This chapter is divided into four sections. Section one deals with the types and characteristic features of inputs. Section two gives the findings of the earlier studies. The third section highlights the selected factors influencing agricultural productivity. The fourth and final section discusses the main findings and results of the regression analysis.

Agriculture in most of the developing economies is still backward, inefficient and traditional in nature. Further, most of the available resources are either not utilized or mis-utilized or under-utilized. Proper development and use of these, through modernization of agriculture therefore would certainly strengthen the country's economy and increase the standards of the people particularly of the rural areas.

Modernization of agriculture means increasing the efficiency and output per unit of land by using and adopting all possible modern means of inputs and agricultural practices. In other words, agricultural development in a particular
country, or region means, over-all improvement of both per
acre and per man-day productivity from land. In majority of
the areas this implies the proper supply of farm inputs to
farm families to enable them to increase the yield and there-
by output. Therefore, the novel use of inputs so as to raise
their productivity happens to be the vital source of agricu-
ltural modernization or development in any country/region,
and it is even more so in a densely populated country like
India.

Agriculture is a special type of occupation where the
growth of plants and animals is affected by natural, econo-
ic, historical, and social factors. It requires different
kinds of treatment to different crops at different places
and times. In other words, the agricultural production is
carried out differently in different areas or regions,
within a country, depending upon local conditions. Hence
the techniques used for modernization of agriculture also
differ. Dr. M.S. Swaminathan\(^1\) has rightly observed that
"modernization in any field of human activity involves
revolutionary changes which help to bridge the gap between
available know-how and its practical application. It is
hence a dynamic process. Its meaning and methods will vary
with both time and place. For example, in the Punjab ...,"

\(^1\) Swaminathan M.S., "Sixth Plan: Modernizing Agriculture"
\(\textit{Yojana}, \text{Vol.25(13), 16 July 1981, p. 8}\)
modernization of agriculture means, the spread of tube wells, tractors, fertilizers high yielding strains of both plants and dairy cattle and better marketing arrangements. On the other hand, modernization in the context of a state like Arunachal Pradesh where farmers still adopt shifting cultivation ..., modernization would imply the replacement of shifting cultivation with settled agriculture. In West Bengal and Kerala where land is the most limiting factor..., modernization would mean maximisation of production per unit of land and labour. This will call for the introduction of land use patterns which can help to optimise production per cubic volumes of both air and soil. In contrast, in Western Rajasthan where water (and not land) is the most limiting factor, modernization would call for the maximisation of output per unit of water. Thus, modernization of agriculture means intensive use of modern methods and practices depending upon the stage of agricultural development, place, time, environment etc. In other words, it also implies the use of improved methods, tillage and other agronomic practices, timely use of new variety of inputs and other land development measures. It goes without saying that minimum infrastructure facilities precede the adoption of improved inputs. Thus, it is observed that there is a complementary relationship between input utilization and availability of necessary infrastructure.
1) Physical Inputs:

Agricultural efficiency and productivity largely depends on the physical inputs used in the farm sector. Physical inputs means all those inputs that are used directly in raising the agricultural output. The most important inputs are land, seeds, fertilizers, manures, pesticides, human and animal power, tools, machinery, implements, water etc. These inputs can be broadly classified into two groups, viz., (1) traditional inputs and (2) modern inputs.

Traditional inputs are those which are used by the farmers in traditional agriculture for operation of their agricultural lands, such as land, labour (human), animal power, local seeds (prepared by farmers themselves), and a few wooden equipments for transportation, tillage, sowing, harvesting etc. The inputs and implements used by the traditional farmers are comparatively few in number, crude and antiquated in character, and simple in kind and very insignificant in value, as compared to the most improved inputs and up to date farm equipments used by farmers in modern agriculture. Another important feature in traditional farming is the use of limited inputs. "The two prime inputs of traditional agriculture are land and labour. Capital is not only much less important in quantity, but also is largely a direct embodiment of labour in the form of land improvements, water
systems, and simple tools". As a result, there is less scope for increasing agricultural output in traditional farming. Briefly, the traditional agriculture depends on the biological sources of energy (animal and human power), rain fall and farmyard manure. Returns to farm families under this method/technique of production are very meagre and the nature of farming is appropriately described as "subsistence farming".

Modern inputs that are used by the farmers in advanced agriculture for operation of their farm lands, are recently innovated by scientists for healthy plant development, soil nutrition, expeditious growth and for multiplying the large scale output. For example, inorganic manures, chemical pesticides, application of water to the fields through modern means like sprinklers, plastic lining materials, pump sets etc., high yielding variety of seeds, improved implements, tractors, land levelling machines, harvesters etc.

Application of modern inputs together will certainly change the entire agricultural production process and gives better results to the farming community. Schultz rightly states that "traditional inputs have a low level of return

at the margin, where as modern inputs hold the promise for agricultural development". 3

Thus the modern agricultural inputs are far more superior to the traditional inputs. Again, the superiority of the modern inputs lies in their innovations based on science and their constructive translation through practical application i.e., technology. In these days science and technology are promising humanity more than ever before. "Thus one of the key features of a modern agriculture is that its current level of production and, to an ever greater extent increments in production are based on a set of purchased inputs of a farm not found in traditional agriculture". 4

One can easily identify various characteristic features of new farm inputs. Mellor identifies five such characteristic features 5 viz., (1) They are the product of research, (2) They tend to be represented by variable costs rather than fixed costs, (3) They have direct effect on the level of crop and livestock yields, (4) They are purchased off the using farms, (5) They are complementary to one another.

2) **Basic Infrastructure Facilities:**

Purposeful use of physical inputs largely depends on the availability of infrastructure facilities in the Country/State/Region. The term infrastructure for agriculture growth refers to all the institutions and service centres. According to the *McGraw Hill Dictionary,* infrastructure means "the foundation underlying a nation's economy (transportation and communication system, power facilities and other public services). It may include such intangible assets as educational and social attitudes, industrial skills and administrative experience. *Everyman's Dictionary of Economics* is more clear in its explanation of the term infrastructure, i.e., "the service regarded as the essential basis for creating modern economy: transportation, power, education, health services, housing. It is also described as social or public overhead capital where the emphasis is on the capital assets that provide the services, roads, bridges, railways, houses, reservoirs etc." To be more specific, the agricultural infrastructure will be defined as follows. "The physical capital and institutions or organizations, both public and private, which provide economic services to and which have a significant effect, directly or indirectly, upon the economic functioning of the individual farm firm, but which

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are external to the separate, individual farm firm".8

The infrastructure as a whole can be broadly classified into three main groups viz., (1) Organisational infrastructure, (2) Service infrastructure and (3) Physical infrastructure. Further this has been viewed by Wharton that the agriculture infrastructure may be categorised into three types under different heads viz.,"(a) capital intensive, (b) capital extensive and (c) institutional infrastructure".9 Now considering the viewpoint of Wharton the components of agriculture infrastructure contains;

(a) capital intensive infrastructure are those which heavily involve reproducible capital for the provision of service, such as irrigation and public water facilities, transport, storage and processing facilities, electricity and power.

(b) capital extensive infrastructure are those in which the capital component is negligible, such as (i) extension education and statistical reporting services, (ii) agriculture research and experiment facilities, (iii) crop and animal protection, control and grading services, (iv) soil conservation services, (v) credit and financial institutions and (vi) education and health facilities.

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(c) Institutional infrastructure consists of formal and informal educational institutions of a legal, political and socio-cultural nature.

Broadly speaking, infrastructure for agricultural growth includes all transportation means, electricity supply, irrigation facilities, implements, processing, storing and grading facilities, distribution centres for the supply of inputs, extension education centres, agencies for plant and animal protection, disease and pest control organizations, financial institutions and various other allied kinds of servicing centres.

Development of these various infrastructure facilities, along with the use of all kinds of inputs in the country not only strengthens the agricultural sector but also helps in the overall development of the country's economy, including development of small and large scale industries. In other words, infrastructure facilities induce both agricultural and industrial development.
The distribution of agricultural growth over different parts of the country has been highly uneven, even though some differences in productivity may remain in view of the differences in climatic conditions, soil fertility, topography, altitudes, etc., in different regions. This uneven distribution of growth has adversely affected the establishment of a progressive and economically balanced economy in the country. Therefore, one has to go very far to identify the factors for the uneven distribution of agricultural growth and productivity over different regions of the country.

According to the Food and Agriculture Organization of the United Nations, the main factors influencing agricultural productivity are, (1) the use of improved seeds; (2) control of pests and crop diseases; (3) provision of irrigation facilities; (4) prevention of soil erosion; (5) use of manures and fertilizers; (6) improved tools and implements and better system of cropping." 10 A.T.Nosher pointed out the following five essential factors for

agricultural growth, viz., (a) markets for agricultural products; (b) constantly changing agricultural technology; (c) availability of equipment in local areas; (d) incentives for production; and (e) efficient transportation system. R.P. Christenson identifies five factors for agricultural development, viz., (1) land resources per person; (2) effective use of abundant labour force; (3) capital inputs and technological innovations; (4) price and other economic incentives; and (5) efficient and well-equipped size of farm units.

According to Mellor technological change for modernizing agriculture depends on five factors, viz., (a) institutions to provide incentives, like land reform measures, which play very crucial role in taking interest in producing more output; (b) research to develop improved production possibilities, particularly adoptive research, which helps in the appropriate utilization of local resources; (c) availability of physical inputs of new improved variety, like improved breeds of livestock, new crop variety, that are vital for maximization of output; (d) institutions to service agricultural production such as

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credit agencies, which are considered as life and blood to the farmers; and (e) communication systems including efficient transportation system, which act as a catalyst in the transformation of economy from poverty to prosperity. The above discussion clearly reveals the important factors for modernizing agriculture. These factors have to be viewed together in any effort designed to increase production. The limitations of season and climate can be overcome in some measure by selecting suitable techniques.

After having studied the important factors for modernizing agriculture, in the succeeding paragraphs an attempt is made to discuss various recent empirical studies on factors affecting variations in agricultural productivity.

Some studies were undertaken in the past to identify the factors that are responsible for estimating the contribution of individual inputs to the agricultural growth. These further have revealed the factors which are responsible for the uneven agricultural productivity in the country.

It has been observed by Prakash and Rajan\(^{14}\) in their work that increasing the use of HYV seeds, fertilizers, irrigation and pesticides are the vital factors for increasing the output of maize, wheat, Jawar etc. The study by

Sharma is concerned with the relative association of per acre productivity in which he has taken into consideration nine important factors, such as holding size, area under tenancy, area cultivated up to 5 acres, percentage of area under mixed tenancy, rainfall, irrigation, land concentration ratio, workers per acre and percentage of hired workers to total agricultural workers in crop zones, and state-zones. His study is based on secondary data from 303 districts. He has taken cross section data for the average of the triennium 1959-1962. Of these 9 factors, average rainfall, gross area irrigated as percentage of gross cropped area, average size of holding, total cultivated area up to 5 acres and hired workers as percentage of total agricultural workers are found to be the most vital factors to explain inter-district agricultural productivity in India.

In another study Hasim and Dadi have examined the factors affecting inter-district per-hectare agricultural productivity variations. They have regressed per hectare output on selected variables. The selected factors explained 61 per cent of inter-district variations. However, the selected factors, viz., land-man ratio and cropping


intensity are found vital to explain the variations.

G.S. Shalla and Y.K. Alagh\textsuperscript{17} have shown that the areas with high agricultural productivity are virtually associated with the areas of rainfall and assured levels of irrigation.

Y.K. Alagh\textsuperscript{18} in his work pointed that irrigation, HYV seeds and fertilizers are closely associated with variations in agricultural productivity among the districts in the Indian Union. D.S. Bhatnagar's\textsuperscript{19} study on Regional Disparities in Agricultural Growth reveals that irrigation, use of fertilizers, improved variety of different crops, and multiple cropping are responsible for the disparities in agricultural growth in different states.

Baldev Singh\textsuperscript{20} has indicated in his study that nearly 90 per cent of inter-district variations in agricultural productivity in Gujarat is explained by the resource

\begin{itemize}
  \item D.S. Bhatnagar, "Regional Disparities in Agricultural Growth", \textit{Kurukshetra}, 16 August 1979, p.4.
\end{itemize}
structure of its agricultural sector. Basing his study on cross section data for the average of 1971-72 to 1972-73, Vaidyanathan\textsuperscript{21} has shown that up to 60 per cent of inter-district variations in agricultural productivity per hectare are explained by physical factors in India.

P.K. Joshi and T. Haque\textsuperscript{22} with the help of Cobb-Douglas type production function using inter-state cross data for the years 1973-74 to 1975-76, concluded that fertilizer consumption, area under HYV, Irrigation, Rainfall and Credit are the important determinants for agricultural growth in a majority of Indian States. Further, the study also revealed that the inter-State variation in agricultural productivity could be explained largely by differences in factors like Fertilizers, Irrigation, HYV seeds, and Credit. In Karnataka, Kerala, Maharashtra, Rajasthan, Orissa and West Bengal, the major part of farm productivity difference was explained by the extent of use of HYV, whereas in States like Tamil Nadu and Gujarat, it was explained by Irrigation, HYV's and Fertilizers.

Ashok Parikh and P.K. Trivedi\textsuperscript{23} have assessed the contribution of increases in irrigated acres, chemical

\textbf{21.} Vaidyanathan \textit{k.}, "Labour Use in Indian Agriculture: An Analysis Based on Farm-Management Study Data", (In: I L O – ARTEP publication, November 1978), p.44.


fertilizers and unirrigated acreage to the growth of output of four crops (rice, tobacco, groundnut, sugarcane) grown in the state of Andhra Pradesh. They estimated a broad input-output relationship of the aggregate production function type using both time series and cross section data for twenty districts for the period 1959-60 to 1974-75. They have concluded that the irrigated area is the most important input, with elasticity coefficient close to unity in most cases. Fertilizer elasticity is generally observed to be much smaller although higher for some individual districts.

In a recent study, by N.V. Dadibhavi using district level data for the year 1975-76 it is concluded that cropping intensity, infrastructure facilities, area under cash crops, fertilizer consumption, rainfall, concentration ratio of land holdings and irrigated area are the significant factors influencing land productivity in Karnataka.

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SECTION - III

Selected Factors Influencing Agricultural Productivity:

This section deals with the specification of variables, influencing agricultural productivity that can be used in the regression analysis for the present study.

Definition of Agricultural Productivity:

Productivity normally means the power of agriculture in a particular area to produce crops with regard to whether that power is due to the bounty of nature or to the efforts of man. The Indian Society of Agricultural Economics adopted the definition of the term productivity as the yield per acre in a particular region, and considered other factors of production as possible causes for the variations while comparing it with other regions. Horring states that productivity broadly denotes the ratio of output to any or all associated inputs, in real term. The productivity of a land may be increased by raising multiple crops in a year on the same land ... It may be increased


also by progressively changing the land from low value crops to high value crops. Thus, the causes of increasing agricultural productivity can be classified as dependent and independent variables.

**Dependent Variables:**

Dependent variable is the product per acre of 240 farm families selected in the sample. The product per acre is calculated in terms of rupees per acre considering the income from various crops (both irrigated and dry) produced by the farmer at 1983-84 prices prevailing in the selected Talukas as per the records of the respective Agricultural Produce Marketing Committees. However, agricultural income does not include sale of farm yard manure, milk, fodder etc., which are negligible in the total income of the farmers.

**Independent Variables:**

(i) **Percentage of Area under irrigation (X_1)**

Assured irrigation has been one of the most important strategies to increase agricultural efficiency and also to reduce uncertainties caused by the so-called vagaries of rainfall. High yield can be expected only if there is sufficient water in the fields. Further, double cropping,

maximum production, more land under the plough, guarantee of the crop, greater profit margin etc., depend largely upon the extent of water supply. Therefore the regions with assured irrigation facilities are expected to have a better yield and high farm productivity. In the present study, availability of irrigation facilities is measured as a percentage of net irrigated area to net area sown of the sample farmers. Therefore, a positive relation between farm productivity and area irrigated is expected. Thus, the higher the percentage of area irrigated, the higher will be the productivity of the farmers.

(ii) Men land ratio ($X_2$)

Land productivity not only depends upon the use of purchased inputs but also on the quality and quantity of human capital. It is generally argued that, the higher the density of population, the higher is the output from the given land. Human capital, particularly family labour, plays a very important role in enhancing the output with given inputs. A family with large number of members (both educated and uneducated) can have advantage over a small family, particularly in agriculture. A family with large members can attend to different agricultural activities. Other advantages of such families may be listed as:

(i) efficient use of resources, (ii) timely work, (iii) timely sowing, (iv) no waste of inputs/outputs, (v) timely operations
(vi) no dependence on hired labour, and (vii) no theft.

In the case of small families having few members, it is quite the opposite. In the present study family size is considered and it is measured as total family members divided by land owned by the family.

Literate and educated worker per acre of land: \(X_3 \text{ and } X_4\)

Education is the foundation for agricultural development. Through imparting proper education a society socialises its members and brings the appropriate changes in its community life. Generally, educated farm-families can make better use of available resources and accept new farm technologies. And it is these families, which are the early adopters of yield raising inputs. Therefore it is said that yield per acre and productivity is very high on educated farm family fields rather than those of illiterate families. Schultz rightly pointed out... "the differences in capabilities of farm people are most important in explaining the differences in the amount and rate of increasing agricultural production".28 Therefore, education is a pre-condition for modernization of agriculture. It is appropriate here to quote Mellor who said that "although education is not in itself a sufficient condition for development of agriculture, it is certainly a necessary condition".29

Some of the typical questions that bother the researchers and policy makers are: (a) what type of education is relevant? (b) Is it formal education or non-formal education or both? (c) If formal education is relevant, whose education is important? – is it the education of the head of the family or any other members of the family?

To know the validity of these questions some studies were carried out by developing countries like Brazil, Nepal, India, Thailand etc. These studies can be classified into two broad categories.

(i) Macro level studies mostly based on secondary data; and
(ii) Micro level studies based on primary data.

The results of these studies are given in Table 5.1.

In the present study an attempt is made to consider the level of education of the members of the sample farm families i.e., (1) literate i.e., less than 4 years of schooling, and (ii) higher elementary i.e., 5 years of schooling and above. However, education of the agriculture workers and informal education of sample families are not considered as it is beyond the purview of the present study.
(iii) **Literate family worker per acre of land** $(X_2)$

Here it is measured as the ratio of the total literate family members to the net cultivated area of the sample family. Farm family members who are at least able to read and write* are treated as literate.

(iv) **Higher elementary and above** $(X_4)$

Family members who have studied up to 5th standard and above are considered in this category. Such members are in a position to grasp the techniques of modern agriculture conveyed to them through various media of communication (Pamphlets, books, journals, radio, T.V., extension lectures etc.) and put these ideas into practice.

(v) **Percentage of area under commercial crops** $(X_5)$

The productivity per acre is greatly influenced by the types of crops grown by the farm families. In other

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* Literate as per definition used in Census of India (1981).
words, the net agricultural income of a farmer depends on the types of crops he grows. Generally, the higher the area under commercial crops, the higher will be the productivity per acre. This variable is measured as the percentage of area under commercial crops to the net area cultivated by the sample households.

(vi) \text{Percentage of area under HYV Seeds (X_6)}

The evolution of quick-maturing photo-sensitive and fertilizers responsive improved seeds have added a new dimension to agriculture. The use of these HYV seeds, along with other complementary inputs such as irrigation, chemical fertilizers and pesticides, has the potential for rapidly and substantially increasing crop production. Thus, adoption of HYV seeds means an immediate profit for the farm families. Further, it improves the crop in quantity and quality. The HYV seeds, which are most commonly used by the sample farmers in the selected taluks are HYV Jawar, Maize, Cotton and Wheat. The percentage of area under high yielding variety of crops to total area cultivated (both irrigated and dry) provides a measure of the use of HYV seeds in different selected villages by the sample farmers. Therefore, the higher the area under HYV seeds, the higher is the farm productivity.
Table - 5.1

Correlation Between Formal Education and Agricultural Productivity

<table>
<thead>
<tr>
<th>Sl. Studies and Particulars</th>
<th>Co-efficient of education on agricultural productivity</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Brazil, Guarani (Pachico &amp; Ashby 1976)</td>
<td>0.072</td>
<td>Less than 5 years of schooling had no significant effect on output.</td>
</tr>
<tr>
<td>2. Brazil, Alto Sao Transisco (Patrick &amp; Kehrberg, 1973)</td>
<td>0.015</td>
<td>Returns of schooling were negative in the traditional agricultural regions, but become positive and increased as the regions become more modern.</td>
</tr>
<tr>
<td>3. India (Punjab and Haryana) Chaudhuri, 1974</td>
<td></td>
<td>Rate of returns to education are high.</td>
</tr>
<tr>
<td>4. India (Punjab) (Sidhu, 1976)</td>
<td>0.038</td>
<td>Education was positively related to production efficiency but more strongly to allocative efficiency.</td>
</tr>
<tr>
<td>5. Nepal, Nuwakat (Calkins, 1976) for more than 7 years schooling</td>
<td>0.53</td>
<td>The co-efficient of education was significant only for 7 or more years of schooling.</td>
</tr>
<tr>
<td>6. Taiwan (Wu, 1977)</td>
<td></td>
<td>Marginal productivity of education in crop production changes from negative to positive at 5.6 years of schooling of the farm operator.</td>
</tr>
<tr>
<td>7. Thailand (Jamison &amp; Lau, 1978)</td>
<td>0.031</td>
<td>The co-efficient for education varied positively with the levels of education.</td>
</tr>
</tbody>
</table>

(vii) Cropping intensity (X_7)

Cropping intensity reveals the area under double cropping in a region/state. By raising two crops in a year from a given acre of land, farm families can produce more and productivity of a given acre can be increased. Thus it is generally argued that the higher the area under double cropping higher is its farm productivity. However, cropping intensity largely depends upon the advancement of the village/region, nature of soil, climate, crops to be grown and other socio-economic factors.

(viii) Number of bullocks per acre of land (X_8)

In India cultivation of land is done largely with the help of bullocks. Though other animals are sometimes used for drought purposes, they are few in number. In fact, the bullock is a multipurpose animal for cultivation; it is a major source of drought power used extensively in transportation, irrigation, ploughing, harvesting etc. It is also a source of supply of manure to the farm and, when used in breeding, it is a reproductive capital asset. Hence, the number of bullocks owned by the farmers will also influence the farm output.

(ix) Implements (X_9)

Implements are also considered as a very important factor for increasing the efficiency of the land. With the
introduction of high yielding variety seeds and multiple cropping, it has become essential to ensure timely farm operations of satisfactory quality that can only be achieved by using farm implements. Thus in the present study the total number of implements owned by the sample farmers is considered. The most commonly owned and used implements by the sample farmers are Cart, Iron plough, Wooden plough, seed drills, land levellers, Sickle, spade, Pickaxe etc. In the present study, only five important implements are considered viz., Iron plough, Wooden plough, seed drill, Cart and land leveller. These are considered mainly because they are very important and available with almost every cultivator and they can be counted with accuracy.

\( X_{10} \)  

**Per acre consumption of fertilizers**

The contribution of fertilizers to increased yield is perhaps the greatest among the purchased inputs. Fertilizers when used in combination with other inputs such as high yielding variety seeds and irrigation water, results in positive interaction, thereby increasing further its contribution to yield increase. (Further, recommended doses, correct method and timely application of fertilizer will certainly give maximum yield per acre). Thus it is observed that the higher the level of consumption of fertilizers the higher is the agricultural productivity expected. The consumption of fertilizer \((N + P + K)\) for all crops (both
dry and irrigated) during a year is considered as the use of chemical fertilizers by the farmers. This is expressed in terms of Kg per acre of land.

(xi) Per acre expenditure on farm yard manure \( (X_{11}) \)

Farm yard manure is another factor, which is considered as traditional, for getting a high yield. This can be applied to all crops grown in the rainy season or under irrigation. The quantity to be applied varies from 5 to 10 cartloads per acre for unirrigated fields to 10 to 20 cartloads for irrigated fields. It is found that best results are achieved when both organic and inorganic manures are used in combination. "The organic matter content of most Indian soils is very low and non-application of organic manure in the face of continuous application of chemical fertilizers would fail to build up good soil physical properties and reduce efficiency of fertilizers".\(^{30}\) Thus, the line of advance lies in fully conserving and utilizing organic manure, on the one hand, and supplementing it by fertilizers in areas which are brought under irrigation.

(xii) Per acre expenditure on pesticides \( (X_{12}) \)

Insects, pests, fungoid diseases and weeds damage crops and nullify the benefits of other improvements such

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as better irrigation facilities, seeds and fertilizers. The control of various types of diseases enables a crop to yield its maximum within the limitation of its environment. In the absence of such control, the degree of damage inflicted on the crop determines the quantum of its yield, which may vary from a poor harvest to none at all. Thus, the use of appropriate quantity of pesticides enhances farm production. However, unlike chemical fertilizer, pesticides do not raise the yield but only control the losses. In the present work, this variable is measured as total expenditure on pesticides divided by the total acreage of sample farmers.

(xiii) Farm size ($x_{13}$)

Size of the farm is an extremely important factor to determine the productivity of the land. It has been a matter of controversy among scholars as to whether small farms necessarily have a greater productivity per unit of land than the big farms.

The debate was initiated by A.K. Sen in 1962 and argued that an inverse size productivity relationship existed in India i.e., as the size of holdings increase productivity declined. Many other scholars like Deepak Sen A K., "An Aspect of Indian Agriculture", Economic and Political Weekly (Annual number), Vol. 14(4,5 and 6), 1962, pp. 234-46.
inzumdar, A.K. Sen, P.K. Bardhan, G.R. Saini
etc., also arrived at the same conclusion. Their conclusion is based on both macro and micro level studies in the country. Further, these studies show that the inverse relationship between farm size and productivity exists mainly because of two important factors viz., (i) intensive use of land and (ii) more use of family labour per unit of land by the small holders. On the other hand, the man-land ratio is very negligible or low in the case of big farmers and thereby the per acre productivity is also low.


Contrary to the above findings, A.P. Rao, 38 Usha Ranj 39 studies revealed that the holding size has no effect on productivity and yield per acre remains constant over different size group of farms. Further, these studies argued that, due to technological change, even big farms can also produce the same yield as produced by the small farms. Similarly, it has also been pointed out by Chattopadhyay and Audra 40 study that the inverse relationship, if it exists at all, is likely to exist in a traditional, static agricultural set up. The productivity of the small farms is not likely to remain high in a dynamic set up characterised by the advent of modern technology. Even then, the inverse relationship between farm size and productivity is a confirmed phenomenon in Indian agriculture. In the present study, size of the land holding is measured in terms of actual land (i.e., number of acres) cultivated by 240 sample farm families.


## TABLE 5.2

Average Values of Selected Characteristics and Their Coefficient of Variation of Sample Families of 240 (1983-84)

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Variable</th>
<th>Mean</th>
<th>Variance</th>
<th>Standard Deviation</th>
<th>Coefficient of Variation ( per cent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Per acre productivity of land (in Rs.)</td>
<td>$X_1$</td>
<td>3288.35</td>
<td>839253.90</td>
<td>9199.40</td>
<td>99.59</td>
</tr>
<tr>
<td>2. Percentage of irrigated land</td>
<td>$X_2$</td>
<td>64.24</td>
<td>674.62</td>
<td>29.57</td>
<td>46.04</td>
</tr>
<tr>
<td>3. Man-land Ratio</td>
<td>$X_3$</td>
<td>0.96</td>
<td>1.09</td>
<td>1.04</td>
<td>108.71</td>
</tr>
<tr>
<td>4. Literate Family Members per acre</td>
<td>$X_4$</td>
<td>0.17</td>
<td>0.57</td>
<td>0.24</td>
<td>137.71</td>
</tr>
<tr>
<td>5. Educated Family</td>
<td>$X_5$</td>
<td>0.13</td>
<td>0.04</td>
<td>0.19</td>
<td>145.88</td>
</tr>
<tr>
<td>6. Percentage of area under Commercial HY</td>
<td>$X_6$</td>
<td>85.71</td>
<td>648.82</td>
<td>25.47</td>
<td>71.32</td>
</tr>
<tr>
<td>7. Percentage of area under Food HY</td>
<td>$X_7$</td>
<td>42.16</td>
<td>466.93</td>
<td>22.11</td>
<td>52.44</td>
</tr>
<tr>
<td>8. Cropping Intensity</td>
<td>$X_8$</td>
<td>1.29</td>
<td>0.06</td>
<td>0.24</td>
<td>18.70</td>
</tr>
<tr>
<td>9. Number of Bullocks per acre</td>
<td>$X_9$</td>
<td>0.20</td>
<td>0.03</td>
<td>0.19</td>
<td>99.46</td>
</tr>
<tr>
<td>10. Number of Agricultural Implements</td>
<td>$X_{10}$</td>
<td>5.39</td>
<td>11.71</td>
<td>3.42</td>
<td>63.48</td>
</tr>
<tr>
<td>11. Per acre use of Chemical Fertilizers</td>
<td>$X_{11}$</td>
<td>129.54</td>
<td>6847.83</td>
<td>82.75</td>
<td>63.88</td>
</tr>
<tr>
<td>12. Per Acre Expenditure on Farm Yard Manure in Rs.</td>
<td>$X_{12}$</td>
<td>65.99</td>
<td>1546.57</td>
<td>39.35</td>
<td>61.59</td>
</tr>
<tr>
<td>13. Per Acre Expenditure on Pesticides</td>
<td>$X_{13}$</td>
<td>144.89</td>
<td>9711.95</td>
<td>98.54</td>
<td>68.01</td>
</tr>
<tr>
<td>14. Farm Size</td>
<td>$X_{14}$</td>
<td>17.52</td>
<td>773.01</td>
<td>19.31</td>
<td>-110.23</td>
</tr>
</tbody>
</table>
Before identifying the determinants of agricultural productivity by using Regression Analysis, it is desirable to find out the extent and degree of association between product per acre (expressed in terms of rupees) and each of the explanatory variables explained in the foregoing Third section. For this purpose zero order correlation matrix between the dependent variable and each of the explanatory variables is computed with the help of the primary data of 240 selected families specifically collected for this purpose for the year 1983-84. After examining the problem of multicollinearity, multiple Linear Regression models determining the factors of farm productivity are presented, the final part of this section discusses the results of the estimated regression models.

The calculated correlation coefficients between product per acre and each of the explanatory variables are presented in the last row of the Table. 5.3. It is clear from the table that product per acre is positively and significantly associated with percentage of area irrigated to net sown area \( X_1 \), literate family members per acre \( X_2 \), educated family members per acre of land \( X_3 \), percentage of area under commercial HYV \( X_4 \), percentage of area under food
Notes: (i) The critical value of the correlation coefficient (with 258 degrees of freedom) at 0.05 per cent level of significance is 0.1647.
(ii) The correlation coefficients are computed from the sample size of 240 farm families.
HYV ($X_6$), number of bullocks per acre of land ($X_8$), per acre use of chemical fertilizers ($X_{10}$), per acre expenditure on farm yard manure ($X_{11}$) and per acre expenditure on pesticides ($X_{12}$). The relation between farm size and productivity is negative and significant. Variables like percentage of area under irrigation ($X_1$), educated family members per acre ($X_4$), percentage of area under commercial HYV ($X_5$), per acre use of chemical fertilizers ($X_{10}$) and per acre expenditure on pesticides ($X_{12}$) are highly correlated with the productivity. However, the coefficient of correlation between product per acre and cropping intensity and number of farm implements are observed to be negative and insignificant. This is largely because most of the farm families in the command area raise HYV commercial cotton, which is an annual crop. Further, the said crop requires less bullock power. Other operations like sowing, applying of fertilizers, weeding and harvesting activities are carried out by human labour.

To know the extent of influence of the explanatory variables on product per acre, Multiple linear regression analysis is used. Since the present study covers the many explanatory variables, it is natural to expect some degree of multicollinearity because of inter-correlation among explanatory variables. However, an attempt is made to reduce the degree of multicollinearity by dropping the inter-correlated variables in the regression equations.
The intercorrelation (co-variance) among the explanatory variables is also given in the zero order correlation matrix in Table 5.3.3. From the correlation matrix, it is clear that some of the explanatory variables are correlated among themselves, such correlated variables have been dropped and care is taken while selecting the explanatory variables in the model.

Regression Models

Four linear models $A_1$ to $A_4$ with different combinations of explanatory variables are examined to identify the factors influencing productivity per acre. The models finally selected are as follows:

\[ Y = \alpha + \beta_1 x_1 + \beta_3 x_3 + \beta_5 x_5 + \beta_6 x_6 + \beta_{10} x_{10} + \beta_{12} x_{12} + \beta_{13} x_{13} + \beta_{1} x_1 + \beta_3 x_3 + \beta_5 x_5 + \beta_6 x_6 + \beta_{10} x_{10} + \beta_{12} x_{12} + \beta_{13} x_{13} + u \quad \text{(A1)} \]

\[ Y = \alpha + \beta_1 x_1 + \beta_3 x_3 + \beta_5 x_5 + \beta_6 x_6 + \beta_{10} x_{10} + \beta_{12} x_{12} + \beta_{13} x_{13} + u \quad \text{(A2)} \]

\[ Y = \alpha + \beta_1 x_1 + \beta_3 x_3 + \beta_5 x_5 + \beta_6 x_6 + \beta_{10} x_{10} + \beta_{12} x_{12} + \beta_{13} x_{13} + u \quad \text{(A3)} \]

\[ Y = \alpha + \beta_1 x_1 + \beta_3 x_3 + \beta_4 + \beta_5 x_5 + \beta_6 x_6 + \beta_{10} x_{10} + \beta_{11} x_{11} + \beta_{12} x_{12} + \beta_{13} x_{13} + u \quad \text{(A4)} \]
Where,

\[ Y = \text{the farm product per acre (expressed in terms of rupees)} \]

\[ X_1 = \text{percentage of area under irrigation} \]

\[ X_2 = \text{Man-Land Ratio} \]

\[ X_3 = \text{literate family worker per acre of land} \]

\[ X_4 = \text{Educated family worker per acre of land} \]

\[ X_5 = \text{Percentage of area under commercial HYV crops.} \]

\[ X_6 = \text{Percentage of area under food HYV crops.} \]

\[ X_7 = \text{Cropping intensity} \]

\[ X_8 = \text{Number of bullocks per acre of cultivated land} \]

\[ X_9 = \text{Number of agricultural implements} \]

\[ X_{10} = \text{Per acre use of chemical fertilizers (N+P+K)} \]

\[ X_{11} = \text{Per acre expenditure on farm yard manure (in Rs.)} \]

\[ X_{12} = \text{Per acre expenditure on pesticides (in Rs.)} \]

\[ X_{13} = \text{Farm size (in acres)} \]

Results of the Regression Equations:

The parameters of the above models are estimated by using the Classical Least squares Method. The results of the models are presented in table 5.4 showing the regression coefficients, 't', values, multiple correlation coefficients (R) and the square of multiple correlation
coefficient ($R^2$). A comparison of (ii) and the relevant zero-order correlation given in the table, 5.3, for the linear models would reveal that there is no multicollinearity of high order.

**Model - A1**

Six explanatory variables are included in this model viz., (i) percentage of area under irrigation ($X_1$), (ii) percentage of area under commercial HYV ($X_5$), (iii) percentage of area under food crops HYV ($X_6$), (iv) Per acre use of chemical fertilizers ($X_{10}$), (v) Per acre expenditure on pesticides ($X_{12}$), and (vi) Farm size ($X_{13}$).

The results show that these variables taken together explain 89.7% of the variation in productivity. The variables percentage of area under irrigation ($X_1$), percentage of area under commercial HYV ($X_5$), per acre use of chemical fertilizers ($X_{10}$) and Farm size ($X_{13}$) significantly affect the dependent variable. The inverse relationship between holding size and productivity has been demonstrated to be true. The relationship between productivity and use of HYV ($X_6$) and per acre expenditure on pesticides ($X_{12}$) is observed to be positive.
In the second model, literate family worker per acre of land ($Z_3$) and per acre expenditure on farm yard manure ($X_{11}$) are tried in place of percentage of area under HYV food ($X_6$) and per acre expenditure on pesticides ($X_{12}$). This model explains 90.37 per cent variation in productivity and *F* statistic is highly significant. The variables - percentage of area under irrigation ($Z_1$), literate family worker per acre of land ($Z_3$), percentage of area under commercial HYV ($X_5$), per acre use of chemical fertilizers ($X_{10}$) and farm size ($X_{13}$) significantly affect farm productivity. The relationship between farm productivity and per acre expenditure on farm yard manure ($X_{11}$) has been observed to be positive and insignificant in this model.

The third model experiments with the inclusion of percentage of area under HYV food ($X_6$) in place of per acre expenditure on farm yard manure ($X_{11}$). This model explains about 90.34 per cent variation in the productivity and the value of *F* statistic is highly significant. Here also percentage of area under irrigation ($Z_1$), literate worker per acre of land ($Z_3$) percentage of area under commercial HYV ($X_5$) per acre use of chemical fertilizers ($X_{10}$) are highly significant at 1 per cent level of significance.
Table - 5.4

Results of Multiple Regression: Dependent Variable
Farm Productivity Per Acre (Y)

<table>
<thead>
<tr>
<th>Model</th>
<th>Independent Variable</th>
<th>Regression Coefficient</th>
<th>'t'</th>
<th>R</th>
<th>R²</th>
<th>'F' Statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
<td>(5)</td>
<td>(6)</td>
<td>(7)</td>
</tr>
<tr>
<td>A1</td>
<td>i) ( x_1 )</td>
<td>13.44*</td>
<td>5.27</td>
<td>0.9471</td>
<td>0.8970</td>
<td>338.66*</td>
</tr>
<tr>
<td></td>
<td>ii) ( x_5 )</td>
<td>31.14*</td>
<td>10.07</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>iii) ( x_6 )</td>
<td>0.79</td>
<td>0.28</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>iv) ( x_{10} )</td>
<td>10.07*</td>
<td>10.68</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>v) ( x_{12} )</td>
<td>0.39</td>
<td>0.45</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>vi) ( x_{13} )</td>
<td>-7.61*</td>
<td>-3.69</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Intercept</td>
<td>56.18</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A2</td>
<td>i) ( x_1 )</td>
<td>13.36*</td>
<td>7.61</td>
<td>0.9506</td>
<td>0.9037</td>
<td>364.41*</td>
</tr>
<tr>
<td></td>
<td>ii) ( x_3 )</td>
<td>823.83*</td>
<td>3.73</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>iii) ( x_5 )</td>
<td>29.03*</td>
<td>11.96</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>iv) ( x_{10} )</td>
<td>9.57*</td>
<td>11.10</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>v) ( x_{11} )</td>
<td>1.14</td>
<td>0.87</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>vi) ( x_{13} )</td>
<td>-4.85***</td>
<td>-2.16</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Intercept</td>
<td>25.41</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### A3

1. $X_1$ 12.81* 5.18 0.9504 0.9034 363.25*
2. $X_3$ 857.99* 3.94
3. $X_5$ 29.15* 11.03
4. $X_6$ 0.81 0.30
5. $X_{10}$ 9.80* 12.02
6. $X_{13}$ -5.25** -2.39
7. Intercept 65147

### A4

1. $X_1$ 13.09* 5.31 0.9521 0.9064 222.13*
2. $X_3$ 30.63 0.08
3. $X_4$ 1379.59* 2.59
4. $X_5$ 27.84* 8.88
5. $X_6$ 0.29 0.11
6. $X_8$ -148.45 -0.53
7. $X_{10}$ 9.32* 9.80
8. $X_{11}$ 0.26 0.28
9. $X_{12}$ 0.18 0.21
10. $X_{13}$ -5.19*** -2.24
11. Intercept 137.11

* Significant at 0.5 per cent level
** Significant at 1 per cent level
*** Significant at 5 per cent level.
The relation between productivity and farm size \((X_{13})\) is observed to be negative and significant at 5 per cent level of significance. However, the relation between productivity and percentage of area under food HYV \((X_6)\) is observed to be positive but turned out to be insignificant.

_Model - A4_

In this model educated worker per acre of land \((X_4)\) and number of bullocks per acre \((X_8)\) have been tried along with the variables already included in the previous models \((A1\) to \(A3)\) to know the joint effect of the relevant explanatory variables. This model explains 90.65 per cent of the variation in the productivity and the joint effect of the explanatory variables included in the model is highly significant as shown by the value of the 'F' statistic. As many as five variables, viz., percentage of area under irrigation \((X_1)\), educated family worker per acre of land \((X_4)\) percentage of area under commercial HYV \((X_5)\), per acre use of chemical fertilizers \((X_{10})\), and farm size \((X_{13})\) significantly influence the farm productivity. The percentage of area under irrigation \((X_1)\), percentage of area under commercial HYV \((X_5)\) and per acre use of chemical fertilizers \((X_{10})\) have a positive effect and coefficients of these variables are highly significant at 1 per cent level of significance. The coefficient of the variable - the percentage of area under HYV food \((X_6)\) is observed to be positive but however it is not significant. The inverse relationship between farm size \((X_{13})\) and productivity is observed again in this model as expected. The
coefficient of this variable is negative and significant at 5 per cent level of significance. The number of literate family worker per acre of land \((X_3)\), number of bullocks per acre \((X_8)\), per acre expenditure on farm yard manure \((X_{11})\) and per acre expenditure on pesticides \((X_{12})\) turned out to be insignificant in explaining the variation in productivity.

From the analysis of the above four models, it is clear that the percentage of area under irrigation, the educated family worker per acre, percentage of area under HYV seeds, per acre use of chemical fertilizers and farm size are found to be significantly influencing the productivity and explain more than 90 per cent variation in productivity. These variables are observed to be the major determinants of the productivity of the sample farm families. Therefore, by providing more irrigation facilities, chemical fertilizers and HYV seeds to the farmers, the farm productivity can be increased. However, farm families face a number of difficulties in getting and using these strategic inputs. By providing these facilities, the difficulties of the farmers can be solved. Therefore, it is worth investigating the nature and dimension of the various problems involved in getting and using these strategic inputs at the micro level. In the present study an attempt is made to analyse the nature and dimensions of the various problems involved in getting and using the major determinants of productivity, viz., (i) Irrigation, (ii) HYV seeds and (iii) Chemical fertilizers. In this respect, an in depth analysis is carried out in the chapters 6, 7, and 8.