CHAPTER I
INTRODUCTION

Agriculture is the backbone of Indian economy. From time immemorial to the 21st century, India has come a long way in the agriculture sector. Indian agriculture sector has performed impressively in terms of increasing productivity and intensity of cultivation. It is by no means a small achievement that the percapita food grains availability at country level has increased to a high level over the last four and a half decades in the face of an assault of population pressure and declining percapita land availability (Singh and Ranjan, 1998). While reviewing India’s agricultural performance since independence, Vaidhyanathan (1994) cautioned that urgent attention should be paid to technological innovations and to removing non-price and institutional constraints, which do not permit the full exploitation of the chosen technology at the farm level. In the course discussion of what agricultural reform measures should be included in the new economic policy, Ahluwalia (1996) identified technology as one of the most important issues. Though technology played a crucial role in alleviating India’s poverty trap, its contribution to agricultural growth has not been impressive. International comparisons revealed a wide gulf in India’s performance between achievements in output and productivity (Kalirajan and Shand 1997). While India compares favourably in terms of total output, it compares poorly in terms of yield per hectare.

The possibility of India being a substantial exporter of agricultural commodities is very high if India globalizes its agriculture. However, if this dynamic future for Indian agriculture is to be achieved, a number of critical requirements must be met. The first and the most important is to secure and sustain high production growth rates. This calls for continuous improvement in productivity. Agricultural productivity of a production unit,
defined as the ratio of its output to its input, varies due to differences in production technology and differences in the efficiency of production process. Efficiency of a production unit may be defined as how effectively it uses variable resources for the purpose of profit maximization, given the best production technology available. The concept of efficiency is further divided into two components technical efficiency and allocative efficiency. Traditionally, researchers have concentrated on the study of allocative efficiency based on the assumption that entrepreneurs operate on technical production function with full technical efficiency. However, in recent literature it is seen that the above assumption is weak and several farmers do not realize the full potential of technology due to several factors such as their managerial skills and differences in production environment. Therefore, there is a need to separate the role played by the environment from the role played by an individual in contributing to production efficiency. This draws attention to the emphasis placed in the recent studies on the concept of technical efficiency.

1.1 Technical Efficiency: Concept

In order to understand how the technology and the technical and allocative efficiencies influence the performance of farms, it is convenient to distinguish three sets of determinants that are responsible for the differences in the performance among the farms. They are,

i. factors related to the farm’s ability to choose input quantities that maximize profit;

ii. factors associated with the method of application of the chosen inputs and

iii. the socio-economic and natural environmental conditions of the production process which are not under the control of the units.
Therefore, three systems of analytical relations constitute the theoretical base: *viz.*,

i. the production function representing technology and its shift over time;

ii. the influence of method of application of specific technical relationship between inputs and output and

iii. the demand equations explaining the levels of inputs used in the production process

Thus, the important tasks in the performance analysis are to model the production technology, differentiating technological change or technical progress from technical efficiency and to model allocative decision-making process, incorporating the production technology. However, the process of modelling is not simple.

### 1.2 Complex Situation

Several problems are encountered in modelling the decision process of production in farms. First, the goal in farm production is not known unambiguously. Though, maximization of aggregate farm profit is generally assumed to be the goal of an entrepreneur, the farmers do not see farming strictly as a business. Even when a simple profit maximizing goal is assumed, it refers to the aggregate profit of the farm which has in general, more than one crop and other productive activities. While technology is enterprise specific, technical efficiency must be studied enterprisewise. It conflicts with the objective of aggregate farm profit and involves the choice of optimal mix. Only after deciding optimal mix of the activities, the attention has to be paid to the technical efficiency of each farm. There are other problems too: specification of appropriate production function, differences in managerial skill of the farmers, their knowledge and their conviction about technological options available to them, resources, constraints, the scale of operation and external factors beyond
the control of the farmers such as drought, floods, attacks of pests, uncertainties in product and factor markets. Apart from this, there are problems in empirical verification of the model arising from autocorrelation, multicollinearity, choice of functional farm and estimation methods. Presence of stochastic disturbance is another problem to be handled in the analysis.

Farming in India is full of risk and uncertainty. The main sources of risk and uncertainty prevailing in crop production are output, and yield instability. The main causes of yield instability are due to fluctuations in biotic and abiotic factors. In such conditions, producers do not only aim to maximize income but also to reduce the risk. Various mathematical models have been formulated to help producers in decision-making taking into account risk and uncertainty.

1.3 Role of Mathematics

Preparing to accommodate quantitative methods of study, any field requires a mathematical model. To develop a model, a real phenomenon is inevitably simplified into a scheme, which then is described invoking a suitable mathematical technique. A mathematical model should involve all the important facets of the phenomenon being studied and all the critical factors on which the success of the operation mainly hinges. In the simplest situations, algebraic equations can suffice. If they are more involved, say, calling for a phenomenon to be considered in its dynamics, then differential equations technique is implemented. In most intricate cases, when both running an operation and its outcome depend on a large number of intimately interrelated random factors, the analytical techniques fail altogether and the analyst has to employ methods of statistical modelling. Various models like the econometric single equation models, simultaneous system of equations, the methods of versatile ordinary least squares, generalized least squares and several variations
in them to take care of computational difficulties find wide applications in agriculture. The Operations Research method helps in decision making with multiple activities, constraints and single or multiple goals in normative analysis. The exercise is begun with the modelling of physical situations and organizational goal(s), in algebraic equations, inequalities and identities and then appropriate tools of analysis are applied to draw specific inferences. The technique must ensure both accuracy and stability. Accuracy is achieved by investigating the limits of the algebraic system. Stability is a property of the algebraic system within which perturbations may tend to either decay or blow up. Perturbations are always present in a computing system. A tendency to generate error may lurk in the physical system itself or computer simulations may themselves introduce perturbations. Techniques that are more sophisticated can however, reduce the error in the results. The efforts for sophistication are never ending, but at a point of time search for a model with maximum possible sophistication is the answer to the problems of ensuring accuracy and stability in the results. It is in this context, the present study is undertaken to measure technical efficiency in farm production with appropriate mathematical models.

1.4 Problem Focus

In the literature, majority of studies examining production performance of farms generally model the production technology using production function. Then technical progress is measured by estimating the intercept terms in the production functions. The implicit assumption in such studies is that farms operate with full technical efficiency. This is a restrictive assumption and is a major limitation for production analysis. Further, given this production function, the allocative decision-making analysis is carried out. Therefore, allocative decision-making analysis also suffers from the limitation. The importance of
differentiating technical progress from technical efficiency in production function analysis was first highlighted by Farrell (1957), who introduced the concept of frontier production function representing production technology with full technical efficiency (TE).

Many agricultural scientists and farm experts have endorsed the view that the performance of agriculture is yet to reach its potential level. Available evidences in the last few years revealed that technological package via its efficient utilization may accelerate the pace of agricultural development in India and so in raising the living standards of the rural population (Battese, 1991 and Jai Singh et al., 2002). However, there are large variations in input practices and output levels among farms in different regions within the country. Therefore, an analysis at the farm level is desirable to have a clear understanding of the existence of the gap between actual output and potential output of agricultural crops in different regions as well as within the same region of the country (Debnarayan and Sudpita, 2004; Mythili and Shanmugam, 2000). Farmers in the developing countries fail to exploit full potential of a technology and make allocative errors (Taylor and Shon, 1986; Ali and Flinn, 1989; Kalirajan and Shand, 1989; Bravo-Ureta and Evenson, 1994; Banik, 1994; Shanmugam and Palanisamy, 1994; Sharma and Datta, 1997; Battese, 1992; Battese and Coelli, 1992).

Movement towards a more dynamic and more competitive environment for the farmers of the country implies that efficiency will become an increasingly important determinant of success of business at the farm level and of economic viability at the sector level. Increasing the efficiency in production is one of the means through which output may be increased. It is a very important factor of productive growth, especially in developing agricultural economies where resources are meagre and opportunities for developing and
adapting better technologies are less. Under these circumstances, reducing the inefficiency is the best option to enhance productivity. An estimate on the extent of inefficiency can also help to decide whether to improve efficiency or to develop new technology to raise agricultural production (Reddy and Sen, 2004)

1.5 Need of the Study

In the context of Tamil Nadu agriculture, a few empirical studies emerged to estimate the technical efficiency of agricultural production at the farm level. Almost all these estimated the efficiency of rice, maize, cotton, and sugarcane farms in different seasons (Kalirajan, 1981; Kalirajan and Obwona, 1994; Mythili and Shanmugam, 2000; Shanmugam and Palanisamy, 1994; Tadese and Krishnamoorthy, 1997 and Shanmugam, 2003). No attempt has been made to measure the efficiency of the crop like turmeric that fetches foreign currency in terms of exports. Moreover, turmeric is one of the oldest spices and had been used in India since ages. The world production of turmeric stands at around 8,00,000 tonnes in which India holds a share of 75-80 percent approximately. India also holds the top position in the list of world's leading exporters.

While global trade in turmeric has been increasing, low productivity and stagnation therein is a cause of concern and may have adverse effect on Indian export products. This calls for improving productivity of turmeric farming not only to improve exports but also the welfare of the producers. Improvements in productivity come from adoption of new technologies and increase in the production efficiency. Inter-state comparisons revealed that Tamil Nadu ranked first in terms of turmeric production but not in terms of productivity. Therefore, the present study has been formulated to measure farm-specific technical efficiency of turmeric crop in the northwestern region of Tamil Nadu.
1.6 Objectives

Though, the overall objective of the study is to measure technical efficiency in crop production using various mathematical models, specific objectives of the study are:

- To assess the suitable functional form of production frontier and to model the structure of production in the farms.
- To assess the effect of half-normal, truncated normal and exponential distributions on the estimation of stochastic frontier models and compare estimation results for technical efficiency.
- To measure technical efficiency in turmeric production in northwestern region of Tamil Nadu using six different specifications of frontier models and Data Envelopment Analysis.
- To compare the results of the Stochastic Frontier Models and Data Envelopment Analysis.
- To suggest policies for maximizing technical efficiency in turmeric production.

1.7 Hypotheses

The following hypotheses are proposed to test the above mentioned objectives.

i. Different farmers employed different quantities of inputs resulting in different levels of output

ii. Different mathematical forms of the production function cannot produce different results

iii. There exist differences in the level of economic efficiency achieved by different economic units.
1.8 Scope of the Study

This study is primarily meant to demonstrate the application of Mathematics to the complex real world conditions of crop production. Particularly it takes care of stochastic disturbances and one-sided error arising from technical inefficiency (TI). The measure of technical efficiency is useful to evaluate the difference between technological progress that sets the production potential and the extent of technology adoption that sets the yield subject to environmental conditions. Therefore, it must be possible to rank the farmers by the level of their technical efficiency. With the measure of technical efficiency, it is possible to measure allocative efficiency. Then the economic efficiency in crop production is measured as a product of TE and AE and farms are ranked. This ranking will show the distribution of farms among different efficiency classes, drawing the attention of agricultural research scientists and policy makers to the less efficiency classes of farms. Further, with a well-defined measure of TE and AE, the factors affecting them can be identified.

1.9 Limitations

In spite of its elaborate methodology, the study has a few limitations, which are listed here:

i. The specification models involve several assumptions about stochastic disturbances, functional form and imposition of a certain specific assumptions on distributions of farm-specific technical efficiency related variables.

ii. Frontier functions assume that all inputs have been taken into consideration. However, in this study as well as others, it is possible to raise questions about whether all inputs have actually been accounted for, since farms that are apparently inefficient may just use less of certain unmeasured inputs.
iii. The addition of an extra input or output in Data Envelopment Analysis does not show any variation in the technical efficiency scores.

iv. Standard Data Envelopment Analysis considers neither multiperiod optimization nor risk in management decision-making.

v. In Data Envelopment Analysis, efficiency measures in small samples are insensitive to the difference between the number of farms and the sum of inputs and outputs. Due to this limitation, many farms may seem to be efficient even though they are not.

1.10 Organisation of the Study

The present study is organised into five chapters viz.,

CHAPTER I- INTRODUCTION

This chapter presents the problem focus, objectives, hypotheses, scope and limitations of the study.

CHAPTER II- CONCEPTS AND REVIEW

Important concepts used in this study are defined. A review of past studies related to the focus of this study is presented to draw specific guidelines.

CHAPTER III- METHODOLOGY

This chapter is devoted to the analytical foundation of efficiency measurement, which has been elaborately dealt with under thirteen sections as mentioned below.

Section 3.1: Choice of the Study Area
Section 3.2: Choice of the Crop
Section 3.3: Period of Study
Section 3.4: Method of Sampling
Section 3.5: Collection of Data
Section 3.6: Analysis of Data
Section 3.7: Production Function
Section 3.8: Frontier Production Function
Section 3.9: Techniques of Efficiency Measurement
Section 3.10: Stochastic Frontier Production Function
Section 3.11: Non-parametric Mathematical Programming Method
Section 3.12: Models used in the Present Study
Section 3.13: Statistical Analysis

CHAPTER IV- RESULTS AND DISCUSSION

The results of analyses are presented and discussed to draw inferences. Summary statistics of the variables used in the study, effects of assumptions on various distributions on the estimated values of technical efficiency are discussed and compared. Results of Data Envelopment Analysis are presented and is compared with that of Stochastic Frontier Analysis.

CHAPTER V- SUMMARY, CONCLUSIONS AND IMPLICATIONS

Based on the results and discussion, Chapter V winds up this study drawing conclusions and policy implications. Suggestions for future research based on the findings are recommended.