CHAPTER I

INTRODUCTION

The growing demand for food and other agricultural products as a consequence of increasing population, rising incomes and changes in food habits, has led governments in moet developing countries to attempt to accelerate agricultural production through economic planning. Effective planning presupposes a serious consideration of the economic potential, resources and constraints of the area in order to determine the options which will promote agricultural development. The appropriate form of intervention or government strategy will depend on these available options.

If we accept that the goal of planning in agriculture is to attain increased production, three major types of strategy would lead to this result - increased input use, diffusion of known but only partially adopted techniques or introduction of new technology. The choice between these options will depend on the existing characteristics of agricultural production.

The simplest situation is where agricultural production is low, while at the same time available inputs are being underutilized; in this case, production can be increased merely by increasing input-use. The most common instance of this is extension of the area under cultivation; where additional land is available, bringing some of it under cultivation can increase agricultural output. Or, if land is scarce, then production from it can be increased by enhancing its quality through more irrigation, chemical fertilizers, pesticides and other inputs. Thus again increased production may result merely from increased input-use, even where one or more inputs are in fixed supply.

However, most densely populated countries of Asia are confronted with a short supply of the essential input, land, so that extension of the land frontier is no longer feasible. In this situation, intensive cultivation of land becomes necessary. Such intensive cultivation may be facilitated within current knowledge by increased use of inputs. When production can no longer be increased through increasing input-use, it may be stimulated through use of better techniques by the farmers or the community. Thus agricultural production may be increased by ensuring diffusion of techniques used in areas of high productivity or by 'progressive' farmers to 'less progressive' ones. This requires identification of areas of high productivity and/or of 'progressive' farmers in these areas. In this case, therefore, intervention includes two aspects: extending the area of better techniques and improving good techniques to better ones. Both these aspects are effected through diffusion.

Once the process of diffusion has been completed, any further increase in production must necessarily be induced from outside the framework of the existing knowledge available to the farmers. It is in this context that technological change assumes increased emphasis as an agent of growth.

The concept of technological change can be given a broader definition to include the process of diffusion, if we distinguish between endogenous and exogenous technological change. Technological change can be termed 'endogenous' if it involves the adoption of hitherto unused but known techniques and inputs. This conforms to the standard definition of technological change as it produces more output from given inputs. Thus in areas, where cultivation is purely on traditional lines, some type of seed selection or improvement in known techniques of cultivation can increase agricultural output. Such change can be brought about from within the existing field of knowledge through the process of trial-and-error. However, from the view-point of the farmers it involves use of 'different' techniques from those already in use.

On the other hand, if improved seed and techniques of cultivation are already in widespread use, further increases in output require a technological breakthrough or the introduction of new inputs like hybrid seed. This type of technological change can be termed 'exogenous', as it originates from outside the existing framework of knowledge.

We can view Indian agricultural development in this framework of endogenous and exogenous technological change. Up to the eighteenth century, increases in agricultural production were largely brought about by extending the land frontier. Once this frontier had reached its limits, pressure of population necessitated intensive cultivation of land. This intensive cultivation coupled with the progressive adoption of better techniques was an endogenous form of technological change through the process of diffusion. Thus, within the framework of traditional agriculture, increased production was achieved through adoption of improved techniques, by the process of trial-and-error. During this phase, research and experimentation centred on improving local strains and concentration on improved local varieties for increased production.

However, since land is a major constraint, after a limit, no further increases in production could be attained under traditional technology. The continuing pressure of population required a technological breakthrough to initiate and sustain any further increase. This breakthrough was inaugurated with the introduction of the Green Revolution.

We will view the breakthrough in Indian agriculture initiated with the Green Revolution as an exogenous change - a movement to new inputs and techniques outside the framework of traditional agriculture. The Green Revolution technology depends on the genetically tailored hybrid seeds accompanied by an intensive use of agricultural inputs (water, fertilizers, pesticides, research and extension services). The modern technology not only heralded the introduction of hybrid seed, but also emphasized the importance of using the appropriate 'package' of inputs and techniques. Recognizing land as a scarce input, the new technology facilitates multiple cropping through the use of modern inputs particularly the early-maturing, short-duration hybrids. It is a major departure from the traditional technology inasmuch as it relies heavily on new inputs developed by modern technology - hybrid seed, chemical fertilizers and pesticides, and is, in this sense, 'exogenous' change.

While distinction between endogenous and exogenous technological change provides a useful framework for considering agricultural development, distinction between the two phases is not clear-cut. Within the endogenous phase, farmers not only adopt known techniques but also adapt them to immediate circumstances. This on-going process of adoption and improvement means that even in the endogenous phase, technology is not static. Moreover, although the Green Revolution can be termed exogenous technological change, once its diffusion gains momentum it too takes on an endogenous aspect. We will see how in recent years, the Green Revolution has already entered on this endogenous phase through the continual movement from early hybrids to later ones.

In the same way, while we may consider the Green Revolution as a technological breakthrough, it is not a complete break with the past. The peasants in India have had a long tradition of seed selection, intensive use of water and manures, careful weeding and other associated practices. Some farmers were also familiar with research stations which date from 1786.* These research stations were experimenting on improved varieties of seed and animal breeds as far back as 1799 (Royle, 1840, p.90). Many of these improvements in traditional practice or technology came into use largely as a result of the laborious, time-consuming process of trial-and-error. Extension services in India were widely established even during the early nineteenth century, bringing the fruits of research to the farmers. In this sense, the Green Revolution technology was merely an extension and intensification of practices with which the farmers were already familiar.

It is for this reason that one would expect a reasonably high level of response from farmers to new developments. After all, many peasants, in India as well as in many other developing countries, took to cultivation of new crops (sugar, tea, coffee, indigo, cotton and groundnut) in the nineteenth century. This was in response to the markets being opened up, because of the steam revolution in transport (railways and steamships). In many cases, these crops were taken up without much promotional effort by the government.

Now that considerable experience and know-how in scientific and technological research has been accumulated, the process of 'learning by trial-and-error' can be either

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* The history of experimental work in India is said to have begun with the establishment of the Botanic Gardens in Calcutta in 1786, though systematic research on Indian vegetation dates as early as 1769 (Sinha, 1973, p.16).

altogether avoided or at least, the period over which such a process goes on can be significantly reduced by proper guidance and advice from experimental stations and the extension services. The importance of diffusion strategies therefore, becomes evident, while population pressure now makes change more urgent.

Yet, before the process of 'learning by trial-and-error' can be eliminated or reduced, a lot more information on the nature and pace of adoption is necessary. For instance, one has to know how quickly the farmers adopt a new technology. One has to answer questions such as: Are non-adopters really 'conservative' or do they suffer from serious constraints which force them to adhere to the 'traditional' technology? If this is so, what can be done to eliminate these constraints? Further, for those who readily adopt the modern technology, is it an individually rational, maximizing decision or do they adopt just because others have adopted? Do these adopters optimize input use? These are some of the issues we will consider as we examine technological change in the development experience of Tamil Nadu.*

Our choice of Tamil Nadu is guided by the fact that this region of India is a large producer of rice. It is also one of the few net rice-exporting States in India. Our analysis of the data centres on the impact of technological change in a developmental perspective on rice productivity and productive efficiency of farmers in the area.

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* Tamil Country - formerly known as Madras State.

FIGURE I

THE REPUBLIC OF INDIA

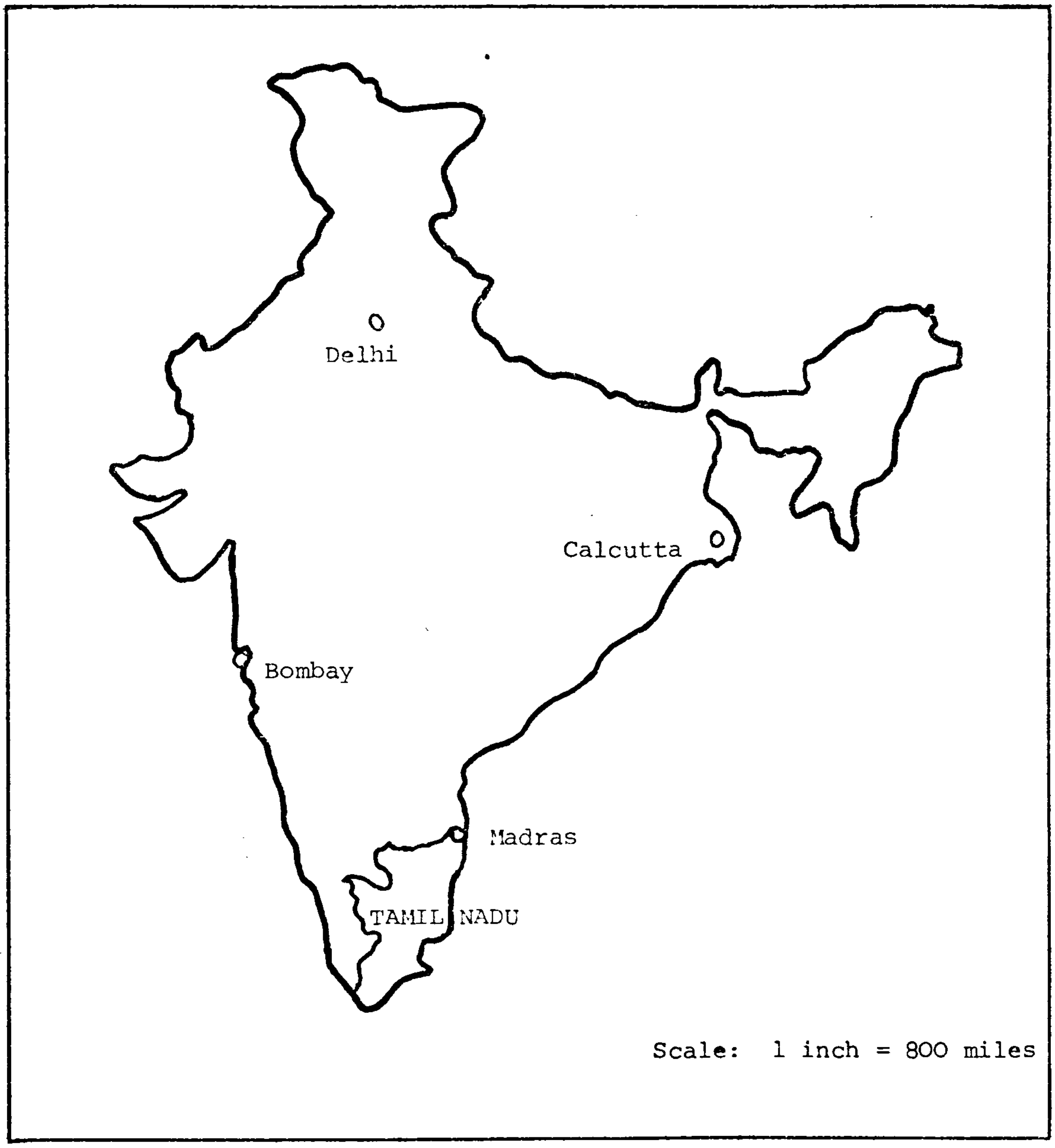
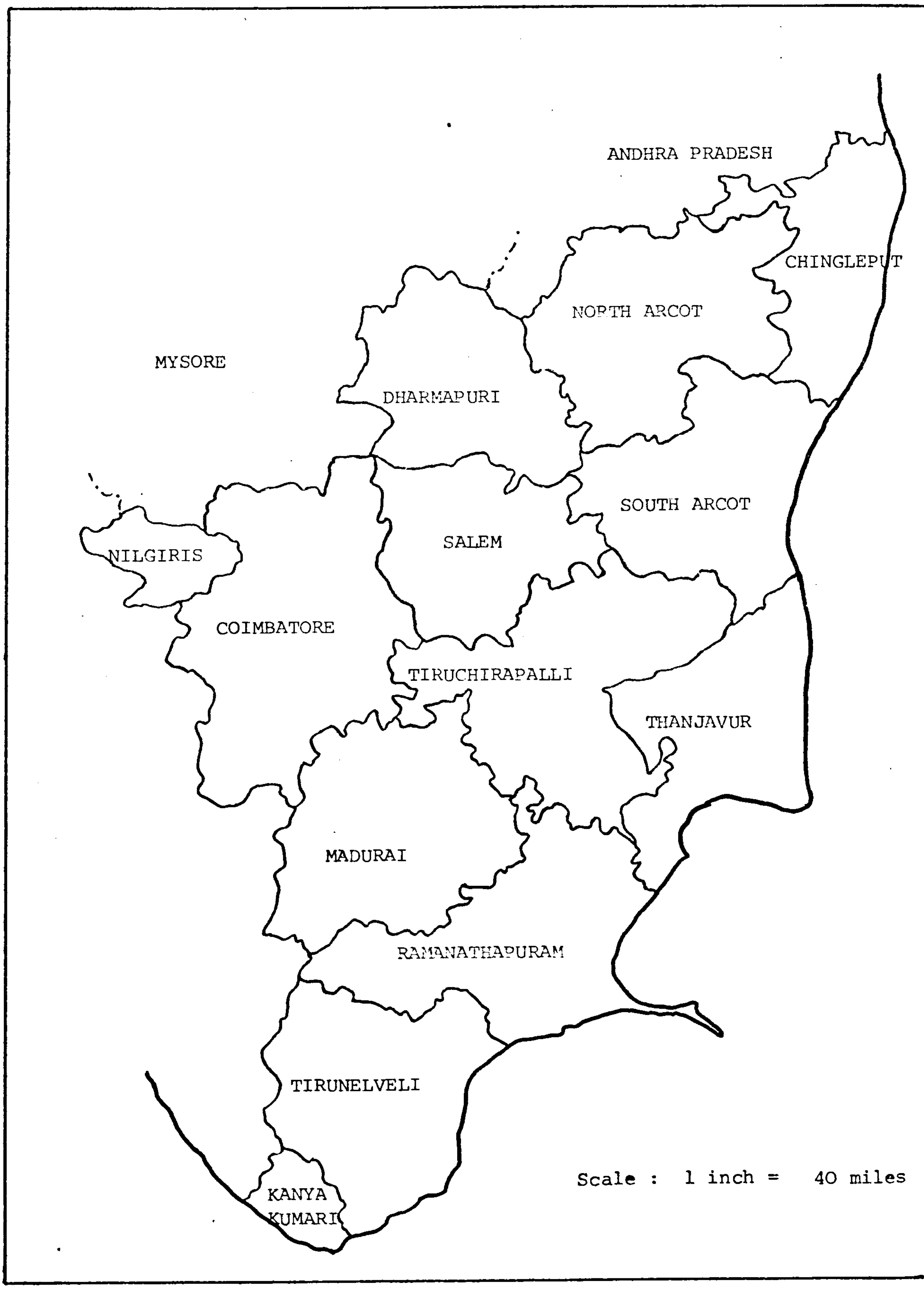


FIGURE II

THE STATE OF TAMIL NADU



The results of the analysis may have important policy implications for the future of rice strategy in the region.

One of the major objects of the exercise is to emphasize the importance of area-specificity in any consideration of technological change and particularly in relation to agriculture. Varying climatic, soil and crop conditions cause difficulty in assessing the response to modern technology. Moreover, different genetic varieties are suitable to different areas and it becomes difficult to establish their genuine technological relationships on aggregate data.

In view of the specificity of technological knowledge, we aim to concentrate our analysis to a single crop - rice, grown on a homogenous canal-irrigated tract in two districts of Tamil Nadu - Coimbatore and Thanjavur. These two districts were purposely selected because Coimbatore has been associated with progressive traditional agriculture, while Thanjavur has been associated with progressive modern agriculture. Thanjavur is one of the first districts selected by the Government for the implementation of the Intensive Agriculture District Programme (IADP). Regular farm records maintained at the IADP Office at Thanjavur provide the required disaggregated farm data for Thanjavur. In Coimbatore, the absence of such records led us to collect our data by personal interview with a sample of farmers.

We also examine the appropriateness of the existing methodological tools for the analysis and measurement of technological change. Attempts to quantify and measure technological change over time reveal the inadequacy of the currently practised methods of economic analysis to conceptualize and include the whole range of factors which constitute this phenomenon.

In dealing with historical data on traditional agriculture, such methodological problems are accentuated. Quality of inputs change over time; this makes it difficult to isolate the impact of technological change to economic growth. We will first place traditional agriculture in its historical perspective and examine it in terms of inter-country comparisons of productivity in the nineteenth century. Our analysis will be conducted on district-level data in order to minimize the effects of climatic changes which tend to bias national or regional analyses. At a lower level of aggregation, these results should be more meaningful.

However, as technological change is a continuous process, its impact is best seen in the long run. Using time-series data on average yields of rice, we will examine whether productivity has been increasing, decreasing or static over time. The effect of developmental factors like planning and irrigation on the growth rates and stability of rice production will be analyzed.

Yet, even at the district-level, the response of farmers to technological change are influenced by several socio-economic factors. These factors will be isolated through factor analysis on our survey data. These determining factors indicate the various socio-economic constraints hampering increased production. Elimination of these constraints could therefore be an effective government strategy.

We define progressive farmers on the basis of their adoption of the recommended 'package' of inputs and practices. However, adoption of the package need not necessarily imply that 'progressive' farmers obtain higher returns to input use. We therefore test whether farmers who adhere to the recommended package of the Agricultural Department are in fact, obtaining higher returns to input use than our so-called 'less progressive' farmers. We also examine the area-specificity of different genetic rice hybrids using production function analysis on data collected in the two districts - Coimbatore and Thanjavur. Thus response to technological change will be measured in terms of returns to input use.

Finally, we use linear programming techniques to examine the potential for further increasing productivity, through changes in crop pattern and input use. We test whether our 'less progressive' farmers could improve their production by altering the input-mix, or whether they are optimizing returns given their resource constraints.

The plan of the study is as follows :

Chapter II describes the historical development of the concept of technological change and the various attempts to measure the rate of technological change in industry. The difficulties of measuring technological change in agriculture using these techniques will be examined. Consequently, within this theoretical framework, the process of technological change in agriculture will be viewed in its endogenous and exogenous dimensions. Both these aspects are implicit in earlier literature, though they are unrelated to empirical analysis. We find that most of the theoretical models for measuring technological change in agriculture, tend to ignore the evolutionary and endogenous nature of the phenomenon.

Any consideration of change would however be lacking in foundation without at least a brief historical view of the past. In Chapter III, therefore, we develop a framework for evolutionary and endogenous technological change which is particularly relevant in the Indian agricultural experience, where the foundation of agricultural technology is firmly rooted in tradition and past experience. The state of traditional agriculture in Tamil Nadu is examined in its qualitative and quantitative dimensions in relation to other countries. Access to late nineteenth century data on China and Japan, the two leading rice producing countries in Asia, enables us to put traditional agriculture in Tamil Nadu in an international perspective. The historical data has been obtained from agricultural records held at India Office (London) and Tamil Nadu Archives (Madras). Much of this data is in the form of impressionistic evidence and hence does not permit any formal statistical testing, but we explore the hypothesis that traditional agriculture in Tamil Nadu was already at a relatively high level in the nineteenth century. We are fully aware that such inter-country comparisons do not produce definitive answers, partly because of the limitations of historical data, but they do serve as broad indicators of the level of agricultural technology in the nineteenth century.

Chapter IV deals with the contribution over time of several forms of agricultural change - extension of area, irrigation and the introduction of modern technology. Much of this analysis is carried out an an inter-district level to emphasize variations in productivity at a lower level of aggregation. Using data on average yields of rice collected from the Season and Crop Reports for Tamil Nadu, we examine the impact of technological change and particularly the Green Revolution, on growth rates and stability of rice production in the region. We also examine the hypothesis that districts of high productivity under traditional technology maintain a 'leading role' in the long period.

Having selected 'progressive districts' on the basis of the analysis in the earlier chapters, factors promoting technological progress will be identified and evaluated in Chapter V. This analysis will be conducted on the basis of farm-level data pertaining to the agricultural year 1973-74, collected by us in personal interviews with 180 farmers in Coimbatore. The important socio-economic variables governing farmers' response to technological change will be elicited through factor analysis. It is felt that such factors can be extremely relevant in evolving a diffusion strategy.

In Chapter VI, we examine the response of farmers to modern technology in terms of returns to input use, using production function analysis, with a view to test whether there have been significant shifts in such functions for the different areas under investigation. Such a shift is most effectively measured at the lowest level of aggregation, to bring out the genuine technological relationships between inputs and outputs. Recognizing the specificity of input-output relationships for different areas and for different strains, we test the level of technology for genetic rice strains separately, using the Cobb-Douglas production function.

The relative profitability and productive efficiency of the different strains in Coimbatore will be explored vis-a-vis similar strains in a corresponding homogenous 'progressive' district, Thanjavur, in order to test the area-specificity of different rice strains. The level of technology for each strain as well as the more optimal varieties for the region will be identified. Concentration on the more optimal varieties in the area can be a positive step towards increasing rice production. We also compare levels of technology, resource use and allocative efficiency of our progressive and 'less-progressive' farmers using production function analysis.

However, this analysis does not test for optimality under the current constaints. In Chapter VII therefore, we examine the potential for increasing output under the new strategy using linear programming techniques. The simulated programme will explore the possibility of optimising output by changing the crop pattern subject to the resource constaints faced by the farmer, and enable us to determine whether or not 'less-progressive' farmers are optimising returns under their resource constraints. Thus policy strategies aimed at optimising resources by altering the input-mix through changes in crop pattern and choice of the more optimal varieties can have a positive effect in increasing productivity, as also in isolating and, later, eliminating the constraints which affect farmers' response to modern technology.

We conclude with a brief discussion of the policy implications which arise from the analysis.