

**ECONOMIC ANALYSIS OF SORGHUM PRODUCTION
IN NORTH KARNATAKA**

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**ECONOMIC ANALYSIS OF SORGHUM PRODUCTION
IN NORTH KARNATAKA**

*Thesis submitted to the
University of Agricultural Sciences, Dharwad
in partial fulfilment of the requirement for the*

Degree of

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in

AGRICULTURAL ECONOMICS

By

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CERTIFICATE

*This is to certify that the thesis entitled "ECONOMIC ANALYSIS OF SORGHUM PRODUCTION IN NORTH KARNATAKA" submitted by Mr. MENTESNOT LEGESSE, for the degree of **MASTER OF SCIENCE (AGRICULTURE) in AGRICULTURAL ECONOMICS** to the University of Agricultural Sciences, Dharwad, is a record of research work carried out by him during the period of his study in this university, under my guidance and supervision and the thesis has not previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar titles.*

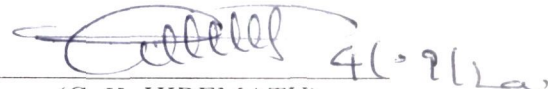
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(Mentesnot Legesse)

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Introduction

I. INTRODUCTION

The importance of agriculture sector for initiating and sustaining economic growth in developing countries is a long recognized fact. Agriculture contributes to economic development in the following areas: (a) supplying food to non-agricultural labour force and agricultural raw materials to industry; (b) providing surplus labour to industry and other sectors of the economy; (c) providing savings and capital resources for the development of industry and other economic sectors; (d) earning foreign exchange needed for industrialization, infrastructural and other investment projects; and (e) providing market and demand for goods and services produced by non-agricultural sectors. Kuznets (1965) argues that a rise in productivity in agriculture is a pre-condition for economic growth and structural change since only then can agriculture generate a surplus and be in a position to fulfil its developmental tasks. It appears that the growth of agriculture, particularly the nature of technological change in the sector is of crucial importance for overall growth as well as the pattern of structural change and intersectoral resource flows.

In developing countries with limited cultivable land, growing population pressure and diminishing returns in agriculture, exploring the possibilities for achieving significant land-augmenting technical progress offered by the 'Green Revolution' technology is of utmost importance. This no doubt requires and increasing inflow of resources into agriculture in the form of new biochemical inputs, investment on irrigation, land and

infrastructure, etc. Whether the final outcome is a net inflow to or outflow from agriculture depends on the efficiency of resource use and genuine technological progress in the sector (Karshenas, 1993).

Indian agriculture witnessed a technological innovation in the mid-sixties which is termed as 'Green Revolution'. The discovery of high yielding varieties (HYVs), the package of practices for realizing their potential, the mechanization of agriculture involving the development of machinery system for irrigation, tillage, harvesting, thrashing etc., are regarded as technological innovations in agriculture. The divisible nature of the new seed-fertilizer technology allows the benefits of technological progress to be spread amongst the small peasant holdings which constitute the core of the agriculture sector of developing countries.

The introduction of high yielding cereal varieties under the High-Yielding Varieties Programme launched during 1966-67 in the country ushered new hopes and dimensions in agriculture (Kiresur *et al.*, 1999). Under this programme, the fertilizer-responsive, photoperiod-insensitive and short duration high-yielding varieties (HYVs) of rice, wheat, sorghum maize and pearl millet were released.

The role of new agricultural technology in the Indian agriculture has been analysed by a number of economists. Narain (1982) observed that relative prices were the effective determinants of the share of non-food grain crops and technological factors (high-yielding seeds and irrigation) have been found to loom large in conditioning the relative share

of food grain crops. Dantwala (1978) found that HYV technology brought about significant improvement in the productivity of cereal crops, but its overall effect on food grain production, especially in per capita terms was not significant.

Food grain production in India has almost reached a plateau with the annual growth rate falling to 1.72 per cent during late 1990s which is almost equal to the annual growth rate of population (Anon., 1999). Total food grain harvest stood at 199.44 million tonnes during 1996-97. As per estimates available in February 1999, the total production of food grains in India during 1997-98 was 192.43 million tonnes comprising of 31.16 million tonnes of coarse cereals (as against 34.1 million tonnes during 1996-97). The record of food grain production achieved during 1999-2000 was 203.75 million tonnes. The production of coarse grains has been almost stagnant as their cultivation is not remunerative being grown mainly on marginal lands under rainfed condition resulting in low yields.

Sorghum scenario

i) World

Sorghum (*Sorghum vulgare*) is the world's fourth most important cereal in terms of both production and area (61 million tonnes and 45 million hectares in 1997). Roughly 90 per cent of the world's sorghum area lies in the developing countries, mainly in Africa and Asia. The crop constitutes one of the main staple food for the world's poorest and most

food insecure people and is genetically suited to hot and dry agro-ecologies subject to low rainfall and drought. There are sharp contrasts in productivity of the crop among regions of the world which ranges from 0.83 t/ha in Africa to 4.36 t/ha in north America mainly due to differences in the degree of commercialization and corresponding adoption of new technologies.

ii) India

In India, sorghum ranks third in area and production after rice and wheat covering an area of about 11 million hectares (1997) which accounts for 24.4 per cent of the world sorghum area. However, the per hectare yield of sorghum in India was 958 kilograms which is the lowest amongst the top sorghum producers in the world. The world average yield of sorghum stood at 1400 kilograms (1997).

Sorghum is grown in both the *kharif* (rainy season) and *rabi* (post rainy season). However, the share of *kharif* is higher in terms of area as well as production which constitutes 55 per cent of the total area and 66 per cent of the total production of the crop. Maharashtra, Karnataka, Madhya Pradesh, Andhra Pradesh and Tamil Nadu are the top five sorghum producing states of India. These five states together account for about 91 per cent of the country's total sorghum production (1996-97).

iii) Karnataka

Karnataka state is the second largest sorghum producer in India. It is the most important crop in terms of area covering 36 per cent of the

total food crops area followed by paddy or rice (24.3%), finger millet (18.1%), maize (7.9%) and pearl millet (7.5%). However, it ranks second in terms of production, next only to paddy in the State with a share of 22 per cent of total production of cereals.

This cereal is cultivated over 2 million hectares of area in the State, out of which only 7 per cent of the area is irrigated which is in fact above the country's average i.e., 5 per cent. The area under hybrid varieties in the State is only 37.7 per cent of total area under sorghum which is far lower than the 72 per cent of all India average.

Though the research system has generated various technologies for higher production of sorghum, the production has been declining during *kharif* season in the 90s and the state is facing plateauing productivity of the crop. The introduction of improved techniques of production has got much attention while little emphasis has been given to improving the technical efficiency level of the small farmers under the existing technology and the allocation of the existing resources at least within the state of arts. Some economists argue that in small holdings, agricultural production under the existing technology can be increased without the use of the high investment capital particularly by drawing on the experience of more efficient farmers. According to Kalirajan and Shand (1986) the core of this notion is that the level of production efficiency is much more affected by the management ability of each farmer than by the use of the traditional inputs, and efforts diverted at improving the traditional farming need not be restricted to introducing new inputs.

Towards this end, the questions to be answered are (i) how far the farmers growing sorghum in the State are able to use farm inputs efficiently in their production system ? and (ii) what are the factors responsible for differences in efficiency levels among farmers under different technology groups ? In line with this, the structure of costs and returns in each group is also an important aspect to be analysed. Such studies and economic surveys would finally contribute to deriving applicable development plans regarding the crop with due consideration of various production systems. The present study seeks to investigate the pattern of growth, resource productivity and the economics of sorghum production under different agricultural technologies with the following specific objectives.

- 1) To document area, production and productivity of sorghum and assess the variability in its production in north Karnataka.
- 2) To analyse the economics of sorghum production.
- 3) To evaluate technical, allocative and economic efficiency of sorghum production with traditional and modern (varietal) technology.

Hypotheses

The hypotheses for the objectives of the study are presented as follows.

1. The area under sorghum in north Karnataka is declining over the years.

2. The production of sorghum in north Karnataka is increasing over the years because of the increasing productivity.
3. The main sources of instability in the production of sorghum are changes in area and productivity.
4. The production of sorghum is profitable, if the risk associated with the process of production and marketing is minimized.
5. Farmers adopting improved technologies are more efficient than those practicing traditional technologies.

The study is organized in six distinct chapters. Chapter I elaborates the background and objectives of the study. Review of literature relating to the investigation is presented in Chapter II. In Chapter III, a detailed description of the study area, the nature and sources of data and the techniques of analysis used in the study are presented. The results of the analysis on growth, instability, costs and returns, efficiencies are presented in Chapter IV. An attempt has been made in Chapter V to further discuss the results presented in Chapter IV with logical interpretation. Chapter VI presents the summary and policy implications of the study.

Review of Literature

II. REVIEW OF LITERATURE

A brief review of related studies relevant to the present investigation are presented in this chapter under the following headings.

2.1 Growth rates

2.2 Instability of production

2.3 Economics of crop production

2.4 Technical, allocative and economic efficiency

2.1 GROWTH RATES

Sharma and Coutinho (1974) while studying the growth of sorghum in Karnataka from 1961-62 to 1972-73 observed that (i) the total volume of change between the first and the last triennium of study period had amounted to a reduction in area by about one-third, (ii) the secondary producing districts including Hassan, Chitradurga, Chickmangalur and Tumkur had recorded more impressive increase in production and productivity and (iii) the trends during study period had indicated that the area declined, whereas the productivity increased and as a result the production had remained more or less static.

Rajapurohit (1983) compared the growth rates of agricultural production in Karnataka for the period 1956-82. The author observed that there had been a major setback in the productivity of rice and jowar in the period 1976-77 to 1981-82 and expressed fears of the new varieties

not being stable and pest vulnerability being high. In contrast, ragi and pulses were observed to have made a major break through. The author attributed the slow growth in food grain production to negative growth in area under food grains as a result of diversion of area to other crops under the process of commercialization of agriculture in Karnataka.

Bisalaiah and Patil (1987) studied the trends of major crops in Karnataka. They found that ragi (finger millet), bajra (pearl millet) and pulses had experienced higher output growth rate, whereas rice and sorghum had recorded lower growth rates during the period 1966-67 to 1977-78. Output growth in case of sorghum, ragi, rice and bajra had shifted from area-cum-productivity led growth during pre-green revolution period to productivity led during the green revolution period. They concluded that productivity increase had contributed substantially to the growth in output of most of the food grains and that of agricultural output growth performance of Karnataka which was higher than the all India performance.

Dalavai (1989) assessed the growth rates of area, production and productivity of sorghum in Dharwad district of Karnataka state for the years 1973-74 to 1986-87 using compound growth rate analysis. The result showed that the area under the crop increased at the rate of 3.99 per cent per annum, but was offset by a sharp decline in productivity (-17.70%) resulting in an overall decline in production by 14.92 per cent.

Sharma (1990) while examining the growth rates in different sub-periods since the early 1950s, reported that the growth rates of food grains production in India declined slightly in the first half of the green revolution period (1967-68 to 1975-78) from the pre-green revolution period (1949-50 to 1964-65) but showed a modest acceleration from 1.9 to 2.5 per cent per year from the first to the second half of the green revolution period (1975-76 to 1983-84). The overall growth rate from 1949-50 to 1983-84 was about 2.6 per cent. It was found by comparing the period of the early 1950s to mid 1960s with the mid-1960s to early 1980s that there was a sharp decline in the latter period in the growth rate of area under food grains. Yield-based growth, however, has increased in importance, contributing over 90 per cent of growth in production from 1975-76 to 1983-84. The study further indicated that most of the yield-based growth came from wheat and rice.

Tripathy (1993) examined the temporal and spatial variations in the growth rates of area, yield and production of major crops in Orissa state, India during two periods i.e., 1970-71 to 1979-80 and 1980-81 to 1989-90. Semi-logarithmic trend equations were fitted to the annual time-series data to obtain compound growth rates. It was found that food grain production in the State increased at the rate of 2.21 per cent per year during the considered period and the major contribution was from maize (6.8%) followed by pulses (6.18%), jowar and bajra (5.06%) and ragi (3.63%).

Kumar and Rosegrant (1994) worked out the annual compound growth rates of area, production and yield of rice at regional and all-India

levels between the period 1969 to 1990 and different sub-periods while assessing the total factor productivity growth in different regions of India and examining the sources thereon. The study highlighted the spatial disparities in agricultural growth in the country. The northern region registered an annual compound growth rate of production of rice at 7.1 per cent as compared to 1.5 per cent in the eastern region for the entire period. But between 1982 and 1990, the eastern region registered an impressive growth rate of 6.8 per cent, most of which was productivity led, as against 5.2 per cent in the northern region and 4.7 per cent at the all-India level.

Sankaran (1994) worked out the compound growth rate of area, yield and production of sorghum at All-India level by classifying the study period in to pre-green revolution (1950-51 to 1964-65) and post-green revolution (1967-68 to 1992-93). In the first sub-period both area and yield of sorghum have increased at the rate of 0.91 and 2.2 per cent per annum, respectively which led to a 2.9 per cent per annum increase in the production of the crop. The result further revealed that the area of sorghum declined by 0.94 per cent per annum during the post-green revolution period, whereas the yield grew to the tune of 1.84 per cent which offset the decline in area and ultimately the rate of growth in production of sorghum was 1.2 per cent per annum. Considering the entire period (1950-51 to 1992-93), the author reported that although the area on sorghum declined by 0.47 per cent per annum, the yield and production increased at the rate of 1.51 and 1.27 per cent per annum, respectively.

Asha Maheshwari (1996) employed simple exponential and kinked exponential model to arrive at the sub period growth rates in her study of agricultural growth in Karnataka, by dividing the period of study into three sub periods *viz.*, (i) the pre-green revolution period from 1955-56 to 1966-67, (ii) the early green revolution period from 1967-68 to 1979-1980 and finally, (iii) later phase of the green revolution period from 1980-81 to 1989-90. A comparison between the pre and the overall post-green revolution period showed that there was an all round increase in the area of crops except in the area under sorghum which was significant. It was concluded that the yield increases brought about by high yielding variety (HYV) seeds in the state were not really revolutionary.

2.2 INSTABILITY OF PRODUCTION

Mehra (1981) examined the instability in Indian Agriculture taking into account the new seed-cum-fertilizer technology adopted in the late sixties. Instability at the national and state levels were measured by comparing data on area, yield and production of individual crops and crop aggregates for two time periods, *viz.*, period I (1949-50 to 1964-65) and period II (1967-68 to 1977-78). He computed standard deviation and coefficient of variation of production to measure the extent of instability and then breaking them in to area and yield variabilities. The standard deviation of yield increased in period II for 15 out of 18 crops studied. However, coefficient of variation increased only for 10 out of 18 crops. Rice and wheat, for which the new technology had been most wide spread, registered a lesser coefficient of variation in the second period despite

increase in standard deviation, indicating how much these two crops had benefited from the stabilizing input of irrigation. Regression analysis of the change in standard deviation of yield identified the new technology as the destabilizing variables and irrigation as the stabilizing variable.

Hazell (1982) in his independent and path finder study of instability in agricultural production, compared two periods, 1954-55 to 1964-66 and 1967-68 to 1977-78 on Indian food grain production and reported that the variance of total cereal production for all-India increased by 342 per cent between the periods. Decomposition of the total change in production variance revealed that increases in the variance of production of individual crops measured at state level accounted for only six per cent of the total change. As much as 82 per cent of the change in production variability could be attributed to increase in the co-variances of production between crops grown within and across states. It was found that simultaneous increase in the variability of the areas sown with individual crops as well as increase in co-variance between areas sown and yield accounted for about 37 per cent of the increase in the variance of total cereal production in India during the period under study.

Rajapurohit (1983) observed that there had been a major set back in the productivity of rice and sorghum in the period 1976-77 to 1981-82 and expressed fears of the new varieties not being stable and higher pest vulnerability. Pulses showed a moderate growth in productivity as compared to stagnation prior to 1975. Further introduction of HYV in 1975-76 had contributed to the high growth with stability incase of finger millet.

In another study, Hazell (1984) compared the sources of increased instability in Indian and U.S. cereal production. The results of the study revealed that variance of total cereal production in India and the United States increased by 240 per cent since the mid 1960s. Increase in yield variance was an important source of this increase in production variability, primarily because of their contribution to increase in yield co-variances between states and crops. The increase in these co-variances was accentuated by a simultaneous loss in offsetting pattern of variation in yields between states and crops. He opined that increase in yield variances in India was due to widespread adoption of the improved seed-fertilizer intensive technology, increased price variability, more erratic rainfall patterns and fluctuating supplies of modern farm inputs.

Reddy and Hiremath (1984) examined the effect of high yielding varieties on production instability in Karnataka. The authors reported that changes in production variances of individual crops influenced total cereal production, through changes in yield co-variances between districts and crops rather than through district yield variability at farm level.

The findings of Walker (1984) revealed that inter-district production co-variances were contributing more than 92 per cent to total increased production variance in sorghum and pearl millet production in semi-arid tropics, India. The change in yield co-variance turned out to be single largest source of these increased inter district production co-variances. It was reported that adoption of hybrids and changes in rainfall co-variances increased the yield co-variances in both the crops. However,

irrigation increased the yield co-variances in sorghum, whereas it led to reduced inter-regional pearl millet yield co-variances.

Pal and Sirohi (1989) studied instability in Indian crop production for time periods *viz.*, 1950-51 to 1964-65 and 1967-68 to 1983-84, using Hazell's statistical identity. It was found that adopting HYVs did not change the probability of shortfall in production. It was observed that the instability in production was comparatively higher in less irrigated crops. Yield variance contributed largely to production variance in pulses and oilseeds and their contribution increased overtime. But the share of yield variances in production variances declined slightly in cereals. The results of the study revealed that after adoption of HYVs, the absolute variability (variance) increased on account of increased sensitivity of HYVs to inputs and weather, especially rainfall. The increased complementarity among inputs and rainfall further enhanced the production variability. It was concluded that there was no structural change in the pattern of sources of production variance after the adoption of HYVs except more positive fluctuations between area and yield.

Tripathy (1993) used standard deviation, variance and coefficient of variation as indicators of instability of crop production in Orissa state, India. The percentage change in coefficient of variation of area, yield and production of different crops both at aggregated and disaggregated level were examined for the period 1980-81 to 1989-90 over 1970-71 to 1979-80. A variance decomposition procedure suggested by Hazell (1982) was employed to examine the components of change in the mean and variance

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of food grains production in the State. The empirical findings of the study showed that food grains production increased by 28.27 per cent between the two periods which was accompanied by less than proportionate increase in standard deviation of production (12.58%) and different components of change in variance of total food grains production, interaction and residual terms stabilized the food grain production in the State. It was further noted that of the interaction terms considered in the decomposition analysis, interaction between changes in the mean areas and yield variances was the most important ones.

Tripathy and Srinivasagowda (1996) studied the variability of food grains production in Orissa using Hazell's decomposition analysis. The empirical findings of the study suggested the need for area stabilizing policies such as price policy for pulses, ragi, millets and maize and yield stabilizing policies for the wheat, sorghum and bajra. The dominance of coastal districts in increased production variability emphasized that yield stabilising measures have to be concentrated in these districts as these districts supply more than one-third of total food grains output of the State.

2.3 ECONOMICS OF SORGHUM PRODUCTION

The studies on economics of sorghum production are limited and hence an attempt has been made to review the studies on economics of production of related crops.

Venkataram and Ramanna (1968) reported that the per acre total cost of local and hybrid varieties of sorghum were Rs.133 and Rs.264,

respectively while the cost of production per quintal of local sorghum (Rs.32.0) was higher than that of hybrid (Rs.23.0). They also observed that the net returns from hybrid sorghum was to Rs.545 as against Rs.229 from the local varieties. The net returns per rupee of investment was Rs.1.07 from hybrid variety while it was Rs.1.72 from local sorghum.

Chourasia and Singh (1972) estimated the gross returns per acre of local paddy at Rs.552.51 whereas it was Rs.1374 with high yielding varieties. The net return for the high yielding varieties was about 236 per cent higher than that of local varieties. The gross return per acre of local wheat was Rs.846 as against Rs.1505 with high yielding varieties (about 175 per cent higher).

Rao (1975) noticed a significant reduction in unit costs and a rise in the share of profit due to the adoption of high yielding varieties. The new technology turned out to be cost saving on all three factors, *viz.*, land, labour and capital. The cost saving on land was highest followed by that on labour. There was also a significant reduction in the unit cost of fixed capital.

Lokamanya and Hiremath (1976) analyzing the cost component of irrigated sorghum production in Chitradurga district of Karnataka, estimated the total cost of cultivation per acre of hybrid sorghum at Rs.644.03. The cost of production per quintal of grain was estimated to be Rs.49.85. The returns per rupee of investment amounted to Rs.1.66.

The actual cash expenses were Rs.486.08 per acre and formed nearly 75 per cent of the total cost of cultivation.

✓ Deshaiah (1980) in his study on a comparative study of the economics of change in production technology in rainfed ragi and groundnut in Tumkur taluk, Karnataka, concluded that, on an average an increase of 35 per cent in total cost was observed in high yielding varieties of ragi as compared to local varieties of ragi. The cost of production per quintal of output higher in local varieties (Rs.134) compared to high yielding varieties (Rs.94). The average returns per hectare under local varieties of ragi was Rs.1237 while under high yielding varieties it was Rs.2277, an increase of 84 per cent.

Srikanta Murthy (1986) in his study on resource productivity of agriculture in Bangalore district, observed that cost of cultivation of paddy per acre was highest on marginal farms and lowest on large farms. Thus, the existence of scale economies was noticed in the cultivation of paddy. The analysis of cost of cultivation of ragi indicated that marginal farmers incurred highest cost per acre followed by small and large farmers. The results did not indicate economies of scale as the cost of production of ragi per quintal was highest for small farmers followed by marginal and large farmers.

Reddy (1989) based on data from 481 sample farmers in Karnataka during 1983-84, 1984-85 and 1986-87, worked out the costs, returns and

profitability of different crops. He reported that the capital expenditure (Machinery and bullock costs, depreciation and imputed value of interest) on an average accounted for more than 40 per cent of the total cost in case of sorghum. Human labour contributed about 30 per cent of the total cost. The price-cost ratio measure indicated that an investment of a rupee in sorghum cultivation yielded an average return of Rs.1.27. Compared to ragi and paddy, the crop was found to be capital intensive with fixed costs accounting for more than 40 per cent of the total cost during the reference period. The net income per hectare was highest (Rs.394.33) during 1986-87 which was Rs.251.32 in 1984-85 and Rs.313.83 in 1983-84.

While examining the nature of technological change in sorghum production in Karnataka through the measurement of technology difference between modern varietal technology (MT) and traditional varietal technology (TT), Kiresur *et al.* (1999) worked out the mean values of various inputs and output per hectare both the technologies which revealed that the average levels of inputs used on the MT farms were higher as compared to those on the TT farms. The gross value of output of MT scored over that of the TT by an appreciable margin and the observed difference in gross value of output between the two technologies was 44.85 per cent.

2.4 TECHNICAL, ALLOCATIVE AND ECONOMIC EFFICIENCY

Frontier production functions form the core of microeconomic theory and a variety of methods are available for measuring technical

efficiency. These methods can be divided into two basic approaches: (i) *the deterministic frontier*, which attribute any deviation from the frontier as being due to inefficiency, and (ii) *the stochastic frontier*, which allows for deviations from the frontier due to random factors beyond the control of the firm operator as well as deviations due to technical inefficiency. Most of the reviews included in this sub-section are stochastic frontier production functions estimated by maximum likelihood techniques as similar model is used in the present study to compute technical efficiency.

Hopper (1966) studied the operations of 43 farms in a village in eastern Uttar Pradesh, India during peak *rabi* season (September-December) of 1954 to measure the allocative efficiency in traditional agriculture and there by test the hypothesis that Indian cultivators using traditional technology make rational profit maximizing allocation of factors. Cobb-Douglas production function was estimated and marginal revenue for products were equated to marginal costs to analyze whether a farmer has allocated his inputs among his production alternatives efficiently and if he was operating under conditions of competitive product factor market. It was found that farmers were “efficient” within the static economic meaning of the term and they appear to have successfully “economized” their resources.

The first application of the stochastic frontier model to farm level agricultural data was presented by Battese and Corra (1977). Data from the 1973-74 Australian Grazing Industry were used to estimate

deterministic and stochastic Cobb-Douglas production frontiers for the three states included in the Pastoral Zone of Eastern Australia. The parameters of the average, pseudo and full frontier production functions were estimated using maximum likelihood method and the value of the variance ratio parameter γ exceeded 0.95 for all regions which is significantly greater than zero. Hence the stochastic frontier production functions were significantly different from their corresponding deterministic frontiers.

Kalirajan (1981) estimated a stochastic frontier Cobb-Douglas production function using data from 70 rice farmers for the *rabi* season in Coimbatore district of Tamil Nadu State, India. The variance of farm effects was found to be highly significant component in describing the variability of rice yields (the estimate for the γ -parameter was 0.81). The relationship between the difference between the estimated 'maximum yield function' and the observed rice yields and such variables as farmer's experience, educational level, number of visits by extension workers, etc. was investigated. In this second-stage analysis, the policy implications of these findings for improving crop yields of farmers were noted.

Bagi (1982) included empirical results on the estimation of a translog stochastic frontier production function using data from 34 share cropping farms in India. The parameters of the model were estimated using corrected least-squares regression. The Cobb-Douglas functional form was judged not to be an adequate representation of the data given the assumptions of the translog model. The variance of the non-negative

farm effects was only a small proportion of the total variance of farm outputs ($\gamma=0.15$). The individual farm technical efficiencies were predicted to be between 0.92 and 0.95. These high technical efficiencies were consistent with the relatively low variance of farm effects which implies that the stochastic frontier and the average production function are expected to be similar.

Lingard *et al.* (1983) attempted to estimate a bias-free agricultural production function with a view to examining efficiency differences among small rice farmers of Central Luzon, the Philippines based on the surveys carried out in 1970, 1974 and 1979. Specification bias, which commonly occurs when management input is omitted from such functions, was circumvented by introducing farm-specific dummy variables into a combined cross-sectional and time-series data set. They reported that the variable most highly associated with technical efficiency was soil type. Credit access, education and land tenure differences were also important variables.

Russell and Young (1983) estimated frontier production function for 56 farms of North West region, England using corrected ordinary least-squares regression (COLS) of deterministic Cobb-Douglas production function during 1977-78. Total revenue obtained from the crop, livestock and miscellaneous activities on the farms was taken as dependent variable and alternative technical efficiency measures, including those of Timmer and Kopp were examined. The measures considered yield substantially similar results. The Timmer technical efficiencies ranged

from 0.42 to 1.00, with average 0.73 while the Kopp technical efficiencies ranged from 0.39 to 1.00, with mean of 0.72.

Shapiro (1983) measured technical efficiency among Tanzanian cotton farmers in Geita district which relied on an outer-bound Cobb-Douglas production function derived with a linear programming methodology. He argued that technical efficiency differentials did not reflect differences in types of inputs but rather differences in how traditional inputs were used. It was found that average level of TE in the sample was 0.663 and thus if all farmers were to modify their operations so as to operate on the outer-bound production function, output would increase by 51 per cent without the use of new inputs and introduction of new technologies. The hypothesis that peasant agriculture is highly efficient and that, hence, important gains in production must rely solely on the infusion of new inputs and technology was finally not supported by the data analysed.

Kalirajan and Shand (1985) estimated stochastic frontier production function using maximum likelihood technique in the analysis of data drawn from a random sample of 91 farmers who were growing high yielding varieties (HYVs) of paddy during the *kharif* season (May-August) of 1977 in Coimbatore district in Tamil Nadu State, India to determine whether the schooling of the farmers had a significant influence on yield of paddy. The farm effects in the model were found to be very highly significant (with $\gamma=0.93$) and it was found that the level of formal education of farmers was not a significant factor, but non-formal

education (understanding of the technology), which was independent of formal education had a significant influence.

Bravo-Ureta (1986) estimated the technical efficiencies of dairy farms in the New England region of United States using a deterministic Cobb-Douglas frontier production function. The parameters of the production frontier were estimated by linear programming methods involving the probabilistic frontier approach. Using the 96 per cent probabilistic frontier estimates, technical efficiencies ranged between 0.58 to 1.00, with an average of 0.82. He concluded that technical efficiency of individual farms was statistically independent of size of the dairy farm operation, as measured by the number of cows.

Karirajan and Shand (1986) investigated the technical efficiency of rice farmers within and without the Kemburu Irrigation Project in Malaysia during 1980. Given the specifications of translog stochastic frontier production function for the output of the rice farmers, the Cobb-Douglas model was not an adequate representation of the data. Maximum likelihood methods were used for estimation of the parameters of the models and the frontiers for the two groups of farmers were significantly different. It was reported that the individual technical efficiencies ranged from about 0.40 to 0.90, such that the efficiencies for those outside the Kemub Irrigation Project were slightly narrower. They concluded that the introduction of new technology for farmers does not necessarily result in significantly increased technical efficiencies over those of traditional farmers.

Huang *et al.* (1986) adopted a stochastic profit function approach to investigate the economic efficiency of small and large farms in two states of India. The variability of farm effects was highly significant and individual farm economic efficiencies tended to be greater for large farms than small farms (the average economic efficiencies being 0.84 and 0.80 for large and small farms, respectively). The authors also considered the determination of optimal demand for hired labour under condition of uncertainty.

Taylor *et al.* (1986) considered a deterministic Cobb-Douglas frontier production function for Brazilian farmers to investigate the effectiveness of World Bank sponsored agricultural credit programme in Minas Gerais State. The parameters of the frontier model were estimated by corrected least squares regression and the maximum-likelihood method, under the assumption that the non-negative farm effects had gamma distribution. The average technical efficiencies for participant and non-participant farmers were reported to be 0.18 and 0.17, respectively. They concluded that these values were not significantly different and that the agricultural credit programme did not appear to have any significant effect on the technical efficiencies of participant farmers.

Ekanayake and Jayasuriya (1987) estimated both deterministic and stochastic frontier production functions of Cobb-Douglas type for two groups ('head' and 'tail' of a major irrigation channel) of 124 rice (unhusked) farmers in an irrigated area in Srilanka during the Wet season of 1984/85 crop year. The parameters of the two frontiers were estimated

by corrected ordinary least-squares (COLS) and maximum likelihood methods. The methods yielded sharply contrasting technical efficiency levels for the 'head' while the results from both methods were similar for the 'tail'. In the 'head', the stochastic frontier approach suggested that all variations in output from the frontier were due to purely random factors, whereas the COLS measures indicated substantial technical inefficiency in the 'head' and the mean sample technical efficiency was only 53 per cent. In the 'tail' both procedures suggested the existence of considerable technical inefficiency and given a sample mean TE of 50 per cent. The authors concluded that deterministic procedures generally tend to overestimate the average level of technical efficiency when estimating firm specific technical efficiency and the extent of this bias is unknown.

Ali and Choudhry (1990) attempted to measure technical, allocative and economic efficiencies in four irrigated cropping regions of the Punjab province of Pakistan by estimating deterministic and probabilistic frontier production function from whole farm survey data for the year 1984-85. The average technical efficiency ranged from 0.80 in the rice region to 0.87 in the sugar cane region implying the existence of a 13-20 per cent potential for increasing farmers income at the existing level of their resources. No significant difference in technical efficiency was found across the regions. The result further revealed that economic efficiency was similar across all cropping region except in the cotton region, which had significantly lower economic efficiency due to higher allocative inefficiency. The analysis indicate that the output loss due to allocative

inefficiency ranged from 30 per cent to 47 per cent while the profit loss amounted to about 2 per cent.

In their analysis of technical efficiency for a large samples of dairy farms in the northeastern states of the USA for the years 1982 and 1983, Bravo-Ureta and Reiger (1990) estimated both deterministic and stochastic frontier production functions. The parameters of the deterministic frontiers were estimated by linear programming, corrected ordinary least square regression and maximum likelihood methods (assuming that the non-negative farm effects had gamma distribution). The stochastic frontier model was estimated by maximum likelihood techniques (given that the farm effects had half normal distribution). The stochastic frontier model had significant farm effects for 1982 but it was not significantly different from the deterministic frontier in 1983. The estimated technical efficiencies of farms obtained from the three different methods used for the deterministic model showed considerable variability but were generally less than those obtained by use of the stochastic frontier model.

Dawson *et al.* (1991) calculated single measures of farm-specific technical efficiency over time for twenty-two rice farms in central Luzon, the Phillipines from the residuals of a stochastic frontier production function. The results of the panel data for the year 1970, 1974, 1979, 1982 and 1984 showed a arrow range of efficiency spread; the best farm achieving over 95 per cent efficiency while the worst was only 84 per cent. They concluded that there was limited scope for increasing output by resource reallocation.

In the study to compare the relative economic efficiency of groundnut production under different varieties, seasons and regions in Karnataka state, India, Umesh and Bisalaiah (1991) used corrected ordinary least-square technique in estimating frontier production and profit function for different technology (two varieties of groundnut) for 320 sample farmers from two districts during 1986-87 (summer) and 1987-88 (*kharij*). A Cobb-Douglas production function was employed with dependent variable, profit and; male-equivalent mandays, area, costs on chemical fertilizer, farmyard manure, seeds and plant protection chemicals and other capital services were taken as independent variables. It was concluded that the average economic efficiency was high in both variety farms, under both seasons and on an average, the groundnut production in both the districts, irrespective of variety and season was found to have a moderately high level of economic efficiency of about 75 per cent.

In a study conducted by Thippa Reddy (1992) on effect of dry farming technology in sorghum production on productivity and returns, the Timmer measure of technical efficiency was employed to assess the efficiency levels of technology adopters and non-adopters. The study revealed that the efficiency levels of technology adopters in the production of sorghum were much superior compared to non-adopters. While allocative efficiency in case of technology adopters was 67 per cent for small farmers, it was 71 per cent among large farmers. The use of resources was lower among non-adopters at 43 per cent for small and 57

per cent for large farmers indicating less efficiency in allocating resources as compared to technology adopters. On an average, economic efficiency was only 30 per cent in case of non-adopters indicating that they can increase the gross income by 70 per cent through better management and optimal allocation of resources.

Bravo-Ureta and Evenson (1994) used stochastic efficiency decomposition methodology to derive technical, allocative and economic efficiency measures separately for cotton and cassava for 148 eastern Paraguay peasant farms. The Cobb-Douglas functional form was used to fit separate stochastic production frontiers for both crops using maximum likelihood procedures. They applied Shephard's Lemma to the cost frontier which yields the minimum cost factor demand equations which in turn, were used to obtain the economically efficient input vector and thereby compute technical efficiency (TE) and economic efficiency (EE) indices. The mean economic (EE) technical (TE) and allocative (AE) efficiency indices computed for the 87 cotton producers were 40.7, 58.2 and 70.1, respectively. The corresponding indices for the 101 cassava producers were 52.3, 58.7 and 88.9. It was concluded that EE and AE were significantly higher in cassava production compared to cotton production, while no difference was found across the two crops for technical efficiency (TE).

In an attempt to measure the technical efficiency in the north-west frontier province of Pakistan, Parikh and Shah (1994) used translog frontier production function on cross-sectional data from 397 farms in

1988-89. The parameters of stochastic production function were estimated by employing maximum likelihood procedure, considering value of output as dependent variable and costs of manure, fertilizer, wage, bullock and tractor per acre as independent variable. At the second stage of estimation, various socio-economic and demographic factors such as family size, age, education and credit were included in the model. Lack of education, restricted credit and fragmented holdings were found to be causes of inefficiency and they, finally, suggested policies which consolidate holdings, provide credit or educate farmers to improve efficiency in agriculture.

Hema kumari *et al.* (1995) studied allocative efficiency of resources used on chrysanthemum flower crop in East Godavari district of Andhra Pradesh state by fitting Cobb-Douglas type production function and using marginal value product (MVP) to opportunity cost (OC) ratio. The results indicated that in case of large farmers, the MVP/OC ratios for all included variables except for plant protection chemicals were less than unity and negative implying excessive utilisation of inputs. However, MVP to OC ratio was found to be higher than unity for chemicals in small group and, manures and fertilizers and human labour in medium group indicating scope to increase the use of these inputs to realise higher returns and profits.

Krishna Rao *et al.* (1995) studied allocative efficiency with respect to watershed and non-watershed villages by classifying the farmers into small, medium and large in the production of castor in Andhra Pradesh

State. Marginal value products were calculated for each input for the three farm groups. Allocative efficiency was then determined statistically by testing the equality between the marginal value product (MVP) and marginal factor cost (MFC) of the inputs. The result showed a considerable potential for increasing profit through reallocation of resources. Human labor was found to be under utilized in all groups of farmers. While cattle labour was over-utilized by small and medium farms.

Panda (1996) used Cobb-Douglas production function to derive frontier production function which was estimated by corrected least squares (COLS) method. He examined Timmer's measure of technical efficiency and Kopp's measure of allocative efficiency of various resources utilized in sericulture farms in Tamil Nadu State. The results of frontier production revealed that the overall technical efficiency (TE) and allocative efficiency (AE) in Drarmapuri district (traditional area) worked out to 86.28 per cent (with a range between 76.63 to 100 per cent) and 87.77 per cent, respectively while the overall, TE and AE for Dindigul Anna district (non-traditional area) was 76.65 per cent (ranging from 56.32 to 100 per cent) and 74.99 per cent, respectively. In both the districts the ratio of marginal value product (MVP) to price revealed that utilisation of these resource inputs could be further increased to maximise the cocoon production.

Croppenstedt and Abbi Mamo (1996) measured the degree of technical efficiency of 249 farmers growing cereals, from five sites of three

regions of Ethiopia in 1993 and 1994, using maximum likelihood method to estimate Cobb-Douglas stochastic frontier production function. The dependent variable considered in their estimation was ratio of total value of grain output in 'meher' (Main) season to output price index and; land, total number of person days in ploughing and weeding, amount of fertilizer applied, number of oxen owned, quality of land, age, and region (dummy) were included as independent variables. The results indicated that 41 per cent of the sampled farmers achieved 70 to 79 per cent technical efficiency with overall average TE of 72 per cent, implying operation of farmers was 28 per cent below the frontier. It was further noted that land quality and average age of household members were important variables in explaining output variation among farmers and on average share croppers were more efficient.

Aswatha Reddy *et al.* (1997) estimated Timmer measure of technical efficiency by employing Cobb-Douglas production function for two categories of total 100 groundnut growing farmers in 10 sample villages of Chitradurga districts, Karnataka state. They found that, small farmers in general achieved relatively higher levels of physical efficiency in growing rainfed groundnut when compared to large farmers and on an average the mean efficiency index of small farmers (0.679) was marginally higher than that of the large farmers (0.646). Moreover, the results indicated that the available potential left unexploited in the given environment ranged between 22.1 per cent for small farmers and 22.40 per cent for the large farmers and they attributed that the inefficiency was due to excessive use of some resources and under use of other resources.

The study conducted on technical efficiency in paddy farms of Tamil Nadu by Tadesse and Krishnamoorthy (1997) considered intra and interecological variations, farm size differences and their interactions to examine the level of technical efficiency across four ecological zones and three farm size groups. The stochastic frontier estimates revealed that farm specific technical efficiency varied between 0.59 and 0.97 with a mean of 0.83 indicating a scope for increasing rice production by 17 per cent by adopting the technology and the techniques used by the best practice of paddy farms. The frequency distribution of the farm specific technical efficiency segregated into the four ecological zones has shown that 36.4, 29.4, 16 and 30.0 per cent of farms in zones I, II, III and IV, respectively, were operating at a technical efficiency of more than 90 per cent and relatively more farms (15.6%) in zone III, zone I (12.12%) and zone II (8.8%) were found to be the least efficient. A similar analysis based on farm size recorded 37 per cent of the most efficient farms (91-97% technical efficiency) were small farms while it was only 26 and 13 per cent of medium and large farms, respectively. On the other hand, the largest proportion (14.3%) of the least efficient farms were large farms while the same was about 8 and 7 per cent of small and medium farms, respectively. It was concluded that paddy farms on small and medium holdings operate at a higher level of technical efficiency than large farms.

Seyoum *et al.* (1998) investigated the technical efficiency of two samples of maize producers in eastern Ethiopia (two districts of Oromial)

using stochastic frontier production function in which the technical efficiency effects were assumed to be the functions of the age and education of the farmers, together with the time spent by extension advisers in assisting farmers in their agricultural production operations. Cobb-Douglas stochastic frontiers were found to be adequate representation of the cross-sectional data of 1995-96 agricultural year, given the specifications of the translog stochastic frontiers for farmers within and outside the extension project and the parameters of the function were estimated using maximum-likelihood method. It was found that the technical efficiencies of the sample farmers within and outside the project were less than unity and the predicted technical efficiencies for the farmers within the project range from 0.748 to 0.990, with the mean of 0.937, while for farmers outside the project it ranged from 0.557 to 0.965 with mean estimated to be 0.794. The result indicated that farmers within the project had higher technical efficiency, relative to their respective frontiers associated with the different technologies.

Xu and Jeffrey (1998) in their study of efficiency and technical progress in traditional and modern agriculture, employed a stochastic parametric decomposition and neoclassical duality model to measure the technical, allocative and economic efficiency of hybrid and conventional rice production using data collected from 180 rice households, distributed over 33 villages in the six counties of China. The frontier functions were used, in combination with regional average input prices, to derive the frontier cost functions. They concluded that efficiency of hybrid rice

production was lower than that of conventional rice production, which is consistent across regions, and for the three measures of productive efficiency. This evidence supported, in the context of Chinese rice production, the 'poor but efficient' hypothesis, i.e., farmers are allocatively efficient with traditional varieties.

Chandra Reddy and Damoder Reddy (1999) calculated marginal value product (MVP) to marginal factor cost (MFC) ratios in the analysis of allocative efficiency of sericulture farms in Chittoor district of Andhra Pradesh state. The MVP to MFC ratio of selected variables in cocoon production indicated that labour and lighting were used in excess than required by small farmers while labour was rationally used in mulberry leaf production. However, the labour use in mulberry and cocoon production by large farmers was more than desired as revealed by the less than unity value of the ratio. The investigation further pointed out that the other inputs in case of both small and large silk cocoon production indicated scope for increased use of these resources since they had more than unity value of MVP to MFC ratio.

In their study, Hazarika and Subramanian (1999) estimated technical efficiency in the stochastic frontier production function model for tea industry in Assam State. They used maximum likelihood techniques to estimate parameters of the function and work out farm specific technical efficiencies of small, medium and large estates. It was found that 29.41 per cent of the total farms who operated large estates belonged to the most efficient category (96 to 99 per cent) and 8.82 per

cent in the least efficient group (64 to 70 per cent). In small and medium sectors 15.15 per cent were highly efficient and 3.03 per cent were least efficient. It was concluded that the variation in the level of technical efficiency was not attributable to the differences in the size of estates.

Sharma *et al.* (1999) attempted to compare efficiency measures obtained from the parametric stochastic efficiency decomposition technique and non-parametric/deterministic frontiers/data envelopment analysis (DEA) approaches for technical, allocative and economic efficiencies in swine production in Hawaii, USA. Under the specification of variable returns to scale (VRS), the mean technical, allocation and economic efficiency indices were 75.9, 75.8 and 57.1 per cent, respectively for the parametric approach and 75.9, 80.3 and 60.3 per cent for DEA; while for the constant returns to scale (CRS) they were 74.5, 73.9 and 54.7 per cent, respectively for the parametric approach and 64.3, 71.4 and 45.7 per cent for DEA. The results from both approaches revealed considerable inefficiencies in swine production in Hawaii and the estimated mean technical and economic efficiencies obtained from the parametric technique were higher than those from DEA for CRS models but quite similar for VRS models, while allocative efficiencies were generally higher in DEA. However, the efficiency rankings of the sample procedures based on the two approaches were highly correlated.

Methodology

III. METHODOLOGY

The procedure and methods followed for the study are presented in this chapter under the following headings:

3.1. Description of the study area

3.2 Sampling design and data source

3.3 Methods of analysis/analytical tools

3.1 DESCRIPTION OF THE STUDY AREA

1. Karnataka

The study pertains to northern districts of Karnataka State, India. The state of Karnataka is located between 11.5° and 19° north latitudes and between 74° and 78° east longitudes. It is the eighth largest state in India both in area and population with an area of 191,800 km² and according to 1991 census, the State's population is about 45 million. About 69.08 per cent of the population in the state live in rural areas. The State is bounded by Maharashtra, Goa, Andhra Pradesh, Tamil Nadu and Kerala in the north, east, south east and south west, respectively. The State has 27 districts, 175 taluks and 27,066 inhabited villages. Table 3.1 shows the area and land use pattern in Karnataka during 1996-97.

Karnataka is situated in tropical zone and enjoys warm climate throughout the year. The mean temperature ranges from 21.5°C to 31.7°C, the maximum and minimum temperatures being 42°C and 14°C, respectively. Northern Karnataka tends to be hotter than the south.

The normal rainfall of the districts ranges from as low as 569 mm to as high as 4029 mm. Average annual rainfall of the state is 1354 mm. The major part of rainfall in the State is received from the south west monsoon which commences in the first week of June and continues till the end of September.

Most part of the State has by red soils. Laterite soils are found in the hilly and coastal regions of the western parts. The northern part of the State has black soils with high moisture holding capacity.

The irrigation potential in the State is estimated at about 25 per cent of the arable land (Anon., 1993). At present, the irrigated area is around 22 per cent and the remaining 78 per cent of the arable land is rainfed (1995-96). The major cereals in the State are sorghum, rice, maize, ragi, bajra and wheat. Sorghum is the most important crop in terms of area (28.8 per cent) and is second (next only to rice) in production (19.9 per cent) among all food grains in the State (1996-97).

2. North Karnataka

North Karnataka comprises the leading sorghum growing districts namely, Bijapur, Bagalkot, Gulbarga, Koppal, Raichur, Belgaum, Bellary, Bidar and Gadag, Haveri and Dharwad districts. These districts account for 92 per cent of total area under the crop in the State contributing 87.6 per cent of the production (1996-97). They put together have 6,298,637 hectares of net cultivated area consisting 60 per

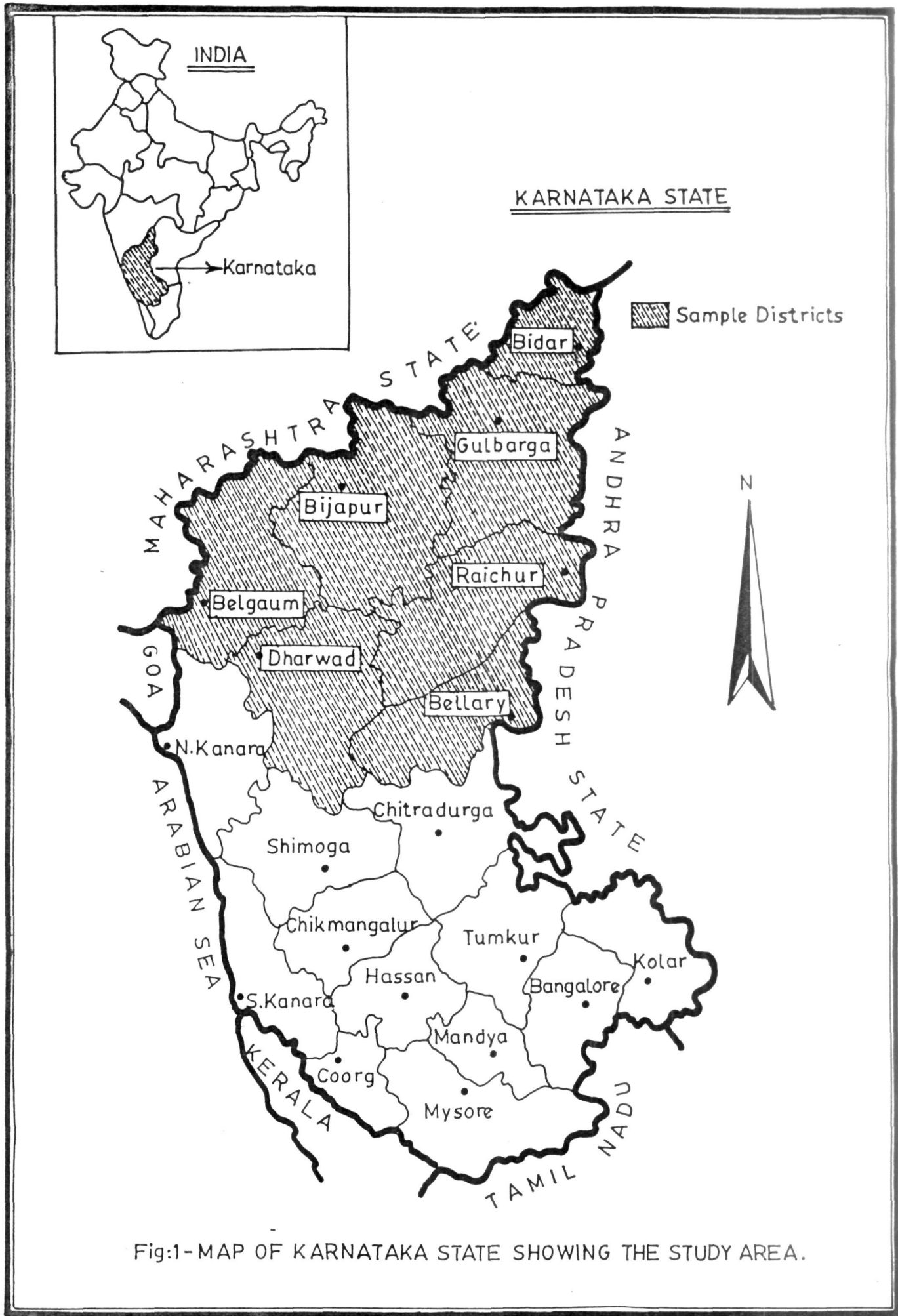


Fig:1- MAP OF KARNATAKA STATE SHOWING THE STUDY AREA.

cent of the net cultivated area of the state (10,419,404 hectares) in 1996-97 (Anon., 1997).

Irrigation facility is very meagre in these districts. Around 21 per cent of net cultivated area is irrigated in the districts as compared to State's average of 22 per cent (1996-97). The major crops grown in these districts are sorghum, groundnut, cotton, maize, bajra, sunflower and safflower.

Agronomically, these districts fall under five agro-climatic zones viz., North Eastern Transition Zone, North Eastern Dry Zone, Northern Dry Zone, Northern Transition Zone and Hilly Zone. Figure 1 shows the study districts of Karnataka.

3. Dharwad district

Erstwhile Dharwad district is located in the northern part of Karnataka between 14°56' and 15°50' N, 74°48' and 76°E and has an area of 13,749 sq.kms which is fourth in area in the State with the population of 3.5 million. It consists of 17 taluks, four of which form the transition belt.

The soils of the district are predominantly red loams with patches of black soils. Red soils are well drained and range from red to pale brown in colour. The district generally has a humid and dry climate with the normal rainfall of 717 mm per annum.

The agricultural seasons in the district can be broadly classified in to *kharif* and *rabi* seasons. *Kharif* season commences in May-June and



Fig.2. MAP SHOWING STUDY TALUKS OF DHARWAD DISTRICT

ends in September. *Rabi* season starts in the month of September-October and ends in February. The total net sown area of the district is as much as 1.06 million hectares of which 16.3 per cent was irrigated. The major food crops of the district in order of importance are sorghum, maize, rice, wheat and pulses. Sorghum is the most important crop accounting for 38.8 per cent of total cereal production in the district (1996-97).

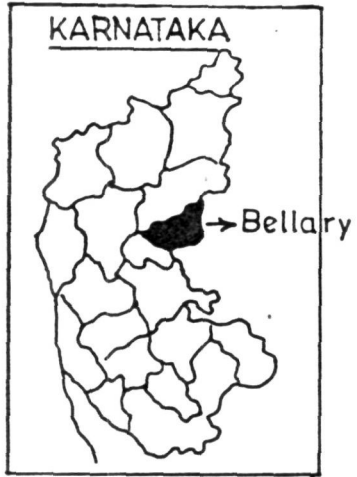
4. Bellary district

Bellary district is situated at 14°30' and 15°40' N and, 75°40' and 77°11'E. The district is bounded by Raichur, Dharwad, Chitradurga and Ananthapur and Kurnool districts on the north, west, south and east respectively.

The total geographical area of the district is 9,885 sq.kms amounting to 5.19 per cent of the area of Karnataka state. The district consists of 8 taluks with 591 villages. According to the 1991 census the total population of the district was about 1.9 million constituting for 4.2 per cent of the population of the State.

Of the total geographical area of 956,220 hectares, the net area sown is 545,886 hectares, out of which 177,910 hectares (32.59%) constitutes the net irrigated area from different sources of water.

The district falls in the transitional belt of Karnataka and the rainfall is sporadic and ill-distributed even within the district. Usually,



BELLARY DISTRICT

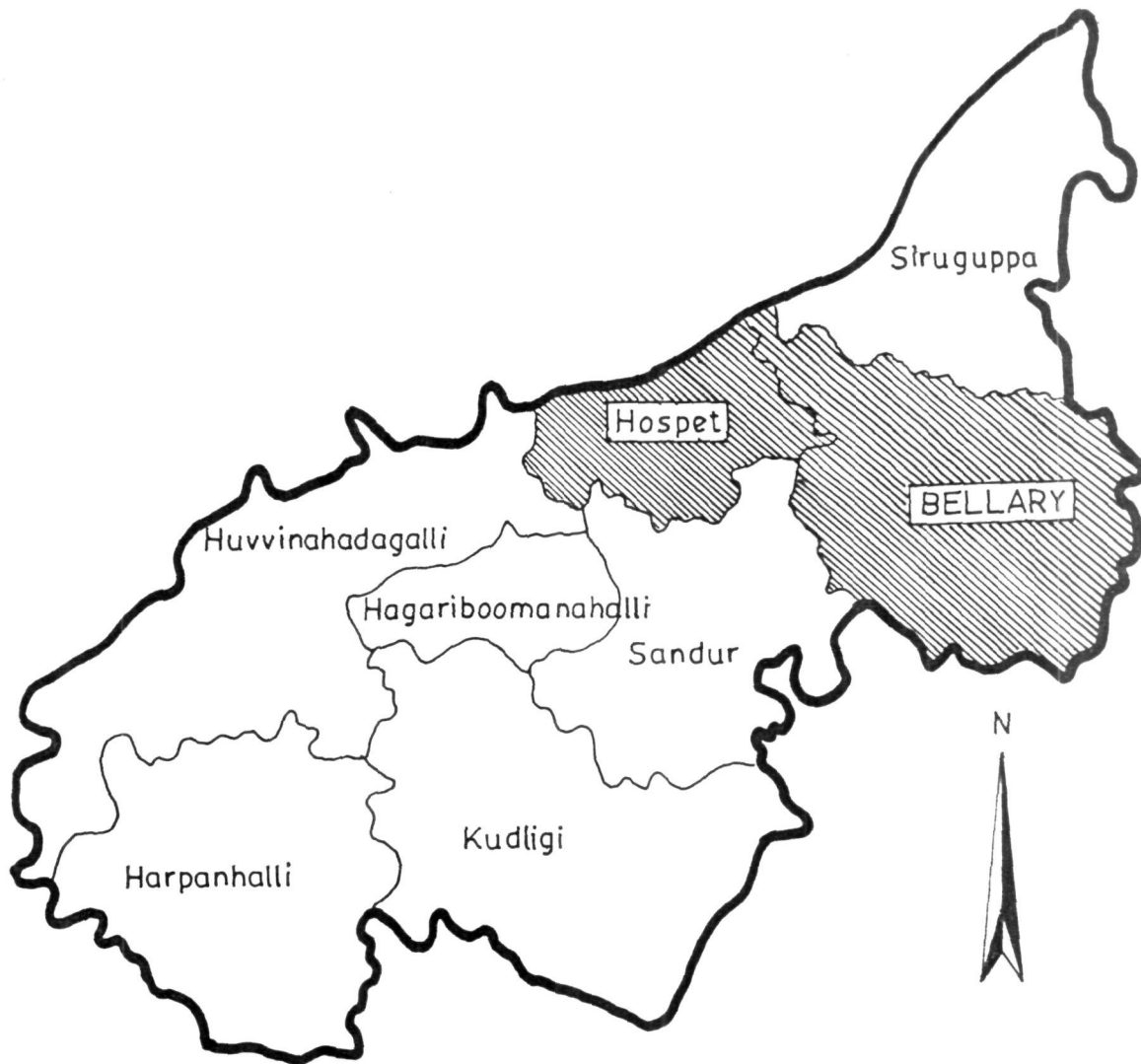


Fig.3. MAP SHOWING THE STUDY TALUKS OF BELLARY DISTRICT.

rains are concentrated from August to November with the light showers during May, June and July months. The average normal rainfall of the district is 639 mm which is far below the State's average. The temperature reaches a maximum of 41°C in summer and a minimum of 20°C during winter. Table 3.1 provides some basic agricultural statistics with respect to sorghum.

The major crops grown in the district are sorghum, paddy, maize, ragi and bajra constituting 45.3, 20.3, 16.2, 11.2 and 6.5 per cent of total area under cereals in that order.

3.2 SAMPLING DESIGN AND DATA SOURCE

3.2.1 Sampling design

Multistage sampling technique was employed in the selection of districts, taluks and villages for the study based on the production of sorghum in the State during *kharif* season. Dharwad and Bellary districts were selected as they have the highest share in production of sorghum in the State in *kharif* season contributing 18.3 and 16 per cent to the State's total *kharif* production, respectively in 1996-97.

Two taluks from each of the selected districts based on the maximum proportion of area under traditional and hybrid varieties in the taluks were selected. From the records Dharwad and Hubli from Dharwad district and Bellary and Hospet from Bellary district were selected based on the above criterion. The study taluks of Dharwad and Bellary districts are shown in Figure 2 and 3, respectively.

Table 3.1. Area and land use pattern in Karnataka and selected districts with reference to sorghum during 1996-97

Sl. No.	Particulars	Area ('000 ha)		
		Karnataka	Dharwad	Bellary
1.	Geographical area	19049.8	1378.2 (7.23)	956.2 (5.02)
2.	Total cropped area	11957.7 (62.77) ¹	1290.5 (10.79)	648.5 (5.42)
3.	Net area sown	10419.4 (54.69) ¹	1056.1 (10.13)	568.8 (5.46)
4.	Forests	3062.4 (16.06) ¹	115.3 (3.76)	119.2 (3.89)
5.	Net irrigated area	2302.3 (22.10) ²	172.5 (7.49)	17.6 (0.76)
6.	Total area under food grains	6856.0 (65.80) ²	595.0 (8.68)	334.5 (4.88)
7.	Total area under cereals	5245.4 (50.34) ²	462.0 (8.81)	271.1 (5.17)
8.	Area under HYVs of cereals	3518.1 (67.07) ³	227.2 (6.46)	240.9 (6.85)
9.	Area under sorghum	1976.3 (37.68) ³	229.2 (11.6)	122.8 (6.21)
10.	Irrigated area under sorghum	141.0 (7.13) ⁴	12.0 (8.51)	23.0 (16.31)
11.	Area under HYVs of sorghum	754.0 (38.15) ⁴	59.0 (7.82)	109.0 (14.46)

Note: 1. The figures in parentheses indicate percentage of each particular to the total of the state.

2. ()¹ indicates the percentage to the total geographical area of Karnataka

3. ()² indicates the percentage out of net area sown

4. ()³ indicates the percentage out of total area under cereals

5. ()⁴ indicates the percentage out of area under sorghum in the state.

The same criterion was used the selection of villages. Two villages from each taluk were selected, i.e. Amminabhavi and Uppinabetageri in Dharwad; Sherewad and Anchatgeri in Hubli; Joladarasi and Chellagurki in Bellary; and Kampli and Sonnapur in Hospet. In all, eight villages were selected for the study. Stratified random sampling method was used to select sample farmers. Hence, for each selected village, separate lists of traditional and hybrid sorghum growing farmers were prepared with the help of village accountants and then from each village five traditional and five hybrid sorghum growing farmers were selected randomly.

Thus, finally from the selected eight villages 40 farmers growing traditional sorghum varieties and 40 farmers growing hybrid sorghum were selected which add up to total sample of 80 respondent farmers. Data collection was done by personal interview method with the help of a pretested schedule prepared for this purpose. The distribution of sample farmers in each district is presented in table 3.2.

3.2.2 Nature and sources of data

The district-wise time series secondary data for the period from 1961-62 to 1996-97 pertaining to area, production and productivity of sorghum were collected from the Directorate of Economics and Statistics, Government of Karnataka, Bangalore.

The period selected for the study in the time series analysis was 1961-62 to 1996-97. Consistent data for selected districts was available

Table 3.2. Sample structure under each technology/variety/group

	Village	Traditional varieties	Hybrids	Total
1)	Amminbhavi	5	5	10
2)	Uppinabetageri	5	5	10
3)	Sherewad	5	5	10
4)	Anchatgeri	5	5	10
5)	Joladarasi	5	5	10
6)	Chellagurki	5	5	10
7)	Kampli	5	5	10
8)	Sonnapur	5	5	10
	Total	40	40	80

from 1961-62 and the latest year for which fully revised estimates of area, production and yield were available on a district basis was up to 1996-97.

The period under study was divided into two sub-periods namely, Period-I : 1961-62 to 1976-77 and Period-II : 1977-78 to 1996-97 in order to analyse the growth and instability of sorghum production. The base for the classification was the preliminary examination of the raw data of area, yield and production for the major sorghum growing districts and state as a whole which revealed that a declining trend in area was exhibited upto 1976-77 and an upward trend later.

The cross sectional primary data for *kharif* season of 1999-2000 from the selected sample of eighty sorghum growing respondents of Dharwad and Bellary districts were collected through pre-tested structured schedule. General information regarding socio-economic status on respondents along with the relevant data on variables directly related to the study were collected.

Definition of terminologies used

The term '**Traditional**' refers to the production practices associated with improved open pollinated and local varieties. In this category improved open pollinated varieties such as M 35-1, SPV-462, CSV-15, CSV-9, CSV-11, SB 462, DSV-4, DSV-5 and Maldandi, and local varieties mainly *Gangawati*, *Billijola* and *Kenjola* were the major ones grown by

sample farmers. The major hybrids included in the study were CSH-5, CSH-11, CSH-14, DSH-3, CSH-13 and CSH-9.

3.3 ANALYTICAL TECHNIQUES

3.3.1 Compound growth rate analysis

Growth in area, production and yield of sorghum in the selected seven northern districts i.e. Bijapur, Bidar, Bellary, Dharwad, Gulbarga, Raichur and Belgaum and for the State as a whole were analysed by computing compound growth rates using the exponential function of the form :

$$Y = ab^te^u$$

Where,

Y = dependent variable (area/production/yield)

a = intercept (constant)

b = regression coefficient which is $= (1+r)$, where 'r' is the average compound growth rate.

t = time period

e = exponential

u = disturbance term

The equation was converted into the logarithmic form in order to facilitate the use of linear regression which was ran separately for area, production and yield of sorghum. The values of 'a' and 'b' were estimated by using ordinary least square (OLS) technique. Later, the original values of the parameters were obtained by taking anti-logarithms of the estimated coefficients. To analyse the long-term trend, the regression was fitted for the whole study period (1961-62 to 1996-97) and two sub periods (1961-62 to 1976-77 and 1977-78 to 1996-97) for the selected districts and for the State as a whole using the time series data. The time period has been classified based on the trend of area in the stage by looking at the graph in which the year 1976-77 was taken as demarcation point. The trend in area till the period 1976-77 was declining and later on it started to increase.

The significance of regression coefficient was tested by using 't' test which was defined as

$$t = \frac{b_i}{se(b_i)}$$

Where,

b_i = Regression coefficient

$se(b_i)$ = Standard error of the coefficient

3.3.2 Analysis of variability in sorghum production

In order to estimate variability in production of sorghum, data were detrended linearly and centered around their respective means for both

the periods separately. The variance of production was decomposed into its constituent sources *viz.*, area variance, yield variance, area-yield covariances and higher order interaction between area and yield. The pattern of changes in the sources of growth and instability was examined using Hazell's (1982) decomposition technique. The decomposition procedure was used in the present study in order to isolate the effects of different factors contributing to variability. The method used is discussed below.

Let P, A and Y denote production, area sown and yield of the crop respectively; the relationship between the three variables can be denoted as:

$$P = AY$$

The average production, E(P), can be expressed as:

$$E(P) = \bar{A} \bar{Y} + \text{COV} (A, Y) \quad \dots \dots \dots (1)$$

Where, \bar{A} , \bar{Y} and $\text{COV} (A, Y)$ are mean area, mean yield and covariance between area and yield, respectively.

To divide the changes in E(P) between the two periods, the average production of each sub periods can be expressed as:

$$E(P_1) = \bar{A}_1 \bar{Y}_1 + \text{COV} (A_1, Y_1) \quad \dots \dots \dots (2)$$

$$E(P_2) = \bar{A}_2 \bar{Y}_2 + \text{COV} (A_2, Y_2) \quad \dots \dots \dots (3)$$

Taking the first period as base period, each variable in the second period can be expressed in terms of its counter part in the first period as follows.

$$\bar{A}_2 = \bar{A}_1 + \Delta \bar{A}, \quad \bar{Y}_2 = \bar{Y}_1 + \Delta \bar{Y}$$

$$\text{and } \text{COV}(A_2, Y_2) = \text{COV}(A_1, Y_1) + \Delta \text{COV}(A_1, Y_1)$$

$$\text{where, } \Delta A = \bar{A}_2 - \bar{A}_1, \quad \Delta Y = \bar{Y}_2 - \bar{Y}_1$$

$$\text{and } \Delta \text{COV}(A, Y) = \text{COV}(A_2, Y_2) - \text{COV}(A_1, Y_1)$$

Equation (3) can be written as:

$$E(P_2) = (\bar{A}_1 + \Delta \bar{A})(\bar{Y}_1 + \Delta \bar{Y}) + \text{COV}(A_1, Y_1) + \Delta \text{COV}(A, Y) \dots \dots (4)$$

The change in average production, $\Delta E(P)$ can be derived by subtracting equation (2) from equation (4). This reduces the relationship to :

$$\begin{aligned} \Delta E(P) &= E(P_2) - E(P_1) \\ &= \bar{A}_1 \Delta \bar{Y} + \bar{Y}_1 \Delta \bar{A} + \Delta \bar{A} \Delta \bar{Y} + \Delta \text{COV}(A, Y) \dots \dots (5) \end{aligned}$$

Change in average production thus has four components, *viz.*, changes in mean area and mean yield, interaction of changes in mean area and yield and changes in variability of area and yield. Table 3.3 shows these four components of source change in average production.

The first two parts $\bar{A}_1 \Delta \bar{Y}$ and $\bar{Y}_1 \Delta \bar{A}$ arose from the changes in the mean yield and the mean area. These are pure effects which arise even if there were no other sources of change. The term $\Delta \bar{A} \Delta \bar{Y}$ is an interaction effect which arose from the simultaneous occurrence of changes in mean yield and mean area. Obviously, this term will be zero if either mean yield or the mean area remains unchanged. The last term, $\text{COV}(A, Y)$ arised from changes in the variability of area and yields, since

$$\text{COV}(A, Y) = \rho[V(A) V(Y)]^{1/2}$$

Where ρ is the correlation coefficient. The change in covariance of area and yield arise from changes in variances of area and yield and from changes in the correlation between area and yield.

In a similar fashion expressed for average production Hazell (1982) derived the variance of production as:

$$V(P) = \bar{A}^2 V(Y) + \bar{Y}^2 V(A) + 2 \bar{A} \bar{Y} \text{COV}(A, Y) - \text{COV}(A, Y)^2 + R \dots (6)$$

Where,

\bar{A} and \bar{Y} denote the mean area and yield

R is residual term

The variance of production is a function of the variances of yield and area sown, the mean area and yield, and the covariance between area and yield. Hence, a change in any of these components would bring about a change in variance of production $[V(P)]$ between two periods in time.

The change in variance of production $\Delta V(P)$ was decomposed into ten sources of change. Table 3.4 indicates the various sources along with the symbols and their components.

To make negative values indicate stability and positive values instability in the course of the study, some adjustments were performed, where necessary in which consistency would be maintained in interpreting the data.

The overall period in the study has been divided into two parts i.e. 1961-62 to 1976-77 and 1977-78 to 1996-97 based on the trend of area of state under sorghum cultivation.

3.3.3 Estimation of costs and returns

The costs were classified in to variable and fixed costs. Variable costs were defined to include costs incurred on seed, chemical fertilizer, farmyard manure, plant protection chemicals and human and bullock labour charges. Fixed costs were defined to include depreciation on farm implements, rental value of land and interest on fixed farm implements. The measurement and definitions of various cost components are as follows:

Human labour

Actual days worked were recorded separately for male, female and children and also for family and hired labour. The days were then converted into mandays. Valuation of family labour was done by imputing the prevailing wage rates of the casual labour engaged for similar operations in the study area. It was assumed that each manday consists of eight hours of work.

Bullock labour

Bullock labour in pair days, both owned and hired, were charged at the prevailing rates in the locality for eight hours of work.

Table 3.3. Components of change in average production

	Source of change	Nature of effect	Components of change
1.	Change in mean yield	Pure effect	$\bar{A}_1 \Delta \bar{Y}$
2.	Change in mean area	Pure effect	$\bar{Y}_1 \Delta \bar{A}$
3.	Interaction between changes in mean yield and area	Interaction effect	$\Delta \bar{A} \Delta \bar{Y}$
4.	Changes in area yield covariance	Effect due to change in variabilities of area and yield and their correlations	$\Delta \text{COV}(A, Y)$

Table 3.4. Components of change in the variance of production

	Source of change	Nature of effect	Components of change
1.	Change in mean yield	$\Delta \bar{Y}$	$2 \bar{A}_1 \Delta \bar{Y} \text{COV}(Y_1, A_1) + [2 \bar{Y}_1 \Delta Y + (\Delta Y)^2] V(A_1)$
2.	Change in mean area	$\Delta \bar{A}$	$2 \bar{Y}_1 \Delta \bar{A} \text{COV}(Y_1, A_1) + [2 \bar{A}_1 \Delta \bar{A} + (\Delta \bar{A})^2] V(Y_1)$
3.	Change in yield variance	$\Delta V(Y)$	$(\bar{A}_1)^2 \Delta V(Y)$
4.	Change in area variance	$\Delta V(A)$	$(\bar{Y}_1)^2 \Delta V(A)$
5.	Interaction between changes in mean yield and mean area	$\Delta \bar{Y}, \Delta \bar{A}$	$2 \Delta \bar{Y} \Delta \bar{A} \text{COV}(Y_1, A_1)$
6.	Change in area-yield covariance	$\Delta \text{COV}(Y, A)$	$[2 \bar{A}_1 \bar{Y}_1 - 2 \text{COV}(Y_1, A_1)] \Delta \text{COV}(Y, A) - [\Delta \text{COV}(Y, A)]^2$
7.	Interaction between changes in mean area and yield variance	$\Delta \bar{A}, \Delta V(Y)$	$[2 \bar{A}_1 \Delta \bar{A} + (\Delta \bar{A})^2] \Delta V(Y)$
8.	Interaction between changes in mean yield and area variance	$\Delta \bar{Y}, \Delta V(A)$	$[2 \bar{Y}_1 \Delta \bar{Y} + (\Delta \bar{Y})^2] \Delta V(A)$
9.	Interaction between changes in area & yield and changes in area-yield covariance	$\Delta \bar{Y} \Delta \bar{A} \Delta \text{COV}(Y, A)$	$[2 \bar{Y}_1 \Delta \bar{A} + 2 \bar{A}_1 \Delta \bar{Y} + 2 \Delta \bar{A} \Delta \bar{Y}] \Delta \text{COV}(Y, A)$
10	Change in residual	ΔR	$\Delta \text{COV}(A, Y)$ — sum of the other components

Farmyard manure

The cost of farmyard manure was computed on the basis of prevailing rates in the locality and if it was purchased by the farmers, the actual cost along with other individual charges paid was considered.

Chemical fertilizers

Actual cost paid for the purchase of chemical fertilizers along with the incidental charges was taken into account.

Seeds

The cost of seed whether purchased or produced on the farm was valued at the market rates.

Rental value of land

The rent paid for an acre of land in the locality was taken as a base to compute the opportunity cost (value) of owned land, i.e. instead of cultivating the land himself, what amount the owner would get if it was let out. Land revenue was omitted in the computation of fixed costs as it was very negligible and considered in miscellaneous expenses.

Interest on working capital

Interest on total working capital was charged at the prevailing rate of 15 per cent per annum, the rate at which commercial banks advance short-term loans, only for six months considering the duration of the crop on the field. The imputed value of family labour was excluded from total variable cost while calculating interest on working capital.

The total amount on capital equipment (farm assets) was calculated at the rate of 12 per cent per annum as it was the rate of interest charged on long-term loans by commercial banks. This interest was worked out on the values of fixed assets, after deducting depreciation for the year. It was apportioned on the basis of the area of land under each crop grown by the farmer during the study period.

Depreciation charges

Depreciation on each capital equipment used in the cultivation of sorghum crop was calculated for each individual farmers separately by straight line method of computing depreciation.

$$\text{Annual depreciation} = \frac{\text{Purchase value} - \text{Salvage value}}{\text{Useful life of the asset}}$$

The average life of the asset as indicated by each farmer was used in computation of the depreciation. The depreciation cost on the assets was apportioned to the crops based on the proportion of area under crops grown by the farmer.

Returns

Gross return including the value of sorghum grain and the value of byproduct imputed on the basis of post harvest prices prevailing in the selected villages was worked out in the reference period.

Net return

The net return was computed by subtracting the total cost of cultivation from the gross income (return) for each sample farmer as well as averages for sample groups.

Cost of production per quintal

The cost of production per quintal of sorghum was arrived at by dividing the total cost of production per hectare by the total per hectare yield of sorghum in quintals.

Net return per rupee of investment

It was obtained by dividing the net return per hectare of sorghum production by the total cost of production per hectare.

Net return per quintal

Net return per quintal was calculated by dividing the net return per hectare to the per hectare yield in quintals.

3.3.4 Technical, allocative and economic efficiency**A. Technical efficiency analysis**

Technical efficiency is the ability to produce a given level of output with a minimum quantity of inputs under certain technology. It refers to the ability to produce the greatest possible output from a given set of inputs. A producer is said to be technically efficient when no matter what

input combination is used, the maximum output is produced. Over all technical efficiency can be expressed as:

$$\text{Overall TE} = \frac{\text{Average output}}{\text{Maximum output}}$$

Regression analysis assumes implicitly that all firms are successful in reaching a maximum output level and indicate “average production functions”, associated with mean output, for given input levels. If, however, firms are not equally efficient, the average relationship might not reflect the maximum production level. These considerations led to the concept of frontier production functions. Currently, the frontier function is widely utilized to analyse technical efficiency of firms.

In the analysis of technical efficiency for the two groups of farmers in the present study, stochastic frontier production was used. Stochastic frontier production function was found to be advantageous over deterministic and probabilistic ones because the later functions ignore the possibility of a firm’s performance to be affected by factors entirely outside the control of a firm (such as bad weather, diseases, etc.) and all deviation from the frontier is labeled as technical inefficiency.

The basic structure of the stochastic frontier model is depicted in Fig. 3.4 in which the productive activities of two firms, represented by i and j , are considered. Firm i uses inputs with values given by (the vector) x_i and obtains the output y_i , but the frontier output, Y_i^* , exceeds the value on the deterministic production function, $f(X_i; \beta)$, because its

productive activity is associated with 'favourable' conditions for which the random error, V_i , is positive. However, firm j uses inputs with values given by (the vector) X_j and obtains the output, Y_j , which has corresponding frontier output, Y_j^* , that is less than the value on the deterministic production function, $f(X_j; \beta)$, because its productive activity is associated with 'unfavourable' conditions for which the random error, V_j , is negative. In both cases, the observed production values are less than the corresponding frontier values, but the (unobservable) frontier production values would lie around the deterministic production function associated with the firms involved.

Following Aigner, Lovell and Schmidt (1977) ; and Meeusen and Van den Broeck (1977), where the error term is composed of two parts, the stochastic frontier production function is defined by:

$$Y_i = f(X_i, \beta) \exp (V_i - U_i) \quad i=1, 2, \dots, N \quad \dots \dots \dots (1)$$

Where, Y_i = Observed output

X_i = The actual input vector

β = the vector of production function parameters

$$\exp (V_i - U_i) = e^{V_i - U_i}$$

V_i = is two sided, symmetric component, normally distributed random error ($V_i \sim N(0, \sigma^2_v)$) which permits random variation in output resulting from factors outside the control of the farm like weather, disease etc. It also capture measurement error, other statistical noise and random shocks.

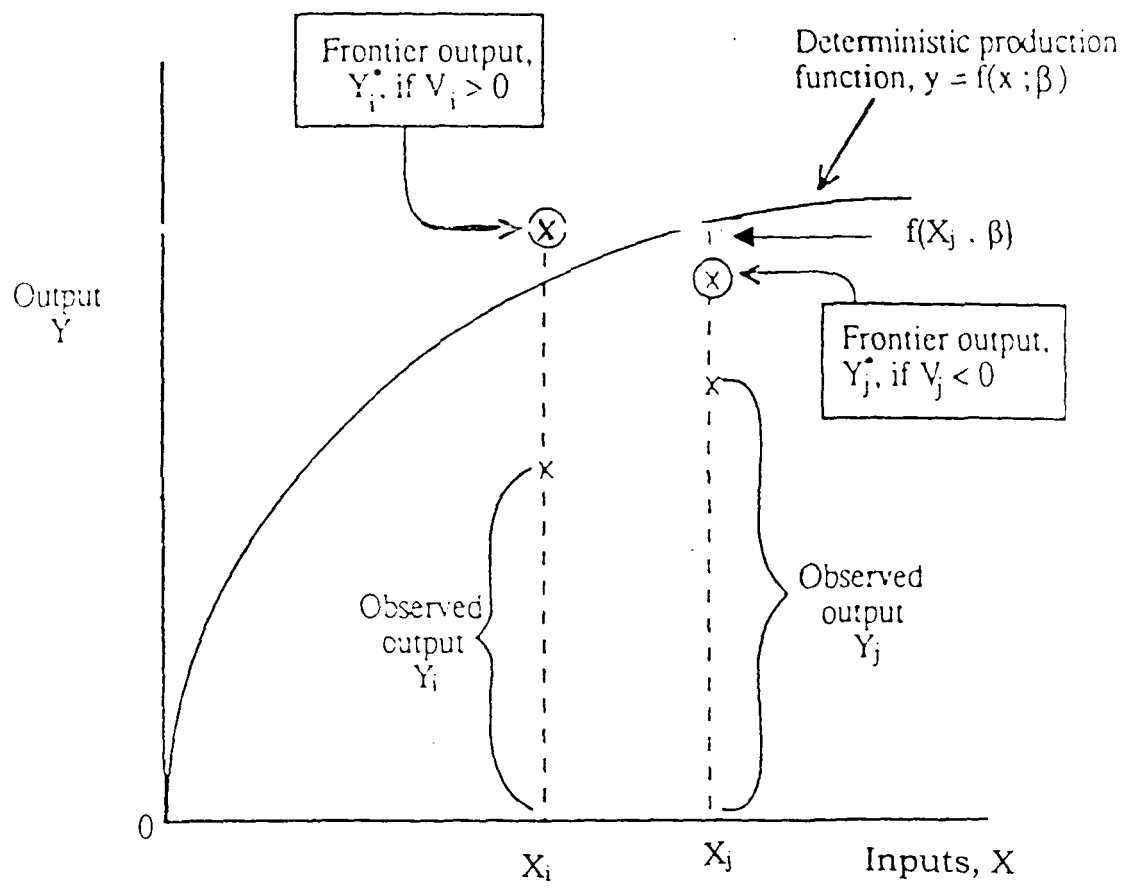


Fig. 3.4 Stochastic frontier production function

U_i = the non-negative one-sided error term. It is one-sided efficiency component with a half normal distribution ($U_i \sim N(0, \sigma^2_u)$). It represents deviations from maximum potential output attributable to technical inefficiency.

Technical efficiency of an individual firm can be expressed as:

$$TE_i = Y_i/Y^*_i$$

Where,

Y_i = The observed output

Y^*_i = The corresponding frontier output

It can be rewritten as:

$$TE_i = f(X_i; \beta) \exp(V_i - U_i) / f(X_i; \beta) \exp(V_i) \dots \dots \dots (2)$$

$$= \exp(-U) \dots \dots \dots (3)$$

In order to empirically measure technical efficiency, the frontier production function was estimated using maximum likelihood (ML) procedure due to the specified distributional assumptions of V (random component) and U (inefficiency component) which provides sufficient information to calculate a conditional mean for U .

The resulting log-likelihood function is written as:

$$\ln L = - \frac{N}{2} \ln [2/\pi] - N \ln \sigma + \sum_{i=1}^N \ln [1 - F [e_i \lambda \sigma^{-1}]] - \frac{1}{2\sigma^2} \sum_{i=1}^N e_i^2 \dots \dots \dots (4)$$

Where,

$F(\cdot)$ is the cumulative distribution of the standard normal density function evaluated at $e\lambda/\sigma$;

$$\sigma^2 = \sigma^2_u + \sigma^2_v \quad (\text{Variance of } E)$$

$$\lambda = \sigma_u / \sigma_v \quad (\text{ratio of two standard errors})$$

$$\text{or } \gamma = \sigma^2_u / \sigma^2 \quad 0 \leq \gamma \leq 1$$

The maximum likelihood estimation used in the study yields estimations for β and λ or γ .

Farm specific measures of efficiency was obtained using Jondrow *et al.* (1982) suggestions of using the conditional distribution of u , given ε for each farm, the measure is the expected value of U conditional on ε . The mean of this distribution can be used as a point estimate of inefficiency error (U_i) given the total error (U_i+V_i) by the following formula.

$$E(U_i / (U_i + V_i)) = \frac{\sigma_u \sigma_v}{\sigma} \left[\frac{\phi(.)}{1 - \Phi(.)} - \left(\frac{U_i + V_i}{\sigma} \right) \left(\frac{\gamma}{1 - \gamma} \right)^{1/2} \right]$$

Where,

$$\gamma = \sigma^2_u / \sigma^2$$

$$\sigma^2 = \sigma^2_u + \sigma^2_v$$

$\phi(.)$ and Φ are standard normal density and cumulative distribution functions evaluated at $[(U+V)\sigma]$ and $[(\gamma/U-\gamma)^{1/2}]$, respectively.

The Cobb-Douglas functional form was used to fit separate stochastic production frontiers for the data on traditional and hybrid sorghum varieties in the study area. Cobb-Douglas functional form was chosen because of the fact that it is widely used in farm efficiency

analyses in developing countries and it fits well even for smaller data sets, apart from relative computation easiness and readily available productivity estimates for the inputs included in the model.

The modified log-linear Cobb-Douglas stochastic frontier model estimated in the study is specified as

$$\ln(Y_i) = b_0 + b_1 \ln(A) + b_2 \ln(S) + b_3 \ln(FR) + b_4 \ln(LB) + b_5 \ln(B) + b_6 \ln(FM) + V_i - U_i \quad \dots \dots (6)$$

where, the subscript 'i' indicates the i^{th} farmer in the sample ($i=1,2, \dots, 40$)

\ln represents the natural logarithm (i.e., logarithm to base e)

Y = the output of sorghum in quintals

b_i = unknown parameters to be estimated

A = area under sorghum in hectares

S = Amount of seed used in kgs

FR = Amount of fertilizer used in kgs

LB = human labour spent in the operations of sorghum production
in mandays

B = Bullock labour used in pair days

FM = Amount of farmyard manure applied in cartloads

V_i s are assumed to be symmetric and identically distributed random errors having $N(0, \sigma^2_v)$ distribution.

U_i s are non-negative random variables, called technical inefficiency effects, which are assumed to be independently distributed such that U_i is

defined by the truncation (at zero) of the normal distribution with mean μ_i and variance σ^2 .

In the measures of technical efficiencies for the two groups of farmers in the present study a computer programme, FRONTIER version 4.1, which calculates the maximum likelihood estimator for equation (3) based on its conditional expectation was used (cf. Battese and Coelli, 1988).

For the sake of completeness, the parameters of the deterministic Cobb-Douglas production function were also estimated using ordinary least squares (OLS) techniques.

B. Allocative efficiency

The concept of allocative efficiency refers to the adjustment of inputs and output to reflect relative prices, the technology of production already having been chosen. These adjustments consider the marginal conditions in such a way that Marginal Value Products (MVPs) should equal Marginal Factor Cost (MFC) for any single variable input, and that marginal value product per unit of input should be equal across different outputs (the principle of equimarginal returns).

The notion of allocative efficiency is clearly goal-oriented, in the sense that different goals generate different allocative efficiency requirements, unlike technical efficiency in which a producer is technical efficient or inefficient, regardless of the producers behavioural goals.

Allocative efficiency measures the degree of correctness in the adoption of factor proportions to current input prices. A producer is allocatively efficient if production occurs in a sub set of the economic boundary of the production possibilities set that satisfies the producer's behavioural objective.

Farm specific allocative efficiency (AE_{ij}) in the use of variable input (i) is:

$$AE_{ij} = MGR_j / OGR_{ij} \quad \dots \dots \dots (7)$$

OGR_{ij} = Output at the optimum level of the i^{th} input, with all other inputs remaining at the level at which they were used by the j^{th} farmer.

MGR_j = Maximum possible output

Farm-specific optimum input level is calculated by equating MVP of an input with its price.

The allocative efficiency (AE_j) of all inputs on the j^{th} farm is estimated to be:

$$\text{Overall } AE_j = MGR_j / OGR_j \quad \dots \dots \dots (8)$$

Where, OGR_j = the j^{th} farmer's output at the optimum level of all variable inputs.

In order to determine whether a particular resource is used optimally, MVP and opportunity cost (factor cost) of one unit of that resource was compared.

This study used the marginal products (MP) as determined from the modified Cobb-Douglas production function, estimated using the ML techniques, at the geometric mean levels of the variables. The MVP of each resource was calculated by multiplying the marginal product of the resource by the price of the product. The formula used to compute MVP is expressed as follows.

$$\text{MVP of } X_i = b_i \frac{\bar{Y}}{\bar{X}_i} P_y$$

Where,

b_i = elasticity of production (regression coefficient) of i^{th} input

\bar{Y} = geometric mean of output

\bar{X}_i = Geometric mean of i^{th} input

P_y = Price of the product

The comparisons of ratios (MVP/MFC) for judging efficiencies are:

MVP/MFC > 1 indicated under use of resources

MVP/MFC = 1 optimum use of resources (allocatively efficient)

MVP/MFC < 1 indicated excess use of resources.

C. Economic efficiency

Economic efficiency is a combination of technical and allocative efficiencies. Technical and allocative efficiencies are mutually exclusive and exhaustive, so that a producer can be efficient in any one way, or in both ways. Thus a producer is economically efficient in a private sense if,

and only if, the producer is technically and allocatively efficient. The simultaneous achievement of both efficiencies provided sufficient condition to ensure economic efficiency.

Farm specific economic efficiency (EE_j) can be estimated using the following equation.

$$EE_j = TE_j \cdot AE_j$$

Where,

TE_j = Farm specific technical efficiency of j^{th} farmer

AE_j = Allocative efficiency of all inputs on the j^{th} farm

Overall economic efficiency was computed using the following formula:

$$\text{Overall EE} = \frac{\bar{Y}}{\hat{Y}^*}$$

Where,

\bar{Y} = Average output

\hat{Y}^* = Output at the optimum level of all variable inputs

Results

IV. RESULTS

In consonance with the objectives of the study the data collected from primary and secondary sources were analysed and interpreted. The results of the present study are presented in this chapter under the following headings.

4.1 Compound growth rates of area, production and yield of sorghum

4.2 Instability in production

4.3 Economics of sorghum production

4.4 Technical efficiency

4.5 Allocative efficiency

4.6 Economic efficiency

4.1 COMPOUND GROWTH RATES OF AREA, PRODUCTION AND YIELD OF SORGHUM

Annual average compound growth rates of area, production and yield of sorghum were worked out for the selected districts of north Karnataka and for the state as a whole for the period 1961-62 to 1996-97. The districts included in the estimation of compound growth rates of area, production and yield were Belgaum, Dharwad, Bellary, Bijapur, Gulbarga, Raichur and Bidar. The growth rates were estimated separately for the two sub-periods, *viz.*, period I (1961-62 thru 1976-77), period II (1977-78 thru 1996-97) and the overall period. Table 4.1 presents the annual

district-wise average compound growth rates of area, production and yield of sorghum. During the overall period (1961-62 to 1996-97), sorghum production registered a significant modest growth of 0.73 per cent per year for the state as a whole. The rate of decline in area was 0.82 per cent per annum and statistically significant in the state. Period-wise analysis revealed that there was a sharp decline in area of sorghum (3.14% per annum) in period I for the state as a whole. This accelerated decline in area under sorghum was observed in all the districts of north Karnataka. However, the magnitude of decline was high in Gulbarga (-6.248%), Belgaum (-3.667%) and Raichur (-3.641%).

The growth rate of area under sorghum was more or less stagnant with a marginal increase of 0.13 per cent per annum which is statistically non-significant for the state as a whole in period II. The same trend was observed in all districts except Dharwad (-0.209%) and Bellary (-0.045%) which recorded negative growth rates. The positive and significant growth rate was noticed for Bijapur district (0.92%). With the lone exception of Bidar district, area declined marginally in other districts throughout the period under study (1961-62 to 1996-97).

The aggregate production of sorghum in period I increased at a compound growth rate of 1.23 per cent per annum, that is statistically not significant, due to spectacular increase in yield at the rate of 4.82 per cent per annum for the state as a whole which off-set a notable decline in area under the crop in the period. The districts Bellary and Bidar registered a fairly high growth rate in production while Belgaum and

Gulbarga districts performed dismally with respect to production growth in the period I.

The production of sorghum in period II showed a modest increase at the rate of 0.36 per cent per annum which is statistically not significant for the state which was better as compared to period I. Among the districts, significant growth rates were observed in Bijapur (3.422%), Belgaum (2.0623%) and Raichur (1.582%) where as a decline in production was noticed in Dharwad district. Other districts reported non-significant positive growth rates ranging from 0.11 in Bidar to 0.38 per cent per annum in Gulbarga.

Graphical representation of the annual compound growth rates of area, yield and production of sorghum at state level during the two sub-periods and the entire period is attempted in Figure 4.1. It can be seen that during the overall period, production of sorghum in the State increased by 0.73 per cent per annum which is statistically significant. District-wise analysis of the period indicated that except Gulbarga (-0.442%) rest of the districts recorded a positive significant growth rates. Among the districts highest growth was observed in Bidar (2.199%) followed by Raichur (1.657%), Bellary (1.302%), Dharwad (0.845%), Bijapur (0.753%) and Belgaum (0.698%).

The growth rate in per hectare production of sorghum was commendable at the rate of 4.82 per cent per annum which is statistically significant for the state as a whole in the first sub-period. Particularly,

Bellary and Bidar achieved relatively impressive yield growth rates of 6.39 and 6.37 per cent annum. The remaining districts reported moderate (1.05% per annum in Belgaum) to fairly high (4.61% per annum in Raichur) growth rates of yield in period I. The compound growth rates were statistically significant in all the districts with the exception of Belgaum and Bijapur.

The growth in yield slowed down to 0.22 per cent which is statistically non-significant in the second sub-period for the state. In all the districts except Belgaum and Bijapur the yield increment rate was lower as compared to period I whereas, Dharwad and Gulbarga performed dismally with respect to yield growth. The highest significant growth was observed in Bijapur district with the rate of 2.48 per cent per annum and, in Dharwad and Bidar the yield growth was almost stagnating over the period of analysis with the magnitude of -0.06 per cent and 0.08 per cent, respectively.

The yield of sorghum registered a modest statistically significant growth rate of 1.63 per cent per annum for the state during overall period. The compounded rate of growth among districts ranged between 0.99 per cent (Gulbarga) to 2.25 per cent per annum (Bellary).

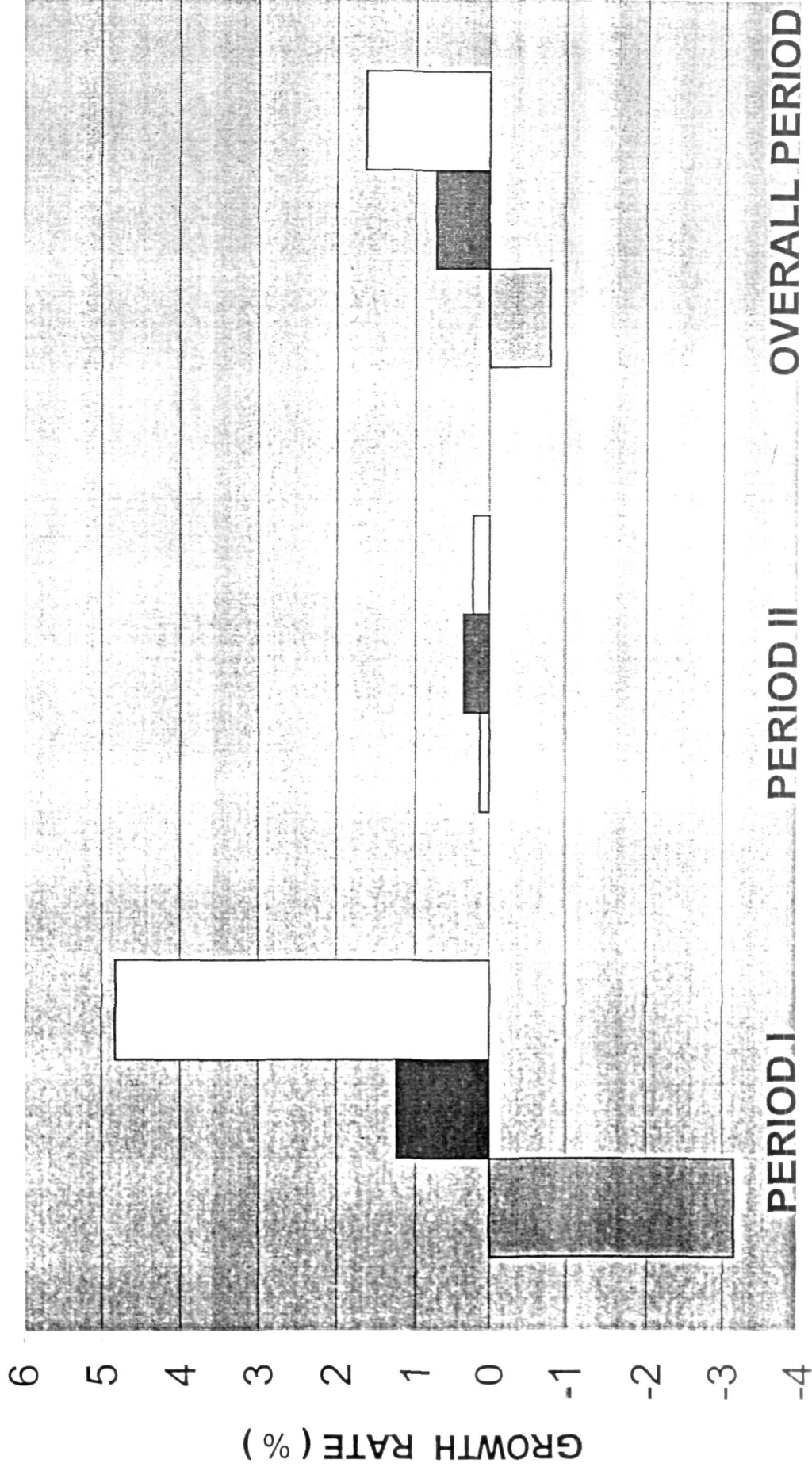
4.2 SOURCES OF INSTABILITY

The exact decomposition of the components of change in the mean and variance of production of sorghum is worked out using statistical identities to measure the magnitude of the sources of change in the

Table 4.1 District wise annual average compound growth rates of area, production and yield of sorghum in north Karnataka

Sl. No.	District	(Per cent)								
		Period I (1961-62 to 76-77)		Period II (1977-78 to 1996-97)		Overall period (1961-62 to 1996-97)				
		Area	Production	Yield	Area	Production	Yield	Area	Production	Yield
1.	Belgaum	-3.667***	-2.698*	1.055	0.850	2.063**	1.209**	-0.642**	0.698*	1.36***
2.	Dharwad	-1.448***	1.011	2.51*	-0.209	-0.28	-0.064	-0.304**	0.845**	1.167***
3.	Bellary	-2.532***	3.636**	6.386***	-0.045	0.23	0.282	-0.918***	1.302***	2.253***
4.	Bijapur	-2.892***	-0.963	2.034	0.925**	3.422***	2.480***	-0.834***	0.753*	1.615***
5.	Gulbarga	-6.248***	-3.435**	2.649*	0.38	0.38	-0.127	-1.483***	-0.442	0.99**
6.	Raichur	-3.641***	0.746	4.612***	0.476	1.582**	1.107**	-0.316	1.657***	1.996***
7.	Bidar	-2.123***	4.05**	6.368***	0.033	0.110	0.081	0.16	2.199***	2.122***
	Karnataka	-3.142***	1.233	4.824***	0.133	0.356	0.223	-0.821***	0.728***	1.627***

***, ** and * - denote significance at 1, 5 and 10 per cent level, respectively.



□ AREA ■ PRODUCTION □ YIELD

variability of production. The changes in production variances and mean production of the crop between the period 1977-78 to 1996-97 over the period 1961-62 to 1976-77 were decomposed using the methodology developed by Hazell (1982). The model has been detailed in chapter III.

4.2.1 Components of change in average production

The changes in the average production of sorghum between the periods were decomposed into their constituent parts *viz.*, the pure effects of change in mean yield and change in mean area, the effect of interaction between changes in mean area and mean yield and the change in covariance between area and yield by using Hazell's (1982) statistical procedure. The decomposition analysis was carried out and the percentage contribution of each component towards change in average production was estimated for each of major sorghum producing districts and for the State as a whole. Table 4.2 depicts the components of change in the mean production of sorghum across districts. The average output increased in the period II for the State as a whole and in all the districts except Bijapur and Gulbarga.

The increase in average production for the State as a whole was predominantly due to the change in mean yield which is around 365 per cent. The negative effect of change in mean area on the change in mean production was about 280 per cent. The effect of the change in covariance between area and yield was almost 30 per cent while the interaction effect had contributed negatively to the tune of 15 per cent. Similar trend was

observed in all the districts except Dharwad wherein the contribution of yield effect to change in mean production was negative (58%). While Bellary witnessed simultaneous positive effect of pure effect *viz.*, change in mean area and change in mean yield accounting for 99.6 per cent of the total change in average production of sorghum. The area and yield effects registered mutually opposite impact on change in average production in all districts barring the two mentioned districts. In Bijapur district the negative area effect was comparatively less (7.6%) and the highest negative area effect was observed in Belgaum.

Changes in mean yield accounted for 884.2 and 416.1 per cent of the increased total production in Belgaum and Gulbarga districts, respectively. The same component accounted for a substantial share in the districts of Raichur (167.1 per cent), Bijapur (111.1 per cent), and Bellary (75.8 per cent). The change in covariance between area and yield was found to be large in Bidar district (105.3 per cent) and negative in Belgaum, Bellary and Bijapur districts. The contribution of Bijapur district to the change in sorghum production at the state level was the highest (345.8 per cent) followed by the district of Bellary (56.53 per cent). All other districts turned out to be negative contributors to the change in sorghum production at the State level.

4.2.2 Components of change in the Variance of Production

The changes in variance of production of sorghum were decomposed into ten components using the analytical procedure

Table 4.2 District-wise components of change in average production of sorghum in Karnataka between 1961-62 to 1976-77 and 1977-78 to 1996-97

Sl. No.	Source of change /district	Change in mean yield $\Delta \bar{Y}$	Change in mean area $\Delta \bar{A}$	Interaction between change in mean area & mean yield $\Delta \bar{Y} \Delta \bar{A}$	Change in covariance between area & yield $\Delta \text{COV} (A, Y)$	Total change in average production	(Per cent)	
							Contribution of districts to the change in production	Contribution of districts to the change in production
1.	Belgaum	884.2	-829.4	-62.2	-92.5	-100 (23,650)	-8.66	
2.	Dharwad	-58.0	-46.4	3.9	0.6	-100 (43,123)	-151.98	
3.	Bellary	75.8	23.8	2.2	-1.8	100 (26,128)	56.53	
4.	Bijapur	111.1	-7.6	-2.9	-0.7	100 (-21,458)	345.80	
5.	Gulbarga	416.1	-518.9	-29.3	32.1	-100 (-13,868)	-21.30	
6.	Raichur	167.1	-257.7	-15.1	5.7	-100 (51,608)	-26.70	
7.	Bidar	20.5	-224.7	-1.1	105.3	-100 (39,767)	-7.23	
	Others	383.8	-362.4	-91.4	-30.0	-100 (11,258)	-33.03	
	State	364.7	-278.5	-15.0	28.8	100 (203,125)	100	

Figures in parenthesis indicate changes in average production (in tonnes) between sub-periods I and II

developed by Hazell (1982) as discussed in chapter 3. The results of the district – wise analysis of sources of change in the variance of production are presented in this subsection.

The sources of change in the production variance of sorghum between the sub-periods of the study is presented in Table 4.3. The change in the variance of sorghum production at the State level was the result of changes in area variance (-209 per cent), change in yield variance (109.1 per cent), change in mean area (-23.67%) and interaction between changes in mean yield and area variance (-23.19%). The change in yield variance and change in mean yield contributed to instability of sorghum production at the state level, accounting for 109.1 and 8.12 per cent, respectively. But change in area variance, change in mean area, interaction effect of mean yield and area variance and, interaction effect of mean area and yield variance contributed to stability of sorghum production in the State in order of 209.0, 23.67, 23.19 and 8.81 per cent, respectively. Among the districts, Gulbarga contributed most (81.56%) to instability of sorghum production in the state followed by Bijapur (15.47%). On the other hand, Belgaum district was the major contributor to stability of sorghum production with a magnitude of 24.21 per cent. It may be seen that the variance of production increased for the State as a whole and in four of the seven major sorghum sowing districts during the second sub-period.

Considering variability of production across districts, change in mean yield had a destabilising effect in the districts of Bijapur and

Belgaum while its effect was not significant or negative in the other districts. However, change in mean area stabilised the production in all the districts with lone exception of Bellary. Production of sorghum in the districts of Belgaum, Dharwad and Bellary experienced stability mainly due to change in yield variance which amounted to be -6.24, -3.82 and -5.3 per cent, respectively. Moreover, the same component was the most significant contributor to instability in the remaining districts of Gulbarga, Bijapur, Bidar and Raichur accounting for 84.88, 21.8, 4.69 and 4.5 per cent, respectively. The most important source of stability at the state level was change in area variance and the same was destabilising factor of sorghum production in Gulbarga (3.36 per cent) and to some extent in Bellary (0.29 per cent). In Belgaum, Dharwad and Bijapur it had relatively high destabilising effect to the tune of 6.95, 3.61 and 3.09 per cent, respectively. A closer look at the analysis of the component of change in the variance of production revealed that apart from the first four sources, the remaining covariance and interaction effect components did not have significant effect on the change in production variance across districts.

4.3 ECONOMICS OF SORGHUM PRODUCTION UNDER DIFFERENT TECHNOLOGIES

4.3.1 Inputs and output in sorghum production

The average input utilisation and output obtained under hybrid and traditional variety sorghum production are summarised in Table 4.4. The

Table 4.3 Analysis of the components of change in the variance of sorghum production (Period 1961-62/1976-77 thru 1977-78/1996-97)

Sl. No	Districts/ source of change	(Percentage)									
		Belguam	Dharwad	Bellary	Bijapur	Gulbarga	Raichur	Bidar	Others	State	
1.	Change in mean yield $\Delta \bar{Y}$	2.13	-0.93	0.05	6.01	-0.95	0.00	0.00	-0.75	8.12	
2.	Change in mean area $\Delta \bar{A}$	-2.69	-3.22	0.70	-1.24	-7.97	-2.27	-0.63	-19.61	-23.67	
3.	Change in yield variance $\Delta V(Y)$	-6.24	-3.82	-5.30	21.80	84.98	4.50	4.69	-1.68	109.10	
4.	Change in area variance $\Delta V(A)$	-6.95	-3.61	0.29	-3.09	3.36	-0.96	-0.08	1.39	-209.00	
5.	Interaction between changes in mean yield & mean area $\Delta \bar{Y}, \Delta \bar{A}$	-0.02	-0.03	-0.01	0.00	0.11	0.04	0.00	0.21	1.01	
6.	Change in area-yield co-variance $\Delta COV(Y, A)$	-0.01	0.00	-0.01	0.00	0.10	0.01	0.00	-0.13	1.43	
7.	Interaction between changes in mean area and yield variance $\Delta \bar{A}, \Delta V(Y)$	0.85	0.49	-0.31	-1.11	-11.56	-0.78	-0.51	0.70	-8.81	
8.	Interaction between changes in mean yield and area variance $\Delta \bar{Y}, \Delta V(A)$	-1.08	0.58	0.06	-2.79	0.39	-0.11	0.00	0.79	-23.19	
9.	Interaction between changes in area & yield and changes in area-yield covariance $\Delta \bar{Y} \Delta \bar{A} \Delta COV(Y, A)$	0.01	-0.16	-0.07	-1.05	-0.24	-0.05	-0.14	0.28	2.55	
10.	Change in residual ΔR	-10.19	1.10	-0.58	-3.06	13.34	1.44	2.77	-6.21	242.46	
	Total change in variance	-24.21	-9.60	-5.19	15.47	81.56	1.82	6.09	-25.00	100	

Note: 1. The figures in columns of each district are the contributions of each district to the state with respect to each component (source).

2. The total change in variance of all districts do not add up to 100 as inter district co-variance is not included.

average seed quantity used per hectare was 7.70 kg in case of hybrid while it was 6.90 kg for traditional varieties. District-wise analysis showed that hybrid variety farmers in Dharwad district used 7.41 kgs of sorghum seed per hectare. While it was 7.98 kgs per hectare in Bellary district and in case of traditional varieties the amount was 6.82 kg in Dharwad district which is slightly lower than that used by Bellary district farmers (6.98 kg/ha).

Chemical fertilizer application in hybrid sorghum (196.00 kg/ha) was found to be higher than the quantity applied in traditional variety of sorghum (134.00 kg/ha). The per hectare of fertilizer use for sorghum production in Dharwad district (186.00 kg) was found to be lower than that applied in Bellary district (206.00) for hybrids and it was 130.00 kg and 138.00 kg in Dharwad and Bellary districts, respectively for traditional varieties.

The average farm yard manure applied per hectare was found to be less in traditional varieties of sorghum (8.86 cartloads) than the quantity used for hybrid varieties of sorghum (15 cartloads). Sample farmers of Dharwad district applied 14.94 and 9.09 cartloads of FYM per hectare for hybrid and traditional varieties, respectively whereas the amount in Bellary was 15.06 cartloads for hybrids and 8.64 cartloads in case of traditional varieties.

On an average human labour employed for cultivation of sorghum was estimated to be around 61 mandays per hectare in hybrid sorghum

farms and 58 mandays in the case of traditional sorghum farms. Human labour use computed at 63.42 and 61.67 mandays per hectare per hybrids and traditional varieties, respectively in Dharwad district was higher compared to Bellary district which was 58.98 and 54.27 mandays per hectare in hybrid and traditional varieties, respectively.

Per hectare average number of bullock pair days used were 87.70 and 79.94 in hybrid and traditional sorghum production, respectively. Bullock labour used for production of hybrid sorghum in Dharwad and Bellary districts was in order of 89.86 and 85.49 pair days per hectare, respectively while it was 76.62 and 83.27 pair days in the former and latter districts, respectively in case of traditional varieties.

The per hectare average yield realised by hybrid sorghum farmers was 22.62 quintals and that of growers of traditional varieties was about 13.69 quintals. Sample farmers of Dharwad district realized 22.52 quintals from hybrid seeds and 13.42 quintals from traditional varieties while in Bellary, the amount was 22.70 quintals for hybrids and 13.96 quintals for traditional varieties.

The amount of byproduct from traditional sorghum varieties was substantially higher than that of hybrids. The quantity of byproduct obtained from hybrid varieties was 7.60 cartloads per hectare whereas the amount recorded to be as much as 11.09 cartloads in case of traditional variety of sorghum.

Table 4.4 Inputs and outputs in sorghum production (rainfed)

Particulars	Hybrid			Traditional			Overall
	Dharwad district	Bellary district	Average	Dharwad district	Bellary district	Average	
I. Inputs							
1. Seed (kg)	7.41	7.98	7.70	6.82	6.98	6.90	7.30
2. Chemical fertilizer (kg)							
N	108	128	118	75	83	79	98.5
P	59	65	62	38	44	41	51.5
K	19	13	16	17	11	14	15.0
Total	186.00	206.00	196.00	130.00	138.00	134.00	165.00
3. Human labour (mandays)	63.42	58.98	61.20	61.67	54.27	57.97	59.58
4. Bullock labour (pair days)	89.86	85.49	87.70	76.62	83.27	79.94	83.82
5. Farmyard manure (cartloads)	14.94	15.06	15.00	9.09	8.64	8.86	11.93
II. Output							
Main product (quintals)	22.55	22.70	22.62	13.42	13.96	13.69	18.16
Byproduct (cartloads)	8.97	6.23	7.60	10.54	11.64	11.09	9.34

4.3.2 Costs and returns of hybrid and traditional sorghum production

The cost and returns of rainfed sorghum production are presented in Table 4.5 and 4.6.

The variable costs per hectare amounts to be Rs. 6761.85 in case of hybrids while, it was Rs.5941.46 for traditional ones. Variable costs constitute 67.33 per cent of total cost of hybrid sorghum production where as it accounted for 64.36 per cent of total costs in traditional sorghum varieties. District-wise analysis showed that the variable costs per hectare amounted to Rs.7158.23 and Rs.6365.48 in Dharwad and Bellary districts, respectively in case of hybrids while it was Rs.6009.06 in the former and Rs.5873.86 in the later for traditional varieties.

Human labour was found to be the major item of variable cost under both technology groups which formed 33.97 and 36.22 per cent for hybrids and traditional varieties, respectively. This cost component had a share of 22.87 per cent out of total cost of production in the former group while in the latter case the share was 23.31 per cent. Costs of bullock labour, fertilizer and farmyard manure were the next major cost items of total variable cost under hybrid as well as traditional system of production contributing 22.17, 18.73 and 7.55 per cent, respectively in hybrid system and 24.42, 15.78 and 8.74 per cent, respectively in traditional technology. Under hybrid sorghum production, the share of bullock labour and fertilizer in the total cost was to the tune of 14.93 and 12.61 per cent, respectively. While cost of bullock labour formed 15.72

per cent of total cost followed by fertilizer cost (10.16 per cent) in traditional case.

Per hectare fixed cost was estimated to be Rs.3,281.05 for hybrid sorghum and Rs.3,289.42 for traditional sorghum which constituted 32.67 and 35.64 per cent of total cost of cultivation, respectively. Fixed cost per hectare was Rs.3,531.00 and Rs.3,031.09 in Dharwad and Bellary districts, respectively for hybrids while it was Rs.3,416.54 in Dharwad and Rs.3,162.29 in Bellary district in case of traditional varieties.

Rental value of land forms the major item of fixed costs (73.37 per cent) and its share was to the tune of 25.28 per cent in total cost of cultivation of hybrid sorghum. Moreover its share was in order of 75.08 per cent among fixed cost items and 26.76 per cent out of total cost of cultivation in case of traditional system which makes it the most important cost item.

The total cost of cultivation of hybrid sorghum was worked out to be Rs.10,042.90 per hectare and that of traditional variety was 9,230.80 per hectare. In Dharwad district, the cost of cultivation for hybrid and traditional sorghum varieties was computed at Rs.10,689.23 and Rs.9,425.60, respectively while it was Rs.9,396.57 for hybrid and Rs.9,036.15 for traditional varieties in Bellary district.

The cost of production per quintal of sorghum worked out to Rs. 443.99 for hybrids, while for traditional varieties it was Rs. 674.28

and for the entire sample the cost of production per quintal of output was Rs. 559.13. Thus the various costs incurred to produce a quintal of sorghum were lower in case of hybrid growing farmers, mainly because of the higher output obtained from hybrids than traditional varieties.

Analysis of the net return per quintal of sorghum revealed that the net return from a quintal of hybrid sorghum at Rs. 231.49 was lower than that of traditional varieties at Rs. 281. This can be readily ascertained by looking in to the differences of per quintal prices between hybrid and traditional varieties which is to a great extent in favour of traditional varieties.

Gross returns per hectare of sorghum production worked out to be Rs.15,278.83 for hybrid sorghum and Rs.13,077.89 in case of traditional sorghum varieties. In case of hybrids, the gross return was Rs.15,35.34 in Bellary districts which was higher than that of Dharwad districts (Rs.15,203.32) while it was Rs.13,235.93 in Bellary and Rs.12,919.86 in Dharwad district for traditional sorghum varieties.

The returns over variable costs was higher in case of hybrid sorghum (Rs.8,516.98) compared to traditional sorghum (Rs.7,136.43). The net return of hybrids computed at Rs.5,235.93 was also better than traditional once at Rs. 3,847.01. The net return per hectare in Bellary district (Rs.4,199.74) was higher than that of Dharwad district (Rs.3,494.28) for traditional varieties and same were true regarding hybrids where in the return in Bellary was Rs.5,957.76 while it amounted to Rs.4,514.10 in Dharwad district.

The net returns per quintal was higher in case of traditional variety of sorghum (Rs.281.00) compared to hybrid sorghum (Rs.231.47). However, the net returns per rupee of investment was estimated to be higher in case of hybrid (Rs.0.53) than traditional sorghum production (Rs.0.42).

4.4 TECHNICAL EFFICIENCY OF SORGHUM PRODUCTION

An attempt has been made to study the technical efficiency of hybrid and traditional variety sorghum farms along with the productivity of resources used in the production of the crop by using the Cobb-Douglas functional form. The analysis was done by fitting separate stochastic frontiers for each group using maximum likelihood procedure. The maximum likelihood estimates for the parameters of the Cobb-Douglas stochastic frontier production functions for the farmers growing hybrids and traditional varieties are given in Table 4.7 and 4.8 respectively. For comparison, the ordinary least square (OLS) estimates which show the average performance of the sample farmers are presented in the same table (4.7 & 4.8). With the adjusted coefficient of multiple determination (R^2) value of 0.917 for hybrid farms and 0.899 for traditional variety farms, the inputs used in the model were able to explain 91.7 and 89.9 per cent of the variation in sorghum production, respectively.

The coefficients of land in the stochastic frontier model for both groups of farmers are estimated to be positive but statistically

Table 4.5 Costs and returns of hybrid sorghum production in north Karnataka

Particulars	(Rs/ha)			% to the total cost (overall)
	Dharwad district	Bellary district	Overall	
I. Variable costs				
1. Seed	326.38	377.18	351.78	3.50
2. Chemical fertilizer	1315.52	1217.92	1266.72	12.61
3. Human labour	2369.85	2224.19	2297.02	22.87
4. Bullock labour	1576.51	1422.08	1499.29	14.93
5. Farm yard manure	553.25	468.52	510.88	5.09
6. Plant protection chemicals	398.68	271.90	335.29	3.34
7. Repairs, maintenance & miscellaneous expenses	118.63	55.97	87.30	0.87
8. Interest on working capital	499.41	327.72	413.57	4.12
Total (Variable) cost	7158.23	6365.48	6761.85	67.33
II. Fixed costs				
1. Depreciation	754.84	286.40	520.62	5.18
2. Rental value of land	2608.02	2469.14	2538.58	25.28
3. Interest on fixed capital	168.14	275.55	221.85	2.21
Total (fixed) cost	3581.00	3031.09	3281.05	32.67
Total (fixed and variable) cost	10689.23	936.57	10042.90	100.00
Cost of production (Rs/qt)	474.02	413.95	443.99	
Returns				
1. Gross returns	15203.32	15354.34	15278.83	
2. Returns over variable costs	8045.11	8988.85	8516.98	
3. Net return over total cost	4514.10	5957.76	5235.93	
4. Net return per rupee of investment	0.42	0.63	0.53	
5. Net return per quintal	200.48	262.46	231.47	
Price per quintal (Rs.)	545.50	581.76	563.63	

Table 4.6 Costs and returns of traditional sorghum production in north Karnataka

Particulars	(Rs/ha)			
	Dharwad district	Bellary district	Overall	% to the total cost (Overall)
I. Variable costs				
1. Seed	222.68	147.58	185.13	2.01
2. Chemical fertilizer	823.83	1051.17	937.50	10.16
3. Human labour	2248.81	2055.10	2151.95	23.31
4. Bullock labour	1421.56	1480.66	1451.11	15.72
5. Farm yard manure	531.75	506.48	519.12	5.62
6. Plant protection chemicals	286.65	258.70	272.67	2.95
7. Repairs, maintenance & miscellaneous expenses	54.54	71.90	63.22	0.68
8. Interest on working capital	419.24	302.27	360.75	3.91
Total (Variable) cost	6009.06	5873.86	5941.46	64.36
II. Fixed costs				
1. Depreciation	860.01	329.12	594.56	6.44
2. Rental value of land	2393.84	2545.69	2469.77	26.76
3. Interest on fixed capital	162.69	287.48	225.09	2.44
Total (fixed) cost	3416.54	3162.29	3289.42	35.64
Total (fixed and variable) cost	9425.60	9036.15	9230.88	100.00
Cost of production (Rs/qt)	701.35	647.20	674.28	
Returns				
1. Gross returns	12919.86	13235.93	13077.89	
2. Returns over variable costs	6910.80	7362.06	7136.43	
3. Net return over total cost	3494.28	4199.74	3847.01	
4. Net return per rupee of investment	0.37	0.46	0.42	
5. Net return per quintal	260.33	301.62	281.00	
Price per quintal (Rs.)	782.75	802.73	792.74	

insignificant in case of traditional varieties. The coefficient of regression for land was 0.581 in case of hybrids (Table 4.7) while the elasticity coefficient for traditional variety farms was 0.496 (Table 4.8).

In case of seed, the elasticity coefficient for hybrid farms was positive (0.075) but it was negative (-0.169) in case of traditional variety farms which however, both were statistically insignificant.

The estimated output elasticity of farmyard manure (FYM) in the sampled hybrid was very small (0.089) but it was statistically significant, where as it was estimated at 0.232 which is statistically not significant in the traditional varieties group.

The contribution of fertilizers to output in both groups was positive to the extent of 0.243 in hybrid farms and 0.092 in traditional variety farms. However, the coefficient of fertilizer was found to be statistically significant in the former case.

The coefficient of human labour in the function was positive for hybrid (0.107) as well as traditional variety (0.870) farms, in fact statistically not significant for hybrid group.

It could be observed from Table 4.7 and 4.8 that bullock labour had negative sign which was unexpected but statistically insignificant in both categories of farms with the amount of 0.029 for hybrids and 0.177 for traditional varieties. This was due to the fact that in many of the farms own bullocks, for which the farmers pays no hiring charge, were available.

Hence, given the minimal opportunity cost of own bullocks, it is likely that animal power could be over used.

Generally, the estimated coefficients of the function using maximum likelihood method were all positive barring bullock labour for hybrid farms. However, seed and bullock labour had negative coefficients in case of traditional variety farms. The sum of elasticity coefficients for hybrid and traditional variety farms were computed to 1.066 and 1.344, respectively. This indicated that there existed nearly constant returns to scale in the former case while increasing returns to scale was seen in the later.

A particularly significant feature of the empirical results was the large value of the variance ratio, γ , which is the ratio of the variance of farm-specific technical efficiency to the total variance of output, was 0.85. This would mean that 85 per cent of the variation in output among the farms is due to the difference in technical efficiency. The γ -parameter associated with the variance of the technical inefficiency effects in the stochastic frontiers of traditional variety farms was estimated to be 0.79.

These results were interesting which indicate that the technical inefficiency effects are a significant component of the total variability of sorghum outputs for both groups of farmers. This implies that the variation of a firms yield from maximum feasible yield arises not from any chance factor, but mainly from divergence from best practices and techniques.

It is evident from the Table 4.7 and 4.8 that the variance estimates of composed error (ε), σ^2 , for hybrid and traditional varieties category were 0.124 and 0.187, respectively, out of which the major part i.e., the variance of one sided asymmetric error related to technical inefficiencies (u) was 0.105 in the former while it was 0.148 in the later case. The remaining error component in the model which is symmetric (V) was 0.019 for hybrid and 0.039 for traditional variety group. The standard error for the composed error term for farms growing hybrid and traditional varieties were 0.352 and 0.432, respectively.

Table 4.9 presents the frequency distribution of the predicted technical efficiencies for hybrid and traditional variety farms. The technical efficiencies of the sample sorghum farmers of both groups were less than one. The predicted technical efficiencies for hybrid category range from 0.453 to almost 1.000, with the mean technical efficiency estimated to be 0.774. For the farmers growing traditional varieties, the technical efficiencies ranged from 0.356 to 0.997, with mean technical efficiency of 0.726. These estimates indicate that, on average, hybrid sorghum growing farmers have higher technical efficiency than those cultivating traditional varieties, relative to their respective frontiers associated with the different technologies.

Table 4.9 shows the frequency distribution of farm specific technical efficiency levels for hybrid and traditional variety farms. The frequency distribution of the farm specific technical efficiency segregated into the two groups shows that 65 per cent of hybrid group is clustered

above 70 per cent technical efficiency level where as 55 per cent of farmers of traditional variety group were operating above 70 per cent technical efficiency level. Relatively more number of farmers fall in this group. On the other hand, 20 per cent of hybrid group farmers attained less than 50 per cent technical efficiency contrary to the relatively higher number (27.5%) of traditional group farmers below 50 per cent level of technical efficiency. There was a wide variation in technical efficiency across the sampled farms in each group from three farmers in the range of 40-50 per cent efficiency level to eleven farmers in 90-100 efficiency range in the case of hybrids. The distribution of traditional variety farms was from 1 farmer in 30-40 range of efficiency to ten farmers in 90-100 technical efficiency range. Farms operating below 50 per cent technical efficiency in hybrid and traditional groups were 7.5 and 12.5 per cent, respectively.

4.5 ALLOCATIVE EFFICIENCY IN PRODUCTION OF SORGHUM

This part of the study examines allocative efficiency level of the sorghum growing farmers in North Karnataka. In order to study the efficiency in the allocation of various resources, the marginal value product of each input was equated to the respective marginal factor cost using the coefficients of OLS estimates in the deterministic frontier model. The analysis distinguishes allocative efficiency of farms according to the technologies (variety category) used. Equality of marginal value product (MVP) to factor cost ratio indicates the optimum resource use efficiency of a particular input, as maximum efficiency of resource or input occurs

Table 4.7 Output elasticities in average production functions and stochastic production frontiers using Cobb-Douglas production function for hybrid sorghum production in north Karnataka

Variable	Average (OLS)	Stochastic frontier (MLE)
B ₀ (Constant)	3.838 ^a (1.146)	4.726 ^b (0.743)
B ₁ (Land)	0.496 (0.345)	0.581 ^a (0.412)
B ₂ (Seed)	0.0495 (0.208)	0.0746 (0.293)
B ₃ (FYM)	0.114 ^c (0.06)	0.089 (0.082)
B ₄ (Fertilizer)	0.132 (0.102)	0.243 ^b (0.109)
B ₅ (Human labour)	0.245 (0.176)	0.107 (0.251)
B ₆ (Bullock labour)	-0.049 (0.176)	-0.029 (0.195)
∑b _i (Returns to scale)	1.085	1.066
Adjusted R ²	0.917	
γ		0.85
$\sigma = \sqrt{\sigma_u^2 + \sigma_v^2}$		0.352
σ_v^2		0.019
σ_u^2		0.105
σ^2		0.124
Log likelihood		0.123
N = 40		

Note: the estimated standard errors of the coefficient estimators are given in parentheses below the estimates, correct to three significant digits

^a Significant at 1 per cent level

^b Significant at 5 per cent level

^c Significant at 10 per cent level

Table 4.8 Output elasticities in average production function and stochastic frontier production functions using Cobb-Douglas production function for traditional sorghum production in north Karnataka

Variable	Average (OLS)	Stochastic frontier (MLE)
B ₀ (Constant)	0.165 (0.886)	0.358 (1.652)
B ₁ (Land)	0.390 (0.463)	0.496 (1.201)
B ₂ (Seed)	-0.304 (0.366)	-0.169 (0.779)
B ₃ (FYM)	0.242 ^c (0.127)	0.232 (0.184)
B ₄ (Fertilizer)	0.123 (0.076)	0.092 (0.064)
B ₅ (Human labour)	0.846 ^a (0.187)	0.870 ^a (0.111)
B ₆ (Bullock labour)	-0.082 (0.162)	-0.177 (0.401)
∑b _i (Returns to scale)	1.215	1.344
Adjusted R ²	0.899	
γ		0.79
$\sigma = \sqrt{\sigma_u^2 + \sigma_v^2}$		0.432
σ_v^2		0.039
σ_u^2		0.148
σ^2		0.187
Log likelihood		0.817
N = 40		

Note: The numbers in parentheses represent standard error of the coefficients

^a Significant at 1 per cent level

^b Significant at 5 per cent level

^c Significant at 10 per cent level

Table 4.9 Frequency distribution of Farm-specific Technical Efficiencies of sorghum farms in north Karnataka using stochastic frontiers

Technical efficiency level (%)	Number of farms	
	Hybrid N=40	Traditional N=40
90-100	11 (27.5)	10 (25)
80-90	10 (25)	7 (17.5)
70-80	5 (12.5)	5 (12.5)
60-70	6 (15)	7 (17.5)
50-60	5 (12.5)	6 (15)
40-50	3 (7.5)	4 (10)
30-40	0 (0)	1 (2.5)
Average TE	0.774	0.726

Figures in parentheses are percentage values

when the returns from the additional unit of input equals the cost of that additional input. Deviation if any, indicates the resource use inefficiency. The MVPs, factor costs and their ratios of different input variables for hybrid sorghum farms are presented in Table 4.10.

The result of the marginal productivity analysis shows that the Marginal Value Product to Marginal Factor Cost ratios of land, seed, farmyard manure, fertilizer and human labour was substantially greater than unity, which indicates the under use of these resources by hybrid cultivating farmers. The ratios were 2.533, 2.319, 3.520 and 1.621 for land, seed, farmyard manure and fertilizer, respectively implying scope to realize additional returns to every rupee spent on these factors over and above the geometric mean levels of use of the respective inputs. Returns can be increased by increasing the use of land, seed, FYM and fertilizer in the production of hybrid sorghum.

In case of bullock labour the marginal value product to opportunity cost ratio was negative (-0.496) indicating excess use of this factor which suggests that the over utilization was to the extent that any additional rupee spent on it would result in a loss of about Rs.0.50. Hence, bullock labour should be reduced till it reaches the optimum economic level (when the ratio is equal to one) to derive higher gross returns in the cultivation of hybrid sorghum.

Generally, high degree of resource use inefficiency can be observed from the same table. Higher gross returns can be accrued by investing

much on seed and using more of land, FYM, fertilizer and human labour and by curtailing the expenditure on bullock labour.

Marginal value product to marginal factor cost ratios of inputs for traditional variety sorghum farms are presented in Table 4.11. As can be seen from the table the MVP to MFC ratios for land, farm yard manure, fertilizer and human labour were positive and greater than unity while the ratios were negative for seed and bullock labour. The use of FYM, human labour and fertilizer were sub optimal as recorded high and positive profitability ratios to the extent of 5.684, 3.446 and 1.365 respectively. This indicate the possibilities of increasing returns by using additional units of these under utilized resource. In the case of land the ratio was 1.163 indicating that land was relatively profitably used which is close to optimum.

It is intriguing to observe that seed was excessively used to a great extent by the traditional variety growing farmers as reflected by high and negative MVP to factor cost ratio (-18.046). Hence, the expenditure on seed has to be rationalised. The MVP to MFC ratio for bullock labour was negative (-0.514) indicating its excess usage by farmers cultivating traditional varieties of sorghum.

Table 4.12 reveals that the existing per hectare level of use of seed, FYM, Fertilizer and human labour in hybrid farms were 64.48, 52.05, 96.17 and 95.79 per cent of the optimum use of these resources. In case of traditional varieties the proportion of existing level of use of FYM,

fertilizer and human labour to the optimum were 20.11, 95.82 and 32.25 per cent, respectively.

Thus the results reveal that both hybrid as well as traditional variety farms under utilized all resources in the production of sorghum with the exception of bullock labour in both categories and seed in the traditional farms, which were used excessively.

Table 4.12 shows the per hectare summary of actual (at arithmetic mean) and optimum level of input use for hybrid and traditional sorghum variety farms. In case of hybrids, seed, FYM, chemical fertilizer and human labour were under utilized to the extent of 35.5, 47.9, 3.8 and 4.2 per cent, respectively, while bullock labour was over utilized. For traditional varieties the magnitude of under utilization of FYM, chemical fertilizer and human labour was recorded to be 79.9, 4.2 and 67.7 per cent, respectively while seed and bullock labour were over utilized.

The deterministic frontier production function was used to compute the maximum (frontier) output and estimate the output at optimum level of use of all inputs.

Table 4.13 reveals that farmers of hybrid sorghum were allocatively efficient to the tune of 67.48 per cent on average which is far better than the 24.13 per cent overall allocative efficiency of traditional variety growing farmers. The actual yield realized by farmers growing hybrid and traditional varieties were 20.53 and 8.92 quintals per farm, respectively while the maximum possible output per farm was 31.43 quintals in the

Table 4.10 Allocative efficiency of hybrid sorghum farms in north Karnataka

(per farm)

Inputs	Actual level of use at Geometric mean	Elasticity of output (OLS)	MVP (Rs.)	MFC (Rs.)	MVP/MFC	Optimum input level	Amount of under utilization (%)
Land (ha.)	0.75456	0.496	7133.601	2816.04	2.533	1.10	32
Seed (kg)	5.66138	0.0495	94.886	40.91	2.319	13.131	57
FYM (cartload)	9.00728	0.114	137.351	39.02	3.520	31.706	71
Fertilizer (kg)	138.2469	0.132	10.362	6.39	1.621	224.178	38
Human labour (mandays)	44.87679	0.245	59.247	37.83	1.566	70.283	36
Bullock labour (pair days)	8.08096	-0.049	-65.804	132.64	-0.496	*	

* The optimum level of use of bullock labour couldn't be worked out as the parameter carries negative sign

Table 4.11 Allocative efficiency of traditional variety sorghum farms in north Karnataka

(per farm)

Inputs	Actual level of use at Geometric mean	Elasticity of output (OLS)	MVP (Rs.)	MFC (Rs.)	MVP/MFC	Optimum input level	Amount of under utilization (%)
Land (ha.)	1.1364	0.390	3385.427	2910.00	1.163	1.322	15
Seed (kg)	7.7654	-0.304	-386.180	21.40	-18.046	*	
FYM (cartload)	9.3708	0.242	254.752	44.78	5.689	53.310	32
Fertilizer (kg)	123.9482	0.123	9.789	7.17	1.365	169.225	27
Human labour (mandays)	63.1197	0.846	132.216	38.37	3.446	217.50	71
Bullock labour (pair days)	10.9441	-0.082	-73.912	143.77	-0.514	*	

* The optimum level of use of seed and bullock labour couldn't be worked out as their coefficients carry negative sign

Table 4.12 Actual and optimum level of inputs of sorghum farms in north Karnataka

Per hectare

Inputs	Hybrid		Traditional	
	Actual	Optimum	Actual	Optimum
Seed (kg)	7.70	11.94	6.91	*
FYM (cartload)	15.00	28.82	3.86	44.06
Fertilizer (kg)	196.00	203.80	134.00	139.85
Human labour (mandays)	61.20	63.89	57.97	179.75
Bullock labour (pair days)	87.70	*	79.94	*

* The optimum level of use of seed in case of traditional variety and that of bullock labour in both categories couldn't be worked out as their coefficients carry negative sign.

former and 12.52 quintals in the later case. The per farm potential output with the optimum allocation of resources used were worked out to about 57 quintals in traditional variety farms whereas this potential output was less than 47 quintals per farm for hybrid farms.

4.6 ECONOMIC EFFICIENCY OF SORGHUM PRODUCTION

Overall economic efficiency is the ratio of average actual output to output at the optimum level of all variable inputs. It is the product of technical and allocative efficiencies of each farm.

Technical efficiency is defined as the ratio of a farmers actual output to technically maximum possible output at the given level of resources. Overall allocative efficiency is expressed as the ratio of technically maximum possible output at the farmers level of resource use to the output obtainable at the optimum level of resource use, determined at the point where marginal value product (MVP) is equated to marginal factor cost (MFC) for each resource under consideration.

Overall technical, allocative and economic efficiencies were computed using the Cobb-Douglas type of production function. The allocative efficiency has been determined taking in to consideration the under use of resources on the different categories of farms and bringing them up to their optimum level of use. However, those resources which were over used have been pegged to average level of use as the rational level of use of these resources cannot be determined from the function, as their coefficients and MVP to MFC ratios carry negative signs, to this

extent the estimated allocative efficiency is understated. Table 4.13 shows the results of overall technical, allocative and economic efficiencies.

As discussed earlier the geometric means of bullock labour in both hybrid and traditional variety farms and seed in case of traditional group were taken as optimum amount due to the fact that the negative sign they carried made impossible to workout the rational level of use of these resources.

The results of frontier production revealed that the overall allocative efficiency show in Table 4.13, were to the tune of 67.48 per cent in hybrid cultivating farmers and 24.13 per cent in traditional variety farms. The relative (i.e., percentage) difference in allocative efficiency was substantially greater than the technical efficiency.

Farmers under hybrid category has achieved an overall economic efficiency of 52.24 per cent while relatively lower level of (17.51%) economic efficiency was attained by those under traditional category. Not surprisingly the greatest difference is exhibited in economic efficiency, since it is calculated as the product of technical and allocative efficiency. The average losses of output due to technical in-efficiencies in hybrid and traditional variety farms were 22.60 and 27.44 per cent, respectively. The estimated percentage loss of total farm output arising from inefficiency in allocation of resources amounted to 75.87 per cent in case of traditional variety farms. The result indicated that the hybrid farms were far better off in terms of loss due to allocative inefficiency which worked out to be only 32.52 per cent.

Potential sorghum production for hybrid seed using farms was 46.61 at the optimum level of all available resources, which could be obtained by reallocating them where as this output at optimum level of use of resources at the disposal of farmers was computed at 51.88 quintals. The frontier output of best practice farmer was 31.45 quintals in case of hybrid farms. However, the maximum output among traditional variety farms was 12.52 quintals per farm. The estimated actual output of sorghum between the two groups has shown a wide gap in which hybrid farms recorded 20.53 quintals in contrast to the 8.92 quintals output of traditional variety farms.

Table 4.13 Efficiency coefficients of hybrid and local variety sorghum

Particulars	Hybrid	Traditional
Technical efficiency (%) (overall)	77.42	72.56
Allocative efficiency (%) (overall)	67.48	24.13
Economic efficiency (%) (overall)	52.24	17.5
Average loss due to technical in efficiency (%)	22.6	27.44
Average loss due to allocative in efficiency (%)	32.52	75.87
Actual output (quintals)*	20.53	8.92
Frontier output (quintals)	31.45	12.52
Optimum output (quintals)	46.61	51.88**

* - The actual output was computed at geometric mean of inputs using Cobb-Douglas production function

** - The optimum output of traditional variety farms was exaggerated as the actual input use of seed and bullock labour are taken as optimum levels.

Discussion

V. DISCUSSION

A critical discussion of the results presented in the previous chapter is attempted in this chapter. The discussions are made under the following broad headings.

5.1 Compound growth rates of area, production and yield of sorghum

5.2 Instability in production of sorghum

5.3 Economics of sorghum production

5.4 Resource productivity

5.5 Technical efficiency

5.6 Resource use efficiency

5.7 Allocative and economic efficiency

5.1 COMPOUND GROWTH RATES OF AREA, PRODUCTION AND YIELD OF SORGHUM

In this section, the growth of area, production and yield of sorghum in Karnataka state is examined at both state and district levels for two sub-periods *viz.*, 1961-62 to 1976-77 and 1977-78 to 1996-97.

Karnataka is the second major sorghum growing State in India, placing Maharashtra state in the first place. During 1995-96, the state accounted for 17.5 per cent of total all-India acreage of sorghum and contributed 17.6 per cent to national production. Sorghum is a major

crop of the State occupying about 36 per cent of the total food grains output. Hence, the economy of the State, particularly of the rural area is greatly influenced by the production of sorghum.

The result presented in Table 4.1 revealed that during the over all period under consideration (1961-62 to 1996-97), sorghum production in the state grew at an annual rate of 0.73 per cent which was due to the higher growth in the yield (1.63%) as the growth rate in area was found to be negative (-0.82%). Similar results were reported by Expert committee on stagnation of agricultural productivity (ECOSAP) in Karnataka (Anon., 1993) and Nachappa (1993) for seventies and eighties.

The growth rate of production of sorghum was less than the population growth rate. The deceleration of growth in the sorghum area in the over all period as well as in Period I was due to diversion of area under sorghum to better remunerative crops like oil seeds (mainly groundnut), horticulture crops and to some extent to pulses. Moreover, in areas where irrigation was introduced, the crop was replaced by sugarcane, cotton and other commercial crops including horticulture enterprises.

The greatest incentive to the farmers in the selection of production of crops is the relative benefit-cost ratio of production of different crops. As per the farm management studies conducted by the Department of Agriculture, the ratio of farm harvest price to the cost of production has been quite low at 0.98 for *kharif* and 1.41 for *rabi* sorghum in 1989-90. Trends in earlier years from 1980-81 to 85-86 were not much different.

These ratios were in favour of competing crops. The prices offered for sorghum were quite low compared to its competing crops thereby it made the farmers to look for other lucrative alternatives.

Decrease in consumption of sorghum by the farm households led to decline in the competitiveness of sorghum. Thus change in tastes and preferences of the farm households is yet another important factor for the declining trend in sorghum area in the State.

In Period-I, the state has witnessed a spectacular growth rate in yield of sorghum which off-set the slumped growth in area. This was mainly because of release of hybrids, during 1965-66 whose yields were substantially higher than the traditional varieties. This result was corroborated by Tejappa (1980) for the period from 1955-56 to 1976-77 and Nachappa (1995) for the seventies. The major reason for observing steep increase in productivity of the crop would be besides the release of hybrids of sorghum which caused a breakthrough in the availability of genetic material for cultivation during early 1960s and 70s, but also improvement in production technology and use of high dose of fertilizers by the farmers. This led to a satisfactory increase in production of sorghum by 4.82 per cent per annum in the period from 1961-62 to 1976-77.

The growth in yield of sorghum during period II was modest owing to the fact that the area of sorghum has been shifted to marginal lands due to the competition of high value crops and the deteriorating potential

of hybrids which are location specific and susceptible for pests and diseases. The area under sorghum also remained more or less stagnant with only a marginal increase of 0.13 per cent per annum. Thus, low growth rates in area as well as yield together resulted in the low growth rate of sorghum production during Period-II.

In later years *rabi* sorghum has gained in importance although its productivity is lower compared to *kharif* sorghum, with both traditional variety and hybrids expanding in area as it fetches comparatively higher prices due to higher preferences by consumers because of its better quality. This could be another reason for overall stagnation of yield of sorghum in the state.

In addition to the factors mentioned earlier low performance of sorghum production could be explained in terms of its non-access under Public Distribution System (PDS) where rice and wheat were sold at subsidized rates which influenced the consumption pattern of the rural households due to the advantage of superior taste at a cheaper price of the PDS commodities.

5.2 INSTABILITY IN PRODUCTION OF SORGHUM

Agriculture is inherently unstable and more so in a state like Karnataka where hardly 21 per cent of the net sown area is irrigated and remaining 79 per cent depends on monsoon (1996-97). During the Green

revolution period there was a tremendous growth in food grain production in the country but also accompanied by a more than proportionate increase in instability. As Sen (1967) observed, planning for minimisation of instability in agricultural production is as important as planning for its increased rate of growth.

In this study, an attempt has been made to examine the extent and sources of instability in sorghum production in Karnataka between two sub-periods, i.e. 1961-62 to 1976-77 and 1977-78 to 1996-97.

5.2.1 Components of change in average production

This section examines the sources of instability by decomposing the changes in average production between the sub-periods.

Absolute average production of sorghum has shown an increasing trend during period II over period I at the State level as well as all major sorghum producing districts with the exception of Bijapur and Gulbarga.

The decomposition of instability in the sorghum production showed that the major components of change in the average production in the state were changes in mean yield (+364.7%) and mean area (-278.5%) (Table 4.2). The negative impact of the latter partially offset the positive contribution of the former. The same trend was observed in Belgaum and Bijapur districts. The contribution of both components turned out to be negative in Dharwad district in contrast to Bellary district where

their impact was positive to the change in average production. In the districts of Gulbarga, Raichur and Bidar, the negative impact of change in mean area was more than the positive impact of change in mean yield.

The interaction effect was generally low and negative across the districts and at state level, barring Dharwad and Bellary districts with positive but negligible amount. The contributions of the covariance terms were relatively small with positive contribution for the state as a whole. However, it was exceptionally higher for Bidar district (105.3%).

The detailed district-wise analysis (Table 4.2) revealed that Bijapur district was the most important contributor to instability of sorghum production in the State followed by Bellary where the major component was change in mean yield. This was mainly because of the fact that Bijapur district was not primarily a *kharif* sorghum producing region and also there was wide fluctuation in rainfall during *kharif* season. All of the remaining districts contributed to stability, Dharwad being the leading district, where the combined stabilizing effect couldn't exceed the positive impact of the two districts (Bijapur and Bellary) which contributed for instability.

Nearly 93 per cent of the area under sorghum in Karnataka state is under rainfed condition and hence a large proportion of sorghum production was from rainfed areas. Moreover, about 68 per cent of the geographical area of the state receives less than 900 mm rainfall and is subjected to frequent draughts, specially in major sorghum growing

districts of the State. Hence, inter year variation in sorghum production in these areas was observed due to uncertainties of yield.

The high yielding varieties (HYVs) of sorghum which cover only 21 per cent of total sorghum area (1989-90) in the State have given consistently higher yield as well as benefit cost ratio. The lower adoption of such technology could be contributed additionally, to instability of sorghum production.

Hazell (1982) indicated that increase in yield variability had been an important source of increased instability in Indian food grain production, which is similar to the case of sorghum in Karnataka. Suresh Pal and Siroshi (1988) observed that increase in yield led to a remarkable increase in the production with stability in groundnut in Karnataka and cotton in Punjab and Rajasthan which is in contrast to the results of the present analysis. Changes in area yield co-variances strengthened the instability in the production of groundnut in Maharashtra and Tamil Nadu and of cotton in Maharashtra and Punjab. The case of sorghum was in Karnataka was not different. Barker *et al.* (1981) identified factors such as climatic changes over time, infrastructure, particularly water control agronomic practices and plant breeding influenced the variability in food grain yield.

5.2.2 Sources of change in the variance of production

The variance decomposition procedure developed by Hazell (1982) was used to examine the sources of change in the variance of production of sorghum during period I over period II.

The decomposition of instability in the production of sorghum in the State (Table 4.4) showed that the prominent source of production instability at the State level was change in yield variance followed by change in mean yield. This was mainly due to the fact that quite a good number of new hybrids and high yielding varieties were evolved during the first period and were highly sensitive to changes in the climatic factors. This was corroborated by the findings of Hazell (1982) who observed that increase in yield variability was an important source of increased instability in Indian food grain production. Hazell (1984) in another study stated that much of the changes in yield variances of sorghum came from increase in the yield variability rather than the yields of the major green revolution crops of rice and wheat.

It is evident from the earlier studies of Barker *et al.* (1981) and Mehra (1981) that yields of crops grown with the new technologies had larger variances as they were more sensitive to weather and diseases. Because they require modern inputs, their yields may also be sensitive to year-to-year variations in input use arising from frequent price changes, or from supply restrictions.

Interaction between changes in area and yield, and changes in area-yield covariance, interaction between changes in mean yield and mean area, and changes in area-yield covariance also contributed to instability, but to a small extent. Change in yield variance had a significant destabilising effect in the districts of Gulbarga, Bijapur, Bidar and

Raichur whereas its stabilising effect was apparent in Belgaum, Bellary and Dharwad.

Change in area variance had the most important stabilising effect on the change in production variance of sorghum at the State level and all the districts with the exception of Gulbarga and Bellary. The change in mean area also exhibited the same effect at state level and in almost all districts. Hazell (1984), however, noted that changes in area variance and change in mean area, to some extent, contributed to instability of total cereal production in India in contrast to the present study observation. The other important component in stability of sorghum production for the State as a whole was interaction between changes in mean yield and area variance.

Generally, the components of change in the variance of sorghum production varied from district to district and therefore, a blanket policy measure cannot be recommended for the entire state to alleviate the problem of instability.

5.3 ECONOMICS OF SORGHUM PRODUCTION

Introduction of high yielding varieties generally calls for higher level of input use, particularly chemical fertilizers and manures (Table 4.6). The results presented in Table 4.4 and 4.5 revealed that hybrid sorghum growers incurred a total cost of cultivation of about Rs.10,043 per hectare

which is higher by about 8.8 per cent (Rs.812) than the total cost incurred by the traditional sorghum growers. The high cost of cultivation of hybrid sorghum was mainly due to higher cost of seed, chemical fertilizer and human labour. This in turn was attributable to increased use of inputs like fertilizer and human labour and the high cost of hybrid.

These results are in line with Umesh (1985), Thippa Reddy (1992) and Kiresur *et al.* (1999) who found that increased use of inputs and adoption of improved agricultural technology led to higher cost of production but also increased yield.

The analysis showed that the average variable cost incurred per hectare of sorghum was Rs.6761.85 for hybrid sorghum as against Rs.5941.46 per hectare in case of traditional varieties.

The per hectare cost of hybrid sorghum seeds was Rs.351 and that of traditional variety was Rs.185.13. Eventhough the amount of seed per hectare used in both categories was more or less same (7.7 kg and 6.9 kg, respectively), the difference in the cost incurred on seed was mainly because of higher price for hybrid seeds.

It is significant to note that hybrid sorghum growing farmers used closely the recommended seed rate (7.5 kg/ha), while those growing traditional varieties used a little lower (6.9 kg/ha) than the recommended rate. The lower seed rate could be attributed either to lack of awareness

about the recommended seed rate and/or higher confidence about traditional varieties with respect to germination percentage of farm produced seeds.

The expenditure incurred on fertilizers by the hybrid sorghum growers was Rs.1266.72 per hectare, while that of traditional variety growers was Rs.937.51. On an average, 196 and 134 kg of chemical fertilizer per hectare was used by hybrid sorghum growers and traditional variety sorghum growers, respectively. The results indicated that hybrid sorghum growers used 18 per cent higher nitrogen (118 kg) than the recommended 100 kg per hectare whereas traditional variety growers used 21 per cent lower than the recommended (79 kg). Both hybrid and traditional variety growers used lower than the recommended potassium to the tune of 17.3 and 45.3 per cent, respectively. Phosphorus was also applied far lower than the recommendation (to the extent of 57.3 and 62.7 per cent in hybrid and traditional varieties, respectively).

The overuse of nitrogen fertilizer in case of hybrids can be attributed to the low fertility level of sorghum lands as relatively better land is allotted to more remunerative crops and sorghum was pushed to marginal areas than the farmers might have also found hybrids more responsive to nitrogen.

Farmers growing hybrid sorghum used 61.2 mandays per hectare with a cost of Rs.2297.02 as against 57.97 mandays and

Rs.2151.95 in case of traditional varieties. The slightly higher use of human labour for hybrid sorghum production over traditional varieties was due to relatively better attention given to hybrids. Generally, in both categories the expenditure constituted by human labour was high (23.09% of total cost of production) which is because of high involvement of family labour in sorghum production. The operations which absorbed most of the labour employed in both groups of farmers were weeding and harvesting.

As in case of human labour, the bullock labour employment was also higher in case of hybrid farms (87.70 pair days) compared to traditional variety sorghum farms (79.94 pair days). By the same token, the cost incurred on bullock labour was higher in hybrids which can be due to the fact that farmers are giving better attention for hybrids as the returns from hybrids are relatively assured because of high yields.

The expenditure incurred on farmyard manure by traditional seed category farmers in the production of sorghum was Rs.519.12 per hectare as against Rs.510.88 in case of hybrids. However, the amount of farmyard manure applied by traditional seed farmers was lower at 8.86 cartloads compared to hybrid growers at 15 cartloads. This could be attributed to the differences in type (quality) of farmyard manure used where in traditional variety growers applied more valued manure from their own livestock.

With respect to plant protection chemicals, hybrid sorghum growing farms incurred slightly higher expenditure (Rs.335.29) than traditional

variety farms (Rs.272.67). The reason for the higher cost incurred on plant protection chemicals for hybrids is that these varieties are more susceptible to insect pests and diseases.

Fixed costs accounted for about 36 per cent of total cost of cultivation and its major portion about 75 per cent was constituted by rental value of land in both categories. Inter category observations showed that rental value of land was higher (Rs.2538.58 per hectare) on hybrid sorghum growing farms compared to traditional variety growing farms (Rs.2469.77). This may be because of the allocation of relatively more fertile lands to hybrids.

Hybrid growing farmers incurred a lower cost per quintal of output (Rs.443.99) than those growing traditional varieties (Rs.874.28). It may lead to a conclusion that hybrid cultivation inspite of being capital intensive requiring higher variable capital, is infact cost reducing with a lower cost per quintal of output produced obviously due to its higher productivity.

Studies by Venkataram and Ramanna (1968), Rao (1975), Deshaiah (1980) and Umesh (1985) have shown that due to their higher yield per acre, cultivation of high yielding varieties had resulted in decreased cost per unit of output and also increased returns.

The yield of hybrid sorghum was far higher at 22.62 quintals per hectare than 13.69 quintals per hectare of the traditional varieties. Thus,

the higher cost of cultivation (Rs.10042.90 per hectare) of hybrids was justified by the higher yield. The results of the present study are in confirmity with the results of Venkataram and Ramanna (1968), Deshaiah (1980), Umesh (1985) and Kiresur *et al.* (1999) who revealed that the cost of producing high yielding varieties was higher because of the adoption of improved method of cultivation and use of more of capital intensive inputs.

As it is evident from Table 4.5 and 4.6 the gross returns realized per hectare from hybrid sorghum was higher by 16.8 per cent compared to that from traditional varieties. Moreover, this hybrid growing farmers realised about 36 per cent higher net return per hectare than farmers growing traditional varieties. The net return per rupee of investment (total cost) worked out to 0.53 for farmers growing hybrids where as it was only 0.42 for traditional variety growers. Chourasia and Singh (1972), Prabhakar (1973), Deshaiah (1980) and Umesh (1985) had also found that the farmers who adopted new technology (HYVs) had obtained a higher gross return per acre as compared to non-adopters. Umesh (1985) and Thippa Reddy (1992) indicated that the farmers adopting new technology had obtained a higher net return per acre which is in line with this study findings.

It was interesting to note that the net return per quintal of output was higher by 21.4 per cent in traditional category farms than hybrid farms

(Table 4.5 and 4.6). This higher return per quintal could be attributed to the much higher unit price of traditional varieties of sorghum over hybrids because of its superior quality consumers preferred traditional variety of sorghum.

The quantity of byproduct (forage) obtained from traditional varieties was substantially higher by about 46 per cent than the hybrid sorghum (Table 4.6). This is due to the inherent varietal character of the varieties as traditional varieties are tall and hybrids are dwarf in nature.

The findings of the study revealed a wide gap (65%) in the yields obtained between hybrids and traditional variety growing farms and an appreciable difference in the net returns realized by the farmers. It is clear from the study that by adopting hybrids, yields can be increased in fact, without considering the forage need of the farmers which is better met by traditional varieties of sorghum.

5.4 RESOURCE PRODUCTIVITY IN SORGHUM PRODUCTION

Regression equations were estimated separately using total output of sorghum as the dependent variable and the amount of land, seed farmyard manure, fertilizer, human labour and bullock labour as independent variables for hybrid and traditional variety farms. The regression equation was estimated in order to capture the nature and magnitude of the effects of the independent variables on the productivity of sorghum. The coefficients were estimated by using the ordinary least squares (OLS) and maximum – likelihood estimation (MLE) techniques

separately. The MLE procedure was employed to estimate the elasticities in stochastic frontier production function to compute farm specific technical efficiency scores due to the fact that half normal error distribution is assumed. However, the overall allocative efficiency for hybrid and traditional variety farms was worked out by making use of OLS estimates.

The production function analysis of MLE indicated that land and fertilizer had a significant contribution to output and their elasticity coefficients (0.581 and 0.243, respectively) were also statistically significant (Table 4.7) for hybrid farms. Decreasing returns were observed for each input where the increase in output was less than the proportionate increase in input. The response of output to seed, farmyard manure and human labour was positive with elasticity coefficients of 0.0746, 0.089 and 0.107, respectively which were all statistically not significant. Bullock labour was found to contribute negatively (-0.029) to the output and was statistically non-significant.

The OLS and MLE estimates for hybrid farms had similar signs for all of the inputs with some variation in magnitude (Table 4.8) but all the elasticity coefficients in the former case were statistically non-significant with the exception of farmyard manure. The high positive and statistically significant coefficients of land and fertilizer in hybrid farms imply that the output of sorghum could be increased substantially by using more of these inputs. A 10 per cent increase in each of land and fertilizer separately, keeping other inputs at existing level of use, would increase

the output by 5.8 and 2.43 per cent, respectively indicating decreasing returns.

The sum of elasticity coefficients was 1.066 (Table 4.7) which is not significantly different from unity indicating constant returns to scale in which doubling the inputs will double the output and so on in hybrid farms. The adjusted coefficient of multiple determination (\bar{R}^2) was 0.92 which implied that 92 per cent of total variation in output was explained by the six variables included in the model.

The output elasticities for traditional variety farms (Table 4.8) revealed that human labour had positive contribution to the output of sorghum with statistically significant coefficient value of 0.87. Similar impact was observed in case of hybrid farms. Human labour was the most important factor among the considered variables in its contribution to output as sorghum production involves intensive labour operations like weeding and harvesting. The contribution of land, FYM and fertilizer towards the increment of output for traditional variety farms was to the extent of 0.496, 0.232 and 0.092 but all were statistically not significant. The production elasticities of seed and bullock labour were negative (-0.169 and -0.177) but statistically non-significant.

The OLS and MLE estimates for traditional variety farms had similar signs for all variables but the coefficient of FYM was significant in OLS case in addition to human labour, which is also true in the later case.

The sum of output elasticities was 1.344 (Table 4.9) indicating increasing returns to scale. Thus, traditional variety growing farms were operating in the first stage of production which means an increase in the level of inputs lead to more than proportionate increase in the level of output of sorghum. This is the case of most of the small farmers in developing countries due to scarcity of resources. In this stage by increasing the level of use of inputs, the physical output could be increased more proportionately, in fact ignoring the economic optimum level of the use of resources.

The value of adjusted of coefficient of multiple determination (0.899) revealed that 89.9 per cent of output variation in traditional variety sorghum farms had been explained by the variables included in the model.

5.5 TECHNICAL EFFICIENCY

There has been unanimity among economists for many decades to accept the theoretical description of a production function explaining the maximum amount of output obtainable from a given input bundle with fixed production technology. The maximum output obtainable from a given bundle of inputs gives rise to the production frontier. In this production function the output of each firm is bounded above by a frontier. With such theoretical development, the earlier empirical works begin with deterministic frontier. Subsequently, the formulation of stochastic production frontier has been one of the most popular areas of

applied econometrics bridging the gap between theory and empirical works (Singh and Kumar, 1998). Its introduction provides finer aspect of a given production process from a practical point of view as compared to the production function (Kataula, 1993).

In production, assessing the efficiency of a farmer becomes very difficult unless the existing situation in which the farmer is operating is thoroughly known. There is no conventional standard to judge whether a farmer is efficient or not. Frontier production function analysis helps to overcome this problem, by deriving a method by which farmers in a particular area can be compared with the most efficient farmer in the group. This gives the analysis in a homogeneous context. Here each individual farmer is compared with the most efficient (best practice) farmers within his peer group and not as against any absolute standard. The assumption here is that a farmer may be inefficient because of certain constraints operating within the region.

As the potential to increase production by bringing more resources into use becomes more and more limited, specially in agriculture of developing countries, it is natural that the efficiency with which farms or farmers use available resources would become more important as a topic of investigation.

In this study, farm specific technical efficiency was measured from the stochastic frontier production fitted separately for hybrid and traditional variety farms. The maximum likelihood estimation yields estimators of input coefficients.

The parameters of composed error variance (σ^2), symmetric error variance (σ^2_v) and one sided error variance (σ^2_u) were estimated to be 0.124, 0.019 and 0.105, respectively for hybrid farms (Table 4.7). The estimate of γ , which is the ratio of the variance of farm-specific technical efficiency to the total variance of output was 0.85. This would mean that 85 per cent of the variation in output among the hybrid farms is due to the differences in technical efficiency. The remaining 15 per cent variation in output came from random error which is out of the control of the farmers like weather, insect pests and diseases, etc.

The average level of technical efficiency appeared to be high in case of hybrid farms (Table 4.9). The minimum estimated efficiency was 45.30 per cent, the maximum 99.98 per cent and the mean level 77.42 per cent. The relatively high level of mean technical efficiency in this group of farmers could be attributed to the use of hybrid varieties as all other factors were considered in similar fashion for all the sample farmers in that particular locality.

The result of the analysis of technical efficiency revealed that in the category of hybrid farms the predicted level of mean technical inefficiency was to the tune of 0.226 (Table 4.12) indicated that, on an average, the output could be increased by more than 22 per cent, without adopting new technology but by following the practice of best performing (most efficient) farmer(s). This would be attained through extension education for less efficient farmers to get lesson from better ones.

The variance of error terms estimated using MLE technique were worked out to be 0.039, 0.148 and 0.187 for σ_v^2 , σ_u^2 and σ^2 , respectively (Table 4.8) for traditional variety farms. Based on these results the computed gamma, γ parameter associated with the variance of technical inefficiency effects in the stochastic frontiers was 0.79. This result indicates that the technical inefficiency effect was a significant component of the total variability of sorghum output which was to the extent of 79 per cent. The symmetric error i.e. the error component which is due to factors beyond the control of the sample farmers took care of the other 21 per cent. This result of high value of γ was in line with the findings of Kalirajan (1981) who reported γ parameter at 0.81.

The mean technical efficiency level of traditional variety farmers was comparatively less (0.726) than that of hybrid farms. The predicted efficiencies for traditional variety sorghum farms ranged from 0.356 to 0.997. Therefore, the least efficient farm can increase its output by 64.4 per cent and on an average there is a scope to raise the output as much as 27.44 per cent for the traditional variety sample farms.

The result of the present study regarding the technical efficiency scores is corroborated by Seyoum *et al.* (1998) in which farmers adopting new technologies attained 0.937 technical efficiency whereas non-adopters' technical efficiency was 0.794. Xu and Jeffrey (1998) reported that average technical efficiency indices for hybrid rice farms in China was lower than conventional rice farms, which is in contrast to the present study. Using stochastic frontier production function various authors estimated mean technical efficiency for different groups of

farmers. Bagi (1982) estimated technical efficiency for crop and mixed farms to be 0.73 and 0.67, respectively and; Taylor and Shonkwiler (1986) for participants and non-participants of credit program in Brazil computed technical efficiency at 0.714 and 0.704, respectively.

The frequency distribution of farmers of various levels of technical efficiency indicated that sorghum farms which achieved more than 80 per cent of technical efficiency were 21 (52.5%) in hybrid farms and 17 (42.5%) in case of traditional variety farms. The number of farms below 50 per cent technical efficiency level was less (20%) in case of hybrids compared to traditional category (27.5%).

5.6 RESOURCE USE EFFICIENCY

The results of resource allocation have to be further examined to judge whether their use was proper. This efficiency of allocation of resources is studied by comparing the ratios of marginal value products and marginal factor costs of each of the factors of production across the different categories of sorghum farms.

The analysis revealed that in case of hybrid farms seed and fertilizer were under utilized as suggested by their MVP to MFC ratios to the extent of 2.32 and 1.62, respectively. The existing use of seed at geometric mean level was 5.66 kg while the optimum use worked out to be 13.13 kg. The result of MVP and MFC ratio suggests additional rupee invested on seed would bring about an increase of Rs.2.30. In case of fertilizer, the optimum level of use computed at 224.18 kg was far more than the actual use of the input (138.25 kg). The profitability ratio implied that return

from output of hybrid sorghum can be increased by Rs.1.62 for every additional rupee spent on fertilizer.

The fact that additional quantity of fertilizer could be profitably employed in hybrid sorghum production is encouraging because the present level of fertilizer use was lower than that of the recommended level.

The ratio of value of marginal productivity to factor cost in case of traditional variety farms (Table 4.12) for human labour was greater than unity. The actual use of human labour per farm at geometric mean level was 63 mandays which was lower than the optimum level of use (217 mandays). Thus, it is evident that the resource was employed profitably but at less than the optimum level in the production of sorghum. There is scope to increase its usage over the current level as the resource was under utilized. It could be observed from the ratio of MVP to MFC of human labour that a return of Rs.3.45, for every additional rupee spent on human labour could be realized.

In the absence of definite relationship between output and land, seed, FYM, fertilizer and bullock labour, in case of traditional variety farms and land, FYM, human labour and bullock labour in hybrid farms as revealed by the statistical non-significance of these elasticity coefficients, nothing can be said about the marginal value product to marginal factor cost ratios for these inputs.

5.7 ALLOCATIVE AND ECONOMIC EFFICIENCY

Allocative efficiency refers to allocation of resources at levels consistent with the price of the resource and productivity. Technical efficiency is a pre condition for maximum output. Allocation of resources some times hindered in situation of resource scarcity and uncertainty of production induced by weather conditions and it is not a true judge of efficiency given the condition under which the farmer operates.

Overall allocative efficiency in case of hybrid farmers was high (0.675) compared to allocative efficiency index of 0.241 for traditional variety farms (Table 4.13). This means that 67.5 per cent of output in hybrid and 24.1 per cent of output in traditional variety farms was realized with present levels of input use to produce maximum output compared with the allocatively most efficient farmer with optimum use of all resources. This would further mean farmers should have reallocated resource so as to cause a 32.52 per cent output in the former and 75.87 per cent output increase in the latter output; however, it was a loss due to allocative error.

The reason for low level of allocative efficiency in sorghum production would be attributable to the fact that the production was trapped in a low level equilibrium level where the technology is low and the input use was also correspondingly low which is below optimum level. This is perhaps induced by the uncertainty of production coupled by shortage of capital.

Thus, it follows that the hybrid as well as traditional variety farms were, on an average, technically less inefficient than allocatively. This result is in line with the findings of Ali and Chaudry (1990) in Pakistan while studying inter regional farm efficiencies. The finding of the present study indicated that both groups of farms attained relatively higher level of technical efficiency whereas, there was a wide gap in allocative efficiency in which hybrid farms were far better off. The largest potential for increasing production efficiency among traditional farms is thus through increasing their allocative efficiency. On the contrary, hybrid farms seem to be more or less equally technical and allocative efficient. Although no attempt is made to derive individual allocative efficiency levels, the findings revealed that poorly managed farms will be poorly run both technically and allocatively.

Although the independence of technical and allocative efficiency depends on the identification sources of both types of inefficiencies, considering the management aspect of sorghum farms, it can be argued that there is little reason to expect to find farms whose managers perform one task well and the other poorly. Hence theoretically in the production of the crop in hybrid and traditional variety farms, technical and allocative inefficiency were positively correlated.

In general the results revealed that sizeable deviations from the optimal allocation of resources given the available inputs and technologies. Hence, important gains in production should not depend only on the introduction of new farming inputs and technologies,

improvement in reallocation of resources, focusing on choice of varieties as one important aspect, has to be considered.

Overall economic efficiency of sorghum production in hybrid farms was 0.522 (Table 4.12) compared to traditional variety farms which is lower (0.175). This implies that there is a potential to increase the gross income by about 47 per cent in hybrid farms and more than 82 per cent in case of traditional variety farms simply by following the practices of best practice farmers and at the same time through optimal allocation of resources jointly.

The wide variation in economic efficiency between the two groups largely came from the difference in allocative efficiency wherein the allocative inefficiency in traditional variety farms was extremely high. This is attributed to the significant difference between the maximum or frontier output which is relatively low and higher level of output that could have been obtained if all the resources were utilized the optimum level of use. This increase in allocative efficiency could be attained partly by increasing human labour.

Available evidence suggests that farmers in developing countries fail to exploit fully the potential of a technology and/or make allocative errors with the result that yields show a wide variation, usually reflecting a variation in management capacity of the farmers. A study carried out in Paraguay by Bravo-Ureta and Evenson (1994) suggested that there was a considerable room for productivity gains to the extent of about 60 and 48 per cent, respectively for cotton and cassava through better use of available resources given the state of technology.

*Summary and
Policy Implications*

VI. SUMMARY AND POLICY IMPLICATIONS

The summary and policy implications of the study based on the findings are presented in this chapter.

The importance of agriculture sector for initiating and sustaining economic growth in developing countries is crucial. The increasing rate of growth of demand for food in the Third World countries must be met largely through technological change in agriculture because of the limited capacity to expand land area. Technological inputs, such as high yielding seeds, fertilizer and irrigation stimulate agricultural output by raising crop yields.

The continuous creation/introduction of new technology has been used as a standard for distinguishing a modern agricultural system from a traditional system (Schultz, 1964). However, in developing countries, some new agricultural technologies have been only partially successful in improving productive efficiency. This is often attributed to a lack of ability and/or willingness to adjust input levels on the part of producers due to familiarity with traditional agricultural systems and/or the presence of institutional and cultural constraints (Ghatak and Ingerset, 1984).

Food grains comprise rice, wheat, coarse grains and pulse. In India, while the production of rice and wheat is showing an upward trend, the production of coarse grains including sorghum and pulses has been nearly stagnant or growing at a very slow pace. This is so because the cultivation of coarse grains is not remunerative. They are grown on

marginal lands under rainfed conditions and give low yields (Anon., 1999).

The introduction of high yielding cereal varieties under the High-Yielding Varieties Programme launched during 1966-67 in the country ushered new hopes and dimensions in agriculture (Kiresur *et al.*, 1999). Under this programme the fertilizer responsive, photoperiod insensitive and short duration high yielding varieties (HYVs) of rice, wheat, sorghum, maize and pearl millet were released.

With an area of about 11.57 million hectares and a production of about 11 million tonnes (1996-97), India is the second largest producer of sorghum in the world and has the largest share (32.3%) of the global area under sorghum (Anon., 1999). One of the major coarse cereals produced in India, stands third among food grains in respect of area and production in the country after rice and wheat.

Karnataka is the second largest sorghum producing state in the country with an area of 2.1 million hectares and a production of 1.9 million tonnes (1996-97) accounting for 18.1 per cent and nearly 17.3 per cent of the area and production of food grains in the country, respectively. It is the most important cereal in terms of area and production and it ranks second to rice among food crops. The northern districts of the state are the leading producers of the crop constituting more than 90 per cent of the total area of sorghum in the state.

This study was mainly concerned with a quantitative assessment of the farm economic performance of rainfed sorghum during *kharif* season

in Dharwad and Bellary districts. The study also attempted to analyse the performance of sorghum in the major growing districts and for the state as a whole from 1961-62 onwards using econometric tools. The specific objectives of the study were :

1. To document area, production and productivity of sorghum and assess the variability in its production in north Karnataka.
2. To analyse the economics of sorghum production.
3. To evaluate technical, allocative and economic efficiency of sorghum production with traditional and modern (varietal) technology.

Time series secondary data on area, production and yield of sorghum for the period 1961-62 to 1996-97 were collected from Directorate of Economics and Statistics (DES), Bangalore. Exponential equations were fitted to the annual time series data to obtain compound growth rates. Instability in the production of sorghum was measured using Hazell's (1982) decomposition model to examine the sources of change in instability of production between the two sub-periods.

The primary data for the study were collected from 80 sample farmers of Dharwad and Bellary districts, 40 each of hybrid and traditional sorghum variety farms. The data was analyzed employing measures of central tendency for estimating the costs and returns. Production function analysis was used to study the resource productivity. Stochastic frontier production function analysis were carried out

separately to examine technical efficiency of farmers growing hybrid and traditional varieties. Marginal value product (MVP) to marginal factor cost (MFC) ratio was used to assess resource use efficiency. Over all allocative and economic efficiency were also computed to estimate the levels of efficiencies of each group of farmers.

The major findings of the study are presented below:

1. Growth Rate Analysis

During the entire period of study (1961-62 to 1996-97), sorghum registered a modest growth in production at the state level because of the increase in yield which offset the decline in area.

Period wise analysis revealed that there was a sharp decline in area of sorghum in the first period (1961-62 to 1976-77) in all the districts and for the state as a whole. The aggregate production in this period increased due to spectacular increase in yield for the State as a whole which offset a notable decline in area under the crop in the period. The districts Bidar and Bellary registered a fairly high growth rate in production while Gulbarga and Belgaum districts performed dismally. The growth rate in yield was commendable at the state level. Particularly, Bellary and Bidar districts achieved relatively impressive yield growth rates.

The growth in area under sorghum was marginally higher in the second period (1977-78 to 1996-97) for the state as a whole. The same trend was observed in all the districts barring Dharwad and Bellary. The

growth in production during second period was relatively higher compared to first period for the State as a whole. Among the districts, the growth rate of production was satisfactory for Belgaum and Bijapur whereas a decline in production was noticed for Dharwad. The growth in yield slowed down in the second period for the state.

2. Instability in the production of sorghum

The average output of sorghum increased in absolute terms in the second sub-period for the state as a whole and in all the districts with the exception of Bijapur and Gulbarga. The increase in average production in the state was predominantly due to the change in mean yield.

The change in mean area and the interaction effect had contributed negatively to the change in average production while the change in covariance between area and yield was positive. The extent of contributions of interaction effect and change in area-yield covariance were relatively smaller. Similar trend was observed in all districts except Dharwad wherein the contribution of yield effect was negative and for Bellary both components of the pure effect contributed positively.

The change in yield variance and change in mean yield were the main factors for instability of sorghum production in the state from among the decomposed components of change in variance of production. The change in area variance, change in mean area, interaction effect of mean yield and area variance and interaction effect of mean area and yield variance contributed to stability of sorghum production.

The change in yield variance was the major component of stability while change in area variance was the most significant contributor to production instability of the crop.

District wise instability analysis revealed that Gulbarga contributed most to instability of sorghum production in the state followed by Bijapur. On the other hand, the major contributor to production stability of the crop among the districts was Belgaum.

3. Economics of sorghum production

The per hectare cost of cultivation of rainfed sorghum was Rs.10,043 and Rs.9231 on hybrid and traditional sorghum variety farms, respectively.

Variable costs constituted the major portion of the total cost of cultivation of hybrid (67.33%) as well as traditional sorghum varieties (64.36%). Human labour was found to be the major item of variable cost under both technology groups with a share of 22.87 per cent of total cost of cultivation in the former and 23.31 per cent in the latter group. Cost of bullock labour, fertilizer and farm yard manure were the other major items of variable cost, in both the groups.

Fixed cost per hectare was estimated to be Rs.3281 for hybrids and Rs.3289 in case of traditional varieties which constituted 32.67 and 35.64 per cent of total cost of cultivation, respectively. Rental value of land formed the major item of fixed cost and of total cost of cultivation in both categories of farms.

Gross and net returns per hectare of hybrid sorghum worked out to Rs.15279 and Rs.5234, respectively and were higher compared to traditional variety farms wherein they were Rs.13078 and Rs.3847, respectively. The net returns per rupee of investment were estimated to be Rs.0.53 and 0.42 with cultivation of hybrid and traditional sorghum varieties, respectively.

The average seed quantity, chemical fertilizer, farm yard manure, human labour and bullock labour used was found to be higher on hybrid sorghum farms compared to traditional sorghum variety farms by 11.6, 46.3, 66.7, 5.2 and 1.0 per cent, respectively.

The per hectare average yield realised by hybrid sorghum farmers was 22 quintals which was far higher than that by traditional variety growers (13 quintals). However, the amount of byproduct from traditional sorghum varieties was substantially higher by about 45 per cent than that of hybrids.

The cost of production per quintal of sorghum worked out to Rs.444 for hybrids and Rs.674 for traditional varieties. However, the net return from a quintal of hybrid sorghum (Rs.231) was lower than that of traditional varieties (Rs.281) due to the lower prices of hybrid sorghum.

4. Technical efficiency of sorghum production

The results of production function analysis indicated that with the adjusted coefficient of multiple determination (\bar{R}^2) value of 0.917 for

hybrid farms and 0.899 for traditional variety farms, the inputs included in the model were able to explain 91.7 and 89.9 per cent of the variation in sorghum production of sampled farmers, respectively.

The elasticity coefficients of maximum likelihood estimates of land, seed, FYM, chemical fertilizers, human labour for hybrid farms were positive while that of bullock labour was negative. In case of traditional variety farms, all variables except seed and bullock labour had positive elasticity coefficients. Hybrid farms were operating almost at constant returns to scale whereas, increasing returns to scale were exhibited by traditional variety farms.

In stochastic frontier production function, a particularly significant feature of the empirical results was the ratio of the variance of farm specific technical efficiency to the total variance of output (γ), which was 0.85 for hybrid farms and 0.79 for traditional variety farms. This implies that 85 and 79 per cent of the variation in output among the hybrid and traditional variety farms respectively were due to the differences in technical efficiency. These results were interesting as they indicate technical inefficiency effects as a significant component of the total variability of sorghum outputs irrespective of the variety.

The estimated technical efficiencies for hybrid category ranged from 0.433 to 1.000, with a mean technical efficiency of 0.774 whereas for the farmers growing traditional sorghum varieties of the range was 0.356 to 0.997, with the mean of 0.726. These estimates indicate that, on an average, hybrid farms had higher technical efficiency than

traditional variety farms, relative to their respective frontiers associated with the different technologies.

The frequency distribution of the farm-specific technical efficiency segregated into two groups indicated that 65 per cent of hybrid farms and 55 per cent of traditional variety farms were clustered above 70 per cent technical efficiency level. On the other hand, 20 and 27.5 per cent of hybrid and traditional variety growing farmers, respectively attained less than 50 per cent of technical efficiency which revealed a wide variation across the sampled farms in each group.

5. Allocative and economic efficiency

The result of the marginal productivity analysis revealed that the marginal value product (MVP) to marginal factor cost (MFC) ratios of land, seed, farmyard manure, fertilizer and human labour was substantially greater than unity in hybrid sorghum farms implying under use of these resources. In case of bullock labour, the MVP to MFC ratio was less than unity indicating excess use of this resource. For traditional variety farms, in addition to bullock labour, seed was also over utilized. Regarding other resources the case was similar to hybrid farms i.e. under utilized.

It can be concluded that higher gross returns would be accrued by investing more on seed, land, FYM, fertilizer and human labour in case of hybrid farms and on land, FYM, fertilizer and human labour in traditional variety farms. Bullock labour from hybrid as well as traditional variety

farms and seed on traditional variety farms have to be withdrawn to achieve higher efficiency.

Farmers of hybrid sorghum were on an average of 67.48 per cent allocatively efficient which was far better than the overall allocative efficiency of 24.13 per cent of traditional variety growing farmers. The actual yield realised by hybrid and traditional variety farms were 20.55 and 8.92 quintals per farm, respectively while the potential output per farm was 31.45 quintals in the former and 12.52 quintals in the latter. The relative difference in allocative efficiency between groups was by far greater than the technical efficiency.

The average losses of output due to technical inefficiencies in hybrid and traditional variety farms were 22.6 and 27.44 per cent, respectively. The estimated percentage loss of total farm output arising from inefficiency in allocation of resources amounted to 75.87 per cent in case of traditional variety farms whereas it was 32.52 per cent on hybrid farms.

Farmers under hybrid category achieved an overall economic efficiency of 52.24 per cent while only 17.51 per cent economic efficiency level was attained by those under traditional category. Not surprisingly the greatest difference was exhibited in economic efficiency since it is calculated as the product of technical and allocative efficiency.

POLICY IMPLICATIONS OF THE STUDY

1. The empirical findings of the present study revealed the decline in the rate of growth of productivity of sorghum from 4.8 per cent in period I to 0.22 per cent in period II. This can be improved through development of improved varieties and hybrids that command high demand by consumers through their quality preferences, larger area coverage under irrigation and application of recommended doses of fertilizer which is, on average, 30.6 per cent higher than the existing level of use.
2. Yield and area variance were the two important aspects with a contribution of 109.10 and -209.00 per cent, respectively to the total change in variance. The empirical evidences suggest that policies directed towards minimizing yield variability should be formulated for sorghum. Development and adoption of less risky technology, assured supply and timely application of farm inputs would be effective in reducing the yield variability.
3. The research effort has to focus in developing varieties based on consumer preferences and extension programme has to popularize hybrids and varieties such as CHS-13, SPV-462 and CSV-15 to increase yield as well as forage from sorghum, since farmers are producing the crop specially in *kharif* for dual purpose.
4. The average level of technical efficiency is higher in hybrid sorghum farms as compared to traditional variety farms. The result indicated

that the output of sorghum on average could be increased by 22 per cent in hybrid farms and by 27 per cent in traditional variety farms, which would reduce, on average, the loss of 29,711.4 tonnes of output in the entire Bellary district and 33,878.3 tonnes in Dharwad district, without adopting new technology but by following the practice of most efficient farmers. This could be attained through extension education for less efficient farmers to get lesson from best practice farmers.

5. The investigation revealed sizeable deviations in the use of inputs from the optimal allocation of resources, particularly FYM (47.9%) and seed (35.5%) in hybrids and FYM (79.9%) and human labour (67.7%) in the production of traditional variety sorghum given the available inputs and technologies which resulted in a loss of 54.2 per cent yield, on an average. Hence, the important gains in production should not depend only on the introduction of new farm inputs and technologies but improvement in reallocation of resources, and choice of varieties are also important aspects to be considered.

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**ECONOMICS OF SORGHUM PRODUCTION IN NORTH
KARNATAKA
2000**

ABSTRACT

MENTESNOT LEGESSE

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The present study investigated the pattern of growth, instability, resource productivity and the economic benefits of sorghum production in Karnataka state. This study was mainly concerned with a quantitative assessment of the farm economic performance of rainfed sorghum under different technologies during *kharif* season of 1999-2000 in Dharwad and Bellary districts of north Karnataka .

The study period was divided in to two: period I (1961-62 to 1976-77) and period II (1977-78 to 1996-97). In the first period the growth rate of yield was substantially higher which offset the decline in area while both area and yield showed a modest increase in the second period. The increase in average production in the State as a whole was predominantly due to the change in mean yield. The changes in yield variance and area variance were the two main components of total change in the variance of sorghum production in the state in which the former contributed to instability while the latter was component for stability.

The study revealed that hybrid sorghum growers incurred a total cost of cultivation of about Rs.10, 043 per hectare which was higher by about 8.8 per cent than that of traditional sorghum growers. The gross returns realized per hectare from hybrid sorghum was more by 16.8 per cent than that from traditional varieties. Moreover, this hybrid growing farmers realised about 36 per cent more net return per hectare than

farmers growing traditional varieties. The net return per quintal of output was higher by 21.4 per cent in traditional category farms than hybrid farms.

The predicted technical efficiencies using stochastic frontier for hybrid farms ranged from 0.433 to 1.000, with mean technical efficiency of 0.774 whereas for the farmers growing traditional varieties the range was from 0.356 to 0.997, with the mean estimated to be 0.726. Hybrid farms had higher technical efficiency than traditional variety farms, relative to their respective frontiers associated with the different technologies.