GREEN REVOLUTION IN PUNJAB

In the earlier chapter we covered the review of literature. This chapter is on Green Revolution in Punjab and its socio-economic and ecological consequences are covered. The main emphasis is to delineate the past and present situation of Punjab. Important studies and relevant matter on Green Revolution is incorporated. This chapter is divided into two sections. Firstly section-A covers Green Revolution and the section-B is on developments in water technology. The effort is to trace the traditional and modern water technology in use.

Section-A

Introduction

Since independence India has seen many changes. Parayil (1992) cites “At the time of independence in 1947, India was a vastly poor nation with almost 90 percent of its population living in nearly 600,000 villages was dependent on agriculture”. Scholars pointed that since independence India in general and Punjab in particular witnessed many problems and out of all food deficiency was the main. Food deficiency took place in Punjab because most of the rich lands, irrigation facilities and other rural infrastructure went to west Punjab, a prerequisite for rapid agricultural development (Sims 1988). Steps like land reforms, legislation on abolition of intermediaries, ceiling of land holdings, protection of tenants etc. were adopted in Punjab during mid fifties. In brief the motive was to bring radical change in Punjab’s Agriculture.

In India the First Five-Year Plan (1951 -56) was primarily devoted to agriculture and rural development. ‘In 1961, the Ford Foundation thus launched its Intensive Agriculture Development Programme (IADP) in India, intended to release Indian agriculture from the ‘shackles of the past’ through the introduction of modern
intensive chemical farming” (Shiva 1991, p.2). The IADP was launched during in 1961 and, as follow-on the Intensive Agriculture Area Programme was launched during 1964-65 to focus on area with the greatest potential for improving agricultural productivity, providing a ready platform to disseminate Green Revolution.

To overcome the food problem Indian Government adopted the new technology called Green Revolution technology during the mid 1960s. The term Green Revolution was first used in 1968 by former USAID director William Gaud, who noted the spread of the new technologies and said, “These and other developments in the field of agriculture contain the makings of a new revolution. It is not a violent Red Revolution like that of the Soviets, nor is it a White Revolution like that of the Shah of Iran. I call it the Green Revolution” (Wikipedia.com).

In Green Revolution, HYV seeds called miracle seeds were introduced in agriculture. “The main idea behind this package was to increase food grain production and eradication of starvation and famines. It appeared as a turning point in Punjab’s history” (Chakravarti 1973, p. 321). The Government of India imported the technology and Punjabi farmers were at the forefront in adopting it (Singh 2008). The reason was, Indian Punjab inherited the agriculturally less productive and food-deficit part of the old Punjab (Randhawa 1986, p. iv). There was a very wide gap of quality and quantity between the land that was lost and that which was available. It was viewed that the motive behind its introduction was to maintain the production level after partition. M.S Randhawa marked “once there are investment opportunities and efficient incentives, farmers will turn sand into gold” (Randhawa 1975, p. 45).

In India, main support to HYV seeds was “Agriculture Finance Corporation”, (A.F.C) a consortium of commercial banks which was set up in 1963 to give medium and long term credit for major macro-level development projects. A.R.C has been reconstituted
as NABARD, the National Bank for Agriculture and Rural Development. Two central bodies related to food production, procurement and distribution were established in 1965 on the World Bank advice. One was Food Corporation of India (FCI) which was responsible for procurement, import, distribution, storage and the sale of food grain. The other was the Agriculture Prices Commission (APC). Number of incentives, guidance, policies and agencies became active after independence. MARKFED for the stocking and distribution of fertilizer since 1966 was started. Land consolidation and donation of land through Gramdan and Bhoodan movements (redistribution of surplus land) took place. Steps by government to provide easy loans and credits to the farmers for adoption of new technology were activated after Independence. Agencies like World Bank, the Rockefeller and Ford foundations, the U.S Agency for International Development and others looked towards the intensification of agriculture.

Parayil mentioned that U.S. land-grant universities (Kansas, Ohio, Missouri, Pennsylvania, and Tennessee) entered into partnership arrangements with the Government of India to establish several other agricultural universities (Parayil 1992, p. 747). Manjit S. Kang in a daily newspaper *The Tribune* 29 January, 2010, cited Mira Kamdar, a Senior Fellow at the World Policy Institute, New York: “If a single institution can take credit for bringing the Green Revolution to Punjab, it is Punjab Agricultural University.”
Up till Green Revolution

After Independence, India’s agriculture was in worst condition. To improve the condition an independent Agricultural Department was established by the Central Government in late 1945. Intensive Agriculture District Program (IADP) was launched in earlier 1960s. According to Dasgupta, the economic situation in India during the mid-1960s was the worst ever during the post independence period as per-capita income was at its lowest, unemployment was rising, and the country was heavily dependent on foreign food aid. Parayil (1992) cites Dantwala suggesting that growth in agricultural production in India up to the year 1965 was disappointingly low, with severe famines still possible.

In 1950-51, Punjab was having total cropped area of 4170 thousand hectares and net area sown was only 3544 thousand hectares (Statistical Abstract of Punjab 1968). “In partition Punjab state got divided in west and east Punjab state and it was left with only 30% of the canals of the old Punjab.

Most of the irrigation that we see today has been constructed since independence” (Gill 1983, p.840). Parayil (1992) cites Dantwala (1977) that “from 1937-38 until 1951-52 the food grain production in India declined at a rate of 0.68 percent per year. Whatever little increases, there were in agricultural production from the time of independence until the early 1960s were attributable to increase in acreage. With Green Revolution, Government put all the efforts to modernize agriculture for bringing prosperity. Prerequisites like proper climate, soil, attitude for hard work, and most important canals for irrigation were available in Punjab.
The Green Revolution

Year of 1966 was a watershed in the history of Punjab on two accounts. The erstwhile Punjab was divided into the states of Punjab and Haryana and Green Revolution technology comprising HYV was introduced.

Green Revolution involved the use of seeds of high-yielding varieties (HYVs), primarily of wheat and rice, and the adoption of a package of improved agricultural practices involving fertilizers, pesticides, controlled water, credits, mechanical threshers, pumps, and so forth. These changes were instituted in place of the “traditional” agricultural practice involving the use of seeds whose genetic makeup goes back thousands of years.

(Parayil 1992, p. 737)

Wheat, which was traditionally both a food and a cash crop, has been joined by rice as became commercial crop for the Punjabi farmer at the expense of the traditional commercial crops such as ground nut, rapeseed and mustard (Sidhu and Sidhu 1988). Thus the traditional choice of crop selection in agriculture got changed with inception of Green Revolution. Gill asserts:

The Green Revolution in India during the 1960s and early 1970s was mainly a wheat revolution. What is more, it was mainly a Punjab revolution. The wheat crop of 1965-66 in the Punjab was a little over 1.9 million metric tons. In 1966-67, the first year, with the Mexican seeds, it jumped to 2.45 million metric tons. In the next four years, as the new seed spread in the state, production rose rapidly until it stood at 5.62 million in 1971-72. By any standard, the rise from 1.9 to 5.6 million metric tons over a five year period is a remarkable achievement. (Gill 1983, p. 831) (emphasis added)

But some scholars viewed that the real gain was started in 1970s because agricultural productivity increased steadily until 1975. According to Chengappa 1989 and Sud 1989 after 1975, the increase in productivity began to level off on an S-shaped productivity curve. By this time farmers in parts of India had realized a two- to threefold increase in
their yield compared to the 1965 base. Agricultural productivity began to show
considerable increase again in the mid-1980s, which some analysts identify as the second
Green Revolution (see Parayil 1992, p.746).

For profit maximization, farmers adopted new crops and compromised with the
sustainable development due to which number of problems grounded their roots.

The earlier practice of inter-cropping was increasingly replaced by single-crop
cultivation based on the new improved seeds and assured irrigation. An important result
of this shift in cropping pattern was greater dependence on canal as well as tube well
irrigation, a major political fall out of which was the sharpening of interstate dispute over
the distribution of river water and a rising discontentment in Punjab particularly among
the Jat Sikh peasantry further, with the rising demand of electricity as well as in
industry…(Abbi and Singh 1997, p.45)

Prerequisite of Green Revolution was the components like assured water supply,
mechanization, fertilizers, insecticides etc. In 1965-66 the number of tractors was 10636.
It increased nearly three times in 1971-72 and showed four times increase just within a
short span of six years. The total numbers of tractors was 68,762 in 1977. In 2001-02
tractors were 365,000.

Mechanization and adoption of new pump technology affected the agriculture and natural
resources. Water table for instance also started declining after inception of Green
Revolution.

In 1964 the entire area of central Punjab had water table above the depth of 15 feet. After
introduction of Green Revolution water table started declining and the area having water
table below 30 feet depth increased from 3 percent in 1973 to 90 percent in 2004. (Hira
2008, p.201)

Ghuman et al. (2007) concluded that the Green Revolution ushered in during the latter
half of the 1960s, transformed the food deficit Indian economy into self sufficient
economy. However, in the mid 1980s the Green Revolution started fading in Punjab as the yield and production experienced a tendency toward stagnation.

Wiser argued, “Each served the other. Each in turn was master. Each in turn was servant. This system of inter relatedness in service within Hindu community was called the Hindu Jajmani system” (Wiser 1969, p. xxi). Central to such a construct of exchange is the idea of reciprocity (Gouldner 1973, p.173-220) with the implicit or explicit assumption that it was a non-exploitative system where mutual gratification was supposed to be the outcome of the reciprocity (Bhattacharya 1985, p.114-15).

**Since Green Revolution**

(i) Social implications

The question what was the social implication of Green Revolution on the different strata of Punjabi rural society? Such a question is important to answer because the impact of Green Revolution is not same for all the categories of farmers.

After independence the social, political and economic forces acted in a way which gave no other option to adopt new package in country. The package increased the production and agriculture became market oriented though it was the manifestation of the new package. It provided mobility to the farmers. The package had manifold affects and it was studied by many scholars.

Frankel observed that after the Green Revolution, “Social polarization and social conflicts have emerged much more quickly than originally anticipated” (Frankel 1971, p. 201). He also pointed out that the Green Revolution contributed to the breakdown of the traditional interdependent relationship between peasants and landlords (Frankel 1973). Thus the traditional social relation changed and capitalistic
relations grounded their roots. It made many of the traditional occupations redundant and
the jajmani relations disintegrated rapidly (Aggarwal 1971; Karanth 1987).

T.K Oommen (1971) asserted that the agrarian unrest and the economic disparity
believed to have resulted from the Green Revolution. Similarly Wolf Ladejinsky (1969)
pointed that the greater the impact of the Green Revolution in an area, the more the
disparity between the rich and poor, and the greater the prevalence of agrarian tension.
Thus the agrarian problems dwelled on the new ground after the Green revolution. Hence
the package was biased toward small and landless farmers. It was shown by many studies
that Green Revolution has widened the gap and increased the social and economic
problems (Brown 1970).

Aggarwal (1971) has found that the large land owning farmers have prospered with the
help of various government agencies, including banks and cooperative societies. The
small cultivators and the land less labourers, on the other hand, are losing ground in many
ways. He notes that one of the most important effects of the Green Revolution has been
on the traditional jajmani system. The demand for traditional services on barter terms has
been completely eliminated. Agriculture has increasingly become market oriented, and
commercial farming is widely practiced in the more progressive areas. This has greatly
added to the demand for seasonal labour at the peak periods of agricultural operations and
as a sequel substantially increased the bargaining power of the farm workers, who can no
longer be forced to do *begaar* for their former jajmans. In fact the farmers himself likes
to pay the wages in cash rather than in kind since, with the rising prices, the traditional
mode of payment often proves costlier. Thus, although the traditional structure got
transformed and a new set of dependencies came in. It jeopardized the century old *agrarian*
setting, cooperation, solidarity. “Murray Leaf and Mahmood Mamdani's extensive field research in
the Punjab also shown the same result that the changes in economic and social factors to be dramatic and irreversible” (Parayil 1992, p.753).

But Mandal and Ghosh (1976, p. 110) stated that Green Revolution has been able to increase income and employment in the villages under study without creating any social tension in the wake of development. Economic values rapidly replacing the former social values and generated urban oriented individualistic behavior between the landowning and the former services castes and even the landless labourers (Kahlon et al.1972, p. 6).

Parayil (1992) pointed that

Before the Green Revolution, almost all cultivators were peasants who mainly produced for subsistence. Markets were rudimentary or nonexistent. Peasants obtained what they could not produce but needed for subsistence from other peasants by exchanging grains and whatever other commodities they produced. Agricultural laborers and other rural skilled laborers like carpenters and blacksmiths were mostly paid in grain or other agricultural produce. Their technology was pre-industrial, with energy supplied mainly by humans and animals. In areas where it took root, the Green Revolution replaced one way of life with another within a short span of two decades. The peasant cultivators became farmers for whom agriculture was a calling beyond subsistence. They sold most of their produce in the markets. Agricultural laborers and other skilled workers whose help was needed in maintaining agricultural machinery were paid in cash. Along with an increase in agricultural productivity came a higher demand for farm labor, and with this came increased wages, which sometimes doubled in four to five years. Modern technology began to make a strong impact on agricultural practices in more favored areas. The social, political, economic, and cultural gap between rural and urban areas began to shrink. (Parayil 1992, p.738) (emphasis added)

Thus the old fabric of Punjab got transformed. The barter system, jajmani system and the traditional culture were shaped. It indicated that the pattern of social intercourse and
interdependent is different in commercialized agriculture production. At one side Punjab has experienced a situation where it achieved the status of ‘food bowl of India’ with the rapid transformation but on other side it directly bearing on the social relations in agrarian society. Jodhka pointed that “Green Revolution was first introduced in Punjab, it also matured here before it did in other places in the country. The new technology raised productivity of land by several folds. It also changed the rural social structure and had a direct bearing on the nature of local and regional politics” (Jodhka 2006, p. 1530).

It is generally believed that new package has brought changes in social relation of production and in the nature of occupation. Shiva argued that it is not merely a technological innovation meant for increasing productivity of land and bringing prosperity to farmers. Its negative consequences far exceeded its benefits. The Green Revolution introduced commercial culture in rural Punjab and destroyed the community. It changed social relations, from those based on mutual obligation to those based purely on the market principle. Shiva marked that

‘Green Revolution’ is the name given to this science-based transformation of Third World Agriculture, and the Indian Punjab was its most celebrated success. Paradoxically, after two decades of the Green Revolution, Punjab is neither land of Prosperity, nor peace. It is a region riddled with discontent and violence. (Shiva 1992, p.19)

As a consequence of new technology “Atomised and fragmented cultivators related directly to the state and the market. This generated on the one hand, an erosion of cultural norms and practices and on the other hand, it sowed the seeds of violence and conflict” (Shiva 1991, p. 171). The development was not equal for all. However it was noted that the important elements with in the society got changed with it.
“The dramatic gains in the income being realized by farmers who are able to use the new seeds, abruptly widens the gap in living standards and the consequent conflicts between them and those are still tied to traditional husbandry practices” (Brown 1970, p.11). It is noticed by the scholar that marginalization of small farmers is the main draw back of the new technology. Oommen (1974), in his paper ‘Impact of the Green Revolution on the Weaker Sections’ has made similar observations. According to him “the small peasants did not benefit from the Green Revolution as much as the big farmers. Agriculture inputs made available with the onset of Green revolution could not be secured by the small peasants as their economic resource base is feeble” (Oommen 1974, p. 421).

The Green Revolution thus started a process of depeasantisation of the peasantry, through increasing costs of cultivation (Shiva 1991, p. 124). Those poor farmers who could not made investment in buying costly inputs faced down fall and suffered from relative deprivation.

The implication of Green Revolution was not limited to peasants (small, marginal or large) but also has affected the labour. Bhalla (1979) in his paper on ‘The Green Revolution in the Punjab: Rural structural changes in Non-Metropolitan regions’ concluded that the Green Revolution has marginally increased the income of agricultural labourers in Punjab. It has created a greater demand for agriculture labour so that the level of wages has become appreciably higher. The number of agricultural workers has increased in all the districts of the state in part owing to the fact that the small farmers with lower landholding find agriculture a non profitable business. On the other hand the number of cultivators has remained more or less the same in all the districts. Agricultural laborers gained in terms of higher wages and more days of work due to the higher volume of crop productivity (Blyn 1983, p. 705-25). Other study pointed that wages in Punjab
have risen significantly and virtually stagnated after the mid-seventies (Rao 1989).

Similarly a case study on the impact of the Green Revolution on rural Punjab by Abbi and Singh prepared in 1997 also concluded that the social gap between the higher and the lower castes became negligible in this period. A major change in the caste hierarchy was visible in both public ceremonial functions and interpersonal relations, strengthening the cross-caste alliance. The cross-caste similarity of lifestyles, helped to promote egalitarian social interaction.

Green Revolution has transformed economy, society and culture too “but at the same time it has become the reason for ethical and moral crisis. Circulation of new cash in a society [disturbed] the old forms of life and dislocated to an epidemic of social diseases like alcoholism, smoking, drug addiction” (Shiva 1992, p.45). The traditional culture and fabric of Punjab lost in new infrastructure of Green revolution. The capitalistic mode of production made land a commodity which was used to generate profit. In profit all the social relations were lost.

Rao (1979, p. 353) analyzed the different variables and the impact of modern technology on two villages of Kolar district of Mysore, now Karnataka. The author is of the view that the new seeds are labour intensive. They have created additional employment for both the classes – farmers as well as agriculture labourers. He asserts that – the additional incomes generated by the new crops has not resulted in the increase of real wages to farm labourers. He also finds that the additional incomes generated by the new farm technology have improved the quality of life of the adopters.
This upward trend in the production affected the social life of the farmers. “The increase in the incomes of farmers raises their investment surplus as well as their credit-worthiness for the purchase of machines…with the rise in the income of farmers, the desire to lessen the drudgery and hard work asserts itself” (Sharma 1993, p.23).

Dependency on market for buying inputs and for selling outputs (produce) of farmers increased. The uncertain production and costly inputs forced farmers to get into the trap of credit. During ancient period, farmers were dependent on moneylenders, who were taking advantage of misery and ignorance and thus exploit the farmers. Government provided solution to this problem and created banks and societies that much of their credit went to the expensive informal sources (Thorner 1964; Oommen 1984).

Green Revolution followed by mechanization. Combination of both increased the food grain production and shifted agriculture. Mechanization not only affected agriculture but it also affected the labour and status of women. It opened a new channel for them. Agriculture needs labour so it provided an opportunity to the women to work in family agriculture work. Their active participation in the fields at the time of irrigation and other important time affected their status.

Women started actively participating in the agriculture. The use of new technology may have improved the bargaining power of female labour for operations such as transplanting and inter-culturing on account of the rise in seasonal demand for such labour (Rao 1989). Post Green Revolution also attracted migrant labour. These *bhaiya* labourers are becoming permanent feature of Punjab agriculture (Abbi and Singh 1997, p. 56). Farmers are now more dependent on the migrant labour for hard work.
because they get cheap labour who live at the farm. The farmer gets both labour and the guardian of the field.

The circumstances have changed dramatically since then. Leaf’s study that credit cooperatives completely replaced private moneylenders between 1965 and 1978 in Punjab villages proves this point.

Pray (1982), in his paper, ‘The Green Revolution: An Appraisal’ has discussed in detail the effects of Green Revolution in all the less developed countries (LDC’s). According to him the Green Revolution has a positive impact on the income and employment in all the countries of adoption. However, regional disparities within the LDC’s have frequently widened, and within the regions that gained, all may have benefited more than labourers. He is of the view that though for the landholders the technology is neutral, “existing structural inequalities and independence shifts in supply of factors of production have led to an unequal distribution of the gains” (Pray 1982, p.33). Pray finds that in most LDC’s the distribution of income and power is worsening and/or the richer members of the commodity are gaining control over land.

(ii) Economic implications

The changes produced by Green Revolution generated interesting debate among the scholars. The economic implications of the new package on the three main social categories: maliks (landlord), kisans (the working peasants) and mazdoors (the labourers) is focus of this section.

Initially it was viewed that the benefits of the package was cornered by the large landholders. It is made out that owners of land are more likely to adopt HYV’s of seeds than tenants because of the risk factors. So it is said that the fruits of Green Revolution are pocketed mainly by the rich and prosperous farmers, and the disparities between them and the have-nots particularly landless agricultural labourers
has increased. The increased disparity leads to a sense of deprivation among the weaker and poorer agrarian classes and their frustrations are manifest in agrarian tensions, occasionally leading to the eruption of violence. It was also viewed that it has affected only small segment of million of farmers (Chakravati 1973).

The large landlord is after modern inputs for cultivating the land. The main tractorisation may have helped large farmers in increasing the possibility of multiple cropping and provided the substitute of labour. However, it seems that the adoption of tractors by small and marginal farmers was not always economically justifiable because of its economic constrain. The larger farmers experienced an absolute increase in their output, the gap between large and medium farmers widened.

Where as the gains from the Green Revolution is different for the labour/ mazdur section. It was viewed by scholars that after Green Revolution cash wages of agricultural labourers had gone up, their purchasing power has in fact come down due to overall increase in prices (Bardhan 1970). In contrast to such view Blyn concluded that agricultural laborers gained in terms of higher wages and more days of work due to the higher volume of crop productivity (Blyn 1983).

According to Abbi and Singh (1997), after the Green Revolution the price of land rose much higher and faster so farmers found it more profitable to redeem their mortgaged land and lease it on cash basis to local farmers. Similarly Bhalla (1974, p.A-139) contends that the “landlords might find it more profitable to continue exploiting the tenants through exorbitant interest charges on consumption loans rather than to make investments in new technology” (Bhalla 1974, p.A-139). Parayil (1992) cited Aggarwal (1974) on the other hand some viewed that the Green Revolution resulted in the transformation of peasants into farmers”.
Changed agriculture after Green Revolution has manifold effects on the different strata of the farmers. The primitive subsistent and traditional mode of production became capitalistic, where production was basically produced for the market. In the market economy, farmers have turns managers of the production process of agriculture because the manual operations have been almost eliminated and the remaining tasks are being done by the migratory available at the low level of wages (Gill and Singh 2006).

Production gains were mostly enjoyed by large farmers. Tenants and small farmers was not the beneficiary. They spent most of their gains in adopting new inputs or returning the credit which they had taken in adopting new technologies. This new technology of Green Revolution involved working capital for the purchase of new inputs. In that situation marginal and small farmers had started struggling to manage these new inputs. In struggle if they were able to manage the cash then the life of the farmer would be easy other wise conflict, tension and other psychological problems resided him.

Scott and Franklin (1969) examined the effects of changing technology on lease adjustment and found that the effects of new technology often resulted in to increasing net rent by shifting costs of new technologies to the tenant in existing share leases or by changing to a cash lease negotiated to produce a higher net income to land.

Robert Repetto (1994) asserted that the “Green Revolution is more tube well revolution than wheat revolution”. Similarly, Dhawan noted that Green Revolution has come to be closely identified with well irrigation, more so with modern wells using pump set technology. Precisely owing to the higher extraction capacity of a pump set as compared to a traditional water lifting mechanism (Dhawan 1982 and 1990). Groundwater resource has come under pressure.
In 1970-71 there were only 1.92 lakh Tube wells in Punjab, in 80-81 there were 6 lakh tube wells, and in 90-91 number went up to 8 lakh, 2000-01 again number rose up to 10 lakh and now there are about 14 lakh tube wells... In 1973 only 3% area of Punjab has water table below 10 meters, it goes up to 14.9% in 1989, 20% in 1992, and 28% in 1997, 53% in 2000, 76% in 2002 and in 2004 the situation goes beyond expectations when 90% area of Punjab is drawing water from the depth of more then 10 meters. More over 30% area of Punjab has depth of 20 meters or even more. (Umender Dutt 2006)

Scholars like Hira (2008) stated that the declining of groundwater has started after inception of Green Revolution. Such alarming situation has jeopardized the initial benefits of Green Revolution. HYV Seeds thus introduced were water thirsty which pushed the farmers to own individual pumps. In 1990-91 tube-wells irrigate 57 percent of the areas and in 2006-7 it rose to 71 percent. Punjab has a network of about 11 lakh tube-wells. It’s net cultivable area is 43,00,000 hectares and bet irrigated area 40,60,000 hectares. And if we notice irrigation through canal it was in 1949-50, 3.6 million acres. In 2001-01 the area irrigated by canals came down to 9,62,000 hectares and through tube-wells it went to 30,74,000 (The Tribune, 24 January, 2008).For managing water for their production farmers installed pumps. In a way it gave way to private pumps. It became a major reason for groundwater exploitation.

Bhalla (1972) noted that Green Revolution in Haryana has helped to increase the output, income and productivity of all categories of cultivators who have adopted the new technology. The output per acre obtained by progressive farmers is almost double that recorded by their non progressive counterparts. All such situation had created discontentment among the farmers and between the productive relations.
Dasgupta (1980) observed that the gains are inequitably distributed between the rural population within a given region. But the cost of the new technology to a large extent is borne by all the regions and by all the sections. Per acre yield of major crops has been rising in the wake of the new technology. Aggregate agriculture income has also gone up. Yet the proportion of rural families under the poverty line is higher today than before. In fact efforts to improve the situation with the package has it’s constrain too.

Rao (1975) inferred that Green Revolution had led to an increase in regional disparities of productivity per acre of major crops. It displaced other crops because farmers found cultivation of rice more beneficial.

After the Green Revolution, agricultural activities have become cash-based individual enterprises requiring high investment in modern inputs and wage labour as is evident from the list of states with high incidence of farmers’ suicides, which are not necessarily backward or predominantly agrarian or with low income, according to the NCEUS report (Financial Express 22 Dec, 2008).

Some scholars even suggested that the Green Revolution technology even lead to a Red Revolution (Ladejinskly 1969 and 1973). That means that it has resulted into violence, discontentment and conflict because small and marginal landholders and labourers did not benefit from the Green Revolution. In managing new implements, inputs for agriculture, farmers evolved in credit system. After such step the whole life and income of the farmers were spent to get rid from the debt, some time indebtedness became so distressing that farmers committed suicide.

Other main effect of Green Revolution is that it increased instability in food grain production. Only rice and wheat cultivation start dominating among the crops and these two crops displaced other crops, cereals etc. All this happened because Green
Revolution pushed agriculture toward mechanization. It introduced new technology for irrigation, and farmers full utilized those technologies and it resulted in depletion of aquifers. Technological innovation increased the production and changed the pattern of production. All the HYV seeds are water intensive which directly affected the water table. Farmers installed advance technology pumps for irrigating water thrust crops and its long term consequence is falling of water table

Brown noted that “the drastic gains in income being realized by farmers who are able to use the new seeds, abruptly widens the gaps in living standards and the consequence conflict between them and those who are still tied to traditional husbandry practices” (Brown 1970, p.11).

From above discussion it is found that Green Revolution affected all the segment of rural society differently. Some segments got benefited and others not.

(iii) Ecological implications

Punjab was considered a wealthy state at one stage, but it is presently facing a number of crises. The roots of present crisis and constrain on ecology is peculiar to discuss. HYV, pesticides, fertilizers and irrigation all these came together with Green Revolution package. In seeking for high production farmers has been using more and more fertilizers and pesticides. By which the excess use of pesticides have entered the food chain and contaminated all components of the environment (Randhawa et al. 1998).

The water demand of the new HYV seeds could not met by the limited and uncertain canal supply. Thus farmers started groundwater has been drafted with tube-wells in large numbers. It required heavy investment and requirement was fulfilled with cheap long-term credits and cooperative banks. “Long-term loans rose from Rs. 3.1 million
in 1960 to Rs. 128 million in 1972” (Gill 1983, p. 831). Thus the problem of indebtedness turned worst.

The continuation of monoculture, i.e., wheat and rice crop rotation, for a quarter of a century resulted in a severe ecological crisis in the form of soil degradation, groundwater depletion and appearance of new pests and diseases (Aulakh and Bahl 2003; Brar and Chibba 1994; Sidhu and Dhillow 1997). Pesticides have emerged as a source of great harm to human health, production and preservation of food, fiber and other cash crops. The indiscriminate use of pesticides in intensive agriculture has created many ecological, environmental and social problems (Dhaliwal et al. 2002).

The signs of acute stress become visible by looking at groundwater situation of different blocks. Researchers like Singh et al. (2003) concluded that (i) in nearly three-fourths of total area of Punjab, the groundwater is over-exploited; (ii) the magnitude of exploitation increases when there is monsoon failure in the region; and (iii) in a significantly large number of blocks, the groundwater balance is highly negative (Singh et al. 2003, p.25).

A comparative analysis of data for Punjab in 1995 shows that poisoning appears to be the most convenient means of suicide. As many as 58 percent persons committed suicide by consuming pesticides (IDC, 1998). This is revealing, as it also gives an idea of the impact of the Green Revolution on the mode of suicide in the state. The use of pesticides is rapidly becoming a serious health hazard in Punjab villages.

Scholars pointed out that cotton was the main crop in the southwest part of Punjab in 1950, and was under long and medium-duration varieties. With the shift from cotton-wheat rotation by the mid-seventies and to early maturation and early flowering varieties,
the incidence of pests increased. This necessitated higher use of insecticides (Dhawan 2000a).

This new seed-fertilizer technology made natural resources as a commodity which is now sold in the market and for greed for more profit, these resources are exploited and resulted in their depletion. Agriculture scientist have pointed out that the abuse of natural resources has led to the environment degradation; the salinisation and water logging are the unintended consequences of the green revolution in India (Ahlawat 2003).

Adoption of HYV seeds increased the production but other problems which accompanied it had worst effect on farmers as well as on ecology. Such water thirsty crop created large pressure on assured irrigation. The only and reliable source of irrigation is groundwater. Studies have shown that groundwater irrigation from private tube-wells is an important factor in the new technology (Dhawan, 1979). Its result is visible by increasing numbers of dark zones in the state.

Depleting water table is one of consequence of Green Revolution’s thirsty crops. It has drastically destabilized the water balance throughout the region. Joshi and Singh suggested that the water table is receding at the rate of 0.3 to 0.5 meter per year due to increase in tube well irrigation (Gill1994). S. V. Ciriacy-Wantrup asserted “The Green Revolution has created a need for more water. Groundwater tables are beginning to fall and will force the replacement of the Persian wheel by deep-well pumps” (Ciriacy-Wantrup 1969, p.1322). Nowadays the result of depletion is the increasing numbers of dark zones.

In 1984 there were 53 blocks as dark zones, in 1995 these were 84 and in 2005 the figure went up to 108 out of total 138 development blocks in Punjab. Ground water
level started falling much faster than assumed. Hira concluded that in 1964 the entire area of central Punjab had water table above the depth of 15 feet. With the inception of the Green Revolution in the 1960s, the water table started declining and the area having water table below 30 feet depth increased from 3 percent in 1973 to 90 percent in 2004 (Hira 2008, p.200). The acute water problem has entrapped the state of Punjab badly.

Malsingh Wala has already declared itself as 'village for sale'. Even earlier village Harkishanpura which was first village to put itself on sale has also severe water problem. There is no water for irrigation neither for drinking. The water crisis made village insolvent and compelled villagers to put village on sale. The situation is almost same in whole of Malwa region. The severe water crisis is also becoming a social stigma upon some villages. It is tough to find bride for village youths as no body wants to marry his/her daughter to these villages. Water crisis is so pitiable that village Buladewala with population of 6000 is getting water from 2 hand pumps only. Situation is so grim that in urban and sub-urban areas people are forced to install expensive submersible pumps to fetch water. More is the depth more it costs on drilling and then it needs further higher capacity motor to fetch water and more power bill; it is unending process not parts of the Punjab. (Umendra Dutt 2006, p.2)

In an article ‘Green Revolution- Inequitable and Inadequate’ cited a report by the M. S. Swaminathan Research Foundation and the United Nations Development Programme mentioned that “the pattern of land ownership and unequal access to water, credit and other resources led to overuse of irrigation water and chemical fertilizer by the rural elite” (Economic Times 19 May, 2003).

Twenty years of Green Revolution, have however succeeded in destroying the fertility of Punjab soils which had been maintained over centuries by generations, and could have been indefinitely maintained if international experts and their Indian followers
had not mistakenly believed that their technologies could substitute land, and chemicals could replace the organic fertility of soils (Shiva 1991). Green Revolution has left the Punjab ridden with discontent and violence. The Punjab is beset with diseased soils, pest-infected crops, waterlogged deserts and indebted and discontented farmers. Instead of peace, the Punjab has inherited conflict and violence (ibid. 1991).

Rapid demographic growth, expansion of water intensive technologies and the new cropping pattern have brought about these crises (Saleth 1994). Such manifestations showed the crisis which has reached unprecedented gravity where the extreme poverty and suicide was the end solution.

**Conclusion**

Technology is an important constituent of the mode of production that alters the social relations. The structure of agricultural production has changed after the introduction of new technology. Agriculture got modernized and commercialized since then. But the gains from this revolution were short lived as the above discussion shows. At present, when growth rates of agricultural production are decelerating and where about 65 percent farmers’ households are under debt, large scale unemployment (approximately 20 lakhs, out of which 15 lakhs are in rural areas), ecosystem is fragile, the state seems to be heading for a serious crisis. So at present stage, rather than blaming the cause, one has to find the solution.
Section B

Developments in Water Technology

Earlier section covered Green Revolution and its implications. This section covers the developments in water technology. It tries to trace the traditional and modern mode of irrigation.

Introduction

Irrigation plays an essential role in development in agriculture and had been extensively practiced from very early times. To tract the earlier mode of irrigation Sengupta mentioned that “It is difficult to decide how exactly irrigation practices had begun in India. But there can be little doubt that the development of irrigation systems received a great impetus after the discovery of iron and extensive use of it from around 3000 years before present” (Sengupta 1985, p.1919). The magnitude of development in irrigation technology for making agriculture easy took boost after introduction of iron. Historical literature traced the earliest irrigation system in Indus valley civilization. In this section an attempt is to present, the outline of the traditional mode that was charas and hult to present tube-well and submersible pumps. Expansion of technology for irrigation in Punjab in particular has been divided into three phases.

Three phases are:

- The first one related to period of Persian Wheel: the period before the Green Revolution. Punjab was self sufficient in water resource and as a result limited groundwater was in use. Canals were also another important source.
• The second was the period of Green Revolution in which dependence on groundwater increased tremendously. Adoption of electric and diesel pumps. Such led to intensive exploitation of groundwater.

• Third is the period of Post- Green Revolution when excessive dependence on pumps for groundwater and it has created an alarming situation.

**First phase**

Irrigation development in Punjab was peculiar to discuss for understanding the changing agriculture and factor which brought these changes. “Irrigation received a boost around the 13th century A.D when the Persian wheel became increasingly popular in Punjab (Habib, 1969). Irrigation was further augmented with the construction of the Shah Nahr by Shah Jahan in the 17 century. Historically, the Majha and the Bist doab regions in Punjab was a greater beneficiary of the extensions in irrigation through wells or canals. During British rule the efforts of irrigation development accelerated. The dynamism of Punjab agriculture during this rule was mainly due to the development of irrigation infrastructure. Immediately after annexation the British government repaired, renovated and expanded the old canals and then, beginning from the 1880s, built a number of new water works with the help of borrowed funds (Islam 1997).

During colonial period, Punjab witnessed a major change in irrigation system, Britishers introduced new technology for irrigation and they followed a policy of rapid agricultural development. Brar The Upper Bari Doab Canal was the first one to be built in 1860-6. The Sirhind Canal was completed by 1887. It irrigated 728,424 hectares in the districts of Firozepur, Ludhiana and parts of the princely states of Patiala, Nabha, Faridkot, Jind, Malerkotla and Kalsia. So with such changes government realized that development in irrigation by the construction of canals,
land can be transformed into prosperous agriculture areas. All such ideas proved true and agriculture of Punjab improved a lot. Thorburn described canal irrigation as “colossal, productive and life creating and preserving.” Chattaraja (2000) cites Report of Abiana Committee that canal water was the greatest boon which the government can confer upon its subjects.

**The phase of Persian wheel**

Traditionally wells were the important source of water for domestic and agricultural purposes in Indigenous societies. From references in the Beburnamah it is clear that there had been considerable use of Persian wheel as early as in the early sixteenth century (Singh, Jan-mar 1985). Various methods were used to lift water from wells: Persian wheel, *charas*, tube-wells powered by oil engines or electricity and now deep submersibles.

The Persian wheel was an intricate piece of construction and in this respect it varied from district to district. But basically it consisted of a large drum (*bair*) over which passed an endless rope or iron-ladder (*mahl*) with miniature buckets attached to it at a distance of one or two feet. The ladder with the buckets reached below the surface of water in the well and the drum with the buckets was revolved with the help of a simple round-about gear worked by a pair of bullocks (Trevaskis 1931).

A Persian wheel had several advantages over the indigenous water lift- *charas* or *dhenkli* firstly, for a Persian wheel, was less water intensive. Second it supplied large volume of water (Islam 1997, p.53). Persian Wheel had leather bag and it was raised and lowered by a team of bullocks walking up and down a ramp) and for shallow lifts *dhenkli* (the counterpoise lift) replaced the *jhatta* (the hide scoop) (Islam 1998, p. z). Increased supply of water became the reason for expansion of cultivated area and
reduced the risk of crop failure. It provided a boost in agriculture development. The main feature of Persian wheel was that it was build, maintain, and operate by farmers themselves and they used it either by themselves or with the help of a small number of villagers. This mode of irrigation played a significant role for society and social relations. For digging and construction of well, all villagers came together and helped one another. At that time, cooperation and solidarity existed among villagers. S. V. Ciriacy-Wantrup mentioned about Persian wheel that

Water is available to the individual farmer where he wants it, when he wants it, and in quantities and over time periods that are under his own control. An irrigation economy dominated by the Persian wheel differs greatly from one that is based on diversion from large rivers, such as in ancient Egypt and Mesopotamia, or, in modern times, from large multipurpose reservoirs. Here, the individual farmer is dependent on other farmers for building, maintaining, and operating the diversion facilities and the canal system that distributes the water. He must take his water at certain points on the canal. He must take his turn as to when the water is available to him. Quantities of water are rationed to him, and these rations may vary over time for reasons outside his own control. (Ciriacy-Wantrup 1969, p.1321)

Further he marked that groundwater resource was being used traditionally. “In northern India, irrigation has been based for centuries on groundwater lifted from open wells by the Persian wheel, a simple but ingenious device to develop groundwater resources where they are available in large quantities not more than some 40 feet below the surface” (ibid 1969, p.1321).

The Persian wheel was such a technology which made easier for farmers to adopt new water technology. It augmented easier installation of suitable engine and pumps in the well. Islam (1997, p. 53) cited according to the Live-stock Census Report, 504 oil
engines with pumps for irrigation purposes and 268 electric pumps for tube-wells were in operation in the province in 1940. “Around 1960, Persian wheel began to be replaced by diesel powered tube-wells either fitted into the existing wheels or freshly installed. Later, in around 1964-65, with the electricity supply becoming available the more costly diesel powered tube wells came to be increasingly replaced by electric powered ones…” (Abbi and Singh 1997, p.45).

However, it is clearly noted from different studies that many indigenous works were directly suppressed by the extension of modern methods. We have already noted such cases as “shrinkage in incidences of traditional well-irrigation in UP and Punjab first, from the extension of canals and lately because of modern groundwater exploitation techniques” (Sengupta 1985, p.1930).

After one century, means in nineteenth century whole picture of irrigation had changed. After independence, government also brought a lot of changes in irrigation system, technology and in methods. Even number of agencies, commissions and policies was developed for the betterment of irrigation. In that scenario everyone aware of the fact that irrigation is the strong tool in the development of agriculture. Among many steps and efforts, Green revolution facilitates the irrigation system.

In 1947, the Indian Punjab was left with only 30% of the canals of the old Punjab. Most of the irrigation that we see today has been constructed since Independence. The Bhakra Dam was built first, then Beas, and now work has started on the Thien Dam. It is also sometimes suggested that the Bhakra Dam was given to the Punjab by the nation. This too is incorrect, since it was built out of the normal plan resources of the state. (Singh 1983, p.840)
**Second phase**

**Introduction of Groundwater Harvesting Technology Demand of Green Revolution**

During the 1960s, Punjab became the bread basket of India as a result of the adoption of a technological package referred to as the Green Revolution. The natural condition of ecology underwent a deep change. At the time of introduction of Green Revolution it was viewed that it was a strategy which was introduced for the underdeveloped and developing countries to increase food grain production but its result or output was paradoxical. According to G.K. Chadha “Green Revolution was short term gains at the cost of long-term losses”. It is interesting to note that during the last five decades there has been a rapid change of technology in irrigation. Besides rain water and canals, *charas* and *hults* (Persian wheel) were used for irrigation before 1950. With Green revolution came in centrifugal pumps, tube-wells and, more recently, submersibles.

Prior to Green Revolution, canals and wells were the sources of irrigation. But after Green Revolution there was a transition to diesel and electric pumps. Villages of Punjab have seen fundamental shifts during the period following the Green Revolution (Jodhka 2006).

Lakwinder Singh asserted

Canals and animal-worked Persian wheels, the two main sources of irrigation, had been used by farmers. Later it gave way to expansion of new technology i.e. was pumps as a source of irrigation. The expansion in groundwater irrigation in the state was facilitated by the availability of underground water at a reasonable depth, availability of local expertise in drilling and lifting technology and active government involvement in rural electrification, subsidized supply of power and expansion of liberal financial assistance for setting up tube-wells. (Singh 2008, p.209)
According to S. V. Ciriacy-Wantrup “Green Revolution has forced the replacement of the Persian wheel by deep-well pumps. Increasing size of farms, related to the Green Revolution, will operate in the same direction because of the Persian wheel's relatively low capacity and high labor requirements. Increased irrigation will increase the need for drainage” (Ciriacy-Wantrup 1969, p.1322). HYV seeds required more water which was only fulfilled by new water harvesting technology, so the farmers had shifted to groundwater for irrigation by using tube wells and submersibles. Mainly irrigation is a lynchpin in the Green revolution package of technological inputs for agriculture (Dubhash 2002). Farmers installed advanced technology pumps for irrigating water thirsty crops.

While there has occurred an explosive growth of power pumps and tube wells since 1951 there has occurred hardly any addition to the number of traditional water-lifts (Dhawan 1975, p.A-31). Modern energized lifting methods have reduced the labour requirement but work against the interest of the poorer cultivators. As against major irrigation projects, in the medium-scale ones the cultivators can know, long before the need arises, how much water is available to them. They are in a position to determine the optimum allocation of water amongst themselves (Sengupta 1985).

As early as in 1971 as much as sixty per cent of ground-water lifted was by the modern methods (Dhawan 1975, p.A-35). After 1971 the rate of expansion of tube-well irrigation has in-creased considerably, so much so that presently this source alone accounts for most part of extension in net irrigated area in the country. The number of dug wells in the operation fell from 235,000 in 1969 to 113,000 in 1978.
in Punjab and Haryana because of depletion of water table to uneconomic depth (Dhawan 1982, p.154).

Billing and Singh pointed out the effect of Green Revolution on labours and said that the “traditional technology combines limited capital, the extent of technical knowledge, and the abundant supply of labour… Hence traditional technology was able to provide at least a small share to most people almost every year…there are, however social benefits which follow from the production of cheaper and larger quantities of farm products made possible by mechanization. Society must weight these alternatives: cheaper more abundant food versus at least some decline in rural employment (Billing and Singh 1969, p. A-221). Where as Hira Singh (2008) pointed that causes for depleting groundwater are changes in the land use pattern, irrigation, shifting cropping pattern and early rice transplantation.

**Third phase**

**Depleting natural resource**

We have discussed the present situation of natural resources and situation of depleting water table in Introduction chapter and in section ecological consequences of Green Revolution. In this section present mode of irrigation and its implications are given in brief.

In present milieu, contracts for tube-well, submersibles installation were entered into. Water became a commodity. Individualistic attitude forced cultivators to install separate tube wells. Consequently water table started declining. According to Dhawan, irrigation from tube wells is a perennial source of water for the farmer and therefore, permitted crop activity in rain-deficient seasons with minimum risk. In present situation, where irrigation
is managed by groundwater and new technology such as pump set with bores are introduced is being used in agriculture. Scholars like Shah (1993) stated that these tube wells farmers prefer electric pump sets as they are cheaper to operate than diesel especially when operating under a flat rate tariff.

Dubhash (2002) pointed out that struggle for access to and control over groundwater, shapes the course of agrarian change and development. Technology which was used for irrigation changed the society and fortune of the farmers. Suggestion made that the groundwater problem in Punjab can be resolved by reducing or stopping the export of virtual groundwater in the form of rice (Shah et al. 2000).

The socio-economic life of the farmers changed dramatically with the use of new advanced water harvesting technologies. Agricultural production and productivity rose bringing prosperity for farmers and agricultural workers. But excessive exploitation of groundwater led also to its depletion and degradation. This can be illustrated with reference to the situation in Punjab.

Instead, Observers (Tantigate 1979; Jayarainan 1981) have noted that “conflicts occurred over irrigation time and productivity decreased in consequence when different crops were cultivated along the same ditches even in modern canal systems. In fact this may be a very important reason why innovations are often refused by the cultivators in irrigated regions which has been a constant bothering for the experts.”

Banerji et al. (2006) mentioned that

Monopoly power is higher if there is low tube-well density and if unlined water channels ‘compel’ farmers to purchase from the nearest tube-well. We find that such models are not directly applicable either to Tabelagarhi or indeed to the region as a whole. For one thing, a uniform water price per hour of tube-well use is set in an informal village-level
agreement at the beginning of the season, and is adhered to in water transactions; so water sellers can only adjust the *quantity* of water sales. Moreover, the price does not vary across the season in response to varying power (and therefore water) availability, to clear the market. Most importantly, tube-well owners who sell water do not choose water sales to maximize profits, in the ordinary sense of the term. (Banerji et al. 2006, p. 3)

Thus it is cleared from the above discussion that pumps have been used for extracting groundwater for agriculture and groundwater has became the mainstay for irrigation. It has serious externalities too. Proper institutions and laws have to implement for proper usage of groundwater.