with the farmers.

After the introduction of new methods of cultivation the production and productivity increased very sharply in Haryana which gave boost to the overall growth of the economy. The productivity of all the crops in Haryana has increased after the introduction of new methods of cultivation, but the productivity of rice and wheat increased at a much faster rate in comparison to other crops. Table 2 shows that the yield of wheat increased from 1425 kg/hectare in 1966-67 to 5183 kg/hectare in 2011-12. Similarly, the yield of rice has also increased from 1161 kg/hectare to 3044 kg/hectare during the same period. It is significant to note that within as span of four decades the average productivity of wheat and rice has increased almost three to four times.

Table 2: Yield of Principal Crops in Haryana

(Kg/hectare)

Crops	1966-67	1970-71	1980-81	1990-91	2000-01	2011-12
Wheat	1425	2074	2360	3479	4106	5183
Rice	1161	1697	2606	2775	2557	3044
Jowar	181	277	354	497	208	500
Bajra	418	939	544	864	1079	2040
Maize	988	1142	1134	1414	2267	2727
Barley	1313	1150	1451	2092	2682	3617
Gram	500	742	629	722	640	924
Rapeseed and Mustard	404	678	634	1338	1369	1364
Cotton A	300	359	387	421	1081	2577
Cotton D	289	299	264	278	319	416
Sugarcane	3400	4504	4067	5273	5713	7319

Source: Statistical Abstract of Haryana, Various issues

The total increase in production is highlighted in Table 3. All crops except maize, grams, rapeseed & mustard and groundnut have shown an increase in production. The production of wheat and rice has been much higher in comparison to other crops.

Table 3: Increase in Total production of Principal crops

(Thousand Tonnes)

Crops	1966-67	1970-71	1980-81	1990-91	2000-01	2011-12
Wheat	1059	2342	3490	6436	9669	13119
Rice	223	460	1259	1834	2695	3757
Jowar	49	57	48	65	23	33
Bajra	373	826	474	526	656	1175
Maize	86	130	81	49	34	30
Barley	239	124	181	107	118	149
Gram	531	789	455	469	80	73
Rapeseed and Mustard	80	89	178	634	560	747
Cotton A	134	188	480	1042	1081	2577
Cotton D	153	185	163	113	302	44
Sugarcane	510	707	460	780	817	695

Source: Statistical Abstract of Haryana, Various Issues

The production of wheat has increased from 1059 thousand tonnes in 1966-67 to 13119 thousand tonnes in 2011-12. Similarly, the production of rice also increased from 229 thousand tonnes to 3757 thousand tonnes during the same period. It is due to the reason that effective support price is available for the paddy and wheat crops. The production of other crops like bajra increased from 373 thousand tonnes in 1966-67 to 1175 thousand tonnes. The production of American cotton has increased from 134 thousand tonnes to 2577 thousand tonnes in the same study period. But on the other hand the production of Desi cotton has increased only 153 thousand tonnes in 1966-67 to 302 thousand hectares in 2000-01 but has decreased 44 thousand tonnes in 2011-12.

1.4 Intensity of Cropping

Intensification is a process that characterises all modern agriculture. The same is true in the case of Haryana. The net area sown didn't increase as much as the area sown more than once. In 1989-90 the intensity of Green Revolution was highest in the Karnal, Kaithal and Jind districts. In the Rohtak, Rewari and Gurgaon districts measure the low intensity of the Green Revolution. On the other side in 2011-12 the highest intensity of Green Revolution was in Bhiwani, Jind, Faridabad, Karnal and Panipat districts. The lowest intensity measured in the Gurgaon, Mewat, Rewari, Rohtak and Yamunanagar. The gap or difference of intensity of the Green Revolution is 16 in the given study period. The lowest intensity region is the industrial belt and sugarcane belt of Haryana where the Paddy-Wheat rotation plays a smaller role.

$$\text{Intensity of Cropping} = \frac{\text{Total Cropped Area} * 100}{\text{Net Area Sown}}$$

By contrast, Rewari district emerged as the one with only a small increase in area sown more than once. The same was true of Panchkula district. The intensity of the Green revolution has been low in both cases. The lack of irrigation, associated with undulating topography and deep water table, limited the scope of multiple cropping (Table 4).

Table 4: Haryana: Intensity of Cropping, 1989-90 to 2011-12

District	1989-90	2011-12	Difference in Points
Ambala	182	193	11
Panchkula	-	168	-
Yamunanagar	157	169	12
Kurukshetra	159	183	24
Kaithal	173	189	16
Karnal	195	199	4
Panipat	156	199	43
Sonipat	150	187	37
Rohtak	129	164	35
Jhajjar	-	173	-
Faridabad	172	203	31
Palwal	-	180	-
Gurgaon	132	137	5
Mewat	-	147	-
Rewari	149	155	6
Mahendragarh	-	185	-
Bhiwani	156	200	44
Jind	180	201	21
Hisar	162	192	30
Fatehabad	-	188	-
Sirsa	154	184	30
Total	158	184	16

Source: Computed from the data of Statistical Abstract 1990 and 2013.

In the high Green Revolution intensity areas, the increase in multiple cropping is significant but not as eastern part of Haryana. Under reference here are the districts of Sonipat, Panipat and Rohtak and Bhiwani from the south-western region. Multiple cropping, associated with an assured base of irrigation, was of a relatively high order her even in 1966-67. This limited the scope of further intensification. The decrease in land left fallow and an increase in intensity of cropping are putting a tremendous strain on the soil fertility. The soil now gets no time to recuperate its strength, farmyard manure is scarce and the practice of green manuring is impossible due to lack of time between harvesting of one crop and sowing of the next. Soils consequently, are suffering from several deficiencies, as discussed earlier.

Section-II

1. ECOLOGICAL COST OF GREEN REVOLUTION

The Green Revolution, beginning in India around the mid-sixties and involving the use of high-yielding variety of seeds, chemical inputs and irrigation, has also aroused a lot of academic interest in terms of its economic and ecological implication. The ecological fallouts of the Green Revolution, which have started surfacing with the passage of time, are now attracting the attention of the government and the academician. It is quite difficult to calculate the monetary values of all types of environmental degradation. But it is possible to know that how much environmental quality is being given in the name of agricultural development. India achieved self-sufficiency in food production only due to Green Revolution. However, this was achieved at a great cost to the nation, both environmental and social (Ramakrishnan, 2008). Agricultural economists in India have been interested essentially in the economic benefits of crop production. Their interest in rural ecology has been negligible (Rao, 1988). In intensive cropping system, the excessive and inappropriate use of agrochemical pollutes waterways, poisons people and upsets eco-system (World Development Report, 2008). Even, after the four decades of Green Revolution, Haryana is neither a land of prosperity nor peace. It is a region ridden with discontent and violence. Instead of abundance, Haryana has been left with diseased soil, pest infested crops, groundwater depletion and water logging deserts (Singh, 2000). The adaptation of new strategy of cultivation has raised many social and environmental problems. The model of intensive cultivation gave birth to a number of ecological problems in Haryana.

1.1 Unsustainable Cropping Pattern

The most dramatic transformation in the cropping pattern is clearly the replacement of the multiple cropping patterns with a cropping pattern dominated by just two crops. At the start of the Green Revolution HYV seeds were available only for few crops which changed the cropping pattern adversely from mixed farming to monoculture (wheat–paddy cycle). Since then all over Haryana, the wheat-paddy cycle Pattern has come to dominate the cropping.

Table 5: Shift in Cropping Pattern

(Area Sown in thousand hectares)

+Crops	1966-67	% of total cropped area	1980-81	% of total cropped area	2011-12	% of total cropped area
Wheat	743	16.15	1479	27.06	2531	39.00
Rice	192	4.17	484	8.86	1234	19.02
Jowar	270	5.87	137	2.50	65	1.00
Bajra	893	19.41	870	15.92	576	8.87
Maize	87	1.89	71	1.29	11	0.16
Barley	182	3.95	124	2.27	41	0.63
Gram	1062	23.06	721	19.44	79	1.21
Rapeseed and Mustard	198	4.30	300	3.63	536	8.26
Cotton A	81	1.76	212	3.88	583	8.88
Cotton D	102	2.21	104	1.90	19	0.29
Sugarcane	150	3.26	113	2.74	95	1.46

Source: computed from the data of statistical abstract, 1967-2013.

Table 4 reveals that in 1966-67 wheat occupied an area of 743 thousand hectares, gram 1062 thousand hectare, maize 87 thousand hectares, rice 192 thousand hectares and bajra 893 thousand hectare with total cropped area of 16.15 per cent, 23.06 per cent, 1.89 per cent 4.17 per cent and 19.41 per cent respectively in Haryana. By 2011-12 of the total cropped area, the area under wheat and rice increased to 39.00 per cent and 19.01 per cent, whereas gram and bajra decreased to 1.21 per cent and 8.87 per cent respectively. Thus, the area under wheat and rice went up from 21.32 per cent in 1966-67 to 69.01 per cent in 2011-12.

There were a number of factors that were responsible for the change in the scenario of the cropping in Haryana. The government policies at the early stage of Green Revolution were much responsible for the shift in cropping pattern. The availability of HYV seeds only for a few crops, the availability of proper marketing including support price and procurement mechanism for selected crops played a positive role to make the cropping pattern unsustainable. The western vision of agricultural development and commercialization of agricultural activities also played a significant role to change the psychology of the Haryanvis farmers to shift towards the unsustainable cropping pattern. Now, the State has lost its number of traditional crops which were not only helpful for balancing the consumption pattern of farming households but also useful for maintaining the soil fertility and micronutrients of the soil. The decline in the area under pulses and increase in area under hybrid wheat-paddy cycle has a serious impact on the fertility of soil. The removal of pulses from cropping pattern has removed a major source of free nitrogen for the soil.

1.2 Ground water use and declining water table

Over the years there has been overexploitation of groundwater, which has been used to meet the increasing demand for water. This has resulted in declining water table in various parts of the country. It is believed that one of the major causes of the decline in groundwater tables is the introduction of water-intensive crops such as paddy and sugarcane into the cropping pattern in certain regions (Bhalla, P:2701-07) Yet, the relationship between groundwater depth and changes in the cropping pattern has not been investigated adequately in the literature so far.

The primary cause of decline in water table is said to be the introduction of water-hungry crops in Haryana. Since there is close correspondence between expansion of area under paddy in a wheat rotation (which is popularly practised in Haryana) and incidence of water depletion, it is strongly believed by many that paddy-wheat rotation is the main cause of the problem. Numerous studies, for example, Chand (1996), Chand and Haque (1997) and Kataki, Hobbs and Adhikary (2001) hold that both in Haryana and Punjab the paddy-wheat rotation is unsustainable and is lowering the 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 (Singh, 2000:100). It is the artificial irrigation system which is a major factor behind the success of Green Revolution in Haryana. The groundwater is playing an important role for the agricultural development. Presently, a major concern of the State is the rapid decline of water table. The dwarf varieties of wheat and rice need much higher irrigation in comparison to the desi verities. The introduction of paddy in late 1970s was probably the most important reason behind the increase in area under artificial irrigation by tube wells and wells. Figure 1 shows that net irrigated area by canals has decreased from 76.64 per cent in 1966-67 to 38.83 per cent in 2011-12. On the other hand, the area irrigated by tubewells has increased from 38.88 per cent in 1975-76 to 61.16 per cent in 2011-12.

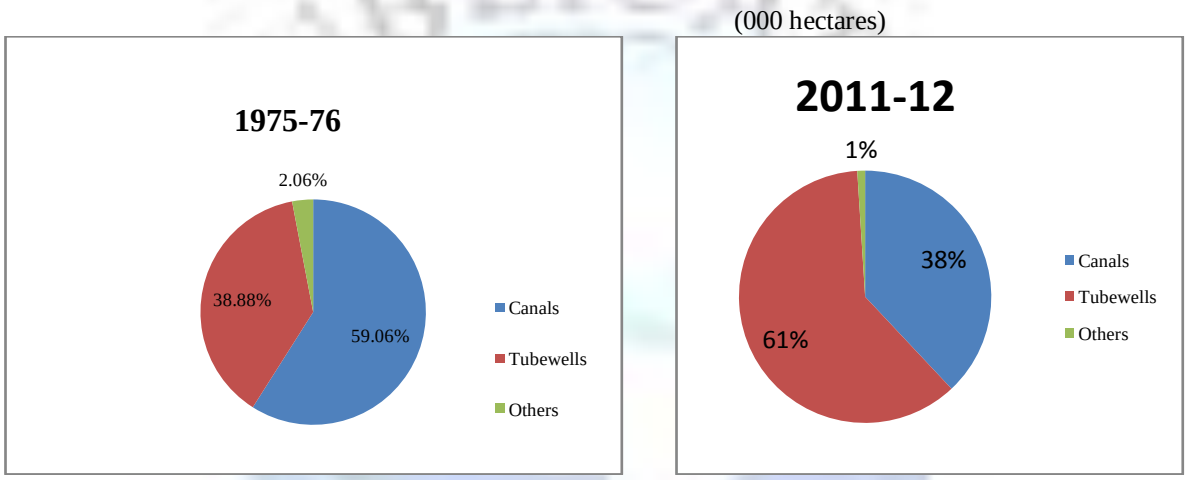

Figure 1: Percentage of Net Irrigated Area in Haryana by Sources

The main reason behind such a huge exploitation of groundwater was that the surface water was not able to meet the demand of agriculture sector. Due to the unsustainable exploitation of groundwater, the level of groundwater in Haryana is depleting very sharply. Out of the 60 blocks in 1997, 37 were overexploited, 11 blocks were critical, 15 blocks were semi-critical and safe. But the situation became much worse in 2013. In 2013 out of 116 blocks 68 were overexploited, 21 blocks were critical, 09 blocks were semi-critical and only 18 blocks were safe (Government of Haryana, Department of Agriculture, Haryana 2013). The groundwater in Haryana is being overdrawn to such an extent that water table has fallen to the levels that make pumping difficult and too costly. Small farmers with little resources are often insecure for water right and most affected. The depletion of groundwater is not only a cause of major environmental crisis but it is also a water deficit region in the History and it is also a major reason behind the increase in cost of cultivation in Haryana. The depletion of groundwater has forced the farmers to replace the traditional pump sets by expensive submersible pump sets.

1.3 Unplanned Canal Irrigation System and Problem of Water Logging

It is ironic that the water scarce state of Haryana suffers from the problem of water logging in parts. Water logging is a situation when the water table rises to an extent that the soil pares in the root zone of a crop become saturated resulting in restriction of the normal circulation of air, decline in the level of oxygen and increase in the level of carbon dioxide. The actual depth of water table when it starts affecting the yield adversely may vary from zero for rice to about 1.5 metres for other crops (Singh, 1998:170)

The flood plains of the Yamuna, Ghaggar, Markanda, Dohan, and Sahibi remain waterlogged for varying durations during rainy season (July to September). The lowlying parts of the upland plain in Kurukshetra and Karnal districts also get waterlogged during the rainy season. Water logging is due to excessive use of water for short-term grain and failure to take step to drain excess water. The economists concentrated more on the impact of irrigation on productivity of

land, rather than on water use efficiency (Nadkarni, 1987). Due to the unplanned canal irrigation system and inadequate drainage system the some districts of the State have been facing the severe problem of water logging and resultant soil salinity. Both salinity and water logging occur when agricultural land is over irrigated. As second or third crops were planned each year after the introduction of new agricultural strategy, the situation becomes worse in the State.

Table 6: District-Wise Waterlogged Area's

(thousand hectares)

Sr. No.	District	Geographical Area	Hilly Area	Area Under Various depth Range In metres			
				Fully waterlogged	Waterlogged	Semi critical	Safe
				0-1.5	1.5-3	3-10	>10
1.	Ambala	159.6	0.3	4.6	14.3	82.7	57.7
2.	Bhiwani	487.1	4.7	0	36.8	167.4	278.2
3.	Faridabad	74.0	8.7	0	0.5	15.9	48.2
4.	Fatehabad	249.1	0	1.6	7.2	59.7	100.6
5.	Gurgaon	124.9	3.8	0	0	6.7	114.4
6.	Hisar	386.1	0	1.4	27.0	229.7	108.0
7.	Jind	273.6	0	0.5	7.4	115.0	150.7
8.	Jhajjar	186.8	0	6.0	60.4	104.4	16.0
9.	Kurukshetra	168.2	0	0	0	0.3	167.9
10.	Kaithal	228.4	0	0	0	38.0	190.4
11.	Karnal	247.1	0	0	0	27.5	219.6
12.	Mahendergarh	193.9	4.6	0	0	5.1	184.2
13.	Mewat	150.0	13.9	0	19.6	52.8	63.7
14.	Palwal	136.5	0.1	0	4.7	89.7	42.0
15.	Panchkula	78.9	39.4	0	0	10.0	29.5
16.	Panipat	125.0	0	0	0	39.8	85.2
17.	Rewari	155.9	2.3	0	0.3	37.1	116.2
18.	Rohtak	166.8	0	5.9	81.8	74.8	4.3
19.	Sonepat	226.1	0	1.1	22.6	146.8	55.6
20.	Sirsa	427.6	0	0	8.9	133.7	285.0
21.	Y.Nagar	175.6	15.3	1.4	13.3	74.8	70.8
	Total	4421.2	93.1	22.5	304.7	1531.9	2469.0

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The total area of Haryana is 4421.2 thousand hectare. In which the districts that are safe from waterlogging have hilly terrain, like, Panchkula, Mewat, Yamunanagar, Faridabad and Bhiwani. The total area that has shown in table 5, depicts that out of total geographical area of the state 22.5 thousand hectare is fully waterlogged (0-1.5m), 304.7 thousand hectares areas is waterlogged (1.5-3m), 1531.9 thousand hectares area is in critical condition (3.0>10.0) and 2469 thousand hectares area is safe from the water logging(<10.0). The problem of fully waterlogging is maximum in Jhajjar, Rohtak and Ambala district where the water depth is 0 to 1.5 metre below. The other districts facing the problem of waterlogging are some areas of Bhiwani, Hisar, Sonepat, where the water depth is 1.5 to 3 metre deep. The safe districts of waterlogging are Panchkula, Yamunanagar, Mewat, Bhiwani, Kurukshetra, Kaithal, Sirsa, Karnal, Jind etc.

1.4 Excessive Use of Chemical Fertilizers and Pesticides

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).The increasing use of chemical fertilizers and pesticides is one of the major reasons behind the environmental crisis in Haryana's agriculture. The excessive use of nitrogen fertilizer and pesticides has increased the concentration of nitrates and pesticide residual in soil, water and food. In the initial stages of Green Revolution, Government of India announced fertilizer subsidy to encourage the farmers towards the HYV seeds. In comparison to the other states of India, the farmers of Haryana inclined more towards the HYV seeds and for the consumption of fertilizers. In 1965-66, Haryana was lagging behind a number of States (most notably, Tamil Nadu, Kerala and Andhra Pradesh) in regard to per hectare fertilizer

consumption. The consumption of nitrogen in Haryana was just 12.6 thousand nutrient tonnes which increased about85 times to 1024 thousand nutrients tonne in 2011-12. Similarly, the consumption of total NPK increased about 109-fold from 13 thousand nutrients tonne in 1966-67 to 1428 thousand nutrient tonnes in 2011-12 (figure 2). There is excessive use of nitrogen fertilizer and under utilization of other fertilizers and micronutrients which make adverse effect on soil's health and deficiency of some important nutrients.

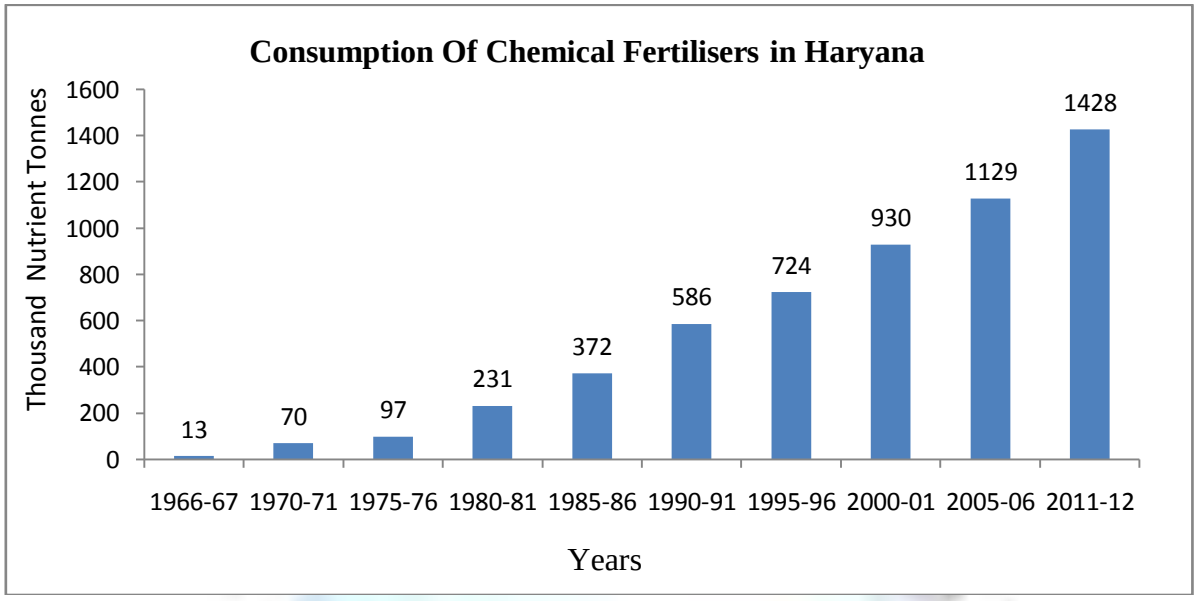

Figure 2

The consumption of chemical pesticides shows that Haryana is again at the top among the Indian states. The consumption of pesticides in Haryana has increased at a rapid rate of 5 times in 5 years of periods. This caused changes in the soil fertility. The use of agro chemicals in Haryana is the highest in India. Fertilizer consumption has increased from 3to 130 kg ha−1 in the last 30 years. Fertilizer 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 (Singh, 2000:100).

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 fertilizers and pesticides. The above analysis provides that from the economic point of view the State of Punjab made spectacular progress after the introduction of new technology of cultivation. With 1.34 per cent of the total geographical area of the country, Haryana is contributing about 11.8 million tonnes of wheat and 3.4 million tonnes rice to the national pool. Agriculture sector is playing an important role in the structural composition of the economy and contributing a large proportion in GSDP and employment. The farmers of Haryana are using each and every part of the soil for cultivation purposes. That's why the net sown area in Haryana is higher than the other parts of the country. Similarly, after the introduction of new methods of cultivation the cropping intensity in Haryana reached its saturation level. The production relations in Haryana's agriculture completely transferred from traditional to modern agriculture. The extension of irrigation facilities and announcement of minimum support price increased the productivity of wheat and rice about three to four times. The total production of principal crops (wheat and rice) also increased very sharply. All this progress establishes Haryana as one of the richest State in economic terms. But, on the other hand, Haryana has been suffering a lot from the ecological point of view. The heavy input based agriculture is affecting each and every aspect of the environment and human health, whether it's cropping pattern, access to groundwater, cost of cultivation and soil fertility. The intensive cropping changed the cropping pattern from multiple cropping pattern to monoculture dominated by wheat and rice. The new varieties of wheat and paddy need much more irrigation in comparison to desi varieties. It is one of the major reasons that the area under artificial irrigation (tubewells and wells) has increased very sharply. The overexploitation of groundwater due to the artificial irrigation system drastically depleted the groundwater table in Haryana. The water table in the State has been depleting at the very fast rate, so in 2013 out of 116 blocks, 68 were overexploited, 21 blocks were critical, 09 blocks were semi-critical and only 18 blocks were safe. It is noted that Haryana is traditionally highly deficit in water yet the groundwater exploitation has reached at an alarming rate. On the

other hand, the unplanned canal irrigation system in the districts like Rohtak, Jhajjar, Ambala and some part of Yamunanagar and Mewat of the State has given birth to problems of water logging and soil salinity. The extensive use of chemical fertilizers and pesticides has also contributed largely in the environmental crisis of Haryana. Haryana is at the top among the Indian States in the use of chemical fertilizers and pesticide consumption. It has not only made an adverse effect on soil health but also on animal and human health.

Suggestions

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. 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.

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