

ECONOMIC BENEFITS AND ECOLOGICAL COST OF GREEN REVOLUTION: A CASE STUDY OF PUNJAB

Paramjit Singh*

The adaptation of various modern agricultural techniques has further strengthened the role of agricultural sector in the economic development and employment generation of Punjab. The cropping intensity in Punjab is 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 : Land Utilisation, Agriculture Productivity

INTRODUCTION

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 State of Punjab was used as a laboratory for the experiment of this new technology. The HYV seeds were adopted first in the district of Ludhiana, Kapurthala and Jalandhar. After a short span of time this technology was expanded sharply to other areas of the state. The introduction of this new technology has completely replaced the old mode of production in Punjab's agriculture. Traditional agriculture was progressively given way to modern and commercial agriculture and sooner Punjab 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 Punjab. But Punjab 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.

* Research Scholar, Dept. of Economics, Punjabi University, Patiala

The present paper is an attempt to look out the economic benefits and ecological cost of the Green Revolution in Punjab. For this purpose, the paper is divided into two sections. The first section examines the major economic benefits of the Green Revolution in Punjab. The ecological cost has been analyzed in the second section.

SECTION-I

ECONOMIC BENEFITS OF GREEN REVOLUTION

From the economic point of view, the agriculture in the State of Punjab has made spectacular progress during the last three decades and there seems to be no parallel example anywhere in the world history of agricultural development (Rangi and Sidhu, 1998). The State of Punjab was known as the 'Bread Basket' of India due to its agricultural performance in 1970s and 1980s. The food surpluses from Punjab have been the backbone of the national food system. Although, Punjab encompasses only 1.5 per cent of the total geographical area of the country, it produces 21 per cent of wheat, 10 per cent of rice and 8 per cent of cotton production in the country. The State is contributing over 50 per cent of wheat and rice in the central pool (Singh, 2000; and Gupta, 2004). The major economic gains of Green Revolution have been examined by focusing on the following points.

GSDP and Employment

The production structure of Punjab is heavily dominated by primary sector activities. Due to the advent of modern methods of cultivation, the agriculture sector of Punjab becomes the leader in economic development. In the case of Punjab economy, agriculture sector constituted 54.27 per cent in GSDP in 1970-71 which slowly came down to 29.87 per cent in 2008-09. But if we compare the share of agriculture sector with the share of industrial or dynamic sector it is still quite high. It is pertinent to note that despite rapid mechanization of agricultural activities in Punjab 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 three decades period it decreased to 38.95 per cent in 2001. The share of agriculture sector in employment is very high in comparison to the industrial sector. In terms of employing the workforce, the industrial sector of Punjab shows a reverse tendency. The share of industrial sector in employment of the total workforce was 11.30 per cent in 1970-71 and it decreased to 8.41 per cent in 2001. After the period of four decades of the advent of Green Revolution and capital-intensive techniques of production in rural economy of Punjab 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.

Shift in Land Utilization

The quantity and quality of land resources in a particular region played an important role in the agricultural development. Except for a strip of Shivalik hills along its eastern border, the entire area of Punjab is flat and plain. Punjab has traditionally been the land of five rivers that's why the land of this region is highly productive.

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, Punjab encompasses total geographical area of 5033 thousand hectares, which constitutes about 1.53 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 83 per cent is the net sown area (Vide Table 1).

Table 1, Land Utilization Pattern in Punjab

(Area in 000 hectare)

| Items | 1960-61 | 1970-71 | 1980-81 | 1990-91 | 2000-01 | 2008-09 |
|---|---------|---------|---------|---------|---------|---------|
| Geographical Area | 5036 | 5036 | 5036 | 5036 | 5036 | 5036 |
| Area Under Forest | 35 | 123 | 216 | 222 | 280 | 296 |
| Uncultural and Barren Land | — | 208 | 96 | 83 | 28 | 23 |
| Land put to Non-agricultural Use | — | 416 | 436 | 343 | 410 | 494 |
| Unculturable Land Excluding Fallow Land | 255 | 92 | 49 | 57 | 22 | 10 |
| Fallow Land | 313 | 139 | 45 | 110 | 43 | 39 |
| Net Sown Area | 3757 | 4053 | 4191 | 4218 | 4250 | 4171 |
| Cropped Area | 4732 | 5678 | 6763 | 7502 | 7941 | 7912 |
| Cropping Intensity (%) | 126 | 140 | 161 | 178 | 186 | 189 |

Source: Statistical Abstract of Punjab, Various Issues.

Due to the introduction of new technology and commercialization of production relations the unculturable and barren land is continuously declining since 1970s. It was 208 thousand hectares in 1970-71 and declined to only 23 thousand hectares in 2008-09. Similarly, the new mode of production in Punjab's agriculture also brought more and more area of fallow land under cultivation. The fallow land declined from 313 thousand hectares in 1960-61 to 110 thousand hectares in 1990-91; and it further declined to 39 thousand hectares in 2008-09. The land put on non-agricultural purposes remains almost same during the period before and after the Green Revolution, because the agricultural development leaves no space for the penetration into other occupations in Punjab.

The table also shows that due to new techniques of production the net sown area has also increased from 3757 thousand hectares in 1960-61 to 4218 thousand hectares in 1990-91; and it marginally declined to 4171 thousand hectares in 2008-09. 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 Punjabis are continuously moving towards better inhabitants. The cropped area has also progressed from 4732 thousand hectare to 7912 thousand hectares between 1960-61 and 2008-09. The cropping intensity has also progressed from 126 in 1960-61 to 189 in 2008-09. 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.

Production and Productivity Trends

The agriculture in Punjab 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 Punjab was confined to wheat only because traditionally Punjab has never a rice growing area. But after a few years, new varieties of rice also became popular with the farmers (Sidhu, 2004).

After the introduction of new methods of cultivation the production and productivity increased very sharply in Punjab which gave boost to the overall growth of the economy. The productivity of all the crops in Punjab 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 production of wheat increased from 1244 kg/hectare in 1960-61 to 4507 kg/hectare in 2007-08. Similarly, the production of rice has also increased from 1009 kg/hectare to 4019 kg/hectare during the same period. It is significant to note that within a span of four decades the average productivity of wheat and rice has increased almost four times.

Table 2, Yield of Principle Crops in Punjab

(Kg/ hectare)

| Crops | 1960-61 | 1970-71 | 1980-81 | 1990-91 | 2000-01 | 2007-08 |
|--------------------|---------|---------|---------|---------|---------|---------|
| Wheat | 1244 | 2238 | 2730 | 3715 | 4563 | 4507 |
| Rice | 1009 | 1765 | 2733 | 3229 | 3506 | 4019 |
| Maize | 1135 | 1555 | 1602 | 1786 | 2793 | 3405 |
| Barley | 768 | 7022 | 1640 | 2754 | 3393 | 3563 |
| Gram | 813 | 797 | 582 | 744 | 953 | 1000 |
| Bajra | 472 | 1176 | 1244 | 1107 | 893 | 1000 |
| Sugarcane | 3654 | 4117 | 5526 | 5941 | 6425 | 6081 |
| Cotton (A) | 269 | 391 | 329 | 481 | 437 | 668 |
| Cotton (D) | 270 | 338 | 241 | 285 | 408 | 541 |
| Rapeseed & Mustard | 505 | 553 | 567 | 1003 | 1218 | 1182 |
| Groundnut | 925 | 970 | 1249 | 816 | 879 | 882 |

Source: Statistical Abstract of Punjab, 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 Principle Crops

(000 tonnes)

| Crops | 1960-61 | 1970-71 | 1980-81 | 1990-91 | 2000-01 | 2008-09 |
|--------------------|---------|---------|---------|---------|---------|---------|
| Wheat | 1742 | 5145 | 7677 | 12159 | 15551 | 15733 |
| Rice | 229 | 688 | 3233 | 6506 | 9157 | 11000 |
| Maize | 371 | 861 | 612 | 333 | 461 | 514 |
| Barley | 52 | 57 | 108 | 101 | 109 | 55 |
| Gram | 7 | 284 | 150 | 45 | 8 | 3 |
| Bajra | - | 243 | 86 | 13 | 5.2 | 5 |
| Sugarcane | 486 | 527 | 392 | 601 | 777 | 467 |
| Cotton (A) | 709 | 818 | 1178 | 1909 | 1199 | 2285 |
| Rapeseed & Mustard | - | 77 | 69 | 67 | 61 | 34 |
| Groundnut | - | 169 | 104 | 9 | 4 | 3 |

Source: Statistical Abstract of Punjab, Various Issues.

The production of wheat has increased from 1742 thousand tones in 1960-61 to 15733 thousand tonnes in 2008-09. Similarly, the production of rice also increased from 229 thousand tonnes to 11000 thousand tonnes during the same period. It is due to the reason that effective support price is available for the paddy and wheat crops.

SECTION-II

ECOLOGICAL COST OF GREEN REVOLUTION

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, Punjab is neither a land of prosperity nor peace. It is a region ridden with discontent and violence. Instead of abundance, Punjab has

been left with diseased soil, pest infested crops, groundwater depletion, water logging deserts and indebted and discontented farmers (Shiva, 1989). 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 Punjab.

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 Punjab, the wheat-paddy cycle has come to dominate the cropping pattern.

Table 4, Shift in Cropping Pattern

(Area Sown in 000 hectare)

| Crops | 1960-61 | 1970-71 | 1980-81 | 1990-91 | 2000-01 | 2008-09 |
|------------------------|-----------------|--------------|-----------------|-----------------|-----------------|-----------------|
| Rice | 227 (5.19) | 390 (8.30) | 1183 (20.52) | 2015 (30.96) | 2612 (37.52) | 2735 (38.17) |
| Maize | 327 (7.48) | 555 (11.82) | 382 (6.63) | 188 (2.89) | 165 (2.37) | 151 (2.11) |
| Bajra & jawhar | 129 (2.95) | 207 (4.40) | 69 (1.20) | 12 (0.18) | 6 (0.09) | 5 (0.07) |
| Groundnut | 679 (15.54) | 174 (3.70) | 83 (1.44) | 11 (0.17) | 4 (0.06) | 3 (0.04) |
| Cotton | 447 (10.22) | 397 (8.45) | 649 (11.26) | 701 (10.77) | 474 (6.81) | 527 (7.35) |
| Sugarcane | 133 (3.04) | 128 (2.72) | 71 (1.23) | 101 (1.56) | 121 (1.74) | 81 (1.13) |
| Sesarmum | 8 (0.18) | 15 (0.32) | 17 (0.29) | 18 (0.28) | 19 (0.27) | 8 (0.11) |
| Wheat | 1400 (32.04) | 2299 (48.91) | 2812 (48.78) | 3273 (50.29) | 3408 (48.95) | 3526 (49.20) |
| Barley | 66 (1.51) | 57 (1.21) | 65 (1.13) | 37 (0.57) | 32 (0.46) | 16 (0.22) |
| Gram | 838 (19.18) | 358 (7.62) | 258 (4.48) | 60 (0.92) | 6 (0.09) | 3 (0.04) |
| Rapeseeds & Mustard | 107 (2.46) | 103 (2.19) | 136 (2.36) | 69 (1.06) | 55 (0.79) | 29 (0.41) |
| Potato | 9 (0.21) | 17 (0.36) | 40 (0.69) | 23 (0.35) | 60 (0.86) | 82 (1.15) |

Source: Statistical Abstract of Punjab, Various Issues.

Note: The figures in parentheses represent percentages.

Table 4 reveals that in 1960-61 wheat occupied an area of 1400 thousand hectares, gram 838 thousand hectare, maize 327 thousand hectares, and rice 227 thousand hectares with total cropped area of 32.04 per cent, 15.54 per cent, 7.48 per cent and 5.19 per cent respectively in Punjab. By 2008-09 of the total cropped area, the area under wheat and rice increased to 49.20 per cent and 38.17 per cent, whereas gram and maize decreased to 0.04 per cent and 2.11 per cent respectively. Thus, the area under wheat and rice went up from 37.23 per cent in 1960-61 to 87.37 per cent in 2008-09.

A number of factors have contributed towards the adverse change in the cropping pattern. 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 Punjabi 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.

Unsustainable Groundwater Exploitation

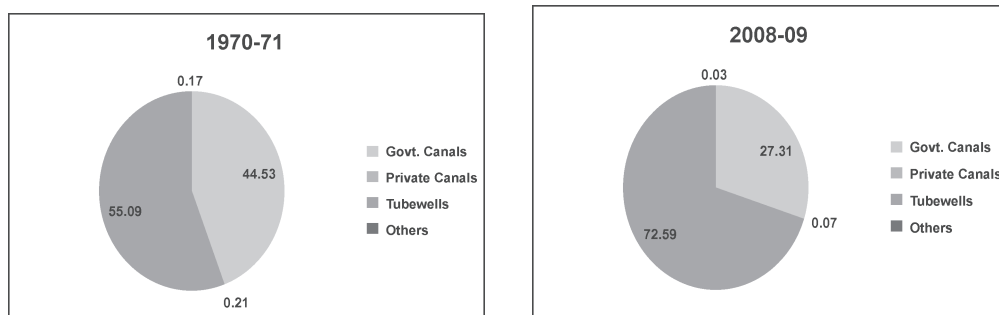
It is the artificial irrigation system which is a major factor behind the success of Green Revolution in Punjab. The groundwater is playing an important role for the agricultural development since rainfall meets 20 per cent of irrigation requirements only. Presently, a major concern of the State is the rapid decline of water table. About 77 per cent area of Punjab is facing the problem of falling water table. To meet the present level of crop production, the demand for water exceeds its supply from different sources. The excess demand is met through the over-exploitation of groundwater, due to which groundwater table is successively going down (Jeevandas et. al., 2008).

The dwarf varieties of wheat and rice need much higher irrigation in comparison to the *desi* varieties. The introduction of paddy in late 1970s was probably the most important reason behind the increase in area under artificial irrigation by tubewells and wells. Figure 1 shows that net irrigated area by canals has decreased from 44.53 per cent in 1970-71 to 27.31 per cent in 2008-09. On the other hand, the area irrigated by tubewells has increased from 55.09 per cent in 1970-71 to 72.59 per cent in 2008-09. 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 Punjab is depleting very sharply. Out of the 118 blocks in 1986, 55 were overexploited, 9 blocks were critical, 18 blocks were semi-critical and 36 were safe. But the situation became much worse in 2005. In 2005 out of 137 blocks 103 were overexploited, 4 blocks were critical, 5 blocks were semi-critical and only 25 blocks were safe (Government of Punjab, Central Groundwater Board, Punjab, 2005). The groundwater in Punjab 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 major reason behind the increase in cost of cultivation in Punjab. The depletion of groundwater has forced the farmers to replace the traditional pump sets by expensive submersible pump sets.

Figure 1: Percentage of Net Irrigated Area in Punjab by Source

(000 hectares)



Unplanned Canal Irrigation System and Problem of Water Logging

Poor water management is leading to land degradation in irrigated areas through salinization and water logging. 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 south western 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.

The unplanned canal irrigation system in Bhakra commanded areas gave birth to the problem of water logging and salinization in Punjab. Table 5 depicts that the area under water logging was 233400 hectare in the year 1998 and it decreased to 12000 hectare in 2006. This decrease was not due to the government efforts and policies. The major reason behind the decrease in area under water logging was the lower rainfall in Punjab. The area is still very high under this severe problem. The problem is mainly concentrated in the districts of Faridkot, Ferozepur, Bathinda and Muktsar.

Table 5: Area Under Water Logging in Punjab

(In hectare)

| Year | Area Under Water Logging |
|------|--------------------------|
| 1998 | 233400 |
| 2000 | 95700 |
| 2002 | 30000 |
| 2004 | 15500 |
| 2006 | 12000 |

Source: Water Resource Directorate, Punjab, Chandigarh.

Due to water logging the level of groundwater rises and when it reaches to the crops root zone, it starts to have a serious impact on crop productivity, ultimately making the land totally unproductive and

rendering the land into wet desert. This water dissolves the salts from the soil and brings them to the surface, when they are deposited of the water evaporation. This resulted in the salinization of soil, again affecting productivity adversely. Water logging does not affect only agriculture production and soil fertility but it also has a devastating impact on trees, roads, buildings and infrastructure (Dharmadhikary, 2005).

Excessive Use of Chemical Fertilizers and Pesticides

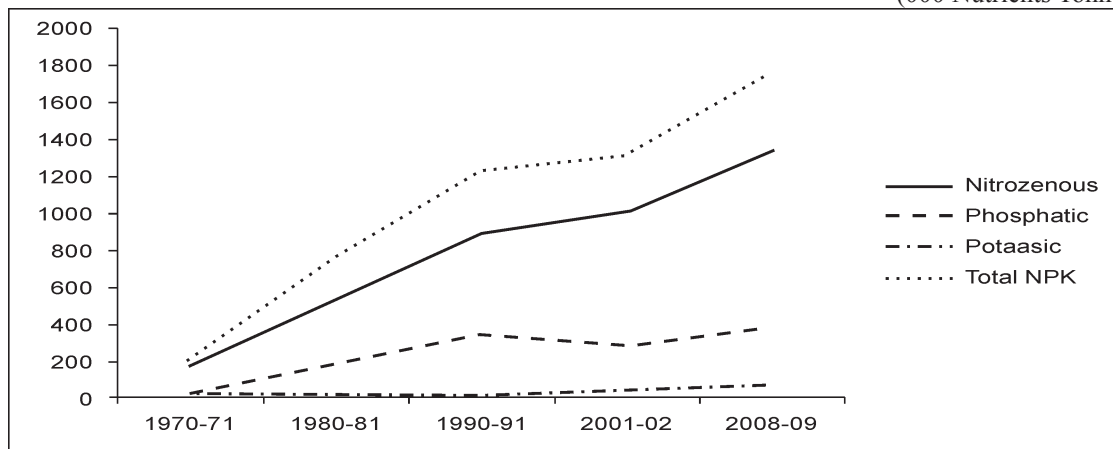
The increasing use of chemical fertilizers and pesticides is one of the major reasons behind the environmental crisis in Punjab's agriculture. The excessive use of nitrogen fertilizer and pesticides has increased the concentration of nitrates and pesticide residual in soil, water, food and feed.

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 Punjab inclined more towards the HYV seeds and for the consumption of fertilizers. In 1965-66, Punjab was lagging behind a number of States (most notably, Tamil Nadu, Kerala and Andhra Pradesh) in regard to per hectare fertilizer consumption. After 1965-66, the per hectare consumption of fertilizers increased so sharply in Punjab that it left all other States far behind (Chadha, 1986). Punjab is now consuming over 8 per cent of the total fertilizer consumption of India.

Figure 2 highlights the consumption of chemical fertilizers in Punjab. The consumption of nitrogen in Punjab was just 175 thousand nutrients tonne in 1970-71 which increased about seven-fold to 1332 thousand nutrients tonne in 2008-09. Similarly, the consumption of total NPK increased about eight-fold from 213 nutrients tonne in 1970-71 to 1768 nutrient tonne in 2008-09. 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: Consumption of Chemical Fertilizers in Punjab

(000 Nutrients Tonne)



As far as consumption of chemical pesticides is concerned, Punjab is again at the top among the Indian states. The consumption of pesticides in Punjab increased from 32000 metric tons (MT) in the year 1980-81 to 5970 MT in 2005-06. Currently, the State is consuming about 17 per cent of total pesticides used in India. Out of these, more than 90 per cent of pesticides are used in the cultivation of cotton, rice and vegetables. A comparison of per hectare usage of the pesticides with other States indicates that Punjab was at the top by consuming 923 grams pesticides per hectare (Singh, 2002; and Government of Punjab, Agriculture for Development, 2007).

The excessive use of chemical pesticides is not only affecting the PH level of soil and water, but also making adverse effect on the health of human beings and animals. It is one of the major reasons behind the increase in cancer cases in different parts of Punjab because the food eaten by us is highly pesticide contaminated. The study conducted by Post Graduation Institute of Medical Education and Research about the effect of chemical pesticides on human health in cotton belt of Malwa region of the State showed that more than half of the pesticides manufactured in the country are estimated to be used on cotton crop. The study tried to find out if cotton cultivation, which is much more pesticide dependent than rice and wheat, could be linked to cancer. A total population of 39,732 families comprising 183,243 people was surveyed in 129 villages of block Talwandi Sabo of Bathinda district, and Chamkaur Sahib block of Ropar district. The number of cancer cases in Talwandi Sabo block was 103 per lakh persons compared to 71 per lakh persons in Chamkaur Sahib block (Kumar, 2005; and Government of Punjab, Agriculture for Development, 2007). Thus, the occurrence of cancer cases in cotton belt of Punjab shows that the use of excessive pesticides is not only making an adverse effect on rural ecology but it is also affecting the health of the farming households. The burning of agricultural wastage after reaping crops and excessive use of machinery are contributing towards environmental pollution.

CONCLUSION

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 1.53 per cent of the total geographical area of the country, Punjab is contributing about 50 per cent of wheat and 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 Punjab are using each and every part of the soil for cultivation purposes. That's why the net sown area in Punjab is the highest as compared to other parts of the country. Similarly, after the introduction of new methods of cultivation the cropping intensity in Punjab reached its saturation level. The production relations in Punjab'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 four times. The total production of principal crops (wheat and rice) also increased very sharply. All this progress establishes Punjab as one of the richest State in economic terms.

But, on the other hand, Punjab 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 Punjab. The water table in the State has been depleting at the rate of 60cm per year during the past two years. The groundwater exploitation has reached at an alarming rate of 110 per cent which means that more water is being used than recharged. On the other hand, the unplanned canal irrigation system in the south western districts 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 Punjab. Punjab 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.

So, the Green Revolution has not only brought prosperity to the State but it has also disturbed ecological balance of the State. Now, it's the time to rethink about the Punjab's model of agricultural

growth. There is an urgent need to substitute the unsustainable methods of cultivation with sustainable and environmental-friendly methods. The green agriculture which involves integrated pest management and nutrient supply should be promoted. It is beneficial for maintaining the productivity of our soil and save our natural resources. To promote the green agriculture the tempo of public investment should be changed from unnecessary expenditures. The knowledge, publicity and cheap institutional credit facilities to the farmers are the necessary conditions to promote organic farming in the State.

References

- Brar, K. K. (1999), *Green Revolution: Ecological Implications*, Dominant Publishers, New Delhi.
- Chadha, G. K. (1986), *The State of Rural Economic Transformation: The Case of Punjab 1950-85*, Saga Publications, New Delhi.
- Dharmadhikary, S. (2005), *Unravelling Bhakra*, Manthan Publication, Bhopal.
- Glaeser, B. (1987), "Agriculture Between the Green Revolution and Ecodevelopment: Which Way to Go?", in Glaeser, B. (ed.), *The Green Revolution Revisited: Critique and Alternative*, Billings and Sons Ltd., London.
- Government of Punjab (2005), Central Groundwater Board, Punjab Chandigarh.
- Government of Punjab, *The Statistical Abstract of Punjab*, Various Issues, Economic Adviser to Government of Punjab, Economic and Statistical Division, Punjab, Chandigarh.
- Government of Punjab (2007), "State of Environment in Punjab", *Agriculture and Environment*, Punjab State Council of Science and Technology, Chandigarh.
- Gupta, S. P. (2004), *The Punjab: An Overview*, ESS PEE Publications, Chandigarh.
- Jeevandas, A. et al. (2008), "Concerns of Groundwater Depletion and Irrigation Efficiency in Punjab Agriculture: A Micro –Level Study", *Agricultural Economics Research Review*, Vol. 21.
- Kumar, R. (2005), An Epidemiological Study of Cancer Cases Reported from Villages of Talwandi Sabo Block, District Bathinda, Punjab, PGIMER, Chandigarh and PPCB, Patiala.
- Nadkarni, M. V. (1987), "Agricultural Development and Ecology: An Economist's View", *Indian Journal of Agricultural Economics*, Vol.42, No.3.
- Pearse, A. (1977), "Technology and Peasant Production: Reflection of Global Study", *Development and Culture*, Vol.8.
- Ramakrishnan, P. S. (2008), *Ecology and Sustainable Development: Working with Knowledge System*, National Book Trust, New Delhi.
- Rangi, P. S; and Sidhu, M.S. (1998), "Growth of Punjab Agriculture: A Critical Appraisal", in Dhaliwal, G.S. et al. (eds.), *Ecological Agriculture and Sustainable Development*, Vol.2, Ecological Society, Ludhiana and Centre for Research in Rural and Industrial Development, Chandigarh.
- Rao, H. (1988), "Agricultural Development and Ecological Degradation: An Analytical Framework", *Economic and Political Weekly*, Vol. 23, No. 52 & 53.
- Shiva, V. (1989), *The Violence of Green Revolution*, Research Foundation for Science and Ecology, Dehradun.
- Sidhu, S. (2004), "Agrarian Crisis in Punjab (Genesis, Government's Response and International Experience)", Paper Presented at National Seminar, Punjabi University, Patiala.
- Singh, S. (2000), "Crisis in Punjab Agriculture", *Economic and Political Weekly*, Vol.34, No.26.
- Singh (2002), "Pesticide Contamination of the Environment of Punjab", *Indian Journal of Ecology*, Vol. 29, No.2.
- World Development Report (2008), *Agriculture for Development*, Oxford University Press, Washington DC.