ignou
THE PEOPLE'S
UNIVERSITY

Indira Gandhi
National Open University
School of Social Sciences

BECE - 214
Agricultural Development in India

Block

4

TECHNOLOGICAL CHANGES IN INDIAN AGRICULTURE

Course Coordinator

Dr. B. S. Prakash, IGNOU, New Delhi

Editors

Prof. D. Narasimha Reddy
Central University of Hyderabad
Hyderabad

Dr. B.S. Prakash
IGNOU
New Delhi

Unit Writers

Unit 11 Prof. S.P. Singh, I.I.T. Roorkee

Unit 12 Dr. Vijay Bhaskar, MIDS, Chennai

Unit 13 Dr. B. S. Prakash, IGNOU, New Delhi & Dr. Nalin Bharti, I.I.T., Patna

Unit 14 Prof. V.C. Mathur, IARI, New Delhi

Print Coordination

Mr. Manjit Singh
Section Officer (Pub.)
SOSS, IGNOU

Cover Design

M/s ADA Graphics
New Delhi

September, 2012

ISBN : 978-81-266-

Further information on Indira Gandhi National Open University courses may be obtained from the University's office at Maidan Garhi, New Delhi-110 068 or visit University's Website http://www.ignou.ac.in.

Printed and published on behalf of the Indira Gandhi National Open University, New Delhi by Director, SOSS.

Laser type setted at Graphic Printers, 204, Pankaj Tower, Mayur Vihar, Phase-I, Delhi-110091.

Printed at :

BLOCK INTRODUCTION

Adoption of technological changes into the methods and practices followed in any sector is important for improving its productivity levels. Once this happens, ensuring its spread for wider practice is equally important. This calls for concerted efforts by the government in which institutions play a crucial role. If the spread is not balanced and uniform, one would face the consequences of imbalanced regional development. Against this backdrop, the four units in the present block traces the process of adoption of new technology, called the green revolution technology, into Indian agriculture. The specific theme and thrust of each unit is as follows.

Unit 11 introduces the theme of Green Revolution. Tracing its origins to the food crisis of 1950s, it spells out the circumstances and initiatives of the government that saw its successful introduction, to begin with, in the more prosperous states of northern India. The technology was designed to work in regions that had well developed infrastructure like good irrigation facilities. The introduction proved successful with the production of wheat and rice improving significantly. The phase largely marked the turn around of the Indian economy from a food deficit country to a food surplus economy. Presenting the positives and the negatives of its adoption, the unit also discusses briefly its subsequent developments on the front of gene revolution.

Unit 12 specifically focuses on the distribution of gains from green revolution practices. Presenting a 'pathway of technological impacts' on the different classes/ regions of a diversified country like India, the unit dwells on its multi-faceted dimensions and profiles. In particular, it discusses the impact from the perspectives of: regional dimension, farm size-economic class contention, producer-consumer welfare, and most importantly, the employment impact dimension. It also suggests a policy strategy for ensuring a better distribution of gains through innovation in the agricultural sector.

Unit 13 deals with the trends in agricultural productivity in India. Beginning with a fairly detailed conceptual overview of issues related to productivity measurement, the unit presents a profile of land and labour productivity trends in the Indian agriculture. Providing also an international perspective in this respect, the unit explains the causes of low productivity in Indian agriculture and the measures required for increasing the same in India.

Unit 14 deals with 'agricultural practices'. Although the concerns for protection of environment and sustainability have recently been widely recognised, the unit describes how the Indian farmers had even traditionally, in terms of their methods/ practices followed, been protective of environmental and sustainability concerns. The contrast between the traditional practices and the modern (or new) practices is presented with a thrust on the issues relating to four aspects viz. production, sustainability, water use efficiency and distributional practices.

UNIT 11 GREEN REVOLUTION

Structure

11.0 OBJECTIVES

After going through this unit, you will be able to:

- explain the concept of green revolution (GR);
- outline the historical context and main features of the first green revolution;
- describe the features of green revolution from both its positive and negative dimensions; and
- indicate the need for post-green revolution efforts that had to be initiated to achieve agricultural development of the regions to which the GR did not spread.

11.1 INTRODUCTION

Agricultural development and food security have been the major concerns of India since independence. The emphasis given has, however, varied with the result that the development of the agricultural sector has witnessed its peaks and troughs intermittently. The First Five Year Plan kept at its core the development of agriculture as its primary focus. Despite this, during the Second Plan, India faced severe food shortage. To deal with this problem, in 1958, India invited a team of experts (led by Dr. S.E. Johnson of US Department of Agriculture) to examine the causes of food grain shortages and suggest remedial measures. The team [in its report entitled "*India's Food Problem and Steps to Meet It*" (1959)] recommended that India should focus more on those areas where the potential of raising agricultural productivity was high. Consequent to this, some already developed regions were selected for intensive cultivation to grow more food grains. Later in 1960s, two major programmes viz. Intensive Agriculture Area Programme (IAAP, 1961) and Intensive Agriculture District Programme (IADP, 1964) were launched. These two programmes made large investments in irrigation, fertilizer, agricultural R&D, education, and extension services which together led to achieve a period of high growth in productivity and production in Indian agriculture, popularly referred to as the green revolution (GR). Although hailed for its success widely, the very fact that it was focused on some already agriculturally developed regions, and it was promoted by intensive investment in those regions, also instilled into its very approach factors favouring a focused regional development. In other words, in its approach and design it was not marked for achieving a balanced development of all regions centered around agricultural development in general. Thus, although the green revolution transformed the food-deficit economy into a food-sufficient one by substantially raising the overall agricultural production, productivity and income, it also generated several negative effects in the rural economy. In particular, its economic and ecological consequences in terms of: (i) depletion of groundwater table; (ii) deterioration in the quality of soil; (iii) increased input cost; (iv) increased credit requirement; etc. marked it for its grey side of the success story. Against this background, in the present unit we will study in detail the positive and negative impacts of the GR on the Indian economy. We will also study about the dimensions of a much needed second GR which in the current circumstances has become crucially needed owing to factors of international perspective and dimensions. But before this, we will begin by making a brief reference to the historical aspects of the first GR.

11.2 CONCEPT OF GREEN REVOLUTION

The term 'Green Revolution' refers to the new agricultural technology developed during the 1950s and 1960s by a team of agricultural experts at the International Centre for Maize and Wheat Improvement in Mexico and at the International Rice Research Institute (IRRI) in Philippines. The technology developed at these two centers was subsequently adopted by most of the developing countries in Asia and Latin America contributing to improving the agricultural productivity and attain self-sufficiency in food grains in these countries. The technology involved the use of high yielding variety (HYV) seeds and adoption of a package of modern agricultural inputs, tools and practices (like chemical fertilizers, pesticides, assured and controlled irrigation, tractors, threshers, electric and diesel pumps, etc.). Although initially the new agricultural strategy was limited mainly to wheat and rice crops, later it spread to other crops. These practices were instituted in place of traditional farm practices which were mostly based on farmers' self-owned inputs and resources [like indigenous seeds, farm yard manure, manual irrigation, use of draught power (animal power), etc.]. The problem with the indigenous seeds was that they were unable to withstand high doses of chemical fertilizer applied to increase productivity whereas the HYV seeds, in conjunction with chemical fertilizers and irrigation, yielded the much needed higher productivity. The term 'green revolution', was coined by Dr. William Gaud (the then Administrator of USAID) who in 1968 used the term to describe the success achieved by the new agricultural technology in developing countries of Asia and Latin America.

11.2.1 The Historical Context

The process of green revolution began with the initiation of agricultural research programme in early 1950s in Mexico by the Rockefeller Foundation team of agricultural experts, including Dr. Norman Borlaug. Dr. Borlaug intensively researched on the Mexican wheat and became successful in inventing high yielding varieties of dwarf wheat in mid-1950s. With the application of HYV seeds for wheat, Mexico became self-sufficient in wheat production by the early 1960s and even began to export. Later on, in 1962, the International Rice Research Institute (IRRI) was set up in Philippines [again with the support of Rockefeller and Ford Foundation] to develop new HYV seeds of rice crop. The new varieties of rice crop developed by the IRRI increased the rice productivity in Philippines even better than in case of wheat in Mexico. Like the Mexican wheat, the rice seed varieties were also highly responsive to the use of chemical fertilizer and irrigation. These two efforts made significant contribution in achieving the green revolution in most of the developing countries, including India. Dr. Borlaug was given Nobel Peace Prize in 1970 for his contribution to agricultural development and solving the world's food problem at that time.

As stated before, India faced severe food shortages during 1950s and 1960s and had to import food grains. India was desperate to overcome shortages of food grains as early as possible. As a result, on the recommendations of Ford Foundation team of agricultural experts, India adopted the new agricultural strategy to grow more food grains, especially wheat and rice, in selected agriculturally developed regions. In the 1960s, the Ford Foundation with the approval of the Indian government initiated the Intensive Agricultural Area Program (IAAP) with better technological inputs to raise agricultural productivity. The emphasis was on concentrating more on those areas where the potential of agricultural development was high in order that rapid increase in food grains production could be achieved. Essential inputs and services were provided to the farmers in these selected districts. The programme proved quite effective in raising the food grains production in the selected regions. In the light of the encouraging results of the IAAP and the growing need for more food grains, the government (during 1964-65) initiated the Intensive Agriculture District Programme (IADP) in 114 selected districts where the potential of agricultural development was high. Both the IAAP and the IADP were based on the 'big push' theory of economic development. The two programmes became the most important steps towards achieving green revolution in India. Dr. Norman Borlaug and Dr. M. S. Swaminathan (agricultural scientists) and Shri. C. Subramanian, the then Minister of Agriculture had been the key persons in bringing the new agricultural technology to India. The main objective of the new strategy was to achieve self-sufficiency in food grains by providing access to farmers the necessary inputs and services. This was done by establishing significant agricultural research, extension and marketing infrastructure under massive public investment in areas of: (i) surface and groundwater irrigation, (ii) manufacturing agricultural equipment and fertilizers, (iii) establishment of Agricultural Price Commission, (iv) nationalization of private banks and (v) setting up of cooperative credit institutions to provide credit facilities to the farmers. In addition, advent of tube-well technology during this period also became instrumental in contributing to the raising of agricultural productivity and changing the cropping pattern especially in Punjab, Haryana and Western Uttar Pradesh. Within a short span of time, the wheat revolution spread over the entire North India and tremendously increased the production and productivity of wheat crop. Later on, a similar revolution occurred in rice crop. The green revolution technology, in spite of its severe criticism on the issues related to equity, ecology and environment, thus made remarkable contribution in transforming the Indian economy from its notorious ship-to-mouth food-deficit status to that of not only a food-self-sufficient country but even a food-surplus country.

11.2.2 Main Features of Green Revolution

Unlike the traditional farm practices which mostly relied on indigenous seeds and internal inputs (non-purchased inputs), the new agricultural technology was mainly based on external inputs (purchased inputs) which required substantial financial resources for its adoption. The GR technology came in a package of HYV seeds – irrigation– fertilizers. All these are needed together in correct proportions as both inadequacy and excessive use of water were harmful to these seeds. Availability of assured and controlled irrigation and use of chemical fertilizers thus became the two critical factors in raising the productivity of HYV seeds. Therefore, GR technology was more suited to the areas that had adequate irrigation facilities as well as proper water irrigation/drainage system. While on the one hand the HYV seeds required high doses of chemical fertilizers for their growth, the use of fertilizers in turn generated weeds, requiring the application of weedicides.

One of the key features of HYV seeds is that they had shorter period of maturity which gave opportunity to farmers to grow more number of crops in a year. Thus, the GR technology helped increase cropping intensity. Higher level of productivity and cropping intensity under the GR technology made it a land-saving technology. However, in order to release the land for next crop, farmers needed to do various farm operations, including crop harvesting and land preparation for the next crop, in time. For this, use of modern farm machines such as tractors, threshers, irrigation pumps, etc were required. Thus, the GR technology helped in attracting more investment in manufacturing of farm machines, irrigation pumps, etc. and also to set up banking and marketing infrastructure facilities in small towns and rural areas. Thus, since the GR technology involved heavy infrastructural investment, the technology was more suited to the big farmers who could afford to purchase the farm machines and equipments optimizing their use because of their large farm sizes. Though investment on heavy machinery was necessary for adoption of HYV crops, more investment on hiring and purchase of other inputs were essential even on small farms. Small and marginal farmers had no capacity to invest since access to credit was limited. Thus, although the HYV-fertilizer-irrigation technology was considered scale-neutral and increased the land productivity irrespective of the size of operational holdings, in practice it was certainly not resource-neutral. It was therefore, necessary to make cost-effective usage of new technology on small and marginal size holdings through some institution building measures like the formation of group-farming.

In brief, therefore, the HYV seeds, use of chemical fertilizers and pesticides, application of modern farm machines, extensive irrigation facilities, multiple cropping, improved credit facilities, support price policy and improved R&D and extension infrastructure came to signify the main features of the green revolution movement in India.

Check Your Progress 1 [answer in about 50 words within the space provided]

1) Would you say that the concept of Green Revolution was unique only to India? Who were the key scientists who played a major role in this respect in India?

....

....

....

2) What key inputs were fundamentally needed for the success of the Green Revolution Technology?

....

....

....

3) What are the two projects under which the GR strategy spread in India? What distinguished the two projects in their basic approach?

....

....

....

4) Which are the key institutions that have contributed to the spread of GR culture in India?

....

....

....

5) Do you think that the GR technology can also benefit the small and marginal farmers segment? How?

....

....

....

11.3 IMPACT OF GREEN REVOLUTION

GR technology in India has made phenomenal impact on agriculture in particular and entire economy in general. It has, however, made both positive as well as negative impacts.

11.3.1 Positive Impacts

On the positive impact front, the GR technology helped to raise the production and productivity of crops, especially wheat and rice, increase cropping intensity, change the cropping pattern from coarse cereals to super cereals and later on to cash crops, including sugarcane and horticultural crops; and solve the problem of food security.

11.3.1.1 Increase in Production and Productivity of Food Grains

One of the most important impacts of green revolution (GR) was on raising the production and productivity of cereal crops, especially wheat and rice. The cereal production was increased due to three factors: (i) increase in net area under cultivation; (ii) growing two or more crops in a year on the same piece of land; and (iii) use of HYV seeds. The GR resulted in a significant increase in the production of food grains from 72.4 million tons in 1965-66 to 131.9 million tons in 1978-79 establishing India as one of the world's biggest agricultural producers. Per hectare yield of food grains increased from 6.3 quintal per hectare (Q/ha) in 1965-66 to 10.2 Q/ha in 1978-79. Percentage of total food grains area under irrigation also increased from 20.9 in 1965-66 to 28.8 in 1978-79. These productivity increases also enabled India to become an exporter of food grains around that time.

Figure 11.1 shows the trends in area, production and yield of wheat crop in India since 1950-51 to 2009-10. It is evident from the graph that the production of wheat has significantly increased during and after the green revolution period. The production went up from 10.4 million tons (MT) in 1965-66 to 35.5 MT in 1978-79 and further to 80.7 MT in 2009-10. The spectacular increase in production of wheat was mainly due to massive rise in its per hectare yield which went up from 8.3 Q/ha in 1965-66 to 15.7 Q/ha in 1978-79 and further to 28.3 Q/ha in 2009-10. Area under wheat also grew notably during the green and post-green revolution periods as can be seen from the Figure 11.1. However, in the recent years, per hectare yield of wheat grew faster than its area, implying that productivity growth in wheat has contributed more to the wheat production than the increase in area under it. Although production of wheat shows significant rise over the period, it also indicates fluctuations across years.

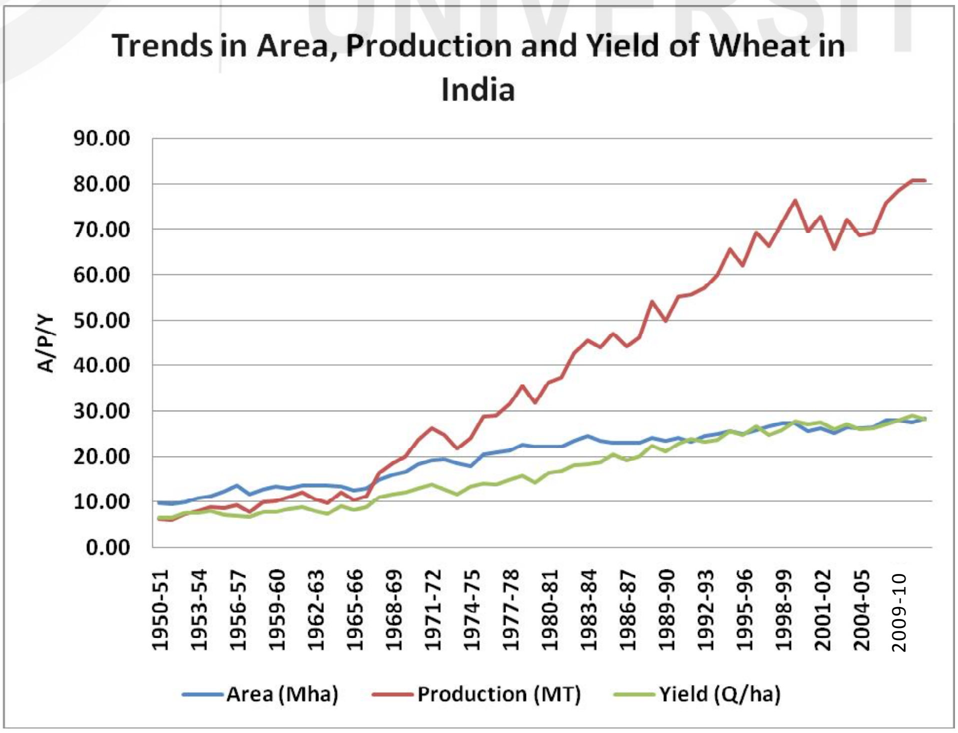

Fig. 11.1: Area, Production and Yield of Wheat in India – 1951-2010

Area, production and yield of rice (paddy) also increased significantly during the green and post-green revolution periods. The production went up from 30.6 MT in 1965-66 to 53.8 MT in 1978-79 and further to 89.1 MT in 2009-10. The per hectare yield of rice increased from 8.6 Q/ha in 1965-66 to 10.7 Q/ha in 1978-79 and further to 21.3 Q/ha in 2009-10. The per hectare yield of rice grew at a rate much slower than that of wheat. This implies that the GR technology had penetrated more in wheat crop than in the rice crop. Further, the area under rice achieved a relatively slow growth when compared to the area under wheat. However, it is important to know that the data on area, production and yield of wheat and rice crops presented in the graphs are all-India aggregates which comprise both the irrigated and the un-irrigated regions.

Estimates of growth rate in area, production and yield of two principal cereal crops (wheat and rice) during four periods viz. pre-green revolution period (1950-51 to 1964-65), green revolution period (1967-68 to 1978-79), post-green revolution period (1979-80 to 1990-91) and post-economic reform period (1991-92 to 2009-10) is presented in Table 11.1. In case of wheat, area recorded the highest growth during the green revolution period (3.3 percent), followed by the pre-green revolution period (2.7 percent); the lowest being in the post-green revolution period and post-reform periods (0.6 to 0.7 percent).

Table 11.1: Compound Annual Growth Rates in Area, Production and Yield of Wheat and Rice during Different Time periods (percent)

Time Periods	Wheat			Rice		
	Area	Production	Yield	Area	Production	Yield
1950-51 to 1964-65 (Pre-GR)	2.7*	4.3*	1.5*	1.5*	4.4*	2.9*
1967-68 to 1978-79 (GR)	3.3*	5.9*	2.5*	0.8*	2.6*	1.7*
1979-80 to 1990-91 (Post-GR)	0.6**	4.2*	3.6*	0.6**	4.3*	3.7*
1991-92 to 2009-10 (Post- reform)	0.7*	1.7*	0.9*	0.1	1.2*	1.1*

Note: * and ** stand for significance at 1% and 5% level respectively.

Similarly, production of wheat recorded the highest growth in the green revolution period (5.9 percent) followed by the pre-green revolution period (4.3 percent). The growth in wheat production in the post-GR period (4.2 percent) of 1980-91 was also not too low but in the post-economic reform period it was the lowest at 1.7 percent. In terms of per hectare yield of wheat, however, the post-green revolution years had the highest yield (3.6 percent). Once again, the per-hectare yield was the lowest (0.9 percent) in the post-reform years of 1992-2010. A similar trend is noticed in the per-hectare yield of rice in which the post-GR years of 1980-91 had witnessed the highest growth (3.7 percent). Like in the case of wheat, for rice too there was a steep decline in the per-hectare yield in the post-reform years of 1992-2010 (1.1 percent).

11.3.1.2 Employment Generation

The impact of GR technology on employment generation in agriculture has been contentious. Critiques of Green Revolution argue that increased mechanization of farm practices in the green revolution regions reduced the employment absorption in agriculture. C. H. Hanumantha Rao, for instance, observed that GR technology in terms of 'seeds-fertilizer-irrigation' package had substantial positive impact on employment generation in agriculture but increased use of farm machines such as tractors contributed to a reduction in the employment generated. However, the use of tractor and other modern machines increased the aggregate level of employment by raising cropping intensity, farm productivity and changing cropping pattern. Moreover, farm machines and equipment also helped generate additional employment in the non-farm activities by way of forward and backward linkages. In other words, the use of technology and better inputs have created significant employment opportunities in the non-agricultural sectors of manufacturing as well as service sectors. Further, expansion of irrigation (which was considered a pre-condition for the adoption of GR techniques) has generated more employment as irrigated crops have more agricultural operations as compared to the un-irrigated ones. In fact, the green revolution regions such as Punjab, Haryana and Western Uttar Pradesh experienced one of the major problems of shortage of agricultural labour resulting in the migration of workers from backward and poor agricultural regions to the GR regions for agricultural employment. Thus, the GR technology has created indirect employment opportunities to the agricultural workers of other regions.

11.3.1.3 Flow of Public/Private Investment in Agriculture

The most important factor behind the success of green revolution in India is availability of assured irrigation. The advent of tube-well technology, especially in the Indo-Gangetic basin, made significant contribution to enhance the per hectare crop yields. The new agricultural strategy required public investment in agricultural infrastructure, including investment in agricultural research, extension, power, roads, irrigation, etc. Government of India made huge public investment in agriculture in the regions where the new strategy was adopted. This investment made favourable impact on accelerating the pace of private investment too in agriculture. Farmers invested in tube-well, tractor & its accessories, electric and diesel pump sets, land levelling & development, etc. The share of mechanical and electrical power in India increased substantially from 39.4 percent in 1971-72 to 86.6 percent in 2005-06. The ratio of human labour in the total power consumption in agriculture declined from 15.1 percent in 1971-72 to 8.6 percent in 1991-92 and further to 5.8 percent in 2005-06. Similarly, the share of draught animal power declined sharply from 45.3 percent in 1971-72 to 15.6 percent in 1991-92 and further to 8 percent in 2005-06. These trends imply that private investment in agriculture after the green revolution significantly increased following the stimulus provided by increased public investment.

11.3.1.4 Land Saving

Land is a limited resource with competing claims for alternative uses. Due to fast growth of population, urbanization and industrialization, demand for land for non-agricultural purposes has been continuously increasing. Release of land for non-agricultural purposes would be a less contentious issue if requirement of land for agricultural purposes is met through raising the productivity of land and other resources. In this context, GR technology is considered land-saving as it significantly increased the per hectare yield of various agricultural crops. Productivity growth in agriculture has also indirectly saved the forest land as in the absence of increased agricultural output due to GR, more forestland would have been converted into agriculture to meet out the requirement. From this point of view, it is also sometimes argued that the green revolution, instead of having negative impact on environment, has had positive impact on it by way of saving the forestland.

11.3.1.5 Impact on Rural Non-farm Economy

The green revolution has made significant positive impact on boosting the rural non-farm economy. It has led to sizeable increases in returns to land thereby raising farmers' incomes. Since farmers and agricultural labour comprise a sizeable proportion of rural population, rise in their income due to agricultural development enhances the demand for locally produced goods and services thereby augmenting the employment and income in the non-farm sectors. Moreover, expansion of demand for farm inputs, repairs & maintenance of farm tools and machines, transportation and marketing services, agro-processing, etc. generates additional income and employment to the rural households engaged in non-agricultural activities.

11.3.2 Negative Impacts

Green revolution in India has also made a number of negative impacts. Since GR technology is based on the strategy of "betting on the strong" with its inbuilt feature of unequal access and 'unbalanced development of regions', it has created disparities in agricultural development across regions and categories of farms. There was also a tendency of growing intensively two or even three of the same wheat or rice crops without any rotation and with heavy doses of water, fertilizers and pesticides. In the process, it has left adverse effects on soil fertility and quantity/quality of water. We can elaborate more on these negative aspects of GR as follows.

11.3.2.1 Decline in Soil Fertility

GR technology has caused deterioration in soil fertility. As per the Working Group Report on 'Natural Resource Management' (Government of India, 2007), the estimated loss to the economy on account of soil degradation during 1980s and 1990s ranged from 11 to 26 percent of GDP. Absence of reliable advice and soil-testing facilities contributes to the indiscriminate and harmful use of chemicals. Use of Farm Yard Manure and Green Manure has declined due to various reasons like decline in draught animals, change in the cropping pattern from legume crops to rice, wheat, sugarcane and other commercial crops, etc. It is also argued that green revolution technology could not promote crop-diversification but rather encouraged the crop-concentration. A recent Greenpeace India Report on '*Soils, Subsidies and Survival*,' (2011) observes that *"indiscriminate use of chemical fertilizers is murdering our soil and threatening our food security. It is time to move away from them and nurture our soil the ecological way"*.

11.3.2.2 Loss of Biodiversity

Biodiversity is necessary for sustaining the rural livelihoods and achieving the food security. But the use of HYV seeds displaced indigenous species and agricultural system that had been built up over generations. This has led to loss of biodiversity and agricultural genetic resources aggravating the genetic vulnerability of many valuable gene pools.

11.3.2.3 Depletion of Groundwater Resources

Development of tube-well technology in 1960s is one of the vital factors in bringing the green revolution in the Indo-Gangetic regions. However, the exponential growth of tube-wells in these regions has also been the main reason in the rapid decline of groundwater resources. While groundwater irrigation is preferred on the equity, efficiency, and private investment grounds, many government policies [e.g. agricultural subsidy on critical inputs, lack of effective regulation on sustainable groundwater usage, etc.] have contributed to rapid depletion of ground water resources.

11.3.2.4 Impact on Small and Marginal Farmers

It is argued that shifting from traditional farming to monoculture had negative effects on small farmers. Small and marginal farmers had to purchase costly HYV seeds, fertilizers, and pesticides for which they took loans at relatively higher interest rates and consequently came under 'debt trap'. Also, over-exploitation of groundwater by rich farmers rendered the accessibility of water to the small and marginal farmers difficult.

11.3.2.5 Over-capitalization in Agriculture

The traditional farming system was mostly based on the locally available farm inputs and implements such as farm grown seeds, wooden and iron ploughs, animal power, farm yard manure, bullock-cart, and other farm tools made by local carpenters and blacksmiths etc. Procurement of these inputs and implements required less or no money as most of them were self-owned or provided by carpenters/ blacksmiths in lieu of food grains provided by the farmers under "Jazmani" system. While the traditional system is on the decline, the emerging practices in agriculture appear to be tending towards more capitalisation in many regions. The new agricultural technology required huge investment in modern farm machines, tractors, pump sets, etc. which in most of the cases remained underutilized due to division of operational holdings. For instance, division of operational holdings encourages the farmers to purchase more tractors and accessories and irrigation pumps which lead to over-capitalization in agriculture. In agriculturally developed regions, such as Punjab and western Uttar Pradesh, there is over-capitalization in agriculture. Chand and Kumar (2004) find an increase in the number of operational holdings as one of the important determinants of private capital formation in agriculture. Division of holdings increases the number that, in turn, raises the demand for investment in farm assets and machinery. It may be relevant to know that the number of operational holdings in India has increased from 97.16 million in 1985-86 to 115.58 million in 1995-96 and further to 120.28 million in 2000-01. The availability of institutional credit and subsidy to the farm sector motivates these divided holdings to increase investment in farm machinery. This type of private investment in agriculture is not desirable, as it increases the unit cost of cultivation, reduces competitiveness of small farmers, and enhances indebtedness among them.

11.3.2.6 Widening Disparities

The GR technology has created disparities across regions, and categories of farms. Since it was based on the "betting on the strong" approach, the disparity was inherent in it. The benefits of the new technology was mainly limited to the few crops, such as wheat, rice, sugarcane and few agriculturally developed regions, having adequate irrigation facilities. Most of the crops and rain-fed agricultural regions did not get sufficient benefits from GR. It is observed that in most of the countries, where the new technology was adopted, its benefits accrued to the farmers of already developed regions, and not to the farmers of the poorest and least developed regions. There is conflicting evidence as to whether it has had "spread effect" or, has intensified income differences across regions. Initially, the green revolution was largely confined to wheat crop in northern India, resulting in a limited contribution to overall economic development of the country. Since the seed-fertilizer technology was not suited to agriculture of the un-irrigated and rain-fed regions, to a greater extent it contributed to inter-regional income disparities. The spread of GR to dry regions proved inappropriate and often caused serious distress to farmers who adopted GR in dry regions based on groundwater resources. GR technology worked effectively on those farms which possessed controlled production environment, such as good quality soils, better irrigation facilities and markets. Since this environment is not sufficiently available in the agriculturally backward regions, farmers of these regions could not get much benefit from the new technology; rather, they lost competitiveness and they remained relatively in the disadvantaged position vis-à-vis their counterparts in the developed regions. C.H. Hanumantha Rao concluded that the technological changes in the Indian agriculture had widened economic disparities between different regions, between big and small farmers and between landholders and land-less workers. However, he observed that in absolute terms in the sense of rise in productivity, production and access to foodgrains, the gains of GR technology reached all sections of the society in general.

11.3.2.7 Impact on Ecology and Environment

As stated before, one of the most adverse consequences of the GR technology is in terms of its ecological and environmental impact. While the increased use of chemical fertilizer and pesticides in agriculture has been the main source of decreased land fertility, it has also polluted the river water resources affecting aquatic life in general and fish production in particular. The productivity stagnation during the recent decades is also generally attributed to the degradation of soil and water resources induced by the agricultural practices particularly in the rice–wheat and wheat-sugarcane production systems of the north Indian states. Thus, the intensive use of fertilizers, pesticides, and weedicides have not only caused degradation of natural resources but also resulted in stagnant productivity.

11.3.2.8 Energy Problems

Another issue related to green revolution technology was its high dependence on fossil fuel energy sources. It is argued that increase in the cost of energy-based agricultural inputs has resulted in an increase in the prices of agricultural products making the GR system economically and ecologically questionable. As observed before, the share of mechanical and electrical power consumption in agriculture has significantly increased over the period. High demand for diesel import has also put more pressure on India's foreign currency reserves.

Check Your Progress 2 [answer questions 2-5 in about 50 words in the space provided]

1) Fill in the blanks

   a) Production of wheat went up from ………. Q/ha in 1965-66 to ………… Q/ha in 1978-79 to ………… Q/ha in 2009-10.

   b) The relative impact of GR technology on the per-hectare yield of rice was much ………. than that in wheat.

   c) In terms of the three main factors viz. area, production and yield, for both the wheat and rice in the post-reform years of 1992-2010 in terms of average annual percentage growth it has been the ……….. as compared to the other three periods of ………, …….. and …………

2) On what basis can you say that the increased agricultural production due to GR technology can be considered environment-friendly?

....

....

....

3) What evidence has become available in the recent years to make a case favouring the adoption of earlier methods of agricultural practices followed in the pre-GR years?

....

....

....

4) State any two pro-agricultural developmental policies which have also contributed to unsustainable use of ground water resources.

....

....

....

5) For what reason is it claimed that the GR benefits has resulted in the widening of economic disparities while accruing overall gain to the economy in general?

....

....

....

11.4 POST-GREEN REVOLUTION EFFORTS

As noted before, the benefits of the first green revolution period (1968-79) were largely confined to a few crops and big farmers of agriculturally developed regions. A large part of India, especially rain-fed regions of eastern states such as Assam, Bihar and Orissa remained largely untouched by the green revolution technology. In view of this, the Government of India initiated specific efforts in the agricultural development of those regions and crops which could not get the benefits of the first green revolution. These efforts centred around: (i) policy thrust on agricultural development of eastern states; (ii) development of rain-fed and un-irrigated agricultural regions to improve people's livelihood and achieve food security; and (iii) greater involvement of agri-business companies in R&D, storage, marketing and processing of agricultural products with a focus on high value horticulture, floriculture and livestock products through contract farming and other innovative efforts.

The main reason why GR technology benefits could not spread to eastern region was that the installation of private tube-wells did not progress well due to the small size of holdings and lack of financial resources to install tube-wells and buy pump-sets. Delay in electrification of villages was also one of the factors in the slow growth of private tube-wells. In view of these reasons the groundwater development in the eastern region was lowest among all the regions. However, owing to the later efforts made by focused policy support to the farmers of the eastern states to improve their productivity and diversification of various crops, agricultural growth significantly increased in Bihar, Orissa and Assam. Further, focus on rain-fed and dry land agricultural regions [which comprise about 60 percent of total NSA (net sown area) accounting for nearly 40 percent of total agricultural output] through government interventions in terms of investment in soil and water conservation and water harvesting related activities contributed to increasing the productivity in these regions. The policy focus in achieving the agricultural development in these regions was one of a holistic approach for conservation, rejuvenation and management of natural resources for sustaining the livelihoods of people by raising agricultural productivity and income. Likewise, initiatives to attract the corporate investment in agricultural sector was made by many mission mode efforts like National Horticulture Mission, National Oilseed Mission, National Food Security Mission, National Bamboo Mission, National Pulses Mission, etc. Other efforts made, besides promotion of contract farming, centred around: (i) institutional credit to small and marginal farmers for purchasing land to enlarge their size of operational holdings, (ii) liberalization of land lease market, (iii) direct marketing of agricultural products reducing the role of intermediaries by amending the APMC Act, etc.

The above outline of efforts made in the post-GR period suggests that while the agricultural growth during the green revolution period was largely driven by the supply side factors, during the post-green revolution period it was driven to a greater extent by the demand side factors. As a result, during the post-green revolution period, agricultural development was more in the direction of diversification towards high value horticulture crops like fruits, vegetables, flowers, etc. besides the development of allied activities like dairy, poultry, and fishery. However, while it is true that huge investment in agricultural R&D, extension, irrigation, power, processing, marketing and supply chain are required to revitalize the farm sector for raising the agricultural income and employment for which a corporate approach is desired, it is also feared that involvement of the agri-business companies, particularly the MNCs in reaping the benefits of genetically modified (GM) seed technology, may create oligopolistic power among these companies which could exploit the farmers in the long run once the intermediaries are eliminated and role of public investment/institutions are reduced. Due to this reason, there is a growing debate on the need for maintaining a balance between the corporate approach and the public investment centred policies.

11.5 FROM GREEN REVOLUTION TO GENE REVOLUTION

As noted earlier (from the estimated growth rates in the productivity of wheat and rice), increase in productivity associated with the GR technology began to taper off during the 1990s. In this context, bio-technology is envisaged to provide the required potential for raising the agricultural productivity and solving the problem of food security. The biotech revolution gained momentum in the early 1980s when large corporations began investing huge amounts in R&D for developing transgenic crops. The use of genetically modified (GM) seeds was recognised to hold the promise of making spectacular increase in the productivity of land and other resources helping the farmer to increase their income from agriculture on the one hand and benefit the consumers by way of providing cheaper and quality food on the other. Use of bio-technology centric methods was also considered scale-neutral as it focused on seeds and not on chemical fertilizers and costly farm machines. The GM seeds are considered to be more productive, more pest-resistant and more suitable to all categories of farms and all the agricultural regions. However, adoption of gene technology in Indian agriculture is subject to debate and discussions, as its positive and negative effects on plants, animals and human lives have not yet been fully examined. While on the one hand environmental, ecological and health related consequences of GM seed technology are weighed more than its economic benefits, on the other hand there are many issues which have attracted the attention of researchers and other activists. Prominent among them are the ethical, safety and proprietary issues. One of the biggest fears of its adoption is the monopoly control of a few multinational bio-seed breeding companies over a basic human need that is food. Thus, although the GM seed technology has immense potential to revolutionize the Indian agriculture, in view of the GM seed technology being costly and proprietary in its character, the technology is feared to be more suited to the resource-rich farmers leaving behind the large marginal and small farmers segments especially in the backward agricultural regions from getting its benefits. However, we must recall that even the GR based technology also favoured only the rich farmers as compared to the small and marginal farmers segment. Thus, the fundamental difference between green revolution and gene revolution may be pointed out as one in which while the former was mostly in the public domain, the latter is feared to keep it largely confined to the private domain. Against this background, the present debate is on ushering in a 'second green revolution' the broad features of which are spelt out in the National Agricultural Policy Vision Document on which you will study more in unit 22.

Check Your Progress [answer in about 50 words using the space given]

1) What are the three directions in which the policy initiatives of the post-GR efforts were centred?

....

....

....

....

2) Mention the two reasons which are identified for the lack of spread of GR benefits to many regions?

....

....

....

....

3) In what way the use of bio-technology (BT) methods considered more beneficial as compared to the GR technology based methods? In spite of this, why is it that its adoption has still not taken off in India?

....

....

....

....

4) What is the fundamental difference between the GR and the GM approaches?

....

....

....

....

11.6 LET US SUM UP

The GR technology and the benefits that accrued out of it helped transform the Indian economy from a state of food deficient country to a food surplus one. However, the benefits of the GR technology did not reach many regions of the country notably the eastern Indian states because of the fragmented holdings held by large number of small and marginal farmers whose capacity to invest capital, much needed for applying the GR technology, was limited. Efforts made by the government to offer foucused policy support, in the post-GR years, improved the situation in this respect. The GR-technology was not environmental friendly as it depended heavily on chemical fertilizers and weedicides which rendered the soil and water resources polluted/contaminated. An alternative to GR technology namely the GM technology became popular for its non-polluting effects around the 1980s. However, the large scale implementation of this technology has not taken its roots yet in view of the many non-economic dimensions of this technology which basically centeres around its proprietary character (i.e. the possibility of rich MNCs/corporate houses making a monopoly of its reach/benefits). Both the GR and GM technologies, from this point of view of wider inclusivity, are unsuited to small and marginal farmers who cannot muster the wherewithal required for benefiting from these technologies i.e. fair amount of capital requirement which is common to both the GR and GM technologies. Of late, therefore, there is a talk on the need for instituting a 'second green revolution' suitable for addressing the issue of food security/insecurity from a more inclusive nature i.e. raising agricultural productivity with an emphasis on including small-marginal farmers, and rain-fed and dry regions as the main components of the process.

11.7 KEY WORDS

Green Revolution (GR) : Refers to a new agricultural technology developed in Mexico and Philippines in the late 1950s and early 1960s for wheat and rice crops respectively which transformed many food deficient countries of Asia and Latin America to food surplus economies. The technology, however, required large capital for purchase of fertilizers and machineries and its applicability was suitable only for regions which were already rich in terms of irrigation and agricultural productivity respects. This feature of the GR technology contributed to many small and marginal farmers and poor states/ regions from being unable to be a part of its process. As a result, many parts of the country could not get its benefits.

High Yielding Variety (HYV) Seeds : These were special seeds which were to be used in the GR technology application areas. Unlike indigenously grown seeds, they could withstand high amount of fertilizers. But for this very reason they were also less environmental friendly as they reduced the fertility of soils. However, their quick yields enabled multiple cropping on the same field during a years thereby raising the productivity of agricultural produce and income/profits of farmers.

Genetically Modified (GM) Seeds : This was an alternative which was developed in 1980s. Unlike the HYV seeds, the GM seeds were not heavily dependent on chemical fertilizers. The technology, however, had a proprietary character associated in view of its limited reach due to the involvement of some MNCs/corporate business houses.

11.8 SELECTED REFERENCES FOR FURTHER READING

Bowonder B. (1979), 'Impact Analysis of the Green Revolution in India', *Technological Forecasting and Social Change,* Vol.15, 297-313.

Ford Foundation. 1959. *Report on India's Food Crisis and Steps to Meet It.* New Delhi: Ministry of Food and Agriculture and Ministry of Community Development.

Freebairn D.K. (1995), '*Did the Green Revolution Concentrate Incomes? A Quantitative Study of Research Reports*', *World Development,* Vol. 23, No. 2, pp. 265-279, 1995.

Griffin, Keith (1974), *The Political Economy of Agrarian Change: An Essay on the Green Revolution,* Harvard University Press, 1974.

Pingali P. and Terri Raney (2005), 'From the Green Revolution to the Gene Revolution: How will the Poor Fare? ESA Working Paper No. 05-09, **www.fao.org/es/esa**

Rao, C. H. H. (1994), *Agricultural Growth, Rural Poverty and Environmental Degradation in India*, Oxford University Press, New Delhi.

Shiva, V. (1993), The *Violence of the Green Revolution: Third World Agriculture*, Ecology and Politics, 2nd ed. London, UK: Zed Books Ltd., 1993.

Singh S.P. (2010), Agriculture under Neoliberal Policy Regime, in *Alternative Economic Survey, India: Two decades of Neoliberalism*, Dannis Books.

11.9 ANSWERS/HINTS TO CYP EXERCISES

Check Your Progress 1

1) See section 11.2.1 and answer.
2) See section 11.2.1 and answer.
3) See section 11.2.1 and answer.
4) See section 11.2.2 and answer.
5) See section 11.2.2 and answer.

Check Your Progress 2

1) a), b) , c) & d); see section 11.3.1.1 and answer.
2) See section 11.3.1.4 and answer.
3) See section 11.3.2.1 and answer.
4) See section 11.3.2.3 and answer.
5) See section 11.3.2.6 and answer.

Check Your Progress 3

1) See section 11.4 and answer.
2) See section 11.4 and answer.
3) See section 11.5 and answer.
4) See section 11.5 and answer.

UNIT 12 NEW TECHNOLOGY AND DISTRIBUTION OF GAINS

Structure

12.0 OBJECTIVES

After reading this unit, you will be able to:

- explain why technological developments in agriculture is important;
- identify the pathways through which gains accrue through new agricultural technologies;
- outline how green revolution (GR) technologies have impacted social groups and regions;
- indicate the potential impacts of new technologies like genetically modified (GM) crops;
- distinguish between the GR and the GM technologies in terms of their major differences; and
- suggest a policy strategy for ensuring better distribution of gains through innovation in the agricultural sector.

12.1 INTRODUCTION

As in the case of production of other commodities, productivity improvements through application of technology are very important to the agricultural sector. Even though increasing yield/output is the objective of technological change, the impacts are not confined merely to output. They also manifest in terms of: (i) employment increase or decrease; (ii) differentiated impacts like when the new technology is capital intensive, it benefits producers with easier access to capital more than the others; (iii) if new technologies are confined to specific crops, producers of those crops tend to gain more leaving out the others from being the beneficiaries of gains; etc. Gains from technological change, therefore, need not be distributed evenly across regions and groups of economic actors. In other words, technological change may create gainers and losers particularly in the short run. In the long run, however, generally some kind of equilibrium is restored. But several barriers continue to prevail in the path of ensuring equitable distribution of gains. This is particularly true in low income countries like India where the institutional development required to ensure a more equitable distribution of gains would not have been established. In this context, the present unit deals with the important issue of how the diffusion of new technologies impact differently on the various social and economic sections of the society and in this light what measures are needed to be taken to ensure the concerns of equity.

12.2 CONCEPTUAL OVERVIEW

How does technological development benefit the society and why does it leave out some sections and benefit only a few in an inequitous manner? And what policy challenge needs to be faced in order that equity concerns are duly addressed? Conceptually, these are the two questions which we shall try to answer in this unit. Technological advancement, as we know well, is inevitable for productivity raise. Recall from your study of earlier units that the agricultural sector has deep linkages with the rest of the economy through its income, employment and consumption effects. Further, ensuring food security without creating food price inflation is always an important challenge for policy makers. In addition to meeting the food requirements of a growing population, the sector also has to ensure a steady supply of raw materials for an expanding industrial sector. As large number of poor households in low income countries rely on this sector for their livelihoods, improvements in output can play an important role in poverty reduction. As a consequence, investments in new technological development and its effective diffusion remains an important dimension of policy-making in both the industrialized and low income economies. Until the 1960s, production could not keep pace with the growing demand for food grains in several low income countries including India. As discussed in the previous unit, in response to combating this severe food shortage, under a broad programmatic intervention called the ‘green revolution’, governments in several of these countries adopted a new technology called ‘high yielding variety seeds’ with complementary inputs of chemical fertilizers and irrigation. Even as such technological advancements led to improvements in yields, its welfare effects remained debatable. There is a wide contention that the poor were unable to participate successfully in the adoption of new technology (during the green revolution in Asia in general) mainly due to their inability to access complementary inputs. While the higher outputs yielded high profits for rich farmers as their marketable surplus was huge (their actual consumption needs being less), for small and marginal farmers who shifted to cash crops it was different. They not only lost their access to subsistence food but also lost out heavily when the prices for their output fell as their ability to withstand such losses was minimal. There are, however, others who argue that over time the gains brought about by introduction of GR technology did benefit even the poor as the productivity of crops improved in general. Facilitating the poor to access the new technologies through credit and markets, which was the key to improving the welfare of the poorer segments of the population, did not take place in the manner and to the extent that was required. In still later years, in case of genetically modified (GM) technologies which promised to provide the next breakthrough in agricultural production, similar concerns of equity and sustainability hampered its application. In such contesting situation, therefore, the policy challenge essentially centre around addressing the distribution of gains. In other words, conceptually, we can broadly identify the following ways through which gains from technological advance in agriculture can accrue to different sections of population:

a) consumers through lower prices;

b) agricultural labour by way of getting more employment opportunities both on-farm and off-farm;

c) subsistence farmers through improved consumption and production albeit of much lower degree than the rich farmers; and

d) agri-business entrepreneurs by way of opportunities for business with lower nominal wages and hence higher surplus for investment enabling cumulative benefits of repeated profit/investment till the stage when the level of wages match improvements in productivity.

12.3 PATHWAYS OF TECHNOLOGICAL IMPACTS

In a more general sense, the pathways of technological impacts can be outlined as follows. In the realm of agriculture, technology can be distinguished for their:

a) embodied technological characteristics: This includes seed/plant varieties embodying genetic technology in the form of disease and weather resistant breeds that are more responsive to chemical fertilizers which can be produced on a large scale (as compared to organic/natural manures which has a natural limit to its production potential). This also includes mechanical and electrical implements embodying engineering technology.

b) dis-embodied technological characteristics: These are forms of knowledge that can be codified into rules and procedures which are essential for effective production and use of new technologies. Farmers trying to use embodied technologies would need to acquire information on how best to use them in the fields. However, even disembodied rules and procedures require farmers to understand and deploy them properly for which 'extension services' in the form of education and training are critical components of technology diffusion. Further, more importantly, even when information access/flow is duly streamlined by appropriate measures, production capabilities would still remain variant among participants depending on the inherent differences in persons/regions to benefit from new technology. The institutional capabilities to aid their better absorption which, inter-alia, depends on aspects of governance in establishing conditions favourable to technology absorption thus remains the key to successful realisation of optimum benefits from technological development.

These differences in the various dimensions of technology requires observable outcomes to assess the impact of technology. These may be called as *pathways* through which the diffusion effects can be quantified and thereby measured. These can be stated as:

a) through increased output (i.e. output augmenting);

b) through improved quality of products produced (i.e. quality improving);

c) through reduction in the crop cycle time and therefore by opening the possibility of increasing cropping intensity (i.e. time reducing); and/or

d) through reduction in the cost of cultivation (by reduced quantity of inputs required or by lowering the price of inputs or by introducing a set of new but cheaper inputs) [i.e. cost/input reducing].

Check Your Progress 1 [answer in about 50 words using the space given]

1) Mention any three ways in which the impact of technological development in agriculture can create both losers and gainers in the short run.

....

....

....

....

2) Which two factors are pointed out as mainly responsible for the GR or HYV technology to have left out the 'small and marginal farmers' out of its ambit of positive influence?

....

....

....

....

3) Conceptually, how would you identify the beneficial influence of technological development in agriculture to the different sections of population?

....

....

....

....

4) State the components which enhance the agricultural output by virtue of its 'embodied technological characteristics'.

....

....

....

....

5) What would you identify as the 'key' to the successful realisation of optimum benefits from technological development?

....

....

....

....

6) What are the four major pathways in terms of which the diffusion effects of technological development in agriculture can be quantified/measured?

....

....

....

....

12.4 PROFILES OF DISTRIBUTION OF GAINS

In an ideal situation where factors for inducing equal distribution of gains are controlled, which would require establishment of well functioning institutions that are developed gradually with the extent of economic development attained by a country, there would be balanced regional development. However, as already noted, in the short term there would inevitably be gainers and losers. If so, what are the dimensions of variation in the distribution of gains owing to technological development? We can identify five main dimensions as follows.

12.4.1 Regional Variation

Disparities across regions arise from: (a) the nature of technological change; (b) differences in factor endowments (like soil conditions and amount of natural rain fall); and (c) institutional differences.

a) Nature of Technological Change: The nature of technological development in the developing world tends to be capital intensive as they largely flow from the advanced capitalist countries. As a result, they tend to favour the more prosperous regions that can better access capital intensive inputs. If capital access is critical to output, then the disparities in the flow of credit too will aggravate such regional differences.

   Many new technologies are also water-intensive requiring access to assured irrigation. In light of this, regions with better irrigation resources tend to benefit more than regions that are more dependent on rainfall for agricultural production. Due to this factor also, in the case of Indian agriculture it is argued that the Green Revolution aggravated the existing regional inequalities since it did not benefit rain fed and resource poor regions.

b) Differences in Factor Endowments: Crop specific technologies like HYV seeds tend to benefit only those who are producing those crops. Regions that are endowed with conditions more suitable for the production of these crops will therefore gain leaving out other regions from being a part of the technological change. In India, the Green Revolution in the initial phases favoured wheat producing regions as the HYVs were introduced primarily in wheat. In the subsequent phases, with the introduction of HYV seeds in rice, rice production regions also benefitted. The Green Revolution, thus, created considerable bias against dry regions which depended on growing so-called coarse grains and millets like *ragi and jowar*. Besides, there has been no improvement in plant varieties in oilseeds or pulses which are the main stay of dry regions. Technological breakthrough by way of evolving high yielding varieties in the type of crops grown in dry land regions is still an unfulfilled task. But, in the short run, several institutional constraints which are an outcome of specific historical factors of socio-economic development pose considerable barriers to the process of such equitable growth.

c) Institutional Differences: Institutional differences refer to variations in landownership patterns, labour and tenancy relations including the nature of other institutions like financial, education, health, etc. Land tenure systems and nature of ownership therefore play an important part in shaping the regional distribution of gains. It has been argued that one reason for the rapid diffusion of gains from HYV rice in Taiwan was the relatively more egalitarian landownership pattern due to land reforms initiated by the state. In contrast, in India the extent of land reforms was poor which contributed to the lower achievement of distributional gains of agricultural development by green revolution. However, historically regions in which ryotwari systems prevailed reaped higher growth and distributional benefits than the regions where zamindari systems of ownership prevailed. Micro studies based on primary data have established that per capita credit flows in the first decade of the green revolution were higher in the ryotwari regions. Policy emphasis therefore requires that use of new technologies should be combined with both land reforms and other forms of institutional development. In other words, while land reforms is necessary, equitable distribution of gains from technological development requires that such reforms should be backed by provision of credit, technical and marketing assistance, educational and health institutions, etc.

12.4.2 Impact on Employment

One of the approximate measures of overall employment effect is employment elasticity. Employment elasticity measures percentage increase in employment for every one percent of increase in output. Technologies may alter the employment elasticities affecting the extent of employment absorption. However, while capital intensive technologies may reduce direct employment absorption, the quantum of indirect employment may increase. For instance, demand for machineries may generate demand for additional labour in repairing services. Enhanced output also may require additional labour requirements in downstream sectors like harvesting and processing. Further, the cropping intensity by way of multiple cropping may become possible which in turn would lead to greater demand for labour over the year. In another dimension, the impact of mechanization on employment will depend on the extent to which its ***labour substituting effect*** is compensated by its ***land-augmenting effect***. An example for this is the United States where in the second half of the 19th century horse-based mechanization led to massive agricultural growth with large tracts of new lands brought under cultivation. The export markets in Europe provided a higher elasticity of demand for its output. However, such a situation cannot happen in land scarce countries like India except for some marginal changes in this regard. But with increased non-farm sector growth, even in such contexts labour can be productively redeployed both within agriculture as also in other sectors. However, a necessary condition for this to happen is that factors to induce the elasticity of final demand must prevail. In its absence, mechanization would lead to a reduction in agricultural employment even if extra land is available.

The experience of Punjab in the post- Green Revolution period reveals the complexity of the relationship between employment and new technologies. Here, in the early years of the green revolution, there was a sharp increase in demand for labour leading to a rise in real wages. This increased the demand for labour and the consequent immigration of labour from other states like Bihar. Simultaneously, the wage increases also incentivised movement towards use of more machinery by the land owners resulting in a decline in real wages in the subsequent period. Further, new technologies may favour certain kinds of labour like tractor drivers, combined harvester operators, displacing unskilled labour leading to segmentation in the labour market. Gender based differences are also likely to emerge.

New technologies can also effect changes to employment relations. If the yearly demand pattern for labour over the year changes, it may induce shift from attached labour to hired labour or in some cases, intensification in the use of attached labour. Such shifts too have implications for wage levels and worker's welfare.

12.4.3 Across Economic Classes

New technologies can also bring about changes in the distribution of income between the different economic classes like: landlord-tenant, employer-labour, etc. When a new technology is introduced, there would also be a new class of entrepreneurs willing to cash-in on the opportunity. This could lead to an increase in land-rent making the class of landlords who earn through leasing their land earn more rental income. Likewise, new technology might require hiring of more skilled workers or training the old workers to work on the new technology. In both these situations, there would be a change in the wage bill of employers as higher skills would attract higher wages. Correspondingly, the income shares accruing to capitalist investors (rich landlord/farmers in agriculture) will change. Land augmenting technological change like green revolution technology (i.e. by way of an increase in the cropping intensity and increased yield per unit area), would also alter the income shares of economic classes in favour of the rich farmers. However, the actual outcome in the distribution of income would depend upon the demand for the output and growth in the supply of complementary inputs vis-à-vis the state of development of an economy. In the industrialized countries, for instance, there has been a decline in land rents over time. But there is as yet not enough evidence to indicate such a trend in India.

Technological change would also have implications for wage-share due to changes in demand for labour in ways other than skilled-unskilled case mentioned above. For instance, yield augmenting technology in agriculture may require the use of more intensive labour during times such as harvesting (in the absence of mechanization in harvesting). This would increase the bargaining power of labour and hence the wage rate and consequently the labour's share of wages. Further, when wage rate increases, it may also lead to wage-saving measures by the employers, reducing thereby the wage-share of the employers. In countries like India, where the labour supply is usually much more than the demand, the possibility of a decline in wage share is likely for the unskilled workers particularly when wages are set at the subsistence level. In such a situation, improved productivity may yield more profits for the capitalist farmer as the increase in demand for labour may not lead to increase in the wage-share of employers.

12.4.4 Across Farm Sizes

Another important dimension of distribution of gains from new technology is across size classes of farms. There is a debate on the farm-size-productivity on which you have studied briefly in unit 5 (section 5.4.2) of this course. The predominance of small scale agriculture in several low income countries including India makes this dimension particularly important. Given the capital bias in most technological changes including in agricultural technology, farmers who can access capital more easily are likely to be the gainers. Thus, the differences in the ability of farms/farmers to access capital strongly influences the nature of benefits/income distribution. If access to institutional credit is less for small farmers, the gains will also clearly be relatively less for the small farmers, reinforcing the accentuation of rural inequalities owing to technological development.

In the absence of concerted state policy for assisting farmers with smaller size of land, large farmers will be regarded as more credit-worthy and hence can have better access to institutional credit. The cost of servicing a loan to a small farmer may be as much as that for a large farmer even though the amount lent could be smaller. This increases the transaction costs for the banks creating in the process an inherent bias against small farmers in respect of institutional credit. It has been observed in the context of several low income countries that small farmers are forced to rely more on informal credit markets who tend to charge exorbitant rates of interest. On the other hand, the large farmers, even in the absence of well developed credit markets, would be able to mobilize capital from their own savings while small and marginal farmers ability to do so would be extremely limited. A well developed small farmer-centric credit policy is, therefore, a must for technological development to yield benefits of an equitable nature in countries like India.

Further, many technologies are subject to scale economies in which case larger farms tend to gain more than the smaller ones. The tractor is a good example for this. It is technically more efficient to design a large rather than a small machine. However, small farms can also benefit by renting-in such machinery. This, however, requires appropriate development of institutions like hiring services on easy terms suitable to the small farmer's ability to cope. With the onset of the green revolution, it was expected that the differences in credit access and scale economies would be dealt with, in course of time, by the establishment of support services required for its effective implementation in regions not already endowed with such services. In other words, it was expected to support the 'inverse relationship hypothesis' by enabling even the small farmers to get the benefit of GR technology. This tendency which can be mitigated by improving the access to the required services for small farmers was, in fact, met with some degree of success at some places. However, this did not happen to the expected degree/scale with large areas remaining outside its beneficial reach. Nonetheless, small farms have certain advantages over large farms in production like if new technologies require more supervision of labour, small farmers can do it better than large farmers. However, due to intense fragmentation of land holdings, the landholding size of a large number of small farmers in the country has fallen far shorter than the optimal farm size. This has therefore caused the need for newer methods of coping with such situations like cooperative farming. Cooperative farming has, however, failed due to several institutional problems. Farmers' groups or collectives are seen as more helpful to small farmers in meeting the needs of technology, credit and marketing.

12.4.5 Between Producers and Consumers

When the cost of production of a crop is reduced due to adoption of new technologies (in terms of improvement in yield per unit of land), it implies a downward shift in the cost function and hence an upward shift in the commodity's supply function. This will result in an increase in economic welfare through consumption of a larger quantity at a lower cost. The distribution of the gains in economic welfare between producers and consumers, however, depends on price elasticities of demand and supply for the commodity. Under conditions of perfect elasticity of demand, which means increasing demand with increasing supply, producers can reap all the gains of new technology adoption. When demand is inelastic, increased supply would result in reduced prices and consumers tend to gain. Since demand is inelastic for several agricultural goods, consumers may gain more than the producers in the short run. In addition, in case of agriculture several goods are perishable and hence producers (particularly the small producers) in the absence of proper storage facilities tend to sell the goods as soon as they are harvested. Such sharp increases in supply tend to bring down prices affecting small producers although for the consumers there would be a gain. However, when production is dominated by large farmers or large companies like plantations, they are likely to have access to storage facilities and can hold onto their output till prices rise again after harvesting season. The poor spend a larger proportion of their income on food than the rich. Hence, when food prices fall their real income increases proportionately more than that of the rich. Though the poor may gain from the price decline as consumers, poor farmers face the prospect of losing both as producers when they sell their produce immediately after harvest at lower prices and buy at a later stage some of their requirements when prices are relatively high.

Check Your Progress 2 [answer in about 50 words using the space given]

1) Which two factors are most crucially needed to ensure a more equitable distribution of gains from technological development?

....

....

....

....

2) What is a necessary condition by which the likely adverse impact on employment by technological change can be effectively prevented?

....

....

....

....

3) In what way a new technology could result in the segmentation of labour markets?

....

....

....

....

4) Give two examples to indicate how technological development would impact the labour market in terms of the relative wage-share of employees and employers.

....

....

....

....

5) How would you say that in the matter of advancing institutional credit to small farmers there could be an inherent bias against them?

....

....

....

....

6) At a certain point, the farm-size hypothesis has got itself negated in India in the context of GR-technology spread/diffusion. Why?

....

....

....

....

12.5 GENETICALLY MODIFIED CROPS AND POTENTIAL DISTRIBUTION OF GAINS

The most recent phase of technological change in agriculture involves genetic manipulation of the seeds so as to maximize the more productive characteristics of the plant and minimize its susceptibility to diseases and pests. These are referred to as genetically modified (GM) crops. It is this change in technology that we referred to in the previous unit as shift from green to gene revolution. While the actual impacts on the distribution of gains are not very clear at this stage, based on the above discussion, we are in a position to infer some possible trends. These may be stated as below.

The first GM crops were commercialised in the US in 1995. By 2004, in less than a decade, GM crops were being grown by more than 8 million farmers in seventeen countries covering an area of 81 million hectares. Such rapid diffusion of any new crop technology is considered unprecedented. The most widely used GM technology involves herbicide tolerance (HT) applied in soya bean and canola, and insect resistance based on genes isolated from Bacillus thuringiensis (Bt), applied in maize and cotton.

There are three major institutional, environmental and agro-ecological differences between the GM and HYV revolution. These are:

i) The supply of HYV seeds and other linked inputs in developing countries was dominated by the public sector. Impetus for GM crop development, on the other hand, has not come from farmers or governments, but from large private corporations based in advanced capitalist economies. As a result, intellectual property rights (IPR) become important and any use that violates the IPR is seen as illegal.

ii) The environmental and other risks associated with GM technology are still unclear. It is possible that the gains realised by one set of farmers may be off-set by the adverse health or environmental effects on consumers and other sets of producers.

iii) Unlike the HYV technology which required favourable conditions like assured irrigation to work well, GM technology can be used to improve the productivity of crops even in poor agro-ecological environments.

It is said that the GM technology provides an opportunity to increase productivity of many neglected secondary crops that have been by-passed by HYV technology like millets, sorghum and ragi that contribute to the food security needs of many poor households in Asia and Africa. Till date however, there are only few GM crop species that have been made commercially available. Soybean, maize, cotton, and canola account for over 99% of the total GM crop species so far released and these are also crops that are predominantly grown in the U.S. The reasons for such a narrow focus are clear. Given the dominance of private capital, profitability considerations become more important than improving the livelihoods of poor farmers in low income countries or ensuring food security among the poor. *Biotechnology research is highly capital intensive and therefore the market size becomes an important criteria in choosing crops for introducing GM technology.*

Since multinationals have little incentive to develop GM crops for small or uncertain markets, technologies suitable for developing countries are unlikely to emerge unless targeted public sector activities are increased considerably. Moreover, suitability at the national level needs to be considered as the GM crop technology needs to be adapted to local conditions before it can be used. Possible barriers to its further diffusion due to protection of intellectual property rights (IPR) also needs to be addressed. Safety concerns by many activist bodies, notably on the environmental front, have also been raised. It is said that consumption of GM crops increases the risk from allergens. The technology has to be therefore approved by national bio-safety and food safety authorities.

If we look at the list of countries where GM crop technologies are commercially available, we find that the poorer countries in Africa and Asia are missing. There are widespread concerns that the proliferation of IPRs would limit the access of poor countries to modern biotechnologies. In practice, only a few middle income countries with a strong national agricultural research system like China, India, or Brazil have so far undertaken research in this domain. The prevailing model for GM crop innovation in developing countries has been one where multinational firms commercialize their products that were initially developed for rich country markets, either directly or in cooperation with local seed producers.

Some studies on the economic impacts of GM crop technology reveal that on an average adopting farmers benefit from income increases through reduced pest control costs and higher effective yields. These studies also suggest that the farm-level benefits tend to be bigger in low income economies than in the advanced capitalist countries. However, as mentioned earlier, impact on local ecologies and health risks for consumers including the threat that it can also harm beneficial pests remain. Loss of bio-diversity is the major feared risk. On the economic front, there is a fear that the control of large corporations over seed supply and distribution can undermine the sovereignty of developing country farmers. There is also the concern that the GM technology may undermine the food security of the rural poor if it induces a shift in cropping pattern among small and marginal farmers from protein rich crops like beans to those rich in carbohydrates like rice or wheat. The ongoing debate on GM crops in general or the ones on Bt cotton or Bt brinjal could be appreciated in the light of different dimensions of GM technology discussed above.

Check Your Progress 3

1) Mention the three major differences between the GR-technology and the GM-crop technology?

....

....

....

....

2) Notwithstanding the feared anxieties about the GM-crop technology, what beneficial features do you see in its application in the developing economies?

....

....

....

....

12.6 LET US SUM UP

New technologies, despite their welfare improving effects also have negative implications for balanced regional development. They also tend to favour certain groups of economic actors like large farmers. Some of the biases in the distribution of gains arise from institutional factors like land tenure systems and lack of credit provisions for the small and marginal farmers. Certain adverse labour market features like gender based segmentation too may accrue contributing to structural weaknesses in the growth process. The GM-technology, a later development to the GR-technology, in spite of its positive features like reduced pest control costs and higher effective yields, is feared to be controlled by large private firms with profit as their primary motive. In such a situation, national concerns like ensuring food security among poor households or livelihood improvement among small and marginal farmers in resource scarce environments are not likely to receive the required priority. Unknown potential environmental risks too can create distortions in the welfare gains of such technologies. The policy strategy to address such biases are yet to shape up. However, for any technological gains to be equity centric, public intervention in asset distribution and progress on the tenurial/land reform fronts, along with credit, marketing and technical support, are of utmost importance. To mitigate some of the fears, there is a strong case for direct public investment in new crop technologies to ensure that research is directed towards areas that have greater implications for social welfare.

12.7 KEY WORDS

Embodied and dis-embodied technological characteristics : Inherent qualities to ward off pests and greater yield in seeds/plants are embodied

or needs technological characteristics. Specific training and extension services needed for the effective diffusion of a technology are dis-embodied technological needs.

GR and GM technology : GR technology is what was implemented widely with public investment and support in the entire Asian region in the 1960s to combat concern of food scarcity. GM technology, on the other hand, was a later development of 1980s, developed with private corporate initiative and therefore feared to result in unknown social and ecological disturbances.

Labour substituting effect : One of the much feared effects of any technological development referring to reduced employment particularly to the unskilled. However, there are views that there would be a net employment gain owing to growth of the sector in both the farm and the non-farm sector fronts.

Farm-size hypothesis : Implies smaller farms yield larger output. The inverse relationship means that 'larger the farm size lower will be the output'. However, a minimum or optimum size of a farm is also equally crucial. In the Indian context, intense fragmentation of land holdings has rendered the many actual farm sizes far shorter than the optimum-minimum.

12.8 SOME USEFUL REFERENCES

1. Hans P, Binswanger and Joachim Von Braun (1991), Technological Change and Commercialization in Agriculture: The Effect on the Poor, *The World Bank Research Observer*, Vol. 6, No. 1, pp. 57-80.

2. Hanumantha Rao, C. H. (1975), *Technological Change and Distribution of Gains in Indian Agriculture*, New Delhi: The Macmillan Company of India Limited.

3. Griffin, K. (1974), *The Political Economy of Agrarian Change: An Essay on the Green Revolution*, Harvard: Harvard University Press.

4. Matin Qaim (2001), Transgenic Crops and Developing Countries, *Economic and Political Weekly*, Vol. 36, No. 32, pp. 3064-3070.

12.9 ANSWERS/HINTS TO CYP EXERCISES

Check Your Progress 1

1) See 12.1 and answer.

2) See 12.2 and answer.

3) See 12.2 and answer.

4) See 12.3 and answer.

5) See 12.3 and answer.

6) See 12.3 and answer.

Check Your Progress 2

1) See 12.4.1 and answer.

2) See 12.4.2 and answer.

3) See 12.4.2 and answer.

4) See 12.4.3 and answer.

5) See 12.4.4 and answer.

6) See 12.4.4 and answer.

Check Your Progress 3

1) See 12.5 and answer.

2) See 12.5 and answer.

UNIT 13 TRENDS IN AGRICULTURAL PRODUCTIVITY

Structure

13.0 OBJECTIVES

After reading this unit, you will be able to:

- distinguish between the terms production and productivity;
- define the concept of 'productivity' along with its associated elements like partial factor productivity, total factor productivity, efficiency, etc.;
- present a comparative profile of productivity in total production of food grains and in major crops between India and other countries;
- discuss the trends in land/labour productivity of Indian agriculture;
- identify the causes of low productivity in Indian agriculture; and
- outline the measures required to be taken for increasing the productivity of Indian agriculture.

13.1 INTRODUCTION

We have already noted in unit 11 that in terms of overall agricultural production, but for intermittent variations, India has consistently achieved improvement in its total production of food grains. To recall, India's total production of food grains was 72 million tons (mt) in 1965-66, 132 mt in 1978-79 and 234 mt in 2008-09 (in 2011-12 it is estimated to cross 250 mt). Notwithstanding this increasing trend, it is also a fact that the average productivity of Indian agriculture is much lower when compared to many other countries. We have also read in unit 11 that increased use of certain critical inputs under the green revolution (GR) technology (i.e. fertilizers and pesticides) contributed to declining soil fertility with the subsequent experience of stagnation/decline in agricultural productivity in the post-GR years. This is also evident from the figures on aggregate production cited above; the average annual increase in the production of food grains declined steeply from 4.6 mt over the 13-year period of 1966-79 (i.e. 60 ÷ 13) to 2.8 mt (i.e. 86 ÷ 31) over the period 1979-2010. This means while achieving increase in total production is necessary, maintaining or increasing the productivity level, which is more related to the use of factor inputs efficiently, is equally important. In other words, while increasing production is necessary for the growth of the sector, it is not by itself sufficient from the point of view of productivity/efficiency considerations. The concept of productivity, in this sense, is treated equivalent to efficiency. We are also aware that owing to scarcity of land and water resources, the only way to increase our agricultural production is to focus on productivity increase i.e. by an optimum usage of inputs for increasing the level of output. There is, thus, a close relationship (and a positive or negative trade-off which ensues) between achieving increased total production and achieving it with due regard to concerns of productivity/efficiency. In this unit, we focus on the different aspects of productivity like its definition/meaning, components, issues of measurement and variables on which data is required for the same, trends, causes of low productivity, measures needed to increase productivity, etc. We begin with a brief conceptual outline of terminologies in order to be able to appreciate the trends in agricultural productivity discussed later in section 13.3.

13.2 CONCEPTUAL OVERVIEW

The above introduction tells us that we must first of all be clear on the distinction between the terms 'production' and 'productivity'. There are also other related concepts like output, value added, factors of production, production function, etc. Each one of this plays an important part when we are dealing with the issue of productivity measurement or trend. Let us, therefore, familiarise ourselves with the meaning or definition of these terms.

13.2.1 Production Vs. Productivity

Production, in empirical terms, refers to a quantified assessment of a situation like the total value of our agricultural production. This can be measured and expressed either in units of a physical measure (i.e. millions of tons) or in terms of its monetary value expressed in millions of rupees or dollars. The value of production so expressed is what we commonly refer to as 'output'. The value of output net of value of inputs that has gone into its making (i.e. output minus input; both expressed in same units – particularly in value terms) is what is widely referred to as 'value added'.

The term productivity, on the other hand, refers to a ratio of 'output' to 'input'. Thus, the per hectare agricultural production is a measure of productivity in which 'output' is taken as total production and 'input' is taken as land. An increase in the value of output can be achieved by changing the value of input (i.e. increase or decrease in the amount of land used). Keeping the 'input', in this case land, constant, increase in output can also be achieved by improving the efficiency of land by use of fertilisers or manures, or by a change in the pattern of land use itself by diversification or cropping culture. An increase in output, achieved by keeping the input constant or by a reduction in the input used, would mean that there is an increase in productivity. This can be illustrated by a simple example. Suppose a production unit, unit-1, produces output valued Rs. 100 by engaging 10 persons. The per person productivity of unit-1 is Rs. 10. Suppose another production enterprise, unit-2, employs only 8 persons but produces a similar output also valued at Rs. 100. The per person productivity of unit-2 is Rs. 12.5. Evidently, unit-2 is more productive than unit-1. Alternatively, if by a change in the manner/ proportion of factor-usage, the same 10 persons in unit-1 produce output equivalent to Rs. 125, then the average per person productivity is 12.5 making the productivity of unit-1 higher than that of unit-2. Essentially, therefore, productivity as a concept refers to a ratio [ratio of 'output to input'] and it can be different or varied depending on the efficient use of factors used in production by different units working in a sector or economy. We may recall here that as per classicists, labour and capital are the two main factors of production. However, even among them there is recognition that there are many other factors which have the potential to cumulatively make a greater impact on productivity influencing in the process both these cognizant factors of production.

13.2.2 Partial Factor Productivity and Total Factor Productivity

Since labour and capital are the two major factors of production, a distinction between 'labour productivity' and 'capital productivity' is commonly made in literature. However, while labour and capital are the two most important factors of production, it is also true that a host of other factors like industrial climate, organisational culture, education & training, research & development, extension services, infrastructure, political stability, etc. also cumulatively goes to determine the contribution to output by labour and capital. In view of this, the concepts of 'labour productivity' (LP) and 'capital productivity' (CP) are referred to as partial factors of productivity. And since by including the residual factors as a third component to represent all other factors which when taken into account signifies the productivity in its totality, the residual factor is referred to as 'total factor productivity'. Usually, in empirical exercises LP is measured as the ratio of 'value added to employment' which provides us an indicator of 'per person or per employee output (or income like in per capita income)'. An improvement in LP over time is thus indicative of the rise in the average level of contribution to production made by workers in that sector. Note that in the illustrative exercise cited in 13.2.1 above, the productivity index computed is LP. Likewise, CP is measured as the ratio of 'value added to capital' in which the denominator is the total capital used in production. CP, thus, provides us a measure of value added per unit of capital used in production. Measurement of TFP is done by two methods called 'growth accounting approach' and 'econometric approach'. We will keep more details on this out of our present discussion as it is outside the purview of our immediate focus vis-a-vis productivity trends in Indian agriculture.

13.2.3 Allocative Efficiency and Technical Efficiency

In the productivity indicator expressed as a ratio of two quantities viz. output and input, the numerator is the total value of 'production' and the denominator is the total value of inputs that has gone into its making. Our main concern is to identify the factors contributing to an inefficient use of resources so that by concentrating on minimising them, a more efficient usage of resources (i.e. inputs) resulting in an optimum realisation of output can be achieved. Viewed from this perspective, a productivity measure (or index) is an indicator of efficiency. If the efficiency (i.e. higher productivity) is attained by a better allocation of resources it is called 'allocative efficiency'. If, on the other hand, the productivity increase is a result of the change in the method of production (like adoption of new technology or a better organisation of methods of production) then the efficiency is referred to as 'technical efficiency'. Empirical studies in productivity analysis, besides measurement of productivity indicators, are also concerned with the identification of the factors contributing to efficient production in terms of the above two types of efficiency. The ratio of value added to total/gross output, which tells us the value added per unit of gross output generated, is another direct measure of efficiency. This measure of efficiency is published in the reports of the Annual Survey of Industries published by CSO (Central Statistical Organisation) in India.

13.2.4 Depreciation and Deflators

It is necessary to use appropriate deflators for converting the nominal values (also called current values) of value based variables like output, value added and wages in order to enable making temporal comparison of changes over time. The usage of deflators converts the variables in current values (also called nominal values) to a constant base making them standardised so that comparison made over time is with respect to a common base. Deflation of value based variables is necessary because the money value changes over time; for instance, Rs. 100 in 1970 and Rs. 100 in 2011 are not the same as the value of money decreases due to changes in prices (mostly inflation) over time. In empirical work, for deflating the value of output (or value added) we use the Wholesale Price Index (WPI). For deflating wages paid to workers, the Consumer Price Index (CPI) is used. In empirical works on productivity, deflating value based variables is very much necessary to get a realistic idea about the ground reality in the real situation.

13.2.5 Production Function

A production function is an equation that specifies the output of a firm for all combinations of inputs. In other words, given a common technology under use, the function provides us with a mathematical form of the expected levels of output to varied combinations of inputs used. Recall that when different firms are operating using a given level of technology, the deployment of factors are done by individual firms with an eye on their expected returns i.e. higher output and profits in which there will be some variation from firm to firm as all firms cannot use the factor inputs in exactly the same measure. Alternatively, a production function can be defined as the specification of the minimum input required to produce expected quantities of output within the potentials of available technology. A production function can be expressed as: $Q = f(X_1, X_2, X_3,...,X_n)$ where Q = quantity of output and $X_1, X_2, X_3,...,X_n$ are the quantities of factor inputs (such as capital, labour, land, raw materials, etc.). The most commonly used form of production function is the Cobb-Douglas production function which is expressed as:

$Q = a\, X_1^b X_2^c$........... The advantage of this form is that by taking logarithm on both sides, the exponential character of the equation gets reduced or transformed into a linear form like: $Q = a + bX_1 + cX_2 + dX_3 + ...$ making it easier for estimating the coefficients involved. Depending on the nature of data that we have we can estimate the parameters a, b, c, etc. by applying what is called as the least squares principle. You will study about this method of estimation in your course on statistics viz. EEC 13 of your BDP programme. We might mention in passing that if we have data on all variables in annual time series, keeping our inputs restricted only to two factors viz. labour and capital, and considering the coefficient 'd' to represent all other factors with X_3 taken as the time variable 'T' [taken in chronological order of 1, 2, 3,..... years], the coefficient 'd' would provide us a measure of 'total factor productivity'. The coefficients of X_1 and X_2 viz. b and c representing the parameter for the variables labour and capital respectively, besides providing estimates of the labour and capital partial factor productivities, also carry major economic significance. If the two coefficients are kept constrained as necessarily adding up to unity (i.e. b + c = 1) it would amount to assuming that there is constant returns to scale i.e. doubling the inputs will double the output, tripling the inputs will triple the output, etc. If this assumption is relaxed i.e. if we allow the sum of these two coefficients to assume values below and above unity, it would amount to considering the model with variable returns to scale. In particular, if the sum of co-efficients is greater than 1 then it means there is increasing returns to scale (i.e. doubling the inputs will more than double the output). If it is less than 1, then it means there is decreasing returns to scale i.e. doubling the inputs will less than double the output. Note also that 'b' is the partial elasticity of output with respect to labour input i.e. it measures the percentage change in output holding the capital input constant. Likewise, 'c' is the partial elasticity of output with respect to capital input, holding the labour input constant.

13.2.6 Isoquants

Theoretically, it is considered that for a given technology there exists a unique production function. Given this, since to achieve a desired level of output, the inputs X_i (i = 1,2,....) can be variously employed, the production function for a given technology is a curve obtained by plotting different combinations of X_is yielding the same level of output. Such a curve, called as isoquant, therefore provides a whole range of alternative ways of producing the same level of output by adopting various combinations of inputs. The idea will be more clear if we consider an illustration using a hypothetical situation as shown in Table 13.1. The Table considers two inputs, labour and capital, and lists various levels of output that can be obtained by employing different combinations of the two inputs. For instance, let us consider an output level of 200 for which there exists three combination of inputs viz. (4, 1), (3, 2), and (1, 4). By plotting these three points on a graph (see Figure 13.1) we get the isoquant-1 (Q_1). Similarly, Q_2, Q_3 and Q_4 are isoquants drawn from the combination of inputs to yield levels of output of 290, 345 and 450. In other words, higher *isoquants* represent higher level of production from which optimum factor combination to produce a certain units of a commodity can be chosen.

Table 13.1: Production Function Showing the Level of Output that can be Obtained by Employing Two Inputs Labour (*L*) and Capital (*K*)

Units of Capital Employed	Units of Labour Employed						
	1	2	3	4	5	6	7
1	40	90	150	200	240	270	290
2	90	140	200	250	290	315	335
3	150	195	260	310	345	370	335
4	200	250	310	350	385	370	390
5	240	290	345	385	420	450	475
6	270	320	375	415	450	475	495
7	290	330	390	435	470	495	510

Data Sources: Data on labour or employment for the agricultural sector (as also for other sectors at various levels of disaggregation) is available in the decennial census reports as also in the quinquennial NSSO survey reports on Employment and Unemployment. Data on value added and capital formation, again for all sectors, is available in the National Accounts Statistics (NAS) published by CSO. Using data from these sources and by suitably adjusting for data requirements like price differences, interpolation of data for intervening years, etc. we can estimate productivity trends by sectors. While these are secondary sources of data by government agencies, another source of secondary data is CMIE (Centre for Monitoring Indian Economy), a private source, which has also become very popular. There are also published estimates like per hectare yield, data on global rank in terms of area, production and yield for many countries, etc. which help us get an international comparative perspective of productivity trends. We will study about these from some of these sources on productivity trends in the agricultural sector in the next section.

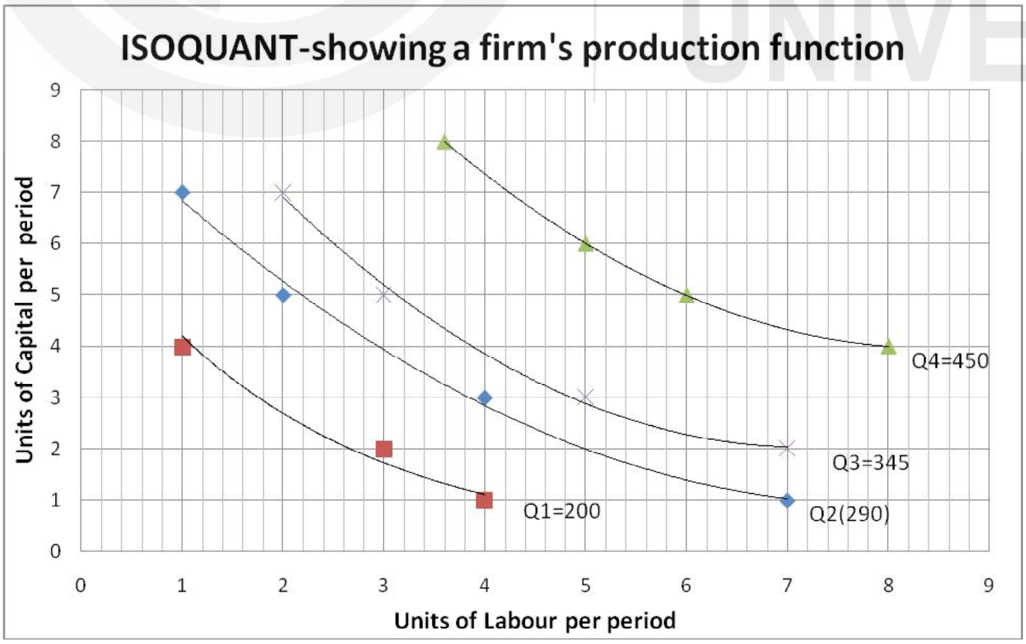

Fig. 13.1 : ISOQUANT Showing a Firm's Production Function

Check Your Progress 1 [answer questions 2 to 4 in about 50 words in the space given]

1) Fill in the blanks.

   a) The average annual increase in the production of food grains during the years 1966-79 was .... mt. Over the next three decades of 1979-2010, this annual increase steeply declined to .... mt.

   b) While achieving increase in total production of food grains is .... for agricultural growth, what is even more important is achieving increase in ....

   c) The variable that we get by subtracting total inputs from total output is called ....

   d) Unit-1 produces items worth Rs. 1,00,000 by engaging 100 persons. Another unit, unit-2, produces similar items using similar technology worth Rs. 1,40,000 by engaging 125 persons. Which of these two units is more productive than the other? What are the values of labour productivity of these two units? Which kind of efficiency, allocative or technical, would you say has contributed to the higher productivity of the more productive of these units?

   e) Capital productivity is measured as the ratio of .... to .... In essence, it gives us the .... of ....

2) Why is the productivity ratio/indicator equated with 'efficiency'? Which is the other direct indicator which is taken as a measure of efficiency?

   ....

   ....

   ....

   ....

3) Why is it necessary to deflate the value based variables in exercises on empirical measurement of productivity? Which price indices can be used to deflate output and wages?

   ....

   ....

   ....

   ....

4) Why is the Cobb-Douglas production function advantageous to apply in practice? Which method is used to estimate its coefficients? How is a relaxation on the assumption of constant returns to scale obtained?

   ....

   ....

   ....

13.3 PRODUCTIVITY IN INDIAN AGRICULTURE

There are two main annual publications which furnish data useful for computing productivity indicators. One is, as already mentioned, National Accounts Statistics (NAS) which publishes data on GDP at factor cost by industry of origin and gross capital formation by industry. A second source is the Economic Survey (ES) which collates data published from different sources. The ES also publishes data on: (i) Wholesale Price Index (WPI) and Consumer Price Index (CPI) besides publishing data both at constant prices and current prices; (ii) area under principle crops aggregated to 'all commodities' and indexed to a base year taken as 100; and (iii) yield per hectare of food grains. Data on global ranking of countries in major agricultural crops by area/production/yield and yield per hectare are published by Indian Agricultural Statistics (an annual publication by the Union Ministry of Agriculture) and CMIE. In this section, using the data from these sources, we shall draw a profile of the productivity trends in Indian agriculture in respect of productivity indicators like: land productivity, labour productivity, etc.

13.3.1 Land Productivity

The land productivity (measured as kg per hectare) shows that there is a steady increase right from 1961 to 2009-10 (Table 13.2). The decline in the year 2010 is due to the data for the latest year being provisional which is likely to be revised when more accurate estimates become available. The observed increase (in absolute figures) needs to be verified by the decadal growth rate which evens out the changes over time averaging the growth to an annual indicator. The growth rates calculated at decadal intervals shows the following:

Table 13.2 Yield Per Hectare of Food Grains (kg/hectare): 1961-2010

Year	1960 -61	1970 -71	1980 -81	1990 -91	2000 -01	2004 -05	2005 -06	2006 -07	2007 -08	2008 -09	2009 -10
Yield	710	872	1023	1380	1626	1652	1715	1756	1860	1909	1798

Source: Economic Survey, 2010-11, Table A-19.

Note: CAGRs (compound annual growth rates): 1971-81: 1.6 percent; 1981-91: 3.0 percent; 1991-2001: 1.7 percent; 2001-09: 2.0 percent; post-reform years growth (1991- 2009): 1.7 percent.

- The highest growth of 3 percent was in the decade of 1981-91 [i.e. the post green revolution (GR) decade].
- There was a steep decline in the growth rate of land productivity during the subsequent decade of 1991-2001 to 1.7 percent per annum. This, however, improved slightly during the subsequent period of 2001-2009 to 2 percent per annum.
- The average growth rate over the 19 year period of post-reform years (i.e. 1991 2009) is 1.7 percent. This is much lower than the growth during the post-GR years (1981-91) of 3 percent.

Land productivity depnds partly on fertility of land and substantially on the technology and inputs used. As we have seen earlier, the GR technology did improve productivity per hectare but it also affected fertility of soil in many areas due to excessive use of chemical fertilizers. Since the availability of arable land is fixed, increase in production of foodgrains depends solely on the increase in productivity. The trend growth rate in land productivity in the last decade (2001-09) was about 2 percent which is close to the rate of growth of population. This indicates that there is no threat to foodgrain availability in India in the immediate future. However, there is increasing pressure on land for non-agricultural use, and unless land productivity increases meeting the food grain needs of growing population would become a problem.

13.3.2 Labour/Capital Productivity

The trends in labour productivity (Table 13.3) also shows that the peak in this respect was in the post-GR years centred around 1991 (0.95 tonnes per agricultural worker). In the post-reform years, there is a steep decline in LP (0.83 tonnes around 2001). There is, however, an improvement in the post-2000 years to nearly its 1991 level. It is important to note that the effect of capital infusion (by way of improved seeds, fertilizers, irrigation, mechanised machineries deployed, infrastructure improvement due to public investment, etc.) also reflects in the trends of LP. The trend for capital productivity (CP) [obtained as a ratio of GDP at factor cost for agriculture and allied activities and gross capital formation in agriculture (using NAS-2010 data at constant 2004-05 prices)] shows that CP has steadily declined from 8.5 in 2004-05 to 7.8 in 2006-07, 7.2 in 2007-08, 5.8 in 2008-09 and 5.7 in 2009-10. The trends in LP and CP, thus, suggests that there is need for more infusion of capital into agriculture and allied activities and infrastructure to improve agricultural productivity.

Table 13.3 Labour Productivity in Agriculture: 1961-2011

Year	Total Food Production (in millions of tonnes: mt)	No. of Agricultural Workers (in millions)	Labour Productivity (in tons)
1961	82.0	131.15	0.62
1981	129.59	147.98	0.87
1991	176.39	195.32	0.95
2001	196.81	235.06	0.83
2011	241.56	258.57*	0.93

Source: (i) Registrar General of India, 2001 (for number of agricultural workers).

(ii) For total food production, Ministry of Agriculture, GoI.

Note: (i) Data for 2011 is an estimate by adding 10 percent of workers in 2001 figures based on the increase in the rural population of 12.18 percent over 2001-2011.

(ii) Figure for 2011 are advance estimates.

13.3.3 Productivity from an International Perspective

The global average of the proportion of total land under cultivation to the total geographical area is about 32 percent. As compared to this, India's proportion of total land under agriculture is higher at 46.1 percent. India's position in this respect is better than countries like U. S. A. (40 percent) and Brazil (10 percent). However, the productivity of land vis-a-vis the potential of HYV seeds as realised by India and what has been achieved by other countries compares very unfavourably for India (Table 13.4). This is also borne out by the relative poor ranking for India for major agricultural crops in spite of its position in terms of production being among the top ranking countries (Table 13.5). While the actual low productivity levels across all crops in India is a cause for concern, it also holds the promise that there is room for increasing the productivity which would ensure better production levels to meet the growing needs of the country. The international perspective, however, reinforces the attention required to be given for raising the productivity levels of Indian agriculture.

Table 13.4: Productivity in India vis-a-vis Other Countries

(Kg/Hec)

	India		*World's Largest Producer*		*World's Most Productive*	
Crop	*Potential of HYV Yield*	*Actual Yield*	**Country**	**Yield**	**Country**	**Yield**
Rice	4,000-5,810	3,002	China	5,807	Australia	8,813
Wheat	6,000-6,800	2,743	China	3,295	Ireland	7,556
Jowar	3,000-4,200	1,196	US	3,704	Italy	5,949
Maize	6,000-8,000	1,841	US	4,505	Netherlands	25,000

Source: CMIE *Indian Harvest*, 2011.

Table 13.5: India's Global Rank in Major Agricultural Crops

	Rank		
Crop	**Area**	**Production**	**Yield**
Rice (paddy)	1	2	52
Wheat	1	2	38
Coarse Grains	3	4	125
Pulses	1	1	138
Oilseeds	2	5	147
Cotton	1	4	77
Jute	1	1	13
Tea	2	1	13
Sugarcane	2	2	31

Source: GoI, MoA, Indian Agricultural Statistics, 2007.

13.4 THE ISSUE OF LOW PRODUCTIVITY

As noted above, productivity of Indian agriculture is low as compared to the productivity at the global level. In particular, Tables 13.4 and 13.5 showed that even though India ranks number one in terms of area under cultivation of rice and wheat, the yield levels are abysmally low compared to China and Australia. Similar contrast in yields exist for coarse cereals and other crops. Even the most productive states in the country fall short of world standards in terms of yields of major crops.

13.4.1 Causes of Low Productivity

Causes for low productivity can be classified into four broad heads viz. (i) demographic factors; (ii) institutional factors; (iii) technological factors; and (iv) policy bias/weakness.

Demographic Factors

- India's total population has increased from 1.03 billion in 2001 to 1.21 billion in 2011 causing demand for more food of both the conventional and the modern kind. But the availability of land is limited and the soil fertility has declined. This is a compelling demographic situation which has caused the land productivity to remain low despite the fact that there is an increasing trend in land productivity over the period of 1961-2010. This is also borne out by the stagnating labour productivity trends particularly in the last two decades.

- Although the industrial sector is expected to absorb the surplus labour from agriculture, due to inadequate employment growth in the industries, the pressure on agriculture for livelihood continues to be high. This is despite the fact that the number of workers engaged in agriculture is declining over time. There is also fragmentation of land holdings resulting in the average size of holdings in India becoming so small (less than two hectares) that they are economically unviable for applying modern methods of production. This is compounded by the poor economic conditions of large number of small farmers due to which implementation of better agricultural practices has continued to remain constrained. The result is low productivity in agriculture per unit of land.

Institutional Factors

- At the time of independence, India inherited a semi feudal agrarian structure with the ownership and control of land concentrated in the hands of a few landlords and intermediaries. Even with the efforts made over the last six decades at instituting land reforms and the partial success we have attained in some respects, the actual cultivator continues to work under hindering conditions to produce more.

- Added to the issue of absentee landowners, increasing tenancy in relatively better irrigated areas, lack of security of tenure, the inadequate infrastructural support in terms of adequate and timely agricultural credit, good rural transport system, marketing/storage facility, etc. have continued to be deterrent factors. There is inadequacy of institutional credit to farmers and continued dependence on high cost informal credit. These factors have cumulatively hindered the achieving of higher productivity in Indian agriculture.

- With increasing dependence on purchased inputs, growing risks associated with new technology, and volatile prices the farming sector faces formidable problems. There have recently been instances when the farmers have faced the problem of 'bumper crops spelling disaster' as they had to sell them off at lower rates due to inadequate storage facility. Such factors have, therefore, continued to act as deterrent for increasing the productivity.

- Institutional development for promotion of entrepreneurship like it has happened in the developed countries are yet to take deep roots in India. All progress made in this direction have at best remained stray examples marking for efforts made at pockets rather than at many places in general. In contrast countries like China have successfully introduced competition in their agricultural operations to bring about a greater level of efficiency in spite of small size of holdings.

- Lack of investment in general, and falling levels of public investment in recent years in particular, have continued to hamper the achieving of higher levels of productivity in Indian agriculture. Public investment in agricultural R & D did not keep pace with the growing challenges. On the contrary, exposure to private trade in improved seeds not only increased costs but also risks, inhibiting small farmers from undertaking measures to improve productivity.

Technological Factors

- Majority of Indian farmers are not exposed to new technologies both due to their poor conditions as also due to the lack of reach by scientists and extension workers. There has been decline in the extension facilities especially since the introduction of reforms and fiscal constraints on public expenditure. As a result, they have continued to operate with traditional methods which are low yielding. In other words, inadequate availability of modern inputs and methods have remained a factor for low productivity.

- Even with all the efforts and investment made in spreading irrigation facilities, less than 50 percent of total agricultural sector has been covered by irrigation. Dependence on uncertain monsoon due to low reach of assured irrigation facility has remained a continuing reason for low productivity in agriculture.

- Inadequate and poor post-harvest technology, which is estimated to result in a loss of close to 30 percent of agricultural produce, has been a major constraint in realising the potential value of agricultural output produced.

- There has been no major breakthrough in the technological front for many decades. This is termed as 'technology fatigue' contributing in no small measure for the stagnating agricultural productivity in the country.

Policy Bias/Weakness

- Indian agriculture has suffered from subtle policy bias with an excessive dependence of policy favouring industry. The state's involvement in promotion of industry was much more than it was for agriculture. High protection offered to industry past the stage of infancy, has made private investment to veer more towards industry than agriculture.

- Infrastructural development also had a similar bias in favour of industry than agriculture. This is despite the fact that the agricultural sector also received policy support on many fronts. So much so, a recent study of 2007 (by the International Food Policy Research Institute) has established that the support for agriculture in India has been inconsistent and largely counter-cyclical to world prices. This is to say, agricultural support increased when world prices were relatively low and decreased when world prices were high.

13.4.2 Measures to Increase Agricultural Productivity

It naturally follows from the above that the measures for increasing agricultural productivity can also be stated in terms of: (i) institutional; (ii) technological; and (iii) incentive structure needed. Briefly, these can be elaborated as follows:

13.4.2.1 Institutional Reforms

- Establishment of better agrarian relations through land reforms, arrangements for adequate agricultural financing, wider and equitable distribution of agricultural inputs for technologically suitable methods are vitally needed for raising agricultural productivity. It is important to state that while many of the institutional arrangements are already in place, their effective implementation which has lacked needs to be focussed upon.

- Another major aspect of institutional reform refers to improving the efficiency of delivery systems. This includes overall rural development measures and empowering democratic institutions like the panchayati raj. This would require suitable devolution of functions for economic and social development including transfer of necessary resources.

13.4.2.2 Technological Improvements

Technological improvements can be classified under two heads viz. (i) biological and (ii) others. The biological innovations refer to focusing on factors that bring about greater land productivity. This would mean developing land saving methods and practices (such as development of better seeds and fertilisers) of a nature that are environmentally sustainable. Other innovations contain several components as follows.

- It is not technical information alone which helps poor farmers. They also require supportive measures like input supplies, extension services, credit facility, post-harvest assistance like storage/marketing, etc. Agro-service centres which hire out consultants and supply sprayers, tractors and threshers must be widely spread out throughout the country. As complementary measures, cooperatives on the lines that are efficiently functioning in countries like Taiwan should be encouraged on a nationwide basis. In the absence of these services, the Indian farmers' ability to adopt modern techniques of crop production, developed in the lab, cannot be increased. And in its absence, increasing the productivity of Indian agriculture will remain crippled.

- Returns to research are known to be high. In the light of this, research efforts should focus on methods and practices which can be applied on smaller farms and dry regions. However, since there is a lower limit beyond which the applicability of technology and capital intensive practices cannot be applied in an economically viable manner, it is necessary to establish institutional mechanisms to help poor farmers with small plots of land to pool their resources and work together. Content of research should be both on plant breeding for food grains and other crops including farm management. Resources need to be spread across issues of land management, farming systems and agro-forestry. Suitable policy changes to encourage private research are also needed as the days which heavily depended on public investment alone are not only impracticable, they cannot also help raise productivity. Since the agricultural sector at the present level of socio-economic development in India continues to be heavily dominated by poor and marginal farmers, institutional development of the desired kind need to be promoted by the government. State must assume greater role as the regulator of efficiency and equity concerns of the society.

- Developments in IT (i.e. information technology) involving ecologically sound concepts and systems like integrated intensive farming systems, expansion of e-chaupals, removing the constrains on the access/use of remote sensing data (except in case of security sensitive maps/data) of value to farming practices, etc. should be put to greater use for improvement of output and productivity. Projects of e-chaupals presently operating in only some states should be expanded to cover all the states.

13.4.2.3 Incentives for Raising Productivity

Improving small farm productivity: The major challenge in this regard is that nearly 80 percent of the land holdings in India are below 2 hectares in size. Unless factor productivity is increased, small farm agriculture will become un-remunerative. However, the smaller the farm, the greater is the need for marketable surplus in order to get returns in cash. Therefore, improving small farm productivity, as a single development strategy, can make the greatest contribution both for raising output/productivity and eliminating hunger and poverty. Accessibility to modern inputs like fertilizers, pesticides and improved seeds at reasonable prices across the nation to small farmers is a must in this respect. Other measures, both on the price and non-price fronts, crucially needed are the following.

- Stabilize the returns from agriculture, especially in rain-fed conditions, by effective crop-insurance schemes.
- Improve the scale of production, which is known to act as a major constraint in increasing productivity by application of modern inputs and methods, by pooling of resources. The concept of public land banks, outlined earlier in unit 5, should be implemented in earnest to overcome the problem of small scale agricultural operations.
- Promote industry-agriculture linkage through 'contract farming' providing the farmers access to better inputs and technology. The collaboration would also help the corporate sector in getting steady supply of quality raw materials.
- Dovetail the industrial reforms to reforms of agriculture by way of rationalising and restructuring the fertiliser industry. It is unrealistic to expect farmers to pay for higher protection and the resulting inefficiency of the fertiliser industry which has deeply set in because of past protective policies pursued to promote its expansion.
- Reorient the public procurement and price support policies and arrangements to redefine their objectives better. A lot of food channelized to these distribution centres have been wasted in corruption and inefficiency rendering the entire system suffer from a non-existing mismatch of demand and supply.
- Remove electricity and irrigation subsidies through reforms of a nature that are capable of addressing the underlying causes of low cost recovery and poor financial performance.
- Noted agricultural economist Schultz had observed more than six decades ago that the poor farmers in developing economies are wise and they only need to be supported properly to capitalise on their wisdom. Extending this logic it is argued that farmers should be involved in different layers of developmental activity concerning their welfare. In particular, their due representation in decision making bodies like input supplying agencies and output marketing boards should be encouraged to act as a catalyst for better resource efficiency and increase the overall profitability of the sector.

- It is also argued that if all farmers are motivated to invest their meagre resources into their land and work in a coordinated manner the output of the sector can be doubled without any additional government investment in the form of subsidies. This calls for promotion of peoples involvement policies and measures by which our East Asian neighbours have reached their present heights. India has to badly catch up on this front during the next 2 to 3 decades if the interests of attaining food security by raising the productivity levels is to be attained.

- Increased farm productivity would need many more workers in an expanded and modernised agricultural sector than the present. In other words, with the declining share of workforce in agriculture the increased productivity level would not only improve the income levels of farmers but also generate additional employment on the non-farm sector. For this, the sector only needs to be modernised with the right approach as outlined above. Herein lies the real challenge which is more easily said than done.

Indeed, it is rightly argued that much of the Indian agriculture has the required resilience to be competitive and can flourish under a liberalised trade regime. However, to club the leakages and make it efficient, domestic reforms (more than the reforms on the external trade front) are needed. This should, therefore, be the immediate short term focus of policy thrust.

Check Your Progress 2 [answer questions 2 to 6 in about 50 words in the space given]

1) Fill in the blanks

   a) The highest growth rate in agriculture attained so far is .... percent and is in the period ....

   b) The post-reform growth in agriculture is .... percent during 1991-2001 and .... percent during 2001-2009.

   c) The highest labour productivity in agriculture attained in India so far is ...... tons. This declined to ...... tons in 2001 but again increased to ...... tons in 2011.

   d) The trend in capital productivity in agriculture during the years 2005-09 has steadily ....

2) In what way the existing demographic situation in India has been a compelling factor in keeping the land productivity low?

   ....

   ....

   ....

   ....

3) Mention any two factors to establish that there has been a policy bias affecting agriculture growth vis-a-vis industry.

   ....

   ....

....

....

4) In what respect the biological innovations should focus in order to improve the Indian agricultural productivity?

....

....

....

....

5) Do you agree that emphasis on 'research' is important to increase agricultural productivity? What would you suggest as the direction in which efforts in this regard should be made?

....

....

....

....

6) Give one example each on the fronts of price and non-price measures which you think is crucially needed to set the course of Indian agriculture on a more productive path.

....

....

....

....

13.5 LET US SUM UP

Even though in absolute terms over a long term of close to six decade period there has been a steady increase in the total agricultural production in India, in relative terms the agricultural productivity is stagnant/declining. Furthermore, in comparison to other developed countries the productivity levels of Indian agriculture is very low. This, along with the fact that our population has been ever increasing making a heavier demand on food needs/varieties, demands that our growing concern for 'food security' can be addressed only by focusing on increasing the agricultural productivity levels. The measures which need to be taken to achieve this objective falls on institutional, technological, price and non-price fronts. The unit has spelt out these aspects with a touch of the related conceptual, theoretical and empirical dimensions.

13.6 KEY WORDS

Productivity : Refers to a ratio of output to input. It brings out the relative picture, as compared to the absolute picture, in which even though in absolute terms the output might be increasing over time, in productivity terms it might not be so. In particular, land productivity, labour productivity and capital productivity refers to the per unit level of output in which the factor inputs considered are land, labour and capital respectively.

Total Factor Productivity : While labour and capital are the two classical factors of production, many other factors not so easily recognizable together accounts for or determines the level of productivity or productivity returns. These are education and training, industrial climate, political stability, etc. It has been empirically demonstrated that the contribution to overall output from TFP is much more than that of the two main factor inputs viz. labour and capital. Measurement of TFP, however, requires greater amount of data like price indices used in deflating value based variables like output, value added, etc.

Growth Rate : Refers to a single empirical indicator of the average growth per year over a period like a decade. The compound annual growth rate or CAGR is obtained by applying the formula: $P_n = P_0(1 + r/100)^n$ where P_0 is the base/initial year value, P_n is the n^{th} year value, 'n' is the no. of years over which the growth rate is sought to be determined and 'r' is the growth rate to be calculated. In microsoft Excel, we can get the value of 'r' by keying in the formula:= rate (n,,-P_0,P_n)*100. Note that there are two commas after 'n' and a 'minus' sign before P_0. The multiplication by 100 is made to get the percentage growth rate. Using the data provided in Table 13.2, you can compute the simple average/annual growth rate and see that its value will be slightly higher than that of CAGR.

Isoquants : Refers to a curve of the production function corresponding to a particular technology. For a two-input situation, it can be thought of as a graph plotted by taking the quantity of one input (say, labour) measured on the X-axis and the second input (say, capital) measured on the Y-axis. Thus, if there are many possibilities of obtaining the same level of output using different combinations of the two inputs, we can draw a curve connecting the points corresponding to the different pairs of two input values. Such a curve, drawn to bulge inwards (as the desired level of output is generally sought to be obtained by applying the minimum values of inputs) is called as an isoquant.

13.7 SOME USEFUL REFERENCES

Mark W. Rosegrant and Robert E. Evenson , Total Factor Productivity and Sources of Long –Term Growth in Indian Agriculture, EPTD Discussion paper No. 7, International Food Policy Research Institute (IFPRI), 1995.

Renuka Mahadevan, Productivity Growth in Indian Agriculture: The Role of Globalization and Economic Reforms, Asia-Pacific Development Journal, Vol. 10, No. 2, 2003.

Sundaram, K.P.M., Gaurav Datt and Ashwani Mahajan, Indian Economy, Part 3: Agriculture in the National Economy, S Chand Group, New Delhi, 2011.

WTO and Indian Agriculture : Implications for Policy and R&D, Policy Paper, 38, National Academy of Agricultural Sciences , New Delhi, 2006.

13.8 ANSWERS/HINTS TO CYP EXERCISES

Check Your Progress 1

1) For a) and b) see 13.1 and answer; for c), d) and e), see 13.2 and answer.

2) See 13.2.3 and answer.

3) See 13.2.4 and answer.

4) See 13.2.5 and answer.

Check Your Progress 2

1) a) and b) see 13.3.1 and answer; c) and d) see 13.3.2 and answer.

2) See 13.4.1 and answer.

3) See 13.4.1 and answer.

4) See 13.4.2.2 and answer.

5) See 13.4.2.2 and answer.

6) See 13.4.2.3 and answer.

UNIT 14 NEW AND EMERGING AGRICULTURAL PRACTICES

Structure

14.0 OBJECTIVES

After reading this unit, you will be able to:

- define the term ‘agricultural practices’ from a holistic perspective;
- discuss the production related practices under its broad constituents;
- explain how concerns of sustainability practices have been duly incorporated into the agricultural practices pursued;
- describe how water use efficiency practices have occupied a place of centre stage in the agricultural practices pursued;

- explain how conservation and post-harvest management practices have contributed to the progress of agricultural development in India; and
- specify some of the new agricultural practices adopted in India.

14.1 INTRODUCTION

It is clear from the earlier units that the Indian agriculture has undergone a great deal of change in terms of agrarian structure, institutional arrangements, technological practices and agricultural production and productivity. Beginning with serious deficiency in food grains production at the time of independence, agricultural production has achieved a great turn around by 1980s with self-sufficiency in food grains production. We have seen the role played by green revolution (GR) in this transformation process. We have also observed that GR which helped to overcome the food problem, brought in its wake several adverse effects like erosion of soil fertility due to excessive use of chemical fertilizers, growing regional disparities due to neglect of dry regions, and growing distress among small-marginal farmers due to high risks without commensurate support systems. A combination of these factors have left the gains of GR a thing of the past, leaving Indian agriculture and the small-marginal farmers in a crisis situation.

At present, Indian agriculture is faced with the challenge of reviving and sustaining agricultural productivity with fair distribution of gains across the regions and across all classes of farmers. In this context, there have been a number of initiatives taken towards adopting new practices in agriculture. These practices are also linked to combating the major challenges faced by Indian agriculture viz. (i) increasing production and productivity of crops by an efficient utilisation of critical inputs, (ii) ensuring sustainability of production systems by practising scientific conservation practices, and (iii) linking production to the market and the changing consumer preferences. Against this background, the present unit focuses on discussing the various agricultural practices pursued in India. The discussion is presented under the following four broad groups of practices: (i) production related practices; (ii) sustainability related practices; (iii) water use efficiency practices; and (iv) conservation and post-harvest management practices.

14.2 PRODUCTION RELATED PRACTICES

Production related practices can be discussed with reference to certain principle components of agricultural resource use. These can be clubbed under: soil, fertilisers, additional nutrients and changes in cropping practices.

14.2.1 Soil Fertility/Health

Soil is a natural resource formed and conditioned by several factors like: (i) climate (temperature and rainfall), (ii) topography of the area, (iii) living organisms like vegetation, (iv) nature of parent material (like type of rocks and minerals), and (v) time. It is thus both a physical as well as a chemical process. During this process, many organic and mineral matter is added, lost and transformed. The importance of soils lies in the fact that it provides a basic medium for the growth of crops. In fact, the type and profile of the soil determines what crops can be cultivated in it. A soil's potential for producing crops is largely determined by its capacity to store water and its other attributes (like acidity, depth, and density) which together determine how well the roots of crops can develop. Changes in these soil attributes directly affect the health of the plant. Further, over time with the continuous cultivation of crops, the capacity of soils to provide the required nutrients diminish. As plants grow, their living cells take up chemical substances from their environment and use them as a source of energy depleting the environment, especially of the quality of soil. This necessitates the use of practices that can help restore or replenish the major nutrients in soils to sustain good plant growth. Simultaneously, many natural factors and anthropogenic factors, including improper practices followed during cultivation, result in degradation of soils making them unfit for cultivation. Thus, management of soils through practices which help to restore soil fertility and health are critical requirements for sustaining the productivity levels of agricultural produce.

14.2.2 Fertilisers

A fertiliser is any natural or synthetic substance which when spread or worked into the soil increases its capacity to support plant growth. Such substances may be: (i) organic materials or (ii) chemical (inorganic) fertilisers. The application of fertilisers is an important and necessary practice both for restoring soil fertility as also provide the stimulus required for higher agricultural growth.

Organic Materials

Before the development of chemical or synthetic fertilisers, organic sources in various forms were used to enhance the soil fertility and improve its physical properties, such as water holding capacity, important for plant growth. Organic fertilisers are natural materials of plant or animal including livestock manure, green manures, crop residues, household waste and compost. Such materials are used as fertilisers either directly or after they are cycled as animal or human food. Today organic substances are used in conjunction with chemical fertilisers to supplement the availability of the latter. The different types of organic manures that are used as fertilisers include: (i) bulky organic manures, (ii) concentrated organic manures, and (iii) bio-fertilisers.

Bulky organic manures include farm yard manure (FYM), compost and green manure. These are added in large quantities to the soil which helps to improve the physical condition of soils. They enhance the activity of micro-organisms in soils by: (a) improving the water-holding capacity of soils; (b) reducing evaporation losses; (c) controlling soil temperature; (d) and providing almost all the nutrients required for the plant growth. Exclusive farm yard manure is mainly cattle dung generally available in villages and easy to apply. However, it is also used as a source of fuel by the farm households and hence FYM is not totally available for use as fertiliser. The amount of nutrients provided by FYM depends upon its quality which is governed by the feed provided to cattle. This means that the quality of FYM in terms of its nutrient contents can be improved by feeding cattle with concentrated feeds (like cotton seed cake, linseed cake, soy meal, wheat bran, legumes, hays and grains). Other types of organic manures are rural and urban compost, sewage material and sludge. *Compost* is obtained by the decomposition of wastes from farmhouses, cattle sheds, town refuse and night soil. Sludge is another thick, soft matter settled as sediments at the bottom of sewage storage tanks which also contain large quantities of plant nutrients. However, these materials must be properly treated as they can otherwise damage soils. Another recent practice followed by farmers is vermi-composting. This is a process by which farm residues or forest litter are used to produce compost by introducing earthworms into the pit in which the residues or litter are stocked. Preparation method is relatively simple and the compost produced contains important elements like carbon, nitrogen and phosphorous. Green manuring has been practiced by farmers in India for long. It involves the ploughing into soil of green plant tissue for improving the physical condition of the soil and also to increase its fertility. Generally the crops selected to be grown for green manuring are those that have a profuse growth of leaves and grow rapidly during the early stages of their life cycle. They are also capable of growing well in poor soils, and have a deep root system. Fertilizing soils through the process of green manuring is more economical than using other types of fertilisers. Certain green manure plants like beans, peas or radishes provide edible substances also. Moreover, during the growth process, these plants prevent erosion of top soil and their deep roots help to break up the hard pan. Farmers incorporate green manure crops in their crop rotations to augment soil fertility. The practice is especially recommended for Gangetic Plains where the rice–wheat systems of production prevail and the productivity of soil is declining.

Concentrated organic manures include oil cakes. Oil cake is the solid residue that remains after some oil containing seeds are pressed and the oil is extracted from them. They are used as cattle feed or as fertiliser depending upon whether they are edible or non-edible. The edible oil cakes are drawn from cotton seed, groundnut, linseed, soybean meal, rapeseed, sesame and coconut. The non-edible oilcakes are cakes derived from the non-edible oilseed crops like castor, neem, safflower, *karanj,* and mahua.

Bio-fertilisers are artificially multiplied cultures of certain soil organisms that can improve soil fertility and crop productivity. They are preparations that have living cells of efficient strains of micro-organisms as active ingredients. These microorganisms have a symbiotic relationship with the plants and help them to take up nutrients. Bio-fertilisers accelerate certain microbial processes in the soil which augment the extent of availability of nutrients in a form easily assimilated by plants.

Chemical/Mineral Fertilisers

Traditionally, farmers have used organic fertilisers (chiefly farm yard manure) to replenish soil fertility. However, the amount of nutrients added to the soil by organic substances are small and the decomposition of organic manure is often a slow process. A better option is the use of chemical or synthetic fertilisers, called inorganic fertilisers. The high yielding varieties resulting from the genetic improvement of plants are highly responsive to chemical fertilisers. This means that their yield potential can be realised only if the right amount and type of fertiliser is provided as crucially required inputs. With a change in cropping systems from monoculture to cultivating two or more crops in a year (made possible by the short duration varieties developed), chemical fertilisers have come to be used extensively.

Chemical fertilisers contain one or more plant nutrients that is easily soluble in water and thus become quickly available to the plants. These are required to be applied in specific doses for different crops determined through scientific research. In addition to the dose, the time and mode of application is also important. The application of this practice resulted in higher productivity of crops under the 'green revolution' methods. The main nutrient supplied through chemical fertilisers are nitrogen (urea, for example, is a nitrogenous fertiliser which is the main chemical required for plant growth), phosphorous and potassium (i.e. NPK). These are the macro-nutrients required for plant growth and survival.

Mineral fertilizers are another form of chemical fertilisers which need to be applied to crops at least twice in a growing season either basally at the planting stage or top-dressed during the stage of vegetative growth. The amount of inorganic fertilizer used in most smallholder farming systems fall far below the standards recommended due to reasons of: (i) poor purchasing power of small farmers, (ii) risk aversion (of higher investment) due to fear of poor and unreliable rainfall, and (iii) insignificant returns owing to unpredictable market factors. However, when available, fertilizer use being not overly labour intensive, allows time for other performing tasks (thereby earning income elsewhere).

14.2.3 Achievement of Synergetic Effect

The use of both organic and inorganic fertilisers is important for stimulating agricultural production. Integrated nutrient supply and management involve the efficient and judicious supply/use of all important nutrients required by the plants/ crops in a balanced manner. It involves the use of chemical or mineral fertilisers in conjunction with organic and biological nutrients to improve or maintain soil productivity. Chemical fertilisers are a concentrated source of nutrients that are absorbed by plants quickly. Organic manures, on the other hand, provide relatively less nutrients but help to improve the physical properties of the soil in a way that is conducive for plant growth. Green manures such as after-harvest-crop-residues augment the supply of nitrogen in addition to improving the soil health and quality. The synergistic effect of the combined use of nutrients with organic farming practices helps in improving the soil's chemical, physical and biological properties. This leads to increased crop productivity.

14.2.4 Calibrated Cropping Practices

Over time, farmers have learnt from experience that the cultivation of the same crop repeatedly on the same land leads to a reduction in the yield of the crop. An alternative practice adopted to overcome this situation is 'crop rotation'. Crop rotation involves the cultivation of different crops in a sequence in which the green manures like the residuals of other crops serve as organic manure. In India, there are three agricultural seasons implying that some crop or the other can be grown all round the year. The three seasons are the rainy or *kharif* season from July to October, the winter or *rabi* season from October to March and *zaid* which extends from April to June. During these seasons, crops may be grown as sole crops or mixed crops (i.e. mixed cropping). When only one crop is grown in a season it is called mono-cropping and if two crops are grown it is called a double cropping system. Rotational cropping is the cultivation of two or more crops in a definite sequence and when more than two crops are taken in a year from a given piece of land it is called multiple cropping. The kind of cropping system that is found in a region is the cumulative result of farmers' experience, personal preferences and skills, government policies, resource availability, response to pests and diseases prevalent in an area, ecological suitability and feasibility, climatic conditions, socio-economic factors, and market demand conditions. Based on the agronomic diversity, the country has been divided into a number of agricultural regions where different cropping systems are predominant.

14.2.5 Sequential Multiple Cropping

The practice of sequential multiple cropping involves the cultivation of short duration crop varieties with intensive input management. This is practiced mainly in irrigated regions and helps to increase land use efficiency. In adopting a particular crop rotation system, a major consideration is the economic return per unit of land. However, profitability of a particular system depends significantly on the input costs and output prices and hence in a country like India it is vulnerable to changes in government policies. Some examples of crop rotations being followed in India are the rice-wheat-cowpea in Orissa, rice-french-bean-groundnut and groundnut-chickpea in Maharashtra, rice-potato-green gram in western parts of Uttar Pradesh, and rice-cabbage-potato and rice-radish-pea-french bean in north-western mid-Himalayas.

Check Your Progress 1 [answer in about 50 words in the space given]

1) Mention the three major challenges around which the various agricultural practices have evolved?

....

....

....

....

2) Into which two groups are fertilisers classified? Which of this refer to natural materials of plant and animal? Why is it not efficient to depend only on such natural fertiliser?

....

....

....

....

3) What are the three major factors that inhibit the small farmers in India from using the chemical fertilisers in adequate quantity/measure?

....

....

....

....

4) Why is 'sequential multiple cropping' not practiced widely in India? In which regions can it be practiced to increase land use efficiency?

....

....

....

....

14.3 SUSTAINABILITY RELATED PRACTICES

Sustainable agricultural practices rest on the principle that we must meet the needs of the present without compromising the ability of future generations to meet their needs. It is defined as pursuing those agricultural practices which, over the long term: (i) enhance the environmental quality and the resource base on which agriculture depends; (ii) provide for basic human food and fibre needs without compromising on environmental quality; (iii) ensure economic viability in terms of input costs involved and the returns realised; and (iv) improve the quality of life of farmers and the society as a whole. In this, the efficient management of both the *human and natural resources* is of prime importance. Management of human resources include consideration of social responsibilities such as: (i) improving the working and living conditions of agricultural labourers, (ii) meeting the needs of rural communities, and (iii) ensuring the consumer health and safety of both the present and the future generations. The management of natural resources, on the other hand, involve maintaining or enhancing the vital resource base for the long term needs. In this section, we shall briefly discuss the practices followed in the management of natural resources like land and water.

14.3.1 Land Degradation and Soil Erosion

Land degradation is a combination of several processes that result in the reduction or loss of the biological or economic productivity of agricultural lands. The processes resulting in degradation of land include soil erosion (caused by wind and/or water), deterioration of the physical, chemical and biological properties of soil and long-term loss of natural vegetation. Erosion of the soil is a major cause of degradation resulting in the loss of top soil and formation of channels and gullies.

Soil erosion continues to be a serious threat to our continued ability to produce adequate food. Numerous practices have been developed to keep soil in place. These include reducing or eliminating tillage, managing irrigation to reduce runoff, and keeping the soil covered with plants or mulch. Enhancement of soil quality can be achieved by the integrated use of nutrients as outlined below.

14.3.2 Integrated Use of Nutrients

The sustainable use of chemical fertilisers involves the use of the right kind of fertiliser based on soil tests which help in identifying the magnitude of specific nutrient deficiency. Soil can be tested for their phosphorous and macro/micro nutrient deficiency at laboratories. Facilities for this are established at agricultural universities, research institutions and mini soil testing laboratories set up at block level. Further, the major nutrient levels (like those of NPK) can also be assessed on the farm itself using mini soil test kits.

Besides the application of the appropriate quantity of a fertiliser based on soil test and plant requirements, the integrated use of both organic and chemical fertilisers in modulated conjunction is a practice that is used not only for stimulating agricultural production but also for ensuring sustainable use of land resources. Integrated nutrient management involve the efficient and judicious supply/use of all important nutrients required by the plants/crops in a balanced manner. This helps to restore and improve the chemical and physical properties of soils.

14.3.3 Irrigation Scheduling

Besides crop specific water requirements, water requirements also vary across different stages of the growth cycle of the plant. Local climatic and soil conditions also influence water availability to crops. Non-availability of water at critical stages of plant growth can hamper flowering and grain development. Likewise, provision of excess water can also be counterproductive as crops cannot utilize excess water and may become stressed from reduced oxygen levels of saturated soils. To counter these effects, 'irrigation scheduling' is a practice followed. This helps in minimising instances where too little or too much water is applied to crops. Proper irrigation scheduling by growers involve fine-tuning of the time and amount of water applied to crops. This is based on factors like: the water content in the crop root zone, the amount of water consumed by the crop since it was last irrigated and during the crop development stage, etc.

14.4 WATER USE EFFICIENCY PRACTICES

Agriculture is a major consumer of water and the availability of fresh water is gradually declining. The intense pressures on our water resources due to the growing demand from agriculture, domestic and industrial sectors are forcing us to look at irrigation not only from the point of view of optimising water management to meet the plant water requirements but also for the more generic issues of enhancing water use efficiency. This basically involves improving the water availability for the plant and minimising water losses during irrigation. From the sustainability angle, the emerging practices include the use of alternative methods of irrigation such as drip and sprinkler irrigation. Through these methods, water losses through evaporation are significantly reduced and water availability for the plant is enhanced.

In the above context, 'water use efficiency' is defined as the yield per unit area and per unit of water used. The water requirement of different crops/varieties differ. For instance, rice requires much more water to produce a unit of dry grain than wheat implying that the water use efficiency of rice measured in kg/ha-cm is significantly lower than that of wheat. Within the same crop, different varieties also have different water requirements and use efficiency. Thus the selection of proper crops and varieties that are better adapted to available water in the growing region is a simple practice that helps to improve water use efficiency. Besides this practice of employing appropriate choice of crop variety, some innovative practices evolved for higher level of water use efficiency are the following.

14.4.1 Conjunctive/Multiple Use of Water

The conjunctive use of water is an irrigation management technique that helps to enhance the productivity and profitability of irrigated agriculture. It involves coordinated use of total water from multiple sources such as rivers, canals and ground water. Coordinated use of water from different sources helps to optimise total water use and ensure water availability for the entire period of crop production/ year. The advantages of conjunctive use of water are to: (i) mitigate shortages of canal or ground water, (ii) increase dependability of existing water supplies, (iii) alleviate the problem of high water tables and salinity on account of canal irrigation, and (iv) facilitate the use of saline ground water through dilution.

Water can be put to number of end uses which may be independent of the intended use of that water. For instance, a community or individual farmer's pond which stores water for irrigation purposes, can also be used to breed fish which is a high value commodity. This leads to an improvement in the economic productivity of water.

14.4.2 Alternative Irrigation Methods

There are three main irrigation methods. These are: (i) surface (or gravity) irrigation, (ii) sprinkler irrigation and (iii) drip irrigation. <u>Surface irrigation</u> is the conventional method of irrigating crops which is still widely used. In this, water is applied to the crop by flooding it on the soil surface, mostly by gravity flow. This is however an inefficient method of irrigation where considerable wastage of water occurs making the overall efficiency level low due to problems of water-logging and salinisation which commonly result. When the entire field is flooded, it is called basin irrigation. Significant water losses of this method led to the development of modified surface irrigation methods such as: (i) the furrow irrigation method and (ii) check basin method. In the *furrow irrigation* method, furrows are designed along the longitudinal slope of the land and water is fed into small channels or strips. Water movements through these furrows, both along the longitudinal slope and laterally, increases the efficiency of water usage. The *check basin* method of irrigation is suitable for level plots. In this, water is run into the plot surrounded by small ridges. The plot is then irrigated by main and lateral channels. The main channel is aligned along the upper end of the field and checks are made on either side of the lateral channels. Both these methods attempt to achieve higher efficiency of irrigation through a control over the speed of water flow and thereby minimising water losses.

The sprinkler irrigation system imitate natural rainfall. In this, water is pumped through pipes and then sprayed onto the crops through rotating sprinkler heads. These systems are more efficient than surface irrigation as they provide water uniformly, reduce run-off and minimise deep percolation losses. However, they are expensive to install and operate besides needing pressurized water supply. Conventional sprinkler systems spray the water into the air losing considerable amounts to evaporation. Low energy precision application (LEPA) offers a more efficient alternative. In this system, the water is delivered to the crops from drop tubes that extend from the sprinkler's arm. When applied together with other appropriate water-saving farming techniques, LEPA can achieve efficiencies as high as 95 percent. Further, since this method operates at low pressure, it also saves as much as 20 to 50 percent in energy costs compared with conventional systems.

Drip irrigation method is the most efficient irrigation method as it employs low-flow technology and deliver water precisely and directly to plant roots at rates that prevent deep percolation and run-off losses. Water is delivered to the crops in slow continuous drops or in a trickle. Installation costs are high but advantages of water saving, enhanced plant growth and yield, and saving of labour and energy compensate the high installation costs significantly. The system also improves efficiency of fertiliser application and does not lead to soil erosion unlike in the case of other methods like surface/sprinkler irrigation. Research has shown that in sugarcane crop, drip irrigation has resulted in 35 percent higher yield, 50 percent saving in water and 50 percent saving in labour costs. Similar increases in yields and savings in water and labour are reported in other crops like banana and citrus from drip irrigation.

14.5 CONSERVATION AGRICULTURAL PRACTICES

Conservation agriculture is different from conventional agriculture in the sense that it does not aim at maximising yields by exploiting the soil and agro-ecosystem resources. Rather, it seeks to optimise yields (and profits), by achieving a balance of agricultural, economic and environmental benefits. Conservation agriculture, in addition to its contribution to sustainable agriculture and rural development, presents a powerful option for meeting the future food demands. This is achieved by adopting practices helpful in: (i) enhancing the efficiency of inputs, (ii) increase farm income, (iii) improve and sustain crop yields and (iv) protect and revitalize soil, biodiversity and the natural resource base. Conservation agriculture, therefore, addresses issues of crop production, natural resource base, bio-diversity, livelihood needs, etc. The practices followed pertain to three interlinked core principles of conservation agriculture viz. minimal soil disturbance, preservation of soil cover and diversification of crop rotation.

Reduced tillage or conservation tillage is a related practice which involves minimum soil disturbance by allowing crop residue (or stubble) to remain on the ground so that it could be incorporated into the soil. Such tillage practices may progress from reducing the number of times the soil is tilled to completely stopping tillage, a practice called zero tillage. The advantages of reduced or zero tillage are the prevention of wind and water soil erosion and retention of fertile top soil. This also results in increased population of earthworms which is helpful in improving soil fertility.

Mulching is another agronomic practice helpful in retaining soil moisture by reducing evaporation, facilitating infiltration of water into the soil, improve the soil structure, and prevent erosion of soil. It involves the covering of the ground around the plants with straw, grass, crop residues, compost or plastic sheeting to restrict evaporation and add organic matter. Live mulching is also practised by farmers in which a fast growing legume is established before or along with a widely spaced grain crop like maize and incorporated into soil at an appropriate time. Grass mulches applied in varying quantities per hectare in wheat and maize have been found to enhance yields by 8 to 58 percent over controlled cultivation.

Contour farming is another agronomic practice followed in hilly areas in which cultivation is done along contour lines rather than up and down the hills. In this, ploughing, seeding, planting and intercultural operations are performed along contour lines resulting in the formation of ridges and furrows. These act as mini barriers and reservoirs by intercepting rain water and reducing runoff of water, nutrient loss and soil erosion.

Incorporation of organic matter into the soil and practising crop rotations are essential components of conservation agriculture. They improve the capacity of soils to produce crops and limit wind and water erosion. However, limiting soil erosion and land degradation are not the only objectives of conservation practices. Their other objectives include: (i) crop-livestock integration in farming systems; (ii) increasing the biomass inputs to soil systems; (iii) optimizing the use of organic and inorganic nutrients; and (iv) practicing the ecosystem-based and integrated management methods to control weeds, pests and diseases. Integrated pest management (IPM) practices currently practised by farmers aim at keeping: (i) pest populations below harmful (called economic threshold) levels (instead of their complete eradication), (ii) protecting and conserving environment including biodiversity, and (iii) making plant protection feasible, safe and economical, even for small farmers. A major component of IPM is the use of biological agents which are natural enemies of the pests and hence limit their populations in the field.

14.6 DISTRIBUTIONAL PRACTICES

Distributional practices are post-harvest management practices. Agricultural commodities are produced for the market where they are purchased for consumption by the end-users or by processors who add value by converting them into processed products. Post-harvest practices and operations create form, time, place and possession utilities. This means making the product available to a consumer in the *form* in which he wants it, at a *time* he requires it and in a *place* where he can buy them. In view of this, depending upon the product, post-harvest practices range from simple practices like cleaning and grading to more complex practices like milling, processing, branding and packaging all of which would contribute to enhancing the shelf life of the commodities. In this section, we list some simple practices followed at the farm level which facilitate the distribution of the commodity in a desired state of quality to the consumers.

Cleaning, Standardization and Grading: Cleaning is a process by which impurities in the form of straw, husk, soil, stones, etc. are separated from the grain. At the farm level, this is done manually and involves sieving, washing and drying of the grains. Washing is very common in case of vegetables, and to a lesser extent in fruits, aimed at removing mud and soil. Standardization is the process of setting standards of product quality based on characteristics like weight, size, colour, appearance, texture, moisture content, staple size, foreign matter content, chemical content, ripeness, sweetness, taste, etc. This makes the product quality uniform for consumers and the process of marketing easier. Grading is the sorting of the produce into different lots according to quality standards of the product. Cleaning and grading practices may be undertaken at the producer's (farm) level or during subsequent stages of the marketing chain. For several products in India, grading is mandatory according to grades fixed by the government. A system of grading of agricultural products referred to as centralized grading system involves enforcement of product purity and quality standards through periodic checking at specified laboratories of the Directorate of Marketing and Inspection. Agricultural products that meet purity and quality standards are granted Agmark labels. Decentralised grading system is followed in case of commodities like fruits, vegetables, cereals, pulses and eggs which do not require elaborate testing arrangements and can be graded on the basis of physical appearance. The purpose of grading is to take advantage of price differentials attributable to differences in physical and purity characteristics of commodities.

Storage: Agricultural commodities are characterized by seasonality in supply but carry regular all year demand. However, their inter-year variability in production is high. Hence, storage is an essential activity that ensures maintenance of the product in its quality and quantity. Storage also facilitates the holding of the commodity by producers till the right price can be obtained in the market. Traditional structures and containers in which grains are stored in rural areas are made from locally available materials, differing in size, shape and capacity. Common structures and containers include gunny bags made of jute; earthen containers made of burnt clay of capacities ranging from half to three quintals, bamboo structures, straw structures (which are circular structures made from un-trampled paddy straw) and masonry structures. Traditional farm and household level storage practices involve the use of salt, ash, camphor, lime, and pongamia leaves. These are mixed with the commodity and placed in different types of structures/containers to prevent pest infestation. Both underground and surface storage structures are used for grain storage. While these are traditional storage practices still prevailing in many places, modern day cold storages are refrigerated structures used for perishable products like fruits, vegetables, milk, dairy and meat products. Cooling prevents deterioration in quality. Cold storage offers the option to keep products stored at the right temperature.

Packaging: Packaging or wrapping and crating products before they can be transported and sold is an important activity. They protect the product, reduces its bulk, facilitates handling and transportation, ensures cleanliness of the product and checks adulteration. All these together enhances the shelf life of the product. Different types of packaging materials are used for different products at different levels of marketing and distribution. These include gunny and cloth bags, wooden crates, straw baskets, PVC and plastic trays, corrugated fibre boards, tin, glass, aluminium foil and cardboard containers. The choice of packaging material and container depends on the nature of the product and marketing level. Factors such as the desired level of protective strength, attractiveness, consumer convenience, economy, and elimination of chemical reaction with the food product are important considerations in choice of materials for packaging. In case of processed products there is a mandatory requirement of providing essential information about packing like date of manufacturing and expiry, price, point of origin, etc. on the product labels. Thus, packaging should be such that they support the labelling requirements.

Check Your Progress 2 [answer in about 50 words using the space given]

1) State the four components on which the practices of sustainable agriculture rests?

....

....

....

....

2) What does the practice of 'integrated use of nutrients' involve? In what way is it beneficial?

....

....

....

....

3) What is 'irrigation scheduling'? In what way it is helpful as a crop production practice?

....

....

....

....

....

4) State the four advantages of 'conjunctive use of water'.

....

....

....

....

....

5) Among the different alternative irrigation methods, which is most beneficial from the point of view of 'water use efficiency'? Why?

....

....

....

....

6) In which of type of region/area, the practice of 'contour farming' followed? In what way this method is helpful in minimising production/environmental losses?

....

....

....

....

14.7 NEW AGRICULTURAL PRACTICES IN OPERATION

There have been a number of programmes to propagate the new agricultural practices. These are gaining importance both in terms of state sponsored initiatives, voluntary initiatives by farming community and, of course, promotional programmes as a part of corporate business interest. Some of these initiatives, which involve overlap of the four practices discussed above, are outlined in this section briefly.

14.7.1 Non-Pesticide Management

There is increasing consciousness about the excessive use of pesticides which raises cost of cultivation and also cause serious damage to environment as much as to the health of practising farmers. The Government of Andhra Pradesh promoted non-pesticidal management (NPM) programme as a part of the scheme called Community Managed Sustainable Agriculture (CMSA). Launched in 2004, as part of the farmers' field school, farmers under CMSA learn to identify insects, pests/predators and their life cycles and develop pest calendars. They also learn to make best use of natural resources and locally available material in crop management. The following are some of the practices farmers adopt under this:

- Early ploughing to destroy the soil borne harmful insects at larva/egg stage.
- Seed treatment for pest minimisation and better germination with ash, cow urine, etc.
- Pheramone traps, sticken plates and bonfires at right season and right places to minimise insects.
- Green sprays.

Besides health and environmental benefits, the main thrust of NPM under CMSA was to reduce farmer's cost without reducing their yields. Within a short period of four years (2004-2008), the NPM spread from a modest 25000 acres in 10 districts to 6.75 lakh acres across 18 districts in Andhra Pradesh.

14.7.2 System of Rice Intensification (SRI) Cultivation

The System of Rice Intensification, known as SRI, is a set of farming practices developed to increase the productivity of land and water, as well as other resources. SRI is based on the principle of developing healthy, large and deep root systems that can better resist drought, water logging and wind damage. It consists of elements to better manage inputs, utilize new ways to transport seedlings, and to manage water and fertilizer application. SRI is derived largely from farmer experimentation and local institutional innovation. The reported benefits of SRI are: increase in paddy yields, better rice quality, reduction in irrigation water use, and reduction in production cost. With climate change, increasing variability of rainfall, and with the growing competition for water and land, SRI offers a new opportunity for increasing the production per drop of water and for reducing agricultural water demand. Further, the organic inputs used in SRI are obtained locally with no production or transportation costs. They improve the soil's productive capacity in the long run. These practices also result in huge energy saving and reduced green house gases. Another offshoot of SRI is that similar methods and practices are now extended to other crops like maize, pulses and even wheat.

14.7.3 Organic Farming

The growing concern on threat of chemical fertilizers and pesticides to not only soil health but also human health has taken the shape of growing demand for food and fibre grown without the use of chemicals as fertilizers or pesticides. This has resulted in a movement in agriculture towards 'organic farming' and has become a world-wide phenomenon. Its success in India depends on the proactive role of the government in evolving institutional mechanisms for certification with minimum hassles to small-marginal farmers. Such efforts are as yet nowhere in sight and the whole certification process is under the control of international commercial conglomerates which mean unaffordable costs to farmers in countries like India.

14.7.4 Adoption of Conservation Agricultural Practices

Conservation agriculture (CA), as mentioned before, aims to achieve sustainable and profitable agriculture. As a consequence, it also aims at improving the livelihoods of farmers through the application of the three principles: minimal soil disturbance, permanent soil cover and crop rotation. CA holds tremendous potential for all sizes of farms and agro-ecological systems, but is most urgently required by smallholder farmers, especially those facing acute labour and water shortage. It is a way to combine profitable agricultural production with environmental concerns and sustainability. It is perceived by practitioners as a valid tool for Sustainable Land Management (SLM).

It is because of this promise that FAO is actively involved in promoting CA, especially in developing and emerging economies. CA can only work optimally if the different technical areas are considered simultaneously in an integrated manner. The multidisciplinary nature of CA will always require the rich mix of expertise available to FAO as it works to promote the CA concept worldwide. Table 14.1 shows the extent of application of CA practices across continents. Clearly, Asia is among the lowest to catch-up on CA practices with South America and North America among the leaders in this report.

Table 14.1 Global Adoption of Conservation Agriculture

Continent	Area (000 ha)	% of Global Total	% of Arable Crop Land
South America	55630	47.6	57.5
North America	39981	34.1	15.4
Australia & New Zealand	17162	14.7	69
Asia	2630	2.2	0.5
Europe	1150	1.0	0.4
Africa	368	0.3	0.1
Global Total	**116921**	**100**	**8.5**

Source: Regional Dialogue .... 2011 (For details see references)

14.8 LET US SUM UP

The need for meeting the growing needs of our huge population necessitated the approach adopted under the green revolution agricultural methods/practices. This helped the country attain a state of food sufficiency and a surplus for export. Alongside this achievement, owing to critical needs experienced on the fronts of productivity and sustainability concerns, improvement in production practices and methods pursued occupied the centre stage of policy on agricultural development. Over time, the Indian agricultural system has adopted many self-learnt and scientifically researched practices. These have helped achieve environmentally friendlier methods of production practices. Among the other purposes that these practices have helped achieve are: increased production, higher incomes, soil and water resource efficiency, reduction in post-harvest loss, etc. The unit has outlined the various methods and practices developed and implemented over the last five decade period in India.

14.9 KEY WORDS

Organic Materials : Organic fertilisers are natural materials of plant or animal including livestock manure, green manures, crop residues, household waste and compost. Such materials are used as fertilisers either directly or after they are cycled as animal or human food.

Bio-Fertilisers : Are artificially multiplied cultures of certain soil organisms that can improve soil fertility and crop productivity. They are preparations that have living cells of efficient strains of micro-organisms as active ingredients.

Sequential Multiple Cropping : Refers to the practice of cultivation of short duration crop varieties with intensive input management.

Integrated Use of Nutrients : Is a practice which involves the efficient and judicious supply/use of all important nutrients required by the plants/crops in a balanced manner. This helps to restore and improve the chemical and physical properties of soils.

Irrigation Scheduling : In order to control the ill effects of deficit/surplus amount of water to crops, 'irrigation scheduling' is followed as a practice. It involves the fine-tuning of the time and amount of water applied to crops. This is based on factors like: the water content in the crop root zone, the amount of water consumed by the crop since it was last irrigated and during the crop development stage, etc.

14.10 SUGGESTED REFERENCES FOR FURTHER READING

1. Handbook of Agriculture (2011). Indian Council of Agricultural Research, New Delhi.
2. Ghosh, Nilabja (2004). Promoting Biofertilisers in Indian Agriculture, Economic and Political Weekly, December 25.
3. Regional Dialogue on Conservation Agriculture in South Asia: Proceedings and Recommendations, APAAR, CIMMYT and ICAR, New Delhi, 2011.
4. Sangwan, Satpal (2000). Level of Agricultural Technology in India (1757 – 1857). *Asian Agri-History*, 11 (1): 5 – 25.
5. V&A Programme (2009), The System of Rice Intensification: Vulnerability and Adaptation Experiences from Rajasthan and Andhra Pradesh, SDC V&A Programme, India.

14.11 ANSWERS/HINTS TO CYP EXERCISES

Check Your Progress 1

1) See 14.1 and answer
2) See 14.2.2 and answer
3) See 14.2.2 and answer
4) See 14.2.5 and answer

Check Your Progress 2

1) See 14.3 and answer
2) See 14.3.2 and answer
3) See 14.3.3 and answer
4) See 14.4.1 and answer
5) See 14.4.2 and answer
6) See 14.5 and answer