Chapter I

INTRODUCTION
1.1: TECHNOLOGICAL CHANGE IN GENERAL

Technology is the complex of all the skills, knowledge and procedures for making, using and doing useful things. It consists of a series of techniques each of which is characterized by the nature of the product, the resource use of machinery, skilled and unskilled manpower, management, materials and energy inputs—the scale of production, the complementary products and services involved etc.¹ The characteristics of each technique reflect the economic and historic circumstances of the economy where the technique is introduced. It is more than just resources or knowledge or methods of production. It is inextricably linked up with the system of technical, economic, institutional, social and political arrangements that characterize the way a society functions. Ishikawa defines agricultural technology as a specific and stabilised pattern of combination of various inputs i.e. (i) labour and other current inputs (ii) land and its structure, (iii) other capital assets and (iv) farming methods.²

The development of techniques is a historical process in which one technique with one set of characteristics replaces

another. Its development and introduction crucially depends on viability in terms of the resource-use characteristic of the technique with resource availability. The efficiency or otherwise of a particular technique depends not only on its own performance and that of its immediate substitutes but also on the surrounding technology.³ An agricultural technology emerges only when a certain combination of inputs is accepted by the local producer farmers on the basis of their production knowledge and under the economic and social conditions surrounding them and is effectively applied in their fields.⁴

A schematic presentation of the processes enabling technical and technological change is as follows:

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³ Stewart, F. (1975), op. cit., p.21
⁴ Ishikawa, Sh. (1991), op. cit.
The socio-economic structure is represented by the distribution of land ownership, land tenure system, extent of irrigation, access to institutions, distribution of political power, structure of village relations, and distribution of operational sizes reacts with a pay-off matrix characterised by economic gains and political gains to generate demand for new technology. The political-bureaucratic structure represented by the basic research system, applied research and extension system interacts with the characteristics desired of new technology to determine the characteristics of the new technology which in turn reacts with the socio-economic structure to determine a pay-off matrix. The chain is replicated.

Griffin (1974) points out that 'change' need not be synonymous with progress. Whether any change is desirable or not depends on one's judgement as reflected in one's objectives. Even if a new technology allows an economy to produce more output with its given resources, it does not follow that it is unambiguously desirable. It is possible to have a situation where average output per head rises and the consumption of certain groups falls or a situation of high growth with acute inequality. Technical progress implies advances in knowledge which improve productivity, efficiency and output, but does not necessarily mean an increase in per capita income, or a reduction in poverty and inequality. The rate of population growth and the size of the labour force are important factors in determining potential gains from technical progress. The distribution of land ownership and access to farm equipment are important in determining the nature and extent of the benefits of technical progress. The distribution of credit and the cost of credit are important factors in determining the adoption of new technologies. The political and bureaucratic structure are important in determining the distribution of the benefits of technical progress. The characteristics desired of a new technology are determined by the characteristics of the socio-economic structure. The pay-off matrix characterised by economic gains and political gains to generate demand for new technology. The political-bureaucratic structure interacts with the characteristics desired of new technology to determine the characteristics of the new technology which in turn reacts with the socio-economic structure to determine a pay-off matrix. The chain is replicated.

human welfare quantitatively through increases in real income per head and qualitatively through widening man's choice of goods and extending his leisure. It may involve new processes of production, new goods and new methods of industrial organisation in the field of management and marketing. Over the years the term 'technological change' has been given a wide range of meanings and interpretations. It may also refer to the effects of changes in the technology and changes in technology itself.

However, the essential quantitative aspect of technological progress is to shift the production function enabling greater output to be produced with the same volume of inputs or the same output with lesser inputs which is essentially an inward movement in input space of the production-isoquant frontier.

The choice of a technique depends on the nature of the decision makers and their objectives, the economic circumstances in the economy concerned and the characteristics associated with different techniques. Such a choice is restricted

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8 Kennedy, C. & A.P. Thirwall (1972), op. cit., p.12
by the knowledge of the decision-maker which may often be incomplete or inaccurate. When a technique developed in a particular environment is transferred to another, the question of appropriateness or otherwise of the technique naturally arises. By appropriate technology we mean a set of techniques which make optimum use of available resources in a given environment. Various terms have been used to describe this technology such as intermediate technology, progressive technology, third world technology, alternative technology etc. The main problem of appropriate technology is its indeterminacy. It is always possible to improve upon any existing set of techniques by substituting some techniques. Besides in a plural society with different interest groups as long as the choice affects the groups asymmetrically the notion of appropriateness may be elusive. The existence problem may be further complicated by the prevalence of an economic and social structure which favours the choice of an inappropriate technology. The appropriate technology for an economy will depend on the following basic determinants.

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10 Stewart, F. (1973) *Op-eit*, p.22

11 Stewart, F. (1973) *Op-eit*, p.95

1. Endowment of capital, labour and natural resources
2. Endowment of technological capability
3. Endowment of managerial capability
4. Structure of the demand for products
5. Degree of market development

Another dimension of this problem of appropriate technology is that because of uncertainty, lack of knowledge, imperfect procedures and the complexity of the system no amount of pre-planning, preparation and organization in the project work can ensure that changes follow a desired path. The need for continual adjustment in the technology, adds a dynamic element to the problem of appropriate technology.

Technological progress is best measured by its effects such as its impact on the growth of national income or on the growth of factor productivity not accounted for by other inputs leaving technical change as a residual. This approach may confound the effect of technological progress with those of productivity raising factors like external economies, improved

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13 Ishikawa, Sh. (1931) : op. cit.

14 Meinersen, J.P. (1978) : The Technology of Rural Development; World Bank Staff working paper, No. 235, p.11
health, education and skill of the labour force, better manag-
ment, changes in product-mix, product innovation, improvements
in the organisation of the market such as the removal of res-
trictions on the mobility and economic effectiveness of resour-
ces etc. It also conceals the particular new factors of produc-
tion that are adopted and employed because it is profitable for
firms to do so.  

Technological progress has another set of measurable
properties that are classified as neutral and non-neutral or
biased. Neutral technological progress affects the inputs equa-
ly while biased technological progress has a biased effect on
the inputs. For instance it may be labour saving or labour
using. These properties can be analysed in terms of various
characteristics such as

a) the degree of returns to scale associated with the
   ruling intensive technology
b) the degree to which technology is capital or labour
   intensive
c) the ease with which the technology permits capital
   to be substituted for labour
d) its efficiency.

Schultz, T.W. (1964): Transforming Traditional Agriculture,
Yale University Press, p.139
Brown (1966) refers to these characteristics taken together as an abstract technology. Technological progress may thus be examined in terms of changes in the characteristics of an abstract technology. Variations in the capital intensity of a technology and in the ease of substitution of capital for labour produce non-neutral technical change. In the Cobb-Douglas production function given as

\[ Y = AK^a L^b \]

where \( Y, K \) and \( L \) stand for output, capital and labour respectively, variations in parameter \( a \) and proportional algebraic changes in \( a \) and \( b \) denote neutral technological progress. Changes in the ratio of \( a \) to \( b \) present non-neutral change.

The analysis involves an examination of the effects of progress on the relationship between certain primal and dual variables which are derived from the production function and which include the input-output coefficients, the factor proportions, the marginal productivities and the marginal rate of substitution. When a certain relationship is postulated to be invariant, one obtains a specific type of technical neutrality. Technical progress is called Hicks-neutral when the

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relationship between the marginal rate of substitution and the factor proportion is invariant. It is Harrod-neutral when the relationship between the capital-output ratio and the rate of profit remains unaltered. In Solow-neutrality the relationship between output per man and the wage rate is unchanged under technical progress. Technical change biases have generally been measured in 2-factor models using value-added functions. A many-factor generalisation for a slightly amended version of Hicks neutrality is available where bias is defined in terms of factor shares.\textsuperscript{19}

\[ B_i = \frac{dx_i}{dt} \cdot \frac{1}{x_i} \]

Where $x_i$ is the share of factor $i$. $dx_i$ indicates that for this share change, relative prices are held constant. Technical change is 1-saving if $B_i < 0$, neutral if $B_i = 0$ and 1-using if $B_i > 0$.

The aggregative specification of a single sector of production inspite of the existence of multisectoral technologies in an economy is a situation necessitated by the inadequacy of


time series data for the inter-industry flow of goods. Recent progress in incorporating multisectoral technologies has been achieved through the development of specifications based on measurement of total primary factor inputs to the whole economy. Mundell (1963) suggested estimation of the production possibility frontier giving an implicit relation between a vector of outputs and a vector of total inputs assuming separability. Diswet (1970) deals with the set of demand functions for primary factors associated with the technology when factor markets are competitive. Hall (1973) making use of the principles of duality between production function and cost function proposes a functional form for the joint cost function and related joint factor demands in which restrictions of separability and non-jointness can be imposed parametrically. Cost and profit functions also can be used to specify the underlying production technology. The theory of duality ensures consistency between the cost or profit functions and production technology. They are computationally simple and by utilizing economic


observations, they permit testing of wider classes of hypotheses. The restrictive assumptions on the divisibility of commodities and convexity and smoothness of production possibilities are not required.

The rate of technical progress may be influenced by the rate of growth of the capital stock or the share of the National Product invested or the period of time over which the capital stock is replaced or the accumulated sum of past investment. It will be endogenous to the processes analyzed by growth models rather than something which is exogenous to those processes in so far as the rate of progress depends upon investment. Eltis (1971) examines such an endogeneous relationship between investment and the rate of technical progress assuming that annual rate of expenditure on research and development can be smoothly transformed into an annual rate of cost reduction. Arrow (1962) discusses a 'learning-by-doing' technical progress as measured by the rate of growth of output per worker is postulated to be a function of cumulative gross investment since the beginning of industrialisation. "Learning" an element in total technical progress depends upon cumulative output.

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Although in most modern price and growth theory, technological change is treated as exogenous, this must be interpreted as an analytical convenience rather than as a serious statement about the economic system.

Examining the basic issues of technology and economic development, Fransman (1986) summarizes the forms of technological change in the Third World as follows:

1) Search for new products and processes
2) Adaptations of products and processes to local conditions
3) Improving products and processes
4) Developing new products and processes
5) Basic research

of these, (1) to (3) predominate. This may be juxtaposed with the following aspects of technological knowledge viz.

1. it is unevenly distributed among the actors
2. it is acquired only at a cost
3. it is almost always incomplete

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it is always to some extent implicit

5. it is acquired, assimilated, stored and recalled in ways that require the operation of complex organizational practices with the result that these processes can never be assumed to occur automatically or with perfection.

6. it is always selectively structured.

It is essentially of the incremental type rather than of Schumpeterian frontier moving type. On the basic issue of the social determinate of a society's capacity for generating technological progress our understanding remains at best rudimentary even though Adam Smith's "Wealth of Nations" dealt largely with questions of technological change and productivity improvement.28

The emergence of technological change in the forefront of economic analysis can be dated in 1956 when Moses Abramovitz found that almost the entire increase in the net product per capita in the United States since 1870 was associated with the rise in something other than the inputs of the physical capital stock and the services of labour.29 The significance of this


'something' subsequently referred to as the residual - was established beyond doubt by a series of studies in the next few years. Further interest was generated by the realization of the role of technology in structural unemployment and in the optimum use of resources which can be used as a counter-cyclical policy. It has emerged as the major source of growth in per capita income. Its role in determining the distribution of income and unemployment, the strength of a country's position in the international market place and the growth of organizational efficiency is not clear.

1.2 TECHNOLOGICAL CHANGE IN AGRICULTURE

Technological change can be an effective means of relieving some of the constraints of agricultural development. It can reduce the marginal cost of production by augmenting one or more conventional scarce agricultural resource. For instance the introduction of new varieties of seeds and of inorganic fertilizers can offset substantially the scarcity of land in land-starved countries. While discussing the transformation of European agriculture, Douring (1966) lists the important aspects


of technological change in agriculture which has an universal validity viz.

1. The enclosures and other changes in the field system.
2. The new crops and the improved crop rotations
3. Improving the old tools
4. The new power-driven implements
5. Power machines
6. Soil chemistry and artificial fertilisers
7. The battle against insects and fungi
8. The genetic improvements.\textsuperscript{32} He further noted

\textit{At the present time, on the other hand, there is a tendency to think of technical progress in agriculture as coinciding with the increased use of mechanical motive power, above all tractors. The true story is not only more complicated but also different from these simplifications. When medieval and modern agriculture are compared it will be seen that the manifold differences both quantitative and qualitative originated at very different epochs and can be largely explained by a number of different reasons.}\textsuperscript{33}

Technological change in agriculture played an important role in shaping economic progress and social organisation. The

\textsuperscript{32}Dowring, P. (1966) \textit{The Transformation of European agriculture} in H.J. Habakkuk and M. Postan ed. \textit{The Cambridge Economic History of Europe Cambridge University Press.}

\textsuperscript{33}Dowring, P. (1966), \textit{op cit.} p.603
change from hunting animals stage to domesticating animals stage, from the stage of gathering berries, fruits etc. to fairly systematic selection and cultivation stage, from shifting cultivation to settled cultivation were dramatic changes in agricultural technology. Social organisations and its supporting institutions appear to be linked with particular technologies. Agricultural development depends largely on technological innovation and its successful transfer. Both are influenced by factor prices, factor scarcity and incentives. Modernised agriculture can contribute significantly to economic growth. The issue of appropriate technology boils down to the following:

1. What forms of capital investment are most appropriate?
2. Should the scarcely available funds be used for
   (i) land development e.g. improved drainage and irrigation;
   (ii) high yielding technology e.g. improved seeds, fertiliser, pesticides
   (iii) technology to improve labour productivity e.g. mechanisation.

(iv) augmenting the knowledge and skills of the farmer through investments in education, training, and extension.\textsuperscript{35}

Mechanisation need not mean simply tractor technology as is evident from the following levels of mechanisation for different operations. (Table 1.1)

Collinson (1977) argues that the first characteristic of appropriate technology is its acceptability to farmers and that an innovation will be appropriate if:

1) its introduction will increase farmers' incomes consistent with their priorities
2) its cost is within the capital resources or debt ceilings of farmers
3) farmers can manage any repercussions it creates on their farming system.

From the social viewpoint, the characteristics of an appropriate technology are as follows:

\textsuperscript{35}Stj E.C. (1986) : "The Role of Farm Mechanisation in Developing Countries: Experiences in Asian Countries" in International Rice Research Institute (1986), Small Farm Equipment for Developing Countries, p.3
<table>
<thead>
<tr>
<th>Operation</th>
<th>Hand tool</th>
<th>Draft animal</th>
<th>Mechanical power</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
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<tr>
<td>Land clearing</td>
<td>Brush hook, hand saw,</td>
<td>Buffalo and elephant</td>
<td>Track-type tractor for clearing</td>
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<tr>
<td></td>
<td>Motor chain saw</td>
<td></td>
<td>skidders for log transport</td>
</tr>
<tr>
<td>Land development</td>
<td>Spade, hoe, Basket, wheelbarrow</td>
<td>Earth scoop, leveling</td>
<td>wheel tractor, track-type dozer</td>
</tr>
<tr>
<td></td>
<td></td>
<td>scraper, bunt forser</td>
<td>motor scraper, excavator</td>
</tr>
<tr>
<td>Land preparation</td>
<td>Hoe, spade</td>
<td>wooden plough, stem</td>
<td>Single axle tractor, power tiller,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>plough, spike barrow, disk barrow</td>
<td>two axle tractor with various</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>implements</td>
</tr>
<tr>
<td>Planting or seeding</td>
<td>Seed distribution by hand, planting stick,</td>
<td>Furrow opener, marker</td>
<td>Tractor seed drill, seeding with</td>
</tr>
<tr>
<td></td>
<td>Jabber, Row marker, Hand-pushed seeder</td>
<td>wheel for stubbling, seed</td>
<td>aircraft</td>
</tr>
<tr>
<td></td>
<td></td>
<td>drill, seed-cum-fertilizer drill</td>
<td></td>
</tr>
<tr>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
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<td>------------------------------------------</td>
<td>------------------------------------------</td>
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<tr>
<td>Transplanting</td>
<td>Hand-operated paddy transplanter</td>
<td></td>
<td>Motorized paddy transplanter</td>
</tr>
<tr>
<td>Harvesting</td>
<td>Finger-hold knife, sickle</td>
<td>Peanut lifter, cutter</td>
<td>power reaper, power-reaper-binder, power thresher, combine harvester</td>
</tr>
<tr>
<td></td>
<td>Scythe, Threshing table,</td>
<td>bar, mower, Reaper,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Reaper, thresher</td>
<td>Reaper binder, Treading harvest</td>
<td></td>
</tr>
<tr>
<td>Crop husbandry</td>
<td>Hoe, weeding hoe, Hand sprayer, water can, irrigation scoop</td>
<td>wooden inter-row weeder, Interrow weeder, Motor knapsacks walkingtype tool carrier, sprayer, Tractor boom sprayer, Riding type tool carrier, spraying with aircraft, diesel or spraying machine, Persian electric irrigation pumps, water wheel</td>
<td></td>
</tr>
<tr>
<td>On-term processing</td>
<td>Pestle and mortar, Flour grinding stone, Hand operated paddy husk</td>
<td>Animal powered sugarcane, Single pass rice mill, Rubber roll crusher, power gear for rice milling unit, Husser mill, driving processing machinery</td>
<td></td>
</tr>
<tr>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
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<tr>
<td>------------</td>
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<td>------------------------------------------</td>
</tr>
<tr>
<td>Crop storage</td>
<td>Sun drying, bag storage</td>
<td>Artificial dryer, bulk storage</td>
<td></td>
</tr>
<tr>
<td>Handling</td>
<td>Carrying, wheelbarrow, sack truck</td>
<td>Elevator fork-truck</td>
<td></td>
</tr>
<tr>
<td>Rural transport</td>
<td>Porter, Push cart, Rickshaw</td>
<td>Slat, pack-harness, bullock cart</td>
<td>Power tiller with trailer, two axle tractor with trailer, Truck.</td>
</tr>
</tbody>
</table>

Source: A.G. Rijk (1936), p. 88. etc.
1. it is consistent with the political philosophy of the nation or region
2. it has a set of distributional (equity) consequences tolerable to society
3. it has a cost that society is willing to bear to make it available to the farmer if necessary to maintain it.

Thus appropriate technology in agriculture depends on the farmer, the rural community and national policy. 36

In selecting the appropriate agricultural technology for Asian countries the following points have to be considered.

1) In most Asian countries, human labour and draft animals will remain the major power source. Therefore priority should go to the introduction of more efficient tools and implements fitted to these power sources.

2) where land is abundant and labour the limited factor (e.g. Malaysia and outer islands of Indonesia) mechanisation must be introduced to increase production per worker and area under cultivation.

36 Collinson, Y.P. (1977): Discussing the need for New Technology, CIARD, Mexico (mimeo)
3) Where land is scarce and labour is abundant and inexpensive (e.g. Bangladesh), biological and chemical technology should be emphasized to raise land productivity. Certain mechanization technology (water pumps, pesticide applicators) may be required as supporting complementary input to biological and chemical technology.

4) Where both land and labour are abundant and underutilized (under marginal and risky agriculture production systems such as semi-arid areas) a well balanced package of biological, chemical and mechanization technology is required.

5) Where both labour and land are scarce (China and Korea) a combination of labour saving mechanization and biological and chemical technology may be applied to achieve high productivity of both labour and land.

6) Where the cost of labour is relatively high compared to capital (Malaysia, East Asia) mechanization is required to reduce cost of agricultural production.\(^{37}\)

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1.3 TECHNOLOGICAL CHANGE IN INDIAN AGRICULTURE: A BRIEF REVIEW

It is not yet possible to reach anything like an assured and acceptable conclusion on the pattern of change in Indian agriculture in the precolonial and colonial period. This state of affairs may be attributed to scanty and biased nature of the data and also the ideological importance attached to the basic question regarding the nexus between colonialism and development. However the overall picture was one of stagnancy interspersed with isolated phases of dynamism. George Blyn's (1966) study of agricultural output, availability and productivity in British India and its constituent regions during 1871-1947 revealed that during the reference period aggregate foodgrains production increased at an average rate of 0.12 per cent. The best performance was that of wheat with an average annual growth rate of production of 0.34 per cent. 38 Shireen Moosvi's (1987) study of the Economy of the Mughal Empire also showed that between 1540-45 and c. 1870 the yields per acre remained practically the same in the case not only of the major foodgrains but also of the cash crops. 39 Baker (1984) writes "At the most general

level India's agricultural sector seems to have been torpid and unresponsive as is evident in the long term failure to produce enough food for everyone to eat. But at a more particular level in specific areas and in specific periods there have been many examples of rapid growth, technological change and sensitive response to forces of the market. The argument for a general condition of torpidity (whether attributed to the climate, the capacity of the people the social structure or the state) is continually cut short by examples of specific dynamism. The 'stagnancy in foodgrain production hypothesis is further supported by the following table on index number of production of selected crops in undivided India (1900-1947).

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Table 1.2

Index number of production of selected crops in undivided India (1900-1947)
(Base : Quinquennium ending 1904-05=100)

<table>
<thead>
<tr>
<th>Quinquennium ending</th>
<th>Rice</th>
<th>Wheat</th>
<th>Jowar</th>
<th>Bajra</th>
<th>Maize</th>
<th>Barley</th>
<th>Gram</th>
<th>Sesamum</th>
</tr>
</thead>
<tbody>
<tr>
<td>1904-5</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
</tr>
<tr>
<td>1909-10</td>
<td>93.2</td>
<td>105.1</td>
<td>100.0</td>
<td>107.4</td>
<td>103.4</td>
<td>109.4</td>
<td>100.0</td>
<td>100.0</td>
</tr>
<tr>
<td>1914-15</td>
<td>103.1</td>
<td>125.3</td>
<td>94.9</td>
<td>106.3</td>
<td>96.5</td>
<td>106.3</td>
<td>114.6</td>
<td>120.0</td>
</tr>
<tr>
<td>1919-20</td>
<td>102.7</td>
<td>119.0</td>
<td>107.7</td>
<td>106.3</td>
<td>106.9</td>
<td>115.7</td>
<td>117.1</td>
<td>140.0</td>
</tr>
<tr>
<td>1924-25</td>
<td>95.6</td>
<td>116.5</td>
<td>89.7</td>
<td>109.4</td>
<td>96.5</td>
<td>103.2</td>
<td>131.7</td>
<td>100.0</td>
</tr>
<tr>
<td>1929-30</td>
<td>93.2</td>
<td>115.2</td>
<td>93.6</td>
<td>103.2</td>
<td>96.5</td>
<td>87.5</td>
<td>107.3</td>
<td>100.0</td>
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<tr>
<td>1934-35</td>
<td>96.9</td>
<td>121.5</td>
<td>92.3</td>
<td>103.2</td>
<td>100.0</td>
<td>87.5</td>
<td>112.2</td>
<td>100.0</td>
</tr>
<tr>
<td>1939-40</td>
<td>92.2</td>
<td>130.4</td>
<td>96.1</td>
<td>93.8</td>
<td>89.6</td>
<td>75.0</td>
<td>104.9</td>
<td>100.0</td>
</tr>
<tr>
<td>1944-45</td>
<td>94.2</td>
<td>131.6</td>
<td>94.9</td>
<td>125.0</td>
<td>96.6</td>
<td>78.1</td>
<td>97.6</td>
<td>100.0</td>
</tr>
<tr>
<td>1945-46</td>
<td>92.8</td>
<td>116.4</td>
<td>72.9</td>
<td>102.3</td>
<td>94.3</td>
<td>74.5</td>
<td>91.3</td>
<td>71.3</td>
</tr>
<tr>
<td>1946-47</td>
<td>99.0</td>
<td>101.6</td>
<td>69.8</td>
<td>98.0</td>
<td>93.4</td>
<td>90.6</td>
<td>102.4</td>
<td>65.6</td>
</tr>
</tbody>
</table>

Note: Weights are based on the value of production during the quinquennium ending 1928-29

<table>
<thead>
<tr>
<th></th>
<th>1904-5</th>
<th>1909-10</th>
<th>1914-15</th>
<th>1919-20</th>
<th>1924-5</th>
<th>1929-30</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rice</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>U.P.</td>
<td>739</td>
<td>747</td>
<td>747</td>
<td>834</td>
<td>739</td>
<td>690</td>
</tr>
<tr>
<td>M.P.</td>
<td>709</td>
<td>659</td>
<td>789</td>
<td>692</td>
<td>633</td>
<td>740</td>
</tr>
<tr>
<td>Bombay</td>
<td>1015</td>
<td>1955</td>
<td>1035</td>
<td>1026</td>
<td>1112</td>
<td>1133</td>
</tr>
<tr>
<td>Madras</td>
<td>1037</td>
<td>1029</td>
<td>1030</td>
<td>1140</td>
<td>1135</td>
<td>1160</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wheat</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>U.P.</td>
<td>907</td>
<td>948</td>
<td>988</td>
<td>1059</td>
<td>913</td>
<td>916</td>
</tr>
<tr>
<td>M.P.</td>
<td>591</td>
<td>621</td>
<td>619</td>
<td>636</td>
<td>634</td>
<td>493</td>
</tr>
<tr>
<td>Punjab (India)</td>
<td>778</td>
<td>869</td>
<td>863</td>
<td>747</td>
<td>817</td>
<td>316</td>
</tr>
</tbody>
</table>

It is true both for cash crops which enjoyed a fair pull from urban and overseas sources of demand and food crops. The North Indian canal building of the Pre-Mutiny period generated a boom in rice and gram production in the West of U.P. and the Doab region in the 1840's wheat cultivation grew rapidly in the Haryana valley in Western-central India in the 1870's and 1880's. The subsistence farmers of Krishna district of Andhra Pradesh exhibited abundant enthusiasm towards irrigation during the late fifties and early sixties of the nineteenth century. Farmers in the Punjab responded to the provision of water from the new canals by moving to the production of fine rice and sugarcane and by adopting three sets of 'new varieties' of sugar cane within the space of a single generation. A study of agricultural production in Eastern Rajasthan during the 18th century brought into sharp focus the enormous range of crops grown.

The cost of production of the 53 crops ranged in the ratio of 1:20 and 1,100 wells were sunk between 1718 and 1725 in a small subregion of eastern Rajasthan. It suggested the

43 Singh, Dilibagh (1989) ; Agricultural production in Eastern Rajasthan during the Eighteenth century workshop on Traditional technologies in Indian Agriculture, March 2-9, 1989, National Institute of Science, Technology and Development, New Delhi
the treasenous dynamism of the medieval Indian Peasant unlike the picture of a crushed, inert peasant usually given to us by some historians.\textsuperscript{44}

There is inadequate recognition of the fact that modernisation of agriculture occurring in the 19th century was the culmination of agricultural change over a long period with misplaced emphasis on mechanical agriculture vis-a-vis the large number of indigenous peasant innovations like transplantation of rice that preceded it. The agricul-tural consultants examining Indian agriculture in the late 19th century and first half of 20th century reported their appreciation at the complexity of technical change and adaptation in Indian agriculture. They mentioned intricate crop rotations and following systems designed to conserve and replenish the soil, elaborate methods of moving and distributing water and knowledge of basic plant biology. In 1889, Dr. J.A. Voorhees, consulting chemist to the royal Agricultural society was asked to advise on the application of agricultural chemistry to Indian agriculture and to effect improvement in it. This might be considered the first serious endeavour to frame a policy of agricultural research suited to the conditions of India.\textsuperscript{45}

\begin{footnotesize}
\\textsuperscript{44}Vatsaegar, Sharan (1989) "Traditional Technologies in Indian Agriculture" Economic and Political weekly, Oct. 21, 1989, p.2350

\textsuperscript{45}National Commission on Agriculture, Volume 1, op.cit., p.123
\end{footnotesize}
In his report submitted in 1893 Vilocher noted that Indian agriculture as a whole was not primitive and backward. In many parts there was little or nothing that could be improved upon. Where agriculture was manifestly inferior it was not because of inherently bad systems of cultivation but want of facilities which existed in the better districts. Hence improvements was possible if the differences of agricultural conditions and practice existing in different parts of the country were reduced by (i) transfer of better indigenous methods from one part to another and (ii) reducing differences which result from physical causes affecting agriculture. The famine commission report of 1901 noted "We are indeed far from thinking that the Indian cultivator is ignorant of agriculture; in the mere practice of cultivation, Agricultural departments have probably much to learn from the cultivator. But in the utilisation of his hereditary skill, in economy of the means of production and in the practice of organised self-help the Indian cultivator is generally ignorant and backward."  

The case of misplaced perception arises unless the relevance of a particular technology is examined in its local setting and its historical content. A classic example is the case of the

Native wooden plough vis-à-vis the English iron plough in colonial India. The native types were considered inferior because the pointed end did not go deep and did not overturn large clods. However a 'scratch' plough conserved soil moisture better and it was the only tool for cultivating paddy under several inches of water. Besides clods overturned under the harsh Indian sun would get baked as hard as bricks. Another misunderstood technique is tank irrigation which dominated pre-modern water works in South Asia. The tank irrigation system represented a system of irrigation which not only made minimal demands on the aquifer but actually made for percolation and annual recharge of the aquifer. Upper parts of this system captured silt which was cleaned out periodically and reused to enrich fields. Local research efforts in the form of agricultural departments appeared in most provinces of India in the 1880's and 1890's. The slow process of experimentation and observation was the characteristic feature in matters of plant breeding and improving cultivation. This was further accentuated by the incomplete scientific understanding of tropical agriculture particularly of soil and plant chemistry. As early as 1944, Dr. Viswanathan then Director of Agriculture, Madras set out a menu of the research & breeding:

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Sangwan, S. (1989) "Trials of strength: the Native wooden plough vis-à-vis the English iron plough in colonial India," workshop on 'Traditional Technologies in Indian Agriculture' March 5-9, 1989; National Institute of Science, Technology and Development, New Delhi.
of crops that were more productive, more adaptable and better able to withstand the climatic vagaries which were the norm for most of India, more small scale irrigation, particularly from wells, more research on the use of available resources, more research on pests and diseases and the establishment of a machinery through which the state could supply co-ordinated packages of improved inputs (seeds, fertilisers, pesticides) technical assistance with irrigation and cultivation practices and supporting finances. He prophetically noted that it would take about 20 years for such a programme to bear fruit.

The common features of sporadic growth were as follows:

1. Whatever single factor started off the spurt, other changes tended to accumulate. For instance a new provision of irrigation might prompt the adoption of new crops, new varieties of seed, different agricultural practices, new marketing methods and different organisation of labour. Thus institutional and technical changes tended to be concentrated together in these short periods.

2. The periods of spurt or boom were generally short and followed by lapse into stagnation or even a subsequent decline.48

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48 Baker, Ch.J. (1934), cit. cit., p. 41
Stokes (1973) provided valuable insight into the dynamics of the Narmada valley wheat boom of the last years of the nineteenth century. He argued that the reasons for the collapse of the boom lay in the development of agrarian society not with the exhaustion of new opportunities for wheat cultivation and export due to demographic growth and demand elasticities. The class of farmers and investors with a properly capitalist outlook migrated to the town with their profit. Those who stayed settled to a life of rentier ease rather than a life of continued accumulation. The flight of active capital from the farming sector resulted in a shift of farming in the Narmada valley to a lower level of intensity and the boom passed. In the case of the farmers of Krishna district in Andhra Pradesh, the major factors dampening and finally aborting agricultural growth unleashed by the completion of the Krishna dam in 1955 were as follows: an inefficient system of water distribution, the farmer's relative unfamiliarity with water management and the high turning saline, rigid water rules prohibiting the farmers from experimenting with crop-mix and a high tax burden especially water tax up to Rs. 4 per acre acted as built-in disincentives under a colonial regime thereby slowing down agrarian expansion and growth.

Such pattern of development may be attributed to the lack of a deliberate state policy for the development of the resources of the national economy for the welfare of the people. Introduction of land tenure systems, opening up of road and rail communications and promotion of export trade in certain agricultural commodities e.g. cotton, jute, indigo etc. within the framework of free trade policy of the colonial power were the important steps taken by the British Government in India.  

The attitude of complacency of the Government about the existing conditions of agriculture was primarily due to the following characteristics of Indian agriculture.

(i) the Indian sub-continent and Burma formed one single unit which together produced a substantial surplus of foodgrains viz. wheat and rice even in famine yrs.

(ii) certain segments of the farm economy which were of special concern to the colonial power, e.g. cotton, jute, indigo and other plantation crops showed marked expansion during the period in response to private initiative and market stimuli.  

51 National Commission on Agriculture: op.cit, p. 123
This view about the attitude of complacency is further substantiated by the fact that contours of a National food policy began to emerge soon after the outbreak of the Second World War. The immediate effects of the World War II on the economy were that commercial crops like jute, cotton and groundnut lost their export market and demand for foodgrains increased pushing up prices. The Government intervened in the foodgrains market for the first time in 1941 by imposing ceiling prices in wheat in the Punjab markets. The Famine Inquiry Commission of 1944 under the chairmanship of Sir John Woodhead urged the Government to recognize its responsibility in making food available to all, ruling out the policy of laissez-faire in the matter of food supply and distribution as inexpedient. During the period 1939 and 1947 the Government took measures not only to meet the immediate food shortage but also to make permanent improvements in agriculture, thereby leading to the emergence of a national production policy. In April 1942 the government of India called a conference of representatives of provinces and the Indian states where recommendations were made for increasing food production within the country. These recommendations became the basis of the Grow-More-Food Campaign which was the first all-India Agricultural development programme initiated and directed from the centre. The conference suggested the following policy measures for the increased production of food and fodder crops.
(i) increase in area under food and fodder crops by bringing new land including fallows under cultivation, double cropping and diverting land from non-food crops to food crops.

(ii) increase in the supply of water for irrigation by improving and extending existing canal, construction of additional wells etc.

(iii) increase in the supply of improved seeds

(iv) increased use of manures and fertilisers. 52

In January 1946 the Government of India issued a 'Statement of Agriculture and Food policy in India' spelling out the objectives to be achieved, the measures to be taken and the respective roles of the centre and the provinces. According to the statement —

"The all India policy is to promote the welfare of the people and to secure a progressive improvement of their standard of living."

This includes the responsibility of providing enough food for all, sufficient in quantity and of requisite quality.

For the achievement of this objective, high priority will be given to measures for increasing the food resources of the country to the fullest extent and in particular to measures designed to increase the output per acre and to diminish dependence on the erratic vagaries of nature. Their aim will be not only to remove the threat of famine but also to increase the prosperity of the cultivator, raise levels of consumption and create a healthy and vigorous population.

The major policy objectives were:

1. Increase in production of foodgrains and protective food
2. Improvement in methods of agricultural production and marketing
3. Stimulating production of raw materials for industry and exports
4. Securing remunerative prices for the producer and fair wages to the agricultural labour.
5. Ensuring fair distribution of the food produced.
6. Promoting nutritional research and education.

53 Quoted from National Commission on Agriculture (1976), Volume No. 1, p. 137
The Grow-More-Food campaign was placed on a planned basis from 1947-48. The foodgrains policy committee appointed in September 1947 under the chairmanship of Shri Purshotandas Thakurdas recommended that greater attention should be paid to minor irrigation, development of local manural resources, distribution of improved seeds and land reclamation. A major change in the approach to agricultural development emerged in 1950-1 when it was decided to concentrate the development efforts in compact areas called 'Intensive cultivation areas' which possessed assured water supplies and fertile soils. This approach based on selectivity of area and concentration of efforts resulted in the Intensive Agricultural District Programme (IADP) and the Intensive Agricultural Areas Programme (IAAP) during the Third Five Year Plan. IADP was characterized by four major innovations.

(i) it emphasized measures for immediate increase in agricultural production.

(ii) only districts with adequate production potential in terms of assured water and infrastructure facilities were selected.

(iii) emphasis was directed towards profitability at the farm level.
(iv) stress was laid on adoption of package of improved practices evolved for individual crops which included use of improved seed, fertilisers and manures, pesticides, improved implements and proper soil and water management practices.\textsuperscript{54}

The National Commission on Agriculture summing up the prospects of agricultural production on the eve of the advent of new agricultural technology noted:

"Nevertheless the unmistakable indication provided by these studies was that much progress could not be made towards improvement of crop production in the country within the confines of the existing production functions and traditional resources as there was little evidence of economic inefficiency in resource use. Significant improvements in Indian agriculture, would, therefore, need induction of new resources, skills and techniques.\textsuperscript{55}

The IADP was started in 1960-61 in three districts and was subsequently extended by stages to another 13. Its performance

\textsuperscript{54} National Commission on Agriculture (1976), Vol. No. 1, p.149

\textsuperscript{55} National Commission on Agriculture (1976) op.cit, p.410
demonstrated the value of the package approach and the advantages of concentrating effort in specific areas. After the mid-term appraisal of the Third Five Year Plan in 1964-65, a modified version of the approach was extended to several parts of the country as the IAP. While both the programmes were concerned with the promotion of intensive agriculture, they operated within the limitation set by existing crop varieties which had relatively low response to fertilizers.\footnote{Panditkar, V.M. & P.K. Balke (1993), \textit{Praag\textit{11}}, p.15} Hybridization techniques for maize and millets were initiated in 1960. In wheat, Mexican dwarf varieties were tried out on a selected basis in 1963-64. Fairly seeds of exotic varieties such as Taichung Native-1 were introduced in 1965.

Although important strides had been made in the development of better seeds and agricultural practices during the 40's and 50's the advent of the Borlaug seed-fertilizer technology during the late 60's marked a new stage in agricultural transformation. The word 'Green Revolution' was coined by Dr. William Bould of the USAID in 1968 to draw attention to the quantum jump achieved in India and Pakistan in improving wheat yield through the use of high yielding semidwarf varieties of wheat developed in Mexico under the Rockefeller Foundation and Government of Mexico wheat
Improvement programme headed by Dr. Norman Borlaug. It brought into sharp focus the potential for improving crop yields in the tropics and subtropics through the use of genetic strains which can respond well to water and soil fertility management. The new technology was essentially land augmenting or land-saving. Irrigation, multiple cropping, use of short-duration HYV of seeds and fertilizer enable the farmers to get more out of per unit of land. Tractorisation, another component of the new technology also was land-augmenting to the extent it facilitates multiple cropping and helps to divert fodder resources and grazing land from the maintenance of plough cattle.

The high yielding varieties (HYV) programme was launched in the country in the Kharif season of 1966-67. It was based on the exotic, high yielding fertilizer responsive short duration crop varieties of paddy, wheat and hybrids of javar, bajra and saure. The introduction of HYV of foodgrains although basically a process innovation also contained features of a product innovation. The first miracle rice IR-8 possessed some properties (taste, milling and cooking characteristics) which differentiated it unfavourably from the local varieties of grain. The emphasis


on a technological breakthrough in Indian agriculture was a change from the earlier period efforts at increasing agricultural production which proceeded more or less on traditional lines involving some increase in irrigated area, more widespread use of better agricultural practices of the traditional kind, popularisation of improved varieties of seeds and gradual increase in the use of chemical fertilizers.

In the new strategy, resources were diverted to potentially productive areas and it represented a deepening and narrowing of the 'package' concept in IADP and IAAP with less emphasis on developing institutional support in the credit and Co-operative fields and more emphasis on the agronomic components of the package. It was to be complemented by a national agricultural programme designed to stabilize farm prices, boost the total availability of credit to agriculture, increase the area irrigated, improve the quality of irrigation and expand the scope of research. The high yielding varieties, exotic as well as locally identified brought about a change in the production scenario with potential yields expected from paddy and wheat varieties. The initial stage varieties were Taichung Native-1, Tainan-3, ADI-27 etc. for paddy, Lerma Rojo, Sonora-64 etc. for wheat and a few hybrids of jowar, bajra and maize. New varieties soon followed such as IR-3, Jaya, Padma, Hassa, Fankaj in the case of paddy, Kalyan Sona,
Sonalika etc. in the case of wheat. The yield advantage of the HYV on the basis of national sample survey organisation crop-cutting experiment is shown below:

Table 1.4
Average yield in kg/ha for 1970-1 to 1972-3

<table>
<thead>
<tr>
<th>Type</th>
<th>Wheat</th>
<th>Rice</th>
<th>Other cereals</th>
</tr>
</thead>
<tbody>
<tr>
<td>HYV</td>
<td>2101</td>
<td>2231</td>
<td>1066</td>
</tr>
<tr>
<td>Others</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1) irrigated</td>
<td>1603</td>
<td>1358</td>
<td>1275</td>
</tr>
<tr>
<td>2) unirrigated</td>
<td>876</td>
<td>743</td>
<td>601</td>
</tr>
</tbody>
</table>

There was a significant difference in the comparative performance of high yielding varieties of wheat, rabi paddy vis-a-vis local varieties of the respective crops. For instance in the case of Kalyan variety of wheat in the districts of Amritsar and Karnal the extra benefit vis-a-vis desi wheat was more than three times the additional cost. High yielding paddy strains grown in Kharif season brought only marginal benefits compared to local varieties.

<table>
<thead>
<tr>
<th>Centre</th>
<th>Cash expenditure per hectare</th>
<th>Additional expenditure</th>
<th>Additional Gross Return</th>
<th>Additional net return</th>
<th>Ratio of additional gross return to additional expenditure</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HIV</td>
<td>Local</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
<td>(5)</td>
<td>(6)</td>
</tr>
<tr>
<td>West Godavari</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kharif (IR-3)</td>
<td>1271</td>
<td>793</td>
<td>478</td>
<td>587</td>
<td>109</td>
</tr>
<tr>
<td>Rabi (IR-8)</td>
<td>1495</td>
<td>1429</td>
<td>416</td>
<td>1126</td>
<td>710</td>
</tr>
<tr>
<td>East Godavari</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kharif (IR-8)</td>
<td>1306</td>
<td>640</td>
<td>666</td>
<td>441</td>
<td>(-)225</td>
</tr>
<tr>
<td>Rabi (IR.*)</td>
<td>1439</td>
<td>1008</td>
<td>431</td>
<td>1484</td>
<td>1053</td>
</tr>
<tr>
<td>Thanjavur</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Kharif (ADT-27)</td>
<td>556</td>
<td>316</td>
<td>240</td>
<td>289</td>
<td>49</td>
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cont'd.
<table>
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<th>(1)</th>
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<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
<th>(7)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rabi (IR-8)</td>
<td>725</td>
<td>543</td>
<td>177</td>
<td>1123</td>
<td>946</td>
<td>6.34</td>
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<tr>
<td>Birbhum</td>
<td>966</td>
<td>362</td>
<td>604</td>
<td>996</td>
<td>392</td>
<td>1.64</td>
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<td>Wheat</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Kotah S.227</td>
<td>544</td>
<td>207</td>
<td>337</td>
<td>598</td>
<td>261</td>
<td>1.77</td>
</tr>
<tr>
<td>Amritsar Kalyan</td>
<td>751</td>
<td>361</td>
<td>390</td>
<td>1355</td>
<td>965</td>
<td>3.47</td>
</tr>
<tr>
<td>P.V.18</td>
<td>686</td>
<td>361</td>
<td>325</td>
<td>994</td>
<td>669</td>
<td>3.05</td>
</tr>
<tr>
<td>Karnal Kalyan</td>
<td>519</td>
<td>334</td>
<td>185</td>
<td>603</td>
<td>418</td>
<td>3.25</td>
</tr>
<tr>
<td>S.308</td>
<td>581</td>
<td>334</td>
<td>247</td>
<td>511</td>
<td>264</td>
<td>2.06</td>
</tr>
<tr>
<td>Faizabad</td>
<td>611</td>
<td>456</td>
<td>155</td>
<td>352</td>
<td>207</td>
<td>2.33</td>
</tr>
</tbody>
</table>

Source: Data from agro-economic research centres, Report of National Commission on Agriculture, Vol.1, pp.434-495
The new technology is built around the use of man-made varieties of wheat, maize and other foodgrains in man-controlled environments. The new varieties are the result of a scientific process of selective breeding and possessed the following desirable qualities:

i) resistance to specific pests or diseases
ii) an increased capacity to absorb nutrients from soil or sunlight.
iii) greater structural strength achieved by the reduction of plant height
iv) shorter growth period facilitating more intensive use of land through multiple cropping
v) greater tolerance of dry spells or cold temperatures
vi) diminished photo-period sensitivity.

The man-controlled environments are achieved by means of the use of chemical fertilizers, carefully timed and rationed application of moisture and appropriate cultivation receipts like weeding, watering, fertilizing, transplanting and plant-spacing all carried out in a specially stipulated manner. This change implies a step away from an agriculture adapted to and relying on a particular environment and towards a much higher degree of domination of the environment.

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The indicators currently used to measure the level of adoption and impact of new technology are as follows:

1) area sown to HYV
2) number or growth in number of the cultivators using HYV
3) growth in the use of complementary inputs such as irrigation, fertiliser, tractors etc.
4) total output

Neither the area sown to HYV nor the number of cultivators using HYV necessarily mean a lasting commitment to the new technology in terms of the area under the crop. The quality and time in the growth in the use of complementary inputs of total output there is an unqualified association between increase in total food grain output and the spread of the new technology thus ignoring or playing down the influence of other factors. The share of HYV in total cereal output rose from 61% in 1967 to 62% in 1975. By 1975, 33% of irrigated cereal area was covered by HYV and it consumed 47% of fertilisers used on cereal crops in 1975. In terms of crop area, the proportion of total area planted to HYV's of wheat and paddy rose from 4.3%.

and 2.5% in 1966-7 to 51.5% and 24.7% in 1972-3 respectively.

Table No. 1.6 and 1.7 give a picture of the progress of selected physical Agricultural Development programmes viz. area under HYV seeds, irrigation, consumption of fertilisers and tractors. There have been tremendous increase in all these indicators of change in agricultural technology.

While studying the impact of technological change in agriculture, one has to keep in mind the multidimensional linkages among different sectors in the economy. Increased production of foodgrains has the potential for large growth inducing linkages. Harris (1957) describes three types of linkages:

1) Backward linkages emerge due to the increase in demand for goods or services produced in other sectors of the economy.

2) Forward linkages emerge due to the supply of agricultural products to agroprocessing industry.

3) Consumption or expenditure linkages emerge when the income obtained from marketed surplus is spent on consumer items.

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<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Paddy</td>
<td>Million hectares</td>
<td>5.59</td>
<td>12.44</td>
<td>15.99</td>
<td>18.23</td>
<td>18.84</td>
<td>21.74</td>
<td>22.73</td>
<td>23.47</td>
<td>24.02</td>
</tr>
<tr>
<td>Maize</td>
<td></td>
<td>0.46</td>
<td>1.13</td>
<td>1.35</td>
<td>1.6</td>
<td>1.72</td>
<td>1.91</td>
<td>2.03</td>
<td>1.80</td>
<td>2.19</td>
</tr>
<tr>
<td>Jowar</td>
<td></td>
<td>0.30</td>
<td>1.96</td>
<td>3.05</td>
<td>3.5</td>
<td>4.37</td>
<td>5.23</td>
<td>5.07</td>
<td>6.08</td>
<td>5.50</td>
</tr>
<tr>
<td>Sare</td>
<td></td>
<td>2.05</td>
<td>2.99</td>
<td>2.96</td>
<td>3.64</td>
<td>4.71</td>
<td>5.42</td>
<td>5.17</td>
<td>4.99</td>
<td>5.27</td>
</tr>
<tr>
<td>Total HVG</td>
<td></td>
<td>15.33</td>
<td>31.39</td>
<td>38.33</td>
<td>43.07</td>
<td>47.48</td>
<td>53.74</td>
<td>54.14</td>
<td>55.42</td>
<td>56.12</td>
</tr>
<tr>
<td>Irrigated area</td>
<td>cumulative utilisation</td>
<td>38.0</td>
<td>45.3</td>
<td>52.6</td>
<td>54.4</td>
<td>53.2</td>
<td>57.6</td>
<td>60.5</td>
<td>62.4</td>
<td>64.4</td>
</tr>
<tr>
<td>through Major &amp; Medium</td>
<td></td>
<td>17.3</td>
<td>20.1</td>
<td>22.6</td>
<td>22.7</td>
<td>24.0</td>
<td>24.6</td>
<td>25.3</td>
<td>25.9</td>
<td>26.5</td>
</tr>
<tr>
<td>through Minor</td>
<td></td>
<td>20.7</td>
<td>25.2</td>
<td>30.9</td>
<td>31.4</td>
<td>34.2</td>
<td>34.0</td>
<td>35.2</td>
<td>36.6</td>
<td>37.9</td>
</tr>
</tbody>
</table>

*The figures for minor irrigation indicate the net benefit after allowing seepage.*

cont...
<table>
<thead>
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<th></th>
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<tbody>
<tr>
<td>Consumption of chemical fertiliser</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Nitrogenous</td>
<td>Million tonnes</td>
<td>1.49</td>
<td>2.15</td>
<td>3.50</td>
<td>3.68</td>
<td>4.22</td>
<td>5.21</td>
<td>5.49</td>
<td>5.65</td>
<td>5.77</td>
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<tr>
<td>Phosphatic</td>
<td></td>
<td>0.46</td>
<td>0.46</td>
<td>1.15</td>
<td>1.21</td>
<td>1.44</td>
<td>1.73</td>
<td>1.83</td>
<td>2.00</td>
<td>2.11</td>
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<tr>
<td>Potassic</td>
<td></td>
<td>0.23</td>
<td>0.29</td>
<td>0.61</td>
<td>0.63</td>
<td>0.73</td>
<td>0.77</td>
<td>0.84</td>
<td>0.81</td>
<td>0.86</td>
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<tr>
<td>Total NPK</td>
<td></td>
<td>2.18</td>
<td>2.89</td>
<td>5.26</td>
<td>5.52</td>
<td>6.39</td>
<td>7.71</td>
<td>8.21</td>
<td>8.47</td>
<td>8.74</td>
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</table>

Source: Economic Survey 1983-9, p.521, Govt. of India.
Table 1.7

Availability of Tractors in India

<table>
<thead>
<tr>
<th>Year</th>
<th>Availability</th>
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<tbody>
<tr>
<td>1961-2</td>
<td>3877</td>
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<tr>
<td>1962-3</td>
<td>4030</td>
</tr>
<tr>
<td>1963-4</td>
<td>4329</td>
</tr>
<tr>
<td>1964-5</td>
<td>6646</td>
</tr>
<tr>
<td>1965-6</td>
<td>7703</td>
</tr>
<tr>
<td>1966-7</td>
<td>11407</td>
</tr>
<tr>
<td>1967-8</td>
<td>15432</td>
</tr>
<tr>
<td>1968-9</td>
<td>17945</td>
</tr>
<tr>
<td>1969-70</td>
<td>18424</td>
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<tr>
<td>1970-71</td>
<td>22041</td>
</tr>
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<td>1971-72</td>
<td>32017</td>
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<tr>
<td>1972-73</td>
<td>33879</td>
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<tr>
<td>1973-74</td>
<td>24994</td>
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<td>1974-75</td>
<td>33740</td>
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<td>1975-76</td>
<td>33252</td>
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<td>1976-77</td>
<td>33146</td>
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<tr>
<td>1977-78</td>
<td>40946</td>
</tr>
<tr>
<td>1978-79</td>
<td>54322</td>
</tr>
<tr>
<td>1979-80</td>
<td>60986</td>
</tr>
</tbody>
</table>

Backward linkage items: Inputs purchased by agriculture such as fertilisers, pesticides, machinery, tools, electricity, fuel and oil.

Forward linkage: Agricultural raw materials for India's manufacturing industries e.g. textile (cotton, wool & jute) for processing (wheat flour, edible oils, sugar, tea etc.)

Consumption linkage: Dependence of agriculture on industries for its consumer needs. 62

A schematic representation of the linkages is shown in the following page.

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62 Harris, Barbara (1987) "Regional Growth linkages from Agriculture and Resource flows in Non-fare economy", Economic and Political Weekly, Jan. 3-10, 1987
A schematic representation of the linkages is as follows:

A proper understanding of the extent of linkages crucially depends on the distribution of benefits from food-grains technology, the consumption patterns accompanying increased income.
of various socio-economic groups, the nature of the production functions in the industries experiencing increased demand and the nature of other restraints to expansion of these industries.  

The problem of linkages may also be examined from the perspective of externalities in the transformation of agriculture. Technological change in agriculture is bound to generate externalities in the form of economic, biological, physical and social impacts that extend beyond the individual farmers who change their technology and reallocate their resource-base. It may involve positive or negative fallouts to groups other than the farmers. Examples of positive-nature externality are reduced real prices for food to consumers who live in urban areas, increased demand for fertilisers, insecticides and machines produced by private firms. In other words, the total impact of variations in the level of output in the agricultural sector is larger than the change in its direct contribution because of these activities dependent upon it despite the existence of large subsistence sector unaffected by market forces.

Swaminathan, (1987) an architect of Green Revolution in India summed up the qualitative benefits of Green Revolution as follows:

64Kellor, J.W. and J.J.Lees (1973), "Growth Linkages of the New Foodgrains Technologies", Indian Journal of Agricultural Economics, 28(1)
1. Generation of self-confidence among farmers, extension workers, scientists and political leaders in their ability to bring about rapid improvements in food production.

2. Increasing political priority for the farm sector subsequent upon the increase in demand for inputs and infrastructure such as rural roads, power supply, marketing arrangements and assured irrigation.

3. Greater social prestige and recognition for farmers and farming sector.

4. Greater emphasis on agrarian reform and rural development.

5. Breather for adjusting population growth rate to the resource potential of each country.65

Ladejinsky (1973) a keen observer of the dynamics of the Green Revolution comments "... the new technology in its present state has nevertheless initiated a salutary change in traditional production patterns along with a psychological urge for better farming and living. These, as nothing else, nourish the promise of future agricultural progress"66


Dantwala (1970) notes

"The Green Revolution has given us breathing space. Its greatest contribution is that it may help to relieve the tension and distraction caused by chronic food shortages, and bring back economists and planners to the more abiding issues of Indian Planning." 67

Lots of work have already been done in these areas. What are the justifications for yet another work? In this connection Myrdal (1970) writes.

"Perhaps in no other field of economic activity are there greater differences among the main underdeveloped regions in South Asia, North East Asia, West Asia, Africa and Latin America as well as among individual countries in these regions and even between districts in the several countries, than in the field of agriculture." 68

In similar vein, the report of the National Commission on Agriculture noted "Agricultural production in a vast country like India is carried on in operational units which differ in endowment and efficiency from size group and from area to area.


It is therefore important to study analytically the structure and organisation of the farm sector and the functional relations binding the factors of production at the micro or farm level. 69

In other words, all India experience or for that matter experience of Punjab or Haryana can not be expected to provide a sound basis for agricultural planning in Manipur. A sound basis should be inter linked with response of agriculture to change. With this perspective the current study seeks to examine the following aspects of technological change in agriculture in Manipur.

1. Has there been an acceleration in the rate of growth of agricultural output with the introduction of the High Yielding Variety technology?
2. How valid is the size Neutrality inference of the HYV technology?
3. Has the shares of factors of production undergone any change?
4. What has been the impact of new technology on farm-employment?

1.4 SCOPE AND CHAPTER OUTLINE OF THE STUDY

The chapter outline of the current study is as follows:

**Chapter II** deals with the agrarian structure of Manipur. The emphasis will be on distribution of land and non-land assets among the rural people particularly the cultivators. The asset structure influences and is influenced by the impact of technological change.

**Chapter III** deals with the various aspects of change in the agricultural technology of Manipur. Rate of growth of output has been examined to reconsider the much-debated issue regarding the acceleration in the rate of growth of agricultural output with the introduction of High Yielding Variety technology. Other measures of change in technology considered in this chapter are irrigation, use of fertiliser, High Yielding Variety seeds and mechanisation. They constitute the main components of the new agricultural technology and their growth patterns will throw light on the character of technological change in agriculture.

**Chapter IV** deals with the employment effects of the HYV technology in general. The review of literature in this chapter is highly selective and yet it will give an idea of the spectrum of differing views.
Chapter V explores the agricultural technology-employment linkage in Manipur. It includes an extensive and intensive examination of the data base for agricultural employment.

Chapter VI deals with the distribution aspect of the income generated in the farm by the new technology.

Chapter VII is a reassessment of the size-neutrality debate of new agricultural technology in the context of Manipur. The issues discussed are the relation between size and productivity and the implications of farm size for the diffusion of the new technology.

Chapter VIII discusses the policy implications of these findings. It will discuss the policy measures which will enable the farmers in Manipur reap the benefits of the New Agricultural Technology and also share equally the benefits. Higher degree of exploitation of the production potential of the technology and equal distribution of its benefits are necessary conditions for the sustainability of the technology.