Chapter - II

TECHNOLOGICAL CHANGE
AND
AGRICULTURE - SOME
THEORETICAL ISSUES
The present chapter is divided into three sections. The first section is an endeavour to deal with the concept of technological change in agriculture and the types of technological changes occurring in it. The second section provides the features of new technology and the process of its adoption. In the third section the role of the new technology is subjected to scientific evaluation.

Section-I

A) The Concepts:

(1) Technology:

Technology means the knowledge, the skills and all the available techniques applied in production to increase the output. It indicates the input-mix in the production of unit of output. It helps to provide greater output from a given amount of input or it plays an important role in economising scarce resources. Vernon W. Ruttan1 opined, "For analytical purposes it is convenient to use the term technology to refer to the body or stock of techniques, procedures, or ways of conducting economic activity. The level of technology can be conceptualised in terms of an aggregate production function whose parameters reflect all of the technical
production possibilities currently available." Specifically, technology may be defined in terms of the proportions in which land, labour and capital are combined into the production of a unit of output. It is a function of the technological change and the relative input prices. Technology is a stock concept.

(2) Technological Change:

Technological change has been taking place at a fast rate in recent years. Technological change means changing the input-mix in order to increase the output with the same resources or to get the same output with a few resources. In other words technological change implies higher level of output at the same cost or the same level of output at a lower cost. Research and experience lead to new techniques and thereby technology changes. Generally technological change is defined in terms of either a productivity index or a production function. But these two ways of defining the technological change are one and the same. A productivity index implies the existence of a production function and vice versa. M.I. Nadiri\(^3\) opines that the productivity indices are deduced either from an explicitly defined production function or from a distribution theory where production function is implicit.

Vernon W. Ruttan\(^4\) in 1956 defined the technological progress as a production of greater output with the
expenditure of a given quantity of resources. In other words technological change leads to higher output per unit of input.

Vernon W. Ruttan in 1960 redefined the technological changes in terms of production function and defined it as a change in one or more of the parameters of the aggregate production function resulting from the addition of new production techniques to the existing stock. This indicates upward shift in the production function.

R.M. Solow stated that technological change is a catch-all expression for any kind of shift in production function, assuming constant returns to scale, homogeneous inputs and competitive equilibrium. He explains that any increase in output, not explained by increase in capital and labours, is the result of technical change.

T.W. Schultz attempted to define the technological improvement as a superior resource that will produce for the economy a higher rate of return relative to its cost than with the (normal) established inputs employed in production.

S. Bisaliah defines technological change as an upward shift in the production function or a downward shift in unit cost functions. Production of more output with no change in the physical volume of inputs encompasses most of the efficiency dimensions implied in the concept of technical
change. An increase in technical efficiency refers to a reduction in the level of each and every input required to produce one unit of output.

The above views on technology and technological change though applicable mainly to industry, are applicable as well to agriculture.

(3) Technological Change in Agriculture:

Well known agricultural economists and several international organisations have sufficiently attempted to define the technological change in agriculture. V.G. Panse and D. Singh\textsuperscript{9} state that technological change in agriculture consists adoption of farming techniques developed through research which in its wake is calculated to bring about diversification and increase of production and greater economic returns to the farmers. Use of fertilisers, pesticides, improved seeds and improved implements are the examples of such techniques. Introduction of irrigation in new area is another very important technological change, although it is being practiced as a part of traditional agriculture for a long time.

C.H. Hanumantha Rao\textsuperscript{10} defined the technological change in agriculture as the use of new or modern inputs such as fertilisers, high yielding varieties of seeds, tractors, pump sets, threshers and harvest combines. Technique refers to the actual mix of input factor; and it is a function of
both technology and the relative prices of input factors. Thus, technological changes may lead to changes in techniques but some of the changes in techniques may be entirely due to the change taking place in the relative prices of inputs.

Quoting from Hazell, J. S. Hillman and E.A. Monke\textsuperscript{11} provide useful definition of new technologies. "If a production function \( y = f(X_1, \ldots, X_n) \) relates to the maximum crop yield per acre (\( y \)) attainable with different but permissible combinations of inputs (\( X_i \)), such as seed, fertilizer and weeding labor, then I shall take the function \( f(\ ) \) to define a technology. Changes in the combinations of inputs represent movements along the production function, e.g. using more or less fertilizer, and are better described as alternative 'techniques'. However, a change in the quality of seed which leads to structural shift in the production function, and increases the per acre yield with the same level of inputs, is clearly a 'new technology'."

Madhusudan Ghosh\textsuperscript{12} stated that when technique of production is merely identified with a vector of inputs, any change in the technique of production can be interpreted as partial or complete replacement of the traditional variety of inputs by a better quality of technologically advanced inputs. New agrarian technology comprises HYV seeds, irrigation, tractors, threshers, insecticides and pesticides, fertilisers, etc.
Richard Grabowski\textsuperscript{13} says that the development and diffusion of a new technological package using high yield seed varieties, once called the 'Green Revolution' is referred to as the new technology.

(4) Induced Technical Change:

Although the role of technology in increasing the production was recognised by traditional economists, they treated the invention as an exogenous shift variable. But the theory of induced technical change developed by Yujiro Hayami and V.W. Ruttan\textsuperscript{14} rejects this view. The theory treats the technical change as endogenous to the development process. It is applicable to those cases where technology is produced and diffused indigenously. The theory explains how differences in factor price movement influences the process and direction of technological change and choice of inputs.

In agriculture if labour is scarce relative to the land, the relative prices of land and labour will also change. Wages will rise in comparison with rent. This creates a derived demand for innovations. Labour saving machinaries will be innovated. In an economy where land is scarce in relation to labour, change in rents wage ratio induces the innovation of land saving inputs such as fertiliser, HYV seeds etc. Technological change is directed towards saving proportionally more of the
scarce factor than of the abundant factor per unit of output measured at constant prices. The study conducted by Yujiro Hayami and V.W. Ruttan\textsuperscript{15} concludes that enormous changes in factor proportions which have occurred in the process of agricultural growth in USA and Japan are explainable in terms of changes in factor price ratios. Such changes in input mixes represent a process of dynamic factor substitution accompanying changes in the production surface induced by the changes in relative factor prices.

The theory of "induced technical change" is superior to the traditional approach. The model explains contrasting pattern of past agricultural development in USA and Japan. However, the theory is not very much applicable to conditions of peasant agriculture in less developed countries. The theory assumes, (1) farmers are fully aware of the factor substitution rates and factor price ratios (2) they are profit maximisers. But these assumptions are unrealistic in less developed countries.

Subrata Ghatak and Ken Ingersent\textsuperscript{16} state, "The barriers to technical change in peasant agriculture may be virtually insurmountable in the short run, for cultural and social reasons, as well as because of economic uncertainty, risk-aversion and lack of knowledge. Thus where agriculture is most backward the
theory of induced technical change may have little immediate relevance."

Model of induced innovation is less concerned with the search process by themselves. The model determines the direction of search, for example, whether the search is more labour intensive or for more capital intensive techniques. These models posit what is essentially a transformation frontier among factor augmenting/and/or saving or reducing in cost. These models take for granted the exploitation of innovation potential. However, mere existence of potential innovation is insufficient to motivate investment to realise them. In most countries the fundamental problem concerns the absence of invention, but not its direction.17

In order to promote technological change in less developed countries Government has to play an important role. This is because of two reasons (1) Private investor can not take up the research because of meagre and uncertain profit. Multi National Companies will neglect the research needs of small scale peasant farmers in less developed countries because they are interested in developing new products for mass markets, primarily in developed markets. (2) Research conducted in the private sector is likely to be capital intensive. Capital intensive technology is not suitable to peasant farmers because investment with them can hardly be contemplated.
Technology developed by the international agricultural research institutions may not be suitable to the biological and economic conditions of the different regions of less developed countries. National research organisation should conduct local trials about the suitability of imported technology to local conditions. Government may also formulate the policy to persuade the farmers to adopt the indigenously developed technology with advantage. Thus, in less developed countries the Government has a greater role to play in developing and diffusing new technology.

In India the most significant technological advance in agriculture occurred with the development of high yielding varieties in 1960’s. The joint efforts of Indian Council of Agricultural Research and Rockefeller Foundation enabled to develop high yielding and fertiliser responsive seeds. Later, state agricultural universities also developed many of the HYVs.

Government of India played an important role in generation and dissemination of new technology by giving institutional, financial and policy supports. India is a very large country with different geographical and ecological conditions and diverse socio-cultural background. That is why uniform technology model is not appropriate. As such Government adopted decentralised science and technology activities.
B) Types of Technological Change:

On the basis of characteristics of innovations, technological changes are classified in different ways. Hicks\textsuperscript{18} explains two general types of Technological changes (1) Neutral Technological Change (2) Non-neutral Technological Change.

(1) Neutral Technological Change:

Neutral Technological Change may alter the production function but does not affect the marginal rate of substitution of inputs relative to each other. It neither saves the inputs nor uses the inputs. Under this type of technical change the output elasticity of capital and hence the output elasticity of labour remains constant.

(2) Non-neutral Technological Change:

Non-neutral technological change alters the production function and affects marginal rate of substitution of inputs relative to each other. There are two types of non-neutral technological changes (a) Labour saving or Capital using (b) Capital saving or Labour using. Technological change is said to be labour saving if the production function is altered in such a way that marginal product of capital rises relatively to the marginal product of labour. If the production function is altered in such a way that marginal product of labour rises relatively
to the marginal product of capital, there is said to be labour using or capital saving technological change.

E.O. Heady classified the technological change into three types. (1) Biological innovations (2) Mechanical innovations (3) Biological - Mechanical innovations.

(1) Biological Innovations:

Biological innovations involve high yielding varieties of seeds, fertiliser etc. This type of innovation increases the total output by improving the genetic quality of the plants and by improving the fertility of the soil. It increases the total cost also. However, cost per unit of output decreases due to the greater output. Total cost increases because of the additional cost of harvesting, handling of greater output and added cost of new seeds etc. Biological technology is mainly land-augmenting in character. It will maintain or increase the demand for labour.

In Japan during the last quarter of the 19th century availability of land was relatively scarce while labour was relatively abundant. Biological technology was developed to save the land or to increase the output per unit of cultivated area. Fertiliser responsive seed varieties were therefore developed. Along with those efforts cultural practices were also improved.
(2) Mechanical Innovation :

Mechanical type of technological change took place due to the invention and use of agricultural machineries, implements, tools, etc. This innovation mainly substituted capital for labour. It did not make physiological effect on total output. E.O. Heady\textsuperscript{20} states, "The term 'mechanical' refers to innovations as a machine which substitutes capital for labor but do not change the physiological outcome of the plants or animals to which it may apply."

Mechanical innovations are tractors, winnowers, seed drillers etc. Mechanical innovations, human as well as animal saving types were mainly introduced in USA. Decline in the price of machinery related to wages encouraged the development of mechanical technology in USA. This type of technological change reduces the total cost of production.

(3) Biological - Mechanical Innovation :

Some of the innovations are both land-augmenting and labour-saving in character. Such type of technological changes are called 'biological-mechanical' type of technological change. S. Bisaliah\textsuperscript{21} writes, "However, it needs to be made clear that all mechanical innovations are not necessarily motivated by labour saving incentives; nor all bio-chemical innovations are necessarily motivated to save land. The mechanical threshing may be introduced to divert labour for preparation of second crop. This in
turn results in the increased cropping intensity, one source of land augmentation. Similarly plant breeding efforts may focus on developing crop varieties more suitable for mechanical harvesting." If pesticides are sprayed with spraying machines, the output increases while the use of labour decreases.

A biological-mechanical innovation may increase or decrease total costs. It depends upon whether added expense associated with the harvesting and handling of the greater output is less than the reduction due to the engineering recombination of resources.22

William N. Parker23 makes three classification in the technological change. This classification is partly based on the technical characteristics of innovations and partly on the economic effects of the innovation. These three types are (1) inventions in power generation, (2) invention in farm machinery, and (3) invention in soil chemistry and plant and animal breeding. Each type of technological change has separate economic effects. Improved source of power saves capital or materials. Improvement in farm implements and machinery saves labour. Inventions in soil chemistry, and plant breeding save the land. This classification is more or less similar to Heady's classification.
Goutam K. Sarkar\textsuperscript{24} broadly classified the technological improvements in agriculture into two types. The first type involves the application of a technologically more desirable amount of particular variable factor of production to the fixed factors, meaning thereby a movement up the existing production function. The second type is adoption of new methods of production or new inputs. This leads to higher production function for a given schedule of factor use or a lower cost function for a given schedule of output. These are known as innovations. Innovations are of two types. The first type is Land saving and the second type is Land using. Land saving technological changes may be classified as follows:

(a) Those involving organisational improvements and the use of new or superior types of non-fixed inputs.

(b) Those involving the use of new indivisible factor units which can be taken advantage of only when output is above a certain level.

The second category of innovations can be described as "land using". This type of innovation would induce the producer to bring more land under cultivation in order to utilise a new machine fully. An example is the substitution of machinery for labour.

J. A. (Jr.) Hopkins\textsuperscript{25} classified the technological improvements as follows: (1) Technological improvements not
involving any appreciable change in either organisation or the management of the firm. (2) Technological changes which modify the farm organisation primarily but affecting the managerial practices only to a less degree. (3) Technological change which affects the management practices but changing the organisation of the farm only to a lesser degree. Improved variety of seeds and chemical fertiliser come under first category, while mechanical power comes under the second category. Change in live-stock sanitation practices, change in the depth of cultivating etc. come under the third category.

C. H. Hanumantha Rao classifies land augmenting technology as (1) those which raise the yield of any particular crop per unit of land, and (2) those which increase total output per unit of land from all the crops grown over a rotational period of time say, a year, through the increased cropping intensity. Due to the complementary relationship between cropped area and labour, some of the land saving techniques like high yielding varieties are labour-saving as well. When the crop yields are raised substantially through the intensive application of fertilisers, there may be some increase in the use of labour for operations such as inter-culturing and harvesting but the amount of labour used per unit of capital or per unit of output is comparatively reduced. Increase in output through the increase in cropping intensity raises the
employment of labour almost proportionately to the increase in capital or output. This type of technological change suits the capital scarce and labour abundant regions.

Section - II

A) Features of New Technology in Agriculture:

Technological progress in agriculture depends upon the supply of new inputs like HYV seeds, fertiliser, pesticides, farm machineries etc. These inputs are the outcome of progress in bio-technology, mechanical technology and chemical engineering. Application of the new inputs depends upon economic factors like price of inputs, profit in the farm sector etc. That is why there are certain technical and economic features common to these inputs.

1. Complementary Nature:

To get maximum productivity, modern inputs are to be used as a package programme. HYV seeds without fertiliser and controlled water would not give maximum yield. As new seeds are more susceptible to pest attack and growth of weeds pesticides are to be necessarily used. New seeds enable multiple crops in a year. To prepare the land and to complete the harvest in time, tractors and harvesters are to be harnessed. So modern inputs are complementary in nature. I. Arnon27 states, "Single practice programmes, such as introducing irrigation, applying fertilizers or adopting new
varieties etc., usually give poor results because no single factor can be fully effective if other essential conditions are lacking. By contrast, certain techniques, when applied in combination, can give spectacular results in very short time. Hence the justification for package programme.

2. Modern Inputs and Package of Practice:

Every new input calls for new agricultural practices. New crop calendar has to be followed with new technology. While using the HYV seeds the farmer should know what type of seed is suitable for a particular type of soil. He should also know the quality and the time of its use. Similarly he should also know the quantity of fertiliser to be used for a particular type of crop. Pesticides are to be used with great care. While purchasing the farm machineries he should be well trained in their use. Machineries are to be maintained with great care. There is a complementary relationship between more than one new form of input and various new farming practices. Thus a high level of productivity for such inputs may depend on close co-ordination of the supply of several inputs and on the educational process of introducing new practices along with the new input forms. As new technology requires new agricultural practices there is need for proper extension facilities. Farmers are to be trained for the effective use of modern technology.
3. Purchased Inputs:

Modern inputs like HYV seeds, fertiliser, pesticides, modern implements and machineries are to be purchased by the farmers. That is why the use of these inputs and thereby the growth of agriculture depends on production, distribution and the price of modern inputs. There is a need for proper organisational and institutional arrangements for production, import and distribution of these inputs. T.W. Schultz opines, "Economic growth from agricultural sector of a poor country depends predominantly upon the availability and price of modern (non-traditional) agricultural factors. The suppliers of these factors in a very real sense hold the key to such growth."

To purchase modern inputs farmers require more credit. The extent of working capital increases. Agriculture is to be carried on, in commercial lines. J.W. Mellor says, "Off-farm purchase, which pulls the farmer into market economy has a number of important ramifications for development policy. It increases the risk problem, it increases the cash needs and possible credit needs, and it provides pressure for increased marketing." Very often inadequate credit facility lands the farmers in financial embarrassment. To exonerate him from debt-trap some public lending agencies should come to his aid so as to lessen his mental agony.
4. Greater Risk:

New technology requires greater investment in agriculture but at the same time it may fail to give adequate returns. Compared with traditional technology modern technology involves more risks and uncertainty. J.W. Mellor mentions three types of risks as follows:

(a) Technical risks: In the initial stage of the development this type of risk is involved. Due to inadequate trial under the conditions experienced by the farmer, recommended innovations may fail to give profit even during the normal weather and price conditions.

(b) Weather risk: Sometimes due to unfavourable weather conditions use of modern inputs may yield less than or no more than without their use. If weather is favourable seed-fertiliser technology will give better yield. If it is adverse the farmer will lose even whatever he has invested on seed and fertiliser.

(c) Price risk: When prices are low it may not be profitable to go in for new technology. This is because new technology is costly in character. There should be adequate support from all agencies including government to ensure the farmers to get fair prices that commensurate with quality of their produce.
5. Quick Maturing:

Major component of the new technology is HYV seeds. These seeds take shorter period of time to mature into plants. This characteristic leads to two consequences: (a) Since each crop requires comparatively lesser time to mature, more than one crop can be raised. In most of the less developed countries where land-man-ratio is adverse and extensive cultivation is almost impossible, this feature of new technology is of great importance. However, V.S. Vyas says, "This advantage was not reaped to the full in most of the countries of Asia as is evidenced by the fact that the index of multiple cropping has not improved in a significant way. In any event, it is lagged behind the index of irrigation......... The major bottleneck in the expansion of multiple cropping is proper water management and investment in the complementary infrastructure." (b) Quick maturing creates the problem of protecting the harvested crop from loss due to rains. Proper storage facility is also required to preserve the produce.

6. Optimal Use:

Even though technologically efficient dosage of inputs gives maximum output, it may not prevail in practice. This is because choice of technology by the farmers depends upon many factors like price of inputs, availability of inputs, availability of finance, nature of the land
ownership etc. If the inputs are not available in required quantities or if the farmer is not able to purchase the inputs in required quantities this will upset the technical optimum. Farmers will adopt the technology keeping the economic viability in mind. If the economically efficient dosage of input is not technically efficient dose then the maximum output can not be obtained.

7. More Expensive:

Compared to traditional methods of cultivation new technology is more expensive. Under traditional technology inputs like seeds, manures etc. are obtained from the farm. But in case of new technology new inputs like HYV seeds, chemical fertiliser, pesticides etc. are to be purchased from outside. Irrigation in the form of pump sets is expensive. Sinking of well, and installing pump sets are costly. These will lead to heavy expenditure. Purchase of farm machineries requires huge capital expenditure. However, the output is greater under new technology.

8. Requirement of Adequate Water:

Under new technology fertiliser application is very high. If water supply is inadequate it will damage the crops. Water is to be supplied in accordance with the requirement of the plant at different stages of its growth. Excessive watering will also damage the crops. That is why controlled water supply is required in modern
B) Adoption of New Farm Technology:

New farm technology helps to produce more with the same quantum of resources. But farmers can not realise this advantage until they adopt it and reap the results. Adoption is a more complicated process in underdeveloped countries than what it is in developed countries. Even profitable technology will take time to spread effectively. In a country like India some of the early adopters discontinued the particular type of new innovation. An innovation is also likely to be rejected in the very process of adoption. Writing about the farm and adoption techniques E.O.Heady\textsuperscript{33} writes, "Each postponement in adoption of techniques where they are clearly profitable to the individual or society, spells economic sacrifice or efficiency forgone." Study of the adoption process is quite essential because the impact of new technology depends not only on the nature of technology but also on the rate of adoption. It also provides useful information to design new technology.

Adoption of new technology by a farmer is a process of decision making. All farmers can not adopt the new
technology at once. Only a small number of farmers of a particular region may be advised to adopt it. By observing the experience of these early adopters others may follow the suit. R.P. Mishra states, "Adoption is a mental process through which an individual proceeds from the stage of first knowing about an innovation to final adoption."

Adoption of a particular innovation takes place in different stages after the new technique of production is invented. These stages are explained as follows.

1. The awareness stage:

   This is the stage of getting initial knowledge of the new innovation. A farmer may get the information by reading the literature or by seeing experiments and the outcomes relating to new innovation undertaken by others. Sometimes he will get the information by chance. However, the potential adopter will get the basic information if he has felt the need for innovation.

II. Attention stage:

   In this stage the potential adopter takes interest in the innovation and tries to get the further information from different sources.

III. Evaluation stage:

   After getting sufficient information a farmer decides whether a particular technology is worth while to adopt or
not. At this stage he may consult early adopters about the cost and benefit of new technology. Keeping in view his social, economic and cultural background a farmer evaluates the technology.

IV. Stage of conducting trial:

After the stage of evaluation the farmer may accept or reject the technology. If the farmer accepts it he will adopt the technology on trial basis. This is an important stage because at this stage each farmer makes his own decision. Moreover, if the trial fails it affects adversely the other potential adopters. Trial is conducted on a small scale. If the innovation is very profitable and that there is no iota of uncertainty about the profit, the farmer may go to the adoption stage without conducting further trials.

V. Adoption stage:

If the trial conducted by the farmer is successful he will adopt the technology. Sometimes farmers may maintain the balance between old and new technology and gradually they will adopt the same completely. Non-availability of new inputs or lack of finance may be responsible for gradual adoption. While recommending the new technique it is tested at the research stations and on selected farms in a particular region. Improved technology
will guarantee greater returns to the farmers. Inspite of all the rosy picture of added profitability new technology will be adopted gradually. To begin with only a part of the recommended practices will be adopted.

Factors Affecting the Process of Adoption:

Many economic, social and personal factors influence the adoption. Milton M. Snodgrass and Luther T. Wallace pointed out the factors which determine the rapidity with which the new technology is actually used. These are (1) receptivity of the new ideas by the society, (2) the efficiency of the communication or education system, (3) the size of the cash outlay required to use the new technology, and (4) the degree of obsolescence of existing production requirement. E.O. Heady explains the causes for the slow rate at which farmers adopt new technology. These are (1) lack of knowledge, (2) lack of capital, (3) uncertainty regarding productivity, (4) managerial requirement, and (5) price ratios under economic instability. Economic causes are the important causes for the slow adoption.

The succeeding paragraphs highlight the different factors affecting the process of adoption.

(1) Economic condition of the potential adopter:

To adopt new technology a farmer has to purchase new inputs like seeds, fertilisers, implements, machineries etc.
This requires finance. Naturally farmers who are financially better off will adopt new technology much in advance. In most of the less developed countries farmers are poor. That is why the adoption process will be very slow. To speed up adoption process in these backward countries Government and other financial institutions should provide credit on easy terms to the genuine farmers.

(2) Education and extension:

Education and extension facilities are very important factors in determining rate of adoption. To understand the different components of new technology and proportion of input-mix, education is required. To carry the new technology from research centre to the farm, efficient extension service is essential. In fact extension agencies play a significant role at different stages of adoption. Harriss\(^37\) rightly pointed out that extension particularly in the case of use of fertiliser is very important from the view point of its efficient and intelligent use. Unfortunately the extension personnel in most of the less developed countries is technically incompetent and incapable of giving correct advice to the farmers. Due to the lack of proper education and existence of effective extension agencies adoption of new technology is very scarce in less developed countries.
(3) Uncertainty:

Uncertainty regarding the increased yield and price of the product affects the process of adoption adversely. In less developed countries, as most of the farmers are poor they are not ready to take risk under such uncertainties. Farmers are uncertain about the quantum of yield due to the lack of sufficient and useful information regarding the new technology. To add to it inadequate demonstration by extension services also creates uncertainty. By providing efficient extension services and minimum support price risk and uncertainties may be substantially reduced.

(4) Managerial requirement:

Adoption of new technology depends on the nature of technology. Some changes though appearing to be simple are actually difficult to manage. Thus, management also plays an important part. In countries like India where farmers are mostly illiterates and as such technology which requires managerial ability is likely to spread slowly.

(5) Size of the holding:

Positive relationship exists between the size of the holding and rate of adoption. Usually big farmers can face the risk and uncertainties. They are easily approachable by the extension workers. Financially they are sound, and thus can adopt the new inputs easily.
(6) Nature of the tenancy:

Usually owner-cultivator adopts the new technology without much hesitation. If the tiller is only a tenant he will not run the risk of adopting the new technology.

(7) Communication:

Adoption at the village level depends on the availability of communication facilities. Villagers who are fortunate enough in having effective communication background tend towards higher degree of adoption.

(8) Responsiveness of the society:

In a dynamic society where people are enlightened, educated and receptive to new ideas, adoption is very quick. But in a traditional society where people are bounded by customs, traditions and superstitions the adoption process is slow. Study conducted by C.Rajagopalan and Jaspal Singh indicated that religious beliefs, superstitions, ignorance, expenses on marriages, poverty, administrative structure, non-availability of agricultural inputs on reasonable terms in good time, the unremunerative and insecure nature of agricultural occupations and jobs away from home are some of the factors hindering the adoption of new technology.
Role of New Technology in Agriculture:

Technological change plays an important role in all production enterprises. It is one of the most important factors in increasing the yield from any production effort. Technological change in agriculture is still more important because the factor land is inelastic in supply. If agriculture is followed on traditional lines production can not be increased to meet the needs of the growing population in the nation. Application of modern technology in the form of improved inputs increases the farm productivity even if the land is less fertile. T.W. Schultz\textsuperscript{39} writes, "The man who farms as his fore fathers did can not produce much food no matter how rich the land or how hard he works. The farmer who has access to and knows how to use what science knows about soils, plants, animals and machine can produce an abundance of food though land be poor. Nor need he work nearly so hard and long." Yet in most of the less developed countries agriculture is followed on traditional lines.

Individual farmer as also society as a whole will be the recipients of immense benefits of technological progress. The farmer will get the benefit because the new technology helps to produce more output with the same resources or the same output at low cost. That is why
profit of the farmer increases at least in the foreseeable future. New technology increases the production of agricultural goods. This in turn increases the supply of essential commodities. Consumers will stand to get foodgrains easily at reasonable rates. Subrata Ghatak and Ken Ingersent write, "With some reservations, technological progress is beneficial both to individuals and society as a whole. Producers adopting improved techniques of production benefit at least in short run from increase in profits. Consumers and nation stand to gain from increased aggregate supplies either through the relief of actual physical scarcity or lower price or both."

The succeeding study highlights the role of new technology in agriculture.

(1) Technological Change and Self-sufficiency in Food:

In recent years technology has played a significant role in increasing the food production in the world and thereby has adequately met the food requirement of the population. Due to increase in the availability of foodgrains, availability of proteins and calories have also increased. Some of the HYVs have higher protein content. The normal level of protein in traditional variety is around 9-12 percent, whereas some of the new varieties have as much protein content as 16-17 percent. In most of the developing countries foodgrains are a major source of both calories and proteins.
In less developed countries population is increasing at a fast rate and as such food requirement is also growing. High income elasticity of demand for foodgrains has also created additional demand for foodgrains. Modernisation of agriculture is the only solution to meet this additional demand for foodgrains. Otherwise it leads to greater strain on balance of payment. E.O. Heady\textsuperscript{41} rightly pointed out that technological progress in agriculture is relatively more important for densely populated and newly independent countries of Asia, Africa and Eastern Europe. It is the technological progress in agriculture alone which has allowed the food production rate in western world to out pace the population growth rate. Increased food production in poor under developed countries will not only provide food self-sufficiency but the surplus food production so generated will be a source of earning foreign exchange for the nation.

2. Technological Change, Production and Productivity:

Technology makes the production possible and technological change helps to produce more with the same resources. Selection of appropriate technology is necessary for efficient production system in the economy. Farm output increased considerably in recent years due to the diffusion of new technology. Per hectare output increases because new technology increases the rate of yield on the one side and
Increase in agricultural productivity is the main cause of agricultural growth in any country. Agricultural productivity no doubt depends upon natural factors like rainfall, nature of the soil, weather condition etc. Apart from these factors technological improvement is the main factor in influencing farm productivity. In recent years new inputs like HYV seeds, fertiliser, irrigation, pesticides, modern implements increased the yield rates considerably. Montague Yudelman\textsuperscript{42} writes, "In Mexico, the first developing country to have benefited on a large scale from the new technology, average yields of wheat have risen from 0.94 tons per hectare in 1949 to 2.64 tons per hectare in 1968. In Philippines a study of 204 farmers indicated that rice yields per hectare rose from 2.3 tons to 4.5 tons in one season when the farmers used the new varieties and other inputs."

Technological change increases the labour productivity in agriculture. In this respect Yujiro Hayami and V.M. Ruttan\textsuperscript{43} state, "It is clear that output per worker in the several LDC’s can be increased by several multiples while land area per worker remains constant or when declines slightly. To achieve increases of this magnitude will require substantial investment (a) in rural education and
(b) in physical, biological and social sciences. The latter is required for the technical and institutional infrastructure needed for the invention, development and extension of more efficient technology."

3. Technological Change and Income of the Farmers:

Technological change increases the per hectare output and it leads to greater marketable surplus and adds to the gross income of the farmers. No doubt new technology increases the cost but marginal rise in cost results in substantial increase in farm income. That is why the net income of the farmers also increases. Farmers who adopt the new technology early, will be the early gainers compared to those who adopt it late. Milton M. Snodgrass and Luther T. Wallace⁴⁴ write, "The effect of technology on the farmer's gross income is determined largely if and when a new technology is adopted. For example, the farmer who was an "early adopter" and used hybrid seed corn before the majority of his neighbours did; was able to increase his gross and net income considerably. With the hybrid seed resulting in higher yields per acre harvested, his dollar return per acre was higher with relatively little additional cost. However, now that practically all commercial corn producers use hybrid seed no individual farmer increases his net income very much as a result of using it; but if farmer was not to use hybrid seed corn now, his low yields would lower his income."
Technological change no doubt increases the income of all types of farmers. But increase in income is not uniform among the farmers. Rich farmers are greatly benefitted because they can afford to purchase modern inputs in adequate quantities; while the poor farmers due to lack of finance can not take the best advantage of the modern inputs in time. In this connection B. Sen opined that technological change has sustained improvement in the per capita income and standard of living of farmers who have been experimenting with it. Since the benefits of new agricultural technology are correlated to irrigation facilities, the size of holding, financial position, education, tenurial and social status of the farmers, the impacts of new agricultural technology on income have not been uniform in different regions and even among different types and sizes of farms within the same region.

4. Technological Change and Employment:

Most of the Less Developed countries are facing the problem of unemployment and under-employment. Due to the high rate of growth of population this problem is becoming more and more serious day by day. There is a greater need to increase employment opportunities in agriculture.

There is no uniform opinion regarding the impact of technological change on employment. Usually land augmenting technological changes increase employment
opportunities. This is because the fertiliser application, weeding, supply of water, harvesting etc. require more labour. Use of HYVs increases the area under double crop. This also increases the employment opportunities. In this connection Robert D'A. Shaw states, "In general we can conclude that the introduction of new cereals varieties by itself does increase the demand for labour. It is impossible at this stage to obtain firm estimate of this increase, though on over all range of 20-25 percent seems to be indicated by recent experience." V.T. Raju using the regression on employment concludes that new agricultural technology has significantly contributed to an increase in the employment of labour. Among the different items of new technology, the application of fertiliser has significantly contributed to an increase in human labour employment, followed by irrigation, improved seeds and plant protection chemicals.

Labour-displacing technological change decreases the employment opportunities. Tractors, harvesters, threshers, winnowers come under this type. Mechanical technology reduces not only the requirement of human labour but also bullock labour. Montegue Yudelman opines that mechanisation short of complete mechanisation of all farm operations, had reduced labour requirements by as much as between 17 percent and 27 percent per hectare, including labour requirements in the non-peak seasons of demand.
Indiscriminate mechanisation adds to problems of unemployment. G.R. Soltani⁴９ studied the labour utilisation in three agricultural regions of the Fars Province in South Central Iran. He concluded that full mechanisation of wheat production results in the displacement of 131 man-hours of labour per hectare.

The distinction between land-augmenting and labour-displacing technologies is quite ambiguous. Labour displacing technological change which is supposed to reduce the cost by saving labour, may at the same time increase the output. Land-augmenting technology may displace labour. New agricultural inputs embodying technical changes can either be land-augmenting or labour-displacing depending on how they are applied.

Theoretically, it is impossible to predetermine whether labour saving technological change will really displace labour or will actually create more jobs. It is jointly determined by the change in factor proportions and change in the profit maximising level of output.⁵⁰

5. Technological Change and Consumption Expenditure of the Farmers:

It is already analysed that technological change increases the farm output and farm income. Increase in the purchasing power of the farmers increases the consumption expenditure. A.C. Gangwar⁵¹ conducted a study on the
impact of 'Green Revolution' on consumption pattern and nutritional status in Haryana in 1970-71 and 1981-82. He concluded that on account of increase in production and income of the cultivators due to 'Green Revolution', per adult male unit expenditure on consumption has increased from Rs. 875 in 1970-71 to Rs.2,274 in 1981-82. 'Green Revolution' has also contributed towards increase in the production and consumption of milk and milk products.

Increase in the consumption expenditure and greater use of qualitative food like milk and milk products improved the health and efficiency of the farmers. This will in turn result in greater work and higher farm output. D.R. Arora, V.K. Agarwal and A.K. Gupta after studying the 'Green Revolution' and social change concluded that benefits of 'Green Revolution' were reaped by all sections of the society. Farmers have spent their increased income on improving their quality of life. Food habits and clothing pattern have also undergone changes in rural Punjab. People have become more conscious of balanced and nutritious diet.

6. Technological Change, Saving and Capital Formation:

The agricultural development in the long run depends upon saving and capital formation in agriculture. Technological progress itself requires additional investment on agriculture, which results in higher per hectare productivity and greater gross income. The increased gross
income gives incentives to the farmers to further invest their surplus funds on the improvement of land, purchase of modern implements, development of irrigation etc. This results in greater capital formation in agriculture. M.S. Randhawa in his study observed that in Punjab technological change increased the profit of the farmers and farmers have been ploughing back their profits on land improvements, sinking tube well, installing underground systems of irrigations, purchase of tractors, pump sets, sprayers and costly implements.

H.K. Pandey, Vishwanath and R.P. Singh conducted the study in Varanasi and Deoria districts of Uttar Pradesh and concluded that technological progress increased the absolute investment and saving. In Varanasi, which is relatively progressive in technology, per farm investment and the savings were Rs. 994 and Rs. 1,234. In Deoria, which is relatively less progressive investment and the savings were only Rs. 645 and Rs. 752.

7. Technological Change and Marketable Surplus:

Use of improved inputs in agriculture transformed the agriculture from subsistence level to profitable farm business level. Diffusion of new technology increases not only the production but also marketable surplus. This type of marketable surplus is necessary for the growth of the economy. Technological improvements reduce the use of
labour per unit of output. This results in generating greater foodgrain surplus in rural area. Decline in the ratio of seed to output also generates marketable surplus. A.S.Kahlon\textsuperscript{55} writes, "The recent technological break-through in agricultural production through seed-fertiliser revolution has accelerated the transformation of the Indian farm economy from subsistence level to a profitable business. With the rapid diffusion of new technology, the proportion of marketable surplus rapidly increased in those areas where wheat revolution was established."

8. Technological Change and Cropping Pattern:

Technological progress brings changes in the cropping pattern. Traditional varieties of crops will be substituted by HYV seeds. High yielding variety seeds are of short duration. That is why new seed technology enables double cropping and multiple cropping. Traditional crop cycle and farm practices will change. Farmers will substitute high value crops for low value crops. Technological change pre-supposes assured irrigation facilities. That is why cropping intensity increases.

9. Technological Change and Leisure Time:

New farm technology always provides better methods of production. It helps to save time and effort with the same level of output as before. Use of mechanical technology
reduces the quantum of manual work. Modern implements and machineries are time saving and as such farmers can afford to enjoy more leisure time. S. E. Johnson\textsuperscript{56} states, "Technological progress has lessened the drudgery of the work both in farm and farm home. More time has become available for recreation and personal improvement. Even when farmers work for long hours, physical exertions are less."

10. Technological Change and Cost of Production:

Technological change leads to downward shift in the cost function. In other words it helps to produce the same level of output at less quantity of resources. Input-output relation improves. In this connection A. N. Sadhu and Amarjit Singh\textsuperscript{57} write, "By virtue of improving input-output relationship, the new technology tends to reduce the cost of production and hence affects the level of agricultural prices. Increase in quantity and quality results in reduced unit cost and this in some situations leads to fall in prices." New technology increases the paid-out cost and cost of cultivation per unit of land. As the unit cost of inputs declines both producers and consumers stand to gain from technological change.

11. Technological Change and Output-processing and Input-servicing Industries:

Technological change increases the production of agricultural products like cereals, pulses, oil seeds, fiber
crops etc. These commodities are to be processed. Increase in the production of these commodities necessitates the establishment of output processing industries in villages.

Modernised agriculture requires new inputs like improved implements, pump-sets, sprayers, tractors, harvesters, winnowers, weeders, threshers etc. These inputs require proper servicing. That is why input servicing industries will also grow.

12. Technological Change and Rural Society:

Technological progress in agriculture brings enormous changes in the socio-economic and cultural life of the rural people. Improvement in rural education, health, life style etc. are closely related to technological change. Use of new technology itself requires certain amount of knowledge to the farmers. While getting the new inputs the farmer has to come in contact with number of institutions. This process will educate the farmers. Better economic conditions of the farmers act as an incentive to send their children to school. Increase in the income of farmers enables them to get better medical facilities. Farmers will get better quality of food, clothing and shelter. Thus, the rural life will improve.
Conclusion:

Technological change in farm sector is an important determinant of change and development in agriculture in particular and the whole economy in general. The use of non-conventional inputs increases the output, income and savings of the farmers. Savings will be reinvested in inputs like fertiliser, HYVs and pesticides which will increase the production in the short run. The savings will be used for land improvements and expansion of tube wells and other forms of irrigation which will promote the growth of agriculture in the long run. Technological change promotes output processing industries and input servicing industries. It leads to substantial improvements in credit, marketing, storage, extension, transportation and other infrastructural facilities. Thus, the benefits of technological progress are not limited to agriculture alone but are extended to other sectors and to the national economy as a whole.
REFERENCES


15. Ibid., pp.1134-1135.


20. Ibid., pp.296-297.


31. Ibid., p.290.


