REVIEW OF LITERATURE
CHAPTER - II
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The present study mainly is an effort to estimate district wise agricultural productivity growth in Karnataka by considering various inputs. Agricultural productivity growth has become sine-quo-non of agricultural progress and technological change by enhancing the income and the productivity of the farm sector. Quite a few studies pertaining to agricultural productivity growth and technical change have been made in India and other developing countries. Though these studies are capable of explaining the growth pattern, yet they do not answer a myriad of questions. In this context, it is relevant to analyse the productivity performance in relation to selected inputs that have gone into the production process. Keeping this in view, the review mainly centres around information on (i) productivity growth performance (ii) measurement of technical efficiency and (iii) use of trend and regression for growth analysis.

2.1. PRODUCTIVITY GROWTH PERFORMANCE:

Chadha (1966) estimated the growth rates in Indian Agriculture. According to his estimates, the overall Agricultural production advanced at an average linear rate of 3.92 per cent, whereas yield grew at 106 per cent per annum over the period 1949-50 to 1964-65. On the other hand, foodgrains showed an average productivity of 1.61 per cent per annum. Among the States, Gujarat ranked first with 4.52 per cent growth of productivity whereas, Rajasthan and Assam showed negative growth rates.
Kahlan et al., (1968) studied the growth performance of the selected crops in Punjab for the period, 1950-51 to 1965-66. They estimated crop-wise and district-wise growth rates. Their study revealed that the extension of irrigation facility to dry districts led to changes in cropping pattern. They also found that overall increase in the growth rates for major crops was the outcome of extended area under these crops rather than from an increase in their productivity.

Sidhu and Sankhayan (1973) analysed the growth rates of area, production and productivity of different crops for the State of Punjab. They found that the rate of growth of output (5.8%) of Cotton was much higher compared to growth rates of other crops. This was attributed to increase in area as well as increase in productivity.

Sharma and Coutinho (1974), while studying the growth of Jowar in Karnataka from 1961-62 to 1972-73 observed that the total volume of change between the first and the last triennium of the studies period amounted to increase in productivity by more than one-third. The Secondary producing districts including Hassan, Chitradurga, Chickmangalore and Tumkur recorded more impressive increase in productivity. The trends during the studies period indicated that the area declined whereas productivity increased.

Pareira (1976) studied the compound growth rates of output at the district and State level in Karnataka for the period 1956 to 1973. The growth rates in the production of Ragi, Cotton, Groundnut and Tobacco were negative during the pre-green revolution period, while the remaining crops had registered positive
growth in production. But, during the green revolution period, all the crops except Bengalgram had positive growth in production. In the State, Shimoga, Raichur and Hassan districts had growth rates of more than four per cent. Tumkur, Dharwad and Kolar districts had registered growth rates of below one per cent in the total agricultural production. The productivity component was the most dominant source of growth during post green revolution period.

Singh and Moorti (1977) compound the growth rates of area, production and productivity. They found that the contribution of productivity to the growth of production was much higher than that of area, both for Cereals as well as other food crops.

Patil and Jha (1978) analysed the pattern of output and input use and productivity growth in 25 districts of Maharastra State for the period 1951-52 to 1971-72. The index number approach was used to measure productivity. The study employed Solows geometric index to reflect both total factor productivity and technological advancement.

The relative role of various technological, institutional and climatic factors in the determination of inter-regional disparities in agricultural productivity in India was examined by Joshi and Haque (1980). Consumption of fertilizers and high yielding variety coverage were found to be the most important determinants of agricultural growth in a majority of States. Next in order to importance were time variable (indicating technological change), irrigation, rainfall and credit. There was significant positive relationship between fertiliser consumption and agricultural productivity in many States. They observed that in the agriculturally
backward States of Himachal Pradesh, Madhya Pradesh, Orissa, Rajasthan and West Bengal the elasticity coefficients of high yielding varieties were very low and non-significant as compared to Punjab. Rainfall affected productivity adversely in Andhra Pradesh and favourably in Madhya Pradesh, Maharashtra and Punjab. The role of credit was found to be non-significant in all States except Uttar Pradesh.

Ranade (1980) examined the effect of cropping pattern, fertilizers and irrigation upon agricultural production across 54 agro-climatic regions covering 16 major States for pre-green revolution (1962-65) and post-green revolution (1970-73) periods. The estimated regression coefficients for all the three variables for both the periods were positive and highly significant.

Chadha (1980) who made comparative studies with respect to yield rates of Rice and Wheat over a period of 1950-51 to 1975-76, concluded that in case of Rice some States had registered fairly impressive increase while others had ostensibly failed to do so, thus, no State was free from periodical fluctuations. In sharp contrast to the performance of Rice, increase in yield levels of Wheat had been quite impressive and sustained except for Punjab and Haryana. Moreover, the periodical fluctuations were also found to be less sharp than in Rice and finally they concluded that among different States there was a variation in yield levels.

Venkataramanan and Prahladachar (1980), estimated and analysed the growth rates in area, yield and output of major crops in six States to study the impact of disparate growth rates of crops on cropping pattern in those States.
The time period covered was 1950-51 thru 1974-75. Overall growth rate was highest in Punjab (5.5 per cent per annum) and lowest in Maharashtra (0.9 per cent per year). Decomposition analysis to find out the relative contributions of component elements namely area growth, yield growth, cropping pattern changes and the interaction between yield growth and cropping pattern changes to the growth in crop output revealed that the contributions varied from State to State. However, with the notable exception of Maharashtra, a significant portion of output growth in those States was explained by yield increases.

Singh and Bokil (1980), while studying trends of production of Wheat in the pre-HYV and post-HYV periods revealed that the growth rates of area and productivity were higher in the post-HYV period than in the pre-HYV period for almost all States. For the States in which growth rates in yield showed downward during the post-HYV period, the authors opined that in these States, most of the potential of the HYV’s was exploited in the first few years of their introduction, approaching a saturation point with regard to the spread of new varieties, consequently further gains were lower.

An exploration of the factors contributing to differential growth of agriculture of Orissa and Punjab was attempted by Singh (1981). He reported that the percapita plan outlays in all the five year plans had been significantly lower in Orissa as compared to Punjab and the country as a whole. This had led to the poor development of infrastructural facilities like electricity, roads and irrigation in the State. Irregular monsoon and lack of assured water supply were the two main factors responsible for wide fluctuations in agricultural production in
Orissa. The important factors contributing to higher production growth rate of foodgrains in Punjab were application of fertilizers, irrigation facility and favourable weather conditions.

Singh (1981) in his study imbalance in agricultural growth in Indian agriculture, made an attempt to identify the factors contributing to differential growth of agriculture of Orissa and Punjab. It was reported that per capita plan outlay in all the Five-year plans in Orissa has been significantly lower than Punjab and the country as a whole. This has led to poor infrastructure facilities like electricity, roads and irrigation facility. He observed that irregular monsoon and lack of assured water supply were the two main factors responsible for wide fluctuation in agricultural production in Orissa. The risk associated with the raising of crops is relatively greater in Orissa as compared to Punjab. It was concluded that higher production growth rate of foodgrains in Punjab was due to higher application of fertilizer doses, irrigation facility and favourable weather condition.

Rao, (1981) found that at the country's level the growth rate for production and productivity of Rice were of the same order during both the pre and the post HYV periods inspite of decline in the growth rate of area. Among the important Rice growing States, the growth rates for productivity were significantly high in Uttar Pradesh, Madhya Pradesh, Tamilnadu and Punjab while there was considerable decrease in Orissa.
Gangawar and Pandy (1982) Analysed the trends in area, production and yield of different Pulse crops and total Pulses for the period 1970-71 to 1980-81 by fitting simple linear trend equation of the form y=a+bt. The production of Grams during the drought years 1973-74 and 1974-75 had declined by 19 and 21 per cent over its production in 1971-72. The percentage annual growth rates with respect to area, production and productivity were 1.06, 0.87 and 0.21 in the case of Tur, 2.62, 2.61 and 0.02 in respect of Moong, 1.84, 2.90 and 3.75 in respect of Urd and 0.40, -0.10 and -0.53 in case of total Pulses, respectively. Thus it is evident that there has been stagnation in Pulse production during the last decade.

Hazell (1982) examined instability in Cereal production in India for two time periods viz., 1954-55 to 1964-65 and 1967-68 to 1977-78. He reported that variance of total Cereal production for all-India increased by 342 per cent between the two periods. Of this increase, only about 6 per cent could be attributed directly to increases in the variances of individual crop yields measured at the State level. The lion’s share of the increase (82 per cent) could be attributed to increases in the covariances of production between crops grown in the same and in different States. It was found that increase in intercrop and interstate yield covariances were the dominant source of the increases in these production covariances. The study finds that simultaneous increase in the variability of the areas sown with individual crops as well as increase in covariances between the 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.

Rajpurohit (1983), compared the growth rates of Agricultural production in Karnataka for the period 1956 to 1982. The author observed that there had been a major set back 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. 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 in case of Ragi.

Ray (1983), employed decomposition of variability analysis to investigate the growth and instability. He reported that major causes for change in the pattern of production were (i) an increase in the variability of rainfall and prices, (ii) an increase in the sensitivity of production in rainfall and prices.

Savant (1983), attempted an investigation of the hypothesis of deceleration in Indian agriculture. He observed that deceleration trend in the growth of foodgrain production commenced in the sixties after an impressive performance in the fifties which was mainly area-led. The reversal of deceleration trend though started in the mid-sixties with the advent of green revolution could not be sustained uninterruptedly beyond 1970-71. Trend function fitted for the entire 31 year period from 1950-51 to 1980-81 indicated stagnation in foodgrain output growth. During the post-green revolution era, foodgrain production registered a modest compound growth rate of 2.24 per cent per annum with main contributions from Wheat followed by Jowar and Bajra. All
the four non-foodgrain crops studied viz., Groundnut, Cotton, Jute and Sugarcane registered significant positive growth in the post-green revolution period.

In a study on growth pattern of agriculture for the period 1960-61 thru 1982-83, particularly focusing on the factors associated with the growth process, Grewal and Rangi (1983) observed that the single most important factor responsible for differentials in value productivity among the districts was irrigation. Micro-level analysis of individual farms from irrigated areas indicated wide fluctuations in productivity and the factors responsible were found to be (i) differential fertilizer use, (ii) variation in timeliness of operation, (iii) differences in the use of weedicides and plant protection chemicals, (iv) financial position of farmers and (v) general attitude towards work.

Mishra (1983), observed that fertiliser consumption and area under crop had positive and significant impact on productivity of Rice in Orissa for the period 1970-71 thru 1980-81. Irrigation and high yielding varieties had positive but non-significant impact. The regression coefficient for rainfall was negative but non-significant implying that the pattern of rainfall distribution, rather than total precipitation, was more relevant to Rice productivity in the State. The major constraints of agricultural development of Orissa were identified to be natural calamities, distribution of rainfall, soil, topography and sociological factors.

Sirohi et.al., (1983), studied the compound growth rates over the period 1976-77 to 1981-82 making use of the data published by the Government of India. The trends of production and productivity of Wheat per hectare had risen
The productivity of Bajra and Pulses were stagnant or had decreased slightly. Rice and Cotton had shown a rising trend. The productivity of total food grains per hectare had also increased.

Desai (1984), analysed Rice production and productivity in Eastern India. It was found that Rice production in Eastern India witnessed less than one per cent growth rate during the period 1971-72 to 1981-82 which was much below all-India productivity of 2.76 per cent. The study showed that all the important States of Eastern India had lower growth rates of productivity than all non-traditional Rice growing States in India and traditional Rice growing States of Western India and Tamil Nadu in Southern India.

Saraswat (1984) studied the compound growth rates of Pulses in Himachal Pradesh for the period 1966-67 to 1979-80 by fitting the exponential function $Y = AB^t$. The results revealed that the compound growth rate of area for the State, as a whole was 2.45 per cent per annum and the two districts of Bilaspur and Una had a higher growth rate than the State acreage. The production and yield have shown a growth rate of 3.33 per cent and 1.52 per cent per annum, respectively. All districts in the State except Shimla, Chamba and Kinnaur revealed positive growth rates. The main reason for slow growth of yield compared to area and production is the prevalence of unprecedented rains during 1971-72 and prolonged drought conditions in 1974-75 and 1979-80, which seriously affected the Kharif crop. Further, unfavourable weather conditions during the years 1969-70, 1973-74, 1976-77 and 1979-80 also affected the rabi crops.
In another study, Hazell (1984) compared the sources of increased instability in Indian and United States 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-1960's. Increases in yield variances were an important source of this increase in production variability, primarily because of their contribution to increases in yield covariances between States and crops. The increase in these covariances 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. The predominant sources of the increase in the variance of total United States Cereal production were focused more narrowly on increases in the means and variances of yields and in the yield correlation between States.

The effect of high-yielding varieties of production instability in Karnataka State was examined by Reddy and Hiremath (1984). It was reported that changes in production variances of individual crops had influenced total Cereal production, through changes in yield covariances between districts and crops rather than through district yield variability at farm level.

The findings of Walker (1984) revealed that interdistrict production covariances 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 covariance turned out to be single largest source of these increased interdistrict production covariances. It was reported that adoption of hybrids and changes in rainfall covariances increased the yield covariances in both the crops. However, irrigation increased the yield covariances in Sorghum, whereas it led to reduced inter-regional Pearl millet yield covariances.

Desai (1984), estimated the growth rate of Rice production and productivity in Eastern India and reported that regional growth rate in Rice production was far below the all India growth rate of 2.76 per cent per annum for the decade ending 1981-82. Growth rate of productivity was also lower for Eastern States as compared to many other traditional and non-traditional Rice growing States. The important traditional Rice growing States which had equally low growth rates of yield as Eastern India were Andhra Pradesh and Kerala, but they had higher level of productivity. The dismal performance of the Eastern States was attributed mainly to the slow rate of adoption of high yielding varieties.

Chatha and Joginder Singh (1985), analysed the compound growth rates of area and production of Pulses in Punjab for two periods i.e., from 1961-62 to 1970-71 the green revolution period and from 1971-72 to 1980-81 for the post green revolution period. The results showed a negative growth rate in area and production during both the periods. This growth rate was highly significant during 1961-71 and non significant during 1971-81. On the whole, the area declined at the rate of 4.83 per cent and the production declined by 4.97 per cent. Mash
during 1971-81, Gram and Massar during 1961-71 showed significantly negative
growth rates in area and production. Moong crop also showed slow-growth
though growth rate in production during whole period was significant at 5 per
cent level.

The impact of different factors governing Rice production in India was
examined by Venkateshwaralu et. al. (1985). They found that during the
seventies contribution of irrigation to the productivity of traditional Rice varieties
was highest at 59 per cent, followed by variety 23 per cent, and nitrogen 18 per
cent. In the case of high-yielding varieties, the largest influence was of nitrogen
at 37 per cent followed by variety 34 per cent and irrigation 29 per cent.

Ball (1985), in another study used Tomqvist-Theil indices of outputs and
inputs to measure productivity growth over the post-war period. The productivity
indices were derived from a flexible multi-output-multifactor representation of the
structure of production constrained to constant returns to scale.

Rangarao and Ray (1985), reported stagnancy in the growth rates of area,
production and yield of Pulses in India during the post-green revolution period.
Gram registered negative and Tur marginally positive growth rates but their
substitute crops of Wheat and Rice registered higher growth rates. The reasons
identified by the authors for the poor performance of Pulses were shortage of
high yielding varieties of Pulses, inadequate irrigation facilities, lack of use of
chemical inputs and farmers' aversion towards Pulse monoculture.
The important traditional Rice growing States which had equally low growth rates of productivity as Eastern India were Andhra Pradesh and Kerala, but they had higher level of productivity. He concluded that low growth rate of productivity of Rice in Eastern India was due to slow rate of adoption of high-yielding varieties.

The findings of the study by Ranga Rao and Ray (1985) indicated that during post-green revolution period (1967-68 to 1983-84), area, production and yield of total Pulses were more or less stagnant. The overall growth rates of area, yield and production of Gram were negative and marginally positive in case of Tur, whereas growth rates of their substitute crops i.e., Wheat and Paddy were much higher. They identified the major factors for low growth rate of Pulses were shortage of high-yielding varieties, lack of use of irrigation, fertilizers and pesticides, tendency on the part of farmers to raise Pulses mixed with other crops and poor management practices.

Sikka and Vaidya (1985), analysed the area, yield and output of major crops in Himachal Pradesh by using compound growth rate function to examine the performance of agriculture in Himachal Pradesh. The aggregate production of Cereals, Pulses and foodgrains have shown positive growth and the highest rate among these was that of Pulses (3.33 per cent). Among the different Pulse crops, Gram showed highest growth rate of 4.20 per cent, 6.16 per cent and 7.30 per cent with respect to area, yield and output respectively for the period 1966-67 to 1979-80. The ecological and topographical factors constitute main constraints for growth in yield and crop output in Himachal Pradesh.
A single farm case study over a 21 years period conducted by Anderson and Findlay (1985) supported the common observation that in Australia, modern Wheat cultivators performed not only with higher average yields but also more variability. The study also suggested that the risk faced by the farmers was not effectively increased since the modern Wheat cultivator yield distribution first statistically dominated the yield distribution of traditional tall cultivator.

According to Hazell (1985), world Cereal production (excluding China) grew at an average yearly rate of 2.7 per cent between 1960-61 to 1982-83, largely as a result of improved yields. This growth has been accompanied by a more than proportional increase in the standard deviation of production. He, applied variance decomposition procedures to data on crop production by major geographical regions of the world to analyse the sources of this increased instability. It was found that the increase in aggregate production variability was predominantly due to increased yield variability and to a simultaneous loss in offsetting patterns of variation in yields between crops and regions. He opined that these changes were probably associated with the sharp increase in the variability of world Cereal and Oil prices since the early 1970s and with the more widespread adoption of improved seed fertilizer intensive technologies.

Mahendradev (1985), examined the performance of all crops in Indian agriculture in late 1970s as compared to early 1970s and early 1960s. His study included 289 districts and 56 agro-climatic regions. It was concluded that technology and demographic forces were operating against the negative growth
regions. Increase in yield through technological factors was offset by population growth in low and very low regions. Technology and demographic forces were operating in favour of very high and high growth regions.

Chatha and Singh (1986), found that growth of area in Pulses was significantly negative and that of Oil seeds though positive but non-significant in Punjab. They opined that risk in productivity and price did not significantly affect the area under Pulses, while in case of Oil seeds the variance in productivity had a significant effect on area.

Ninan (1987), studied the growth behaviour of edible Oil seeds in India by a disaggregate analysis of the time-series data covering the pre and post-green revolution phase of Indian agriculture. State to State variations in the performance of Oil seeds were observed. The study also highlighted the negative impact of the green revolution on edible Oil seeds, whose output growth rates were either stagnating or declining in the post-green revolution period. Area appeared to be the main source of growth in output of most edible Oil seeds, yield being of secondary importance.

Mahendradev(1987), computed the unadjusted and weather adjusted trend growth rates for foodgrain production in each of the 17 major States for two time periods viz., 1960-61 to 1969-70 and 1970-71 to 1984-85. The results of his analysis showed that the inclusion of rainfall index in the trend equation improved the value of $R^2$ in most States indicating the importance of weather as an explanatory variable for variations in foodgrain production.
Bisalaiah and Patil (1987), studied the trends of major crops in Karnataka. They found that Ragi, Bajra and Pulses had experienced higher output growth ratio during the period 1966-67 to 1977-78, whereas, Rice and Jowar had recorded lower growth rates. In case of total Pulses, the pattern of output growth was area-cum-productivity led, during both the pre-green and post green revolution period. Output growth pattern in case of Jowar, Ragi, Rice and Bajra had shifted from area-cum-productivity led growth during pre-green revolution period to productivity led during green revolution period. They concluded that productivity increase had contributed substantially to the growth in output of most foodgrains and that agricultural output growth performance of Karnataka was above all India performance.

Saxena (1987), in his study, vertical growth rate in agricultural sector in India, examined the growth rate of production of Cereals for 32 years i.e., 1951-52 to 1982-83. It was observed that overall growth rate of Cereals production was 0.47 per cent. The plan-wise analysis indicated that Cereals production registered positive and significant growth rates during all the plans excepting third and sixth plan. All the same, there has been increase in almost all the important determinants upon which Cereals production is dependent. On the other hand, there has been a fall in the important Cereals.

Pal and Sirohi (1988), studied the sources of growth and instability in the production of commercial crops in India and changes in their pattern in the green revolution period. They concluded that the growth and stability in the production of commercial crops were complementary rather than competitive processes in
the intensively irrigated regions. There was no change in the frequency of shortfall in production. However, the intensity of shortfall has increased over time and Groundnut was the worst affected crop. It was observed that instability was more prominent in disaggregated production at the State level and may be much higher at the farm level. The results of the study lead to yield stabilising policies in Groundnut and Cotton and area stabilising policies in Sugarcane, Jute and Potato.

Achoth et al., (1988), reported that production of Pulses in Karnataka had registered a significant increase during the decade following the green revolution period. This increase was contributed by the increase in production in Gulbarga district. The instability in production for the State as a whole had increased in the decade after the green revolution. Most of this instability was contributed by minor Pulse growing districts. The instability induced by the change in the area variance was the largest single component which increased the instability of Pulse production in the State.

Kannan and Pushpagadan (1988) concluded from their studies in Kerala that the decline that took place in Kerala’s agriculture since the mid seventies has been such that it has wiped off the growth rate achieved during the sixties and early 70's. In short, Kerala has lost two decades of growth in agriculture. They have attributed this to the inadequate as well as ill conceived development of critical factors such as water management and land development. This has been exacerabated by the increasing environmental degradation taking place in Kerala since mid seventies.
Webster and William (1988), analysed the data from 16 Wheat growers and 18 Barley growers in south east England. Results showed that the variability of yield increased for both Wheat and Barley. Wheat yields became more positively correlated between farms, but not in Barley. The results for Wheat were consistent with the hypothesis of an increase in the number of controlled factors in the production process. Sixteen per cent of the increase in variability of Wheat production was due to changes in yield variances and covariances. The increase in variability of Barley production is not statistically significant.

Sadasivan (1989), has made an attempt to study the pattern of Pulses production in India from 1955-56 to 1984-85. The analysis was done for disaggregate levels of seasons, periods, States and crops. He used log-linear function to estimate growth trends. It was concluded that stagnancy in Pulses production at all-India level was the net result of changing situation at the disaggregate level rather than an overall stagnancy.

Singh et al., (1989), worked out linear growth rates of area, yield and production of important Oil seed crops for major Oil seeds producing States of India for pre and post-green revolution periods. Their study showed that linear growth rate of production for total Oil seeds remained the same in both the periods. Before green revolution, the annual growth rate of area was 3.14 per cent and declined to 1.14 per cent after green revolution period. However, growth rate of productivity of Oil seeds improved from -0.80 per cent to 0.98 per cent after the introduction of new crop production technology. The decrease in
area was attributed to diversion of land from Oil seed crops to Wheat and Paddy. During post-green revolution period, the growth rate of production of Groundnut in the entire country decreased and there was slight improvement in production growth rate of rapeseed and mustard.

Pal and Sirohi (1989), analysed the sources of instability in crop production and yield in different States in India between two periods say 1950-1965 and 1967-1984. The empirical findings of this study showed that yield variance contributed largely to variance of production in Pulses and Oil seeds and increased over time. After adoption of high yielding varieties, the absolute variance increased on account of increased sensitivity of high yielding varieties to inputs and weather especially rainfall. The intensive use of irrigation lead to comparatively stable production of food grains.

Tripathy and Bhuyan (1989), in their study growth of crop output in Orissa, found that during the period 1970-71 to 1984-85, foodgrains production in the State grew at the rate of 1.69 per cent to which area and yield contributed 1.27 per cent and 0.42 per cent, respectively. Except Rice, all the major crops recorded high growth rates of area and production. Rice registered the lowest growth rate of production due to significant decline in its area. A significant increase in productivity was found in Wheat and Maize. The growth rate of yield of Ragi was negative but non-significant. They concluded that area expansion was the main factor behind additional foodgrains production in the State during post-green revolution period.
Bandyopadhyay (1989), analysed the contrasts between the behaviour patterns of the production of Rice in West Bengal and Wheat in Punjab-Haryana during the pre and post-green revolution periods. The analysis revealed that there had been an outward shift of the production frontier of Wheat in Punjab-Haryana in the post-green revolution period. But this parametric shift in production frontier was not accompanied by an increase in the rate of growth of production of Wheat, the rate falling from 7.73 per cent to 5.31 per cent per annum. West Bengal recorded a general fall in the rate of growth of Rice production, particularly in the northern districts, accompanied by a widening year-to-year fluctuations.

Sharma and Gandhi (1990), examined the annual compound growth rates of foodgrain production in India during several time periods since early 1950s. They found that the growth rate of foodgrain production declined somewhat from the pre-green revolution period (1949-50 to 1964-65) to the first half of the post-green revolution period (1967-68 to 1975-76). From first to the second half of post-green revolution period (1975-76 to 1983-84) the growth rate showed a modest acceleration from 1.9 per cent to 2.5 per cent per annum. The overall growth rate was 2.6 per cent per annum which indicated that the rate of growth of foodgrain production had recovered and was being sustained. The analysis also revealed the declining potential of area-led production growth rate, yield based growth rate sharply increasing in importance contributing over 90 per cent of growth during 1975-76 to 1983-84, thus bringing to the fore the criticality of the policies for sustaining yield and technology-based growth in the future.
Based on a study in Karnataka, Vasudha (1990) used Cobb-Douglas production function to assess the relationship between agricultural output (in value term) and selected explanatory variables. The period of analysis was 1956 to 1983. It was observed that gross cropped area, fertilizer consumption, animal labour and human labour were statistically significant variables explaining variation in agricultural output. The study further reveals that agriculture production had increased at the rate of 3.11 per cent per annum during the period under study and growth in production was predominantly contributed by fertilizer and irrigation.

Singh and Byerlee (1990), have made an attempt to estimate coefficient of variation of Wheat yields for 57 countries from detrended data for various periods between 1951 and 1986. It was found that coefficient of variation in Wheat yields was determined by country size, moisture regime and temperature. Technological variables, such as level of adoption of high yielding varieties and fertilizer dose, had no effect on differences in yield variability across the countries. Analysis of yield variability for the same set of countries for three periods from 1951 to 1986 showed a general decline in yield variability since 1975 in developing countries. Analysis of Wheat variability in India at the State and district levels confirms the analysis of country level data. The study reveals that coefficient of variability of Wheat yields in India in the period 1976-85 has fallen to less than half the level in the 1950s and this decline is statistically significant.
Feng (1990), using total factor productivity (TFP) reviewed the efficiency change in Chinese agriculture since 1949. The first part analysed the changed trend of TFP by dividing the 4 decades into 3 stages. The second part measured the share of TFP in total agricultural output growth. Part three discussed the basic patterns of TFP growth in general and the Chinese output pattern in particular.

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

Bhatia (1991), found that during the period 1949-50 to 1989-90, growth rate of production of Pulses was much lower than foodgrains and population growth rate. It was reported that growth rate of production of total Pulses was
1.39 per cent per annum during pre-green revolution period (1949-50 to 1964-65) as against 0.78 per cent in post-green revolution period (1967-68 to 1989-90). The relatively higher growth rate of production of Pulses in the pre-green revolution period was mainly because of higher growth rate of area. However, growth rate of productivity had improved from -0.22 per cent in pre-green revolution period to 0.57 per cent in post-green revolution period.

Chattopadhyay and Maity (1991), made an attempt to study structural change in composition of foodgrains production in India for two time periods i.e., pre-green revolution period (1950-51 to 1967-68) and post-green revolution period (1968-69 to 1984-85). They found that a structural break in the time trend in Wheat production had taken place in the early seventies. The relative stability of the production of Rice has been hampered during the post-green revolution period and a sharp drop in the production of other Cereals has occurred in the seventies. It was further revealed that trends in the composition of Cereals production during the two periods were significantly different from each other and the breaks in the trends could not be explained only in terms of the movement of prices of the crops.

Azam et al., (1991), emphasised that productivity growth is an important component of economic growth in research programme relating to agriculture and were found to have contributed to productivity growth. This study is one of the first to quantify the economic impacts of agricultural research in Pakistan employing both partial factor productivity and total factor productivity indices. A comparison of TFP changes in the Indian State of Punjab and Pakistan
provinces utilising comparable data and computational methods have been made. This analysis is comparable to the studies in other countries usually referred to as TFP decomposition. Estimates of benefits based on total surplus (producer plus consumer) were utilised to compute marginal internal rate of return (MIRR) to investment in research.

Cooke and Sundqvist (1991), used Tomqvist input quantity indices to derive total and partial factor productivity measures for U.S. Cotton across time, region and scale. Total factor productivity for U.S. Cotton increased by 2 per cent per year between 1974-1982. The partial productivity measures revealed that yield growth was about 6 per cent and input use increased by about 4 per cent per year. Cotton enterprises in Alabama and Mississippi gained and those in the Texas high plains lost competitive advantage relative to California in 1982. Cotton enterprises with very large (1750-5900 acres) and large (950-1749 acres) area were 2 per cent more productive than medium size enterprises (570-949 acres).

Dolakia and Dolakia (1991), observed that developing countries have dramatically increased the agricultural output in the later half of the 20th century which were largely attributed to higher productivity of land and labour. The study focused on agricultural modernization of India, questioning whether it has actually raised agricultural growth rates and productivity levels. The nature and extent of modernization were evaluated taking into account the impact of Government policy. There was evidence to suggest that the green-revolution in
the primary sector has led to significant increases in total factor productivity (TFP).

Luh and Stefanou (1991), evolved a measure of productivity growth adjusted for deviations from the long-run equilibrium. An empirical application to U.S. agriculture permitted identifying the dynamic linkages between technical change and productivity growth in agriculture. Total factor productivity as dynamically measured grew at 1.50 per cent per annum. The combined effect of scale, quality adjusted input growth, and long-run disequilibrium input use contributed only 3.44 per cent of the growth, while technical change dominated the growth of total factor productivity.

The growth and instability in Wheat production in Madhya Pradesh was analysed by Jayadevan (1991) comparing for two time periods (1950-51 thru 1964-65 and 1965-66 thru 1986-87) across five region of the State. At the State level rate of growth of production of Wheat declined from 3.74 per cent to 3.06 per cent between the two periods. Increase in output in the pre-green revolution period was mainly area-led accounting for 63.90 per cent, whereas in the post-green revolution phase it was productivity-led (66.67 per cent).

Mitra and Jena (1991), attempted a decomposition analysis of growth rates of Groundnut production in Orissa for two time periods; period I (1950-53 thru 1962-65) and period II (1967-70 thru 1983-86), to examine the relative contribution of the basic components of yield, area and their interaction. The growth rate of area during the period II (9.33 per cent per annum) was found to be more than double when compared to that of period I. The compound growth
rate of production of Groundnut for the entire period was an impressive 10.47 per cent per annum brought about by significant growth of both area and yield.

Naidu and Munikrishnudu (1991), used both linear and exponential growth functions to estimate and compare growth and instability in agricultural production in Chittoor district of Andhra Pradesh for the two time periods viz., period I (1954-55 thru 1964-65) and period II (1965-66 thru 1985-86). Their analysis revealed more ‘area effect’ than ‘yield effect’ in the growth rate of output of all crops except Sugarcane in the pre-green revolution period. But it was vice-versa in the post-green revolution phase (period II) in respect of all crops except Groundnut and Sugarcane.

Evenson (1992), analysed the determinants of changes in TFP in U.S. agriculture over the 1950-82 period. Separate measures for growth of crop and livestock sectors were attempted. The statistical analysis related to TFP growth in each sector and to past investments in public sector agricultural research and extension programme, private sector research and development, schooling of farmers, geo-climatic factors, off farm employment opportunities and farm policy regimes. The study found that TFP growth has been highest in the crop sector. The combined crop and livestock sectors produced TFP growth rates well above those realised in the economy at large. Public sector agricultural research contributed to TFP growth in both the sectors. A distinction was made between pre-technology research and applied research. The study showed that those State research systems with highest investments in pre-technology science research contributed to most of TFP growth. Investment in agricultural extension
and farmer education also contributed to TFP growth. Similarly, research and development in private sector also contributed in TFP growth in the agricultural sector.

Fleisher and Liu (1992), observed that despite widespread reforms in agricultural policy, Chinese agriculture experienced stagnation. This study is based on data collected from 1200 farm households. Using a Cobb-Douglas production function, the hypothesis concerning economies of scale, diseconomies of multiple plots and multiple crops were tested. The stagnation of Chinese agriculture was attributed to the restricted nature of economic reforms. Market limitation which gives rise to super abundance of labour, multiple cropping and severely restricted plot sizes prohibited the expansion of production that would have occurred if economies of specialisation and plot consolidation could be realised. The continuation and extension of reforms to encompass transfer of cultivation rights, long term leases and expansion of credit markets to facilitate specialisation and self-sufficiency in terms of crops was suggested to expand output and growth in Chinese agriculture.

Kumar and Mruthyunjaya (1992), assessed the total factor productivity (TFP) growth in Wheat production for the States of Punjab, Haryana, Uttar Pradesh, Madhya Pradesh and Rajasthan. The Tomqvist-divisia index was used to compute the total output, total input, TFP and input price indices for Wheat grown in major States of India based on micro-level farm data for the post-green revolution period (1970-71 to 1988-89). The results showed that the technical change in Wheat production benefitted consumers relatively more than
The total factor productivity or technical change was found to contribute more than one third to total output growth. Market infrastructure, research and mechanisation were indicated as the most important sources of growth in TFP. It was opined that the area under modern varieties has already reached the ceiling levels particularly in front-line States. Thus, the need for varieties was emphasised to achieve breakthrough in yield levels.

Thrtle and Bottomley (1992), studied indices of total factor productivity (TFP) which measures aggregated output per unit of aggregate input, providing a guide to the efficiency of agricultural production. This paper outlined the relationship between production functions and TFP indices. An index for the period 1967-90, constructed from the U.K. aggregate agricultural accounts showed that TFP grew at an average rate of 1.9 per cent per annum and an increased growth in TFP was observed since the U.K. joined the European Community. At the aggregate level, this change was explained by increased aggregate output and decreased aggregate input in about equal proportions. Disaggregation shows the intensification effect of the common agricultural policy price regime. There has been rapid growth in the output of farm crops, relative to other enterprises, and in the use of agricultural chemicals.

Acharya (1993), studied the compound growth rates of Pulses in India for different periods namely pre-green revolution period (1950-51 to 1964-65), Green revolution period (1966-67 to 1980-81) and post-green revolution period (1981-82 to 1990-91). During 1950-51 to 1964-65, the area, production and productivity of total Pulses have registered a growth rate of 1.77, 0.40 and 2.19
per cent per annum respectively while during 1966-67 to 1980-81. Pulses were pushed to marginal lands as irrigated and fertile lands got diverted to Wheat and Paddy where the increased prices made these crops more profitable. As a result area and yield of Pulses declined considerably. The production of Pulses increased at the rate of 0.97 per cent per annum during 1981-82 to 1990-91. This happened due to improvement in the yield per hectare.

Choudhari et al., (1993), in their study on growth rates in area, production and productivity of Gram in Bihar indicated that the compound growth rate in area (-4.62%) and production (-3.32%) were negative while in productivity it was positive (1.67%) and significant.

Singh et al., (1993), analysed the compound growth rates of area, production and productivity of Gram in Bihar for the period 1960-61 to 1989-90. The results revealed that the compound growth rate of Gram showed negative growth in case of area (4.62 per cent) and production (3.22 per cent) whereas in case of productivity the growth rate of 1.67 per cent was positive and significant (at 1 per cent), implying thereby the increase in productivity per unit area despite reduction in gross area owing to various factors.

Thirtle et al., (1993), constructed an index of total factor productivity (TFP) for the Zimbabwean commercial agricultural sector. The TFP grew at an impressive rate of 3 per cent per annum over the period 1970-89. It was pointed that despite the change in Government policy that directed resources towards the communal lands, the sale of commercial farms coupled with political uncertainty had no effect on the TFP growth rate. The disaggregation provided
evidence that the commercial farmers have been reluctant to invest and the minimum wage legislation and other factors reduced employment in this sector.

Kaushik (1993), indicated that during period-I, most of the growth in Oil seeds output in India was due to the growth in area where as during period-II, it was mainly due to the improvement in the productivity. The study further revealed that the fluctuations in yield has to be controlled to bring in stability in the output. This would mean concerted research efforts should be made in developing new varieties of Oil seeds where yield potential was stable across different agro-climatic zone.

Singh et.al., (1993), tried district-wise analysis of the performance of Gram in Bihar for the period 1960-61 to 1989-90. The production decelerated at the rate of 3.32 per cent per annum despite a modest positive growth rate of 1.67 per cent per annum in productivity. Similar declining trend in growth rates of area and productivity was discernable in almost all districts covered in the study.

Tripathy and Srinivasa Gowda (1993), used exponential functions to estimate and compare the district wise compound growth rates of area, yield and production of Groundnut in Orissa during the seventies (1970-71 to 1979-80) and the eighties (1980-81 to 1989-90). The structural change in the growth pattern between the decades was examined employing a Chow's test. Despite negative growth rates of yield in both the decades, growth rate of production had been impressive, which increased form 4.56 per cent per annum in the seventies to 7.87 per cent in the eighties, mainly because of a high growth rate in area
increase. The structural change in the growth function, especially that of yield and production in almost all the district covered, was apparent from the significant 'F' values obtained in the Chow's test.

Hiremath et al., (1994), studied the growth rates in area, production and productivity of important Pulse crops in Karnataka for the period 1984-85 to 1993-94 for important Pulse crops. The annual growth rate in area under Redgram decreased steadily (0.067 per cent) over the period from 1984 to 1994 whereas in other Pulse crops it increased. The area under Blackgram showed the highest growth rate of 6.51 per cent followed by Greengram (5.4 per cent) and Bengalgram (1.12 per cent). With respect to production, Blackgram registered a higher growth rate (12.15 per cent) followed by Greengram (2.35 per cent). Production of Bengalgram and Redgram decreased over a period of time by 1.31 per cent and 1.57 per cent respectively. With respect to productivity Blackgram showed the highest growth rate (5.50 per cent) followed by Greengram (4.9 per cent) and both were statistically significant. The growth rate of Bengalgram was 0.38 per cent and that of Redgram was -3.25 per cent.

A comparative analysis of the performances of West Bengal's agricultural sector during the 1980s and during the period upto 1980s was attempted by Saha and Madhura (1994). They observed that for the State as a whole aggregate output grew at 6.4 per cent per annum during the 1980s which was highest among 17 States. The high agricultural growth was fairly widespread with all but two districts reporting an annual growth of above five per cent. Decomposition of growth in output revealed that in most districts contribution of
productivity growth to total output growth was substantially higher than contribution of growth in area.

Kumar and Rosegrant (1994), analysing the returns to research for Rice production in India observed the input index recording a growth rate of 6 per cent per annum in the northern region while the southern region registered the lowest growth rate at 1.1 per cent per annum. During the same period the output increased by 6.8 per cent per annum in northern region while it was 0.8 per cent in the western region. In terms of TFP, southern region recorded the highest growth rate at 1.85 per cent. The TFP negative growth rate (-0.98 per cent) in the western region attributed to wide fluctuations in weather. However, the effect was statistically nonsignificant. The TFP growth during the post green revolution (1981-88) period had declined when compared to the green revolution period. The slowdown in adoption of modern varieties and declining trend of investment in lowering of TFP. Market infrastructure, research, canal irrigation and balanced use of fertilizers were identified as the important factors contributing to growth in TFP. The marginal returns to public investment in Rice research for different regions were very high. The internal rate of return to public research in Rice was very high (55 per cent). The scope for future productivity gains in Rice production was found to be in eastern and southern regions of India. The need to target public investments in research, irrigation and infrastructure was emphasised.
Rosegrant and Evenson (1994), estimated the trends in TFP for the Indian crop sector. The growth in TFP was observed to be 1.13 per cent per annum during the period 1956-87. In the same period the total output grew at 2.25 per cent per annum while the growth in input was recorded at 1.11 per cent per annum. Thus, productivity growth accounted for just over one half of total output growth in the Indian crop sector. The decomposition of TFP revealed that public expenditure, expenditure on extension, irrigation and foreign private research had a significant and positive impact on TFP in all periods. The impact of markets as a proxy for rural investment was observed to be positive and significant in the first and the third periods. The impact of relative wages was negative in the first two periods. An increase in non-farm income tightens the labour market in agriculture which induces increased efficiency in production. The estimated effect of irrigation and literacy on TFP was strongly positive. The contribution of HYVs to TFP growth was modest at around seven per cent. The returns to public agricultural research worked out at 53 per cent during the post-green revolution period. The returns to public extension were high at 61 per cent for the entire period and 52 per cent for the final sub-period. It was clear that TFP growth was mainly due to investments, primarily in research, extension, markets and irrigation.

Evidence for deceleration in Indian foodgrain production in the 1980s was observed by Thampan (1994). The trend analysis of different crops over sixth and seventh five-year plan periods covering the eighties revealed that growth in production during the VII plan period was much less for all the Cereals and
Pulses compared to that during the VI plan period. In the case of Rice, the annual growth rate of production declined from 7.8 to 5.4 per cent between the plan periods and for Wheat the decline was more glaring, from 6.9 to 2.8 per cent. The reasons attributed for the deceleration of output growth were indiscriminate use of chemical inputs and neglect of soil health.

Goswami et al., (1995), made an attempt to analyse the compound growth rates of area, yield and production of total Pulses, Gram and Tur. The compound growth rate of area of total Pulses and Gram (1.77 and 1.82 per cent, respectively) was higher in Phase-I (1950-51 to 1964-65) as compared to Phase-II (1967-68 to 1980-81) and Phase-III (1981-82 to 1990-91). However, the highest growth rate of area of Tur to the extent of 2.28 per cent was noticed in Phase-III. The growth rate of total Pulses and Gram was found to be 1.04 and 1.03 per cent in Phase-III. While growth rate of yield of Tur was negative both in Phase-I and Phase-III. Higher compound growth rate of production to the extent of 2.19 and 2.66 per cent in case of total Pulses and Gram was noticed in Phase-I. The highest, 0.82 per cent compound growth rate in production of Tur was noticed in Phase-III. Increase in area contributed for higher growth rate in production of total Pulses and Gram for Phase-I while increase in yield was responsible in growth in production in Phase-III.

In Karnataka, the yield increases brought about by HYV seeds were not really revolutionary. But there was a qualitative difference. During 1955-56 to 1966-67, the gross irrigated area rose by 3.10 per cent per annum (vinked exponential rate), while in during 1967-68 to 1979-80, it increased at its rate of
1.70 per cent per annum the first trend break being significant at one per cent level. On the other hand, fertiliser use per hectare went up from 2.22 kgs in period 1 to 19.08 kgs during 1967-68 to 1979-80 and 47.38kgs during 1980-81 to 1989-90. Thus in earlier period irrigation was responsible for growth, while mid period it was due to the HYV seeds and chemical fertilisers (Asha Maheshwari, 1996).

Patel et al. (1996), studied the compound growth rates of Pulses in selected districts of Gujarat for the period 1949-1991. For Gujarat State as a whole, the production growth rate for the study period worked out to 3.05 per cent, the growth rate in area and yield was 0.70 per cent and 2.19 per cent, respectively. Surendranagar district registered highest growth rate in area (4.78 per cent) and production (6.82 per cent). The figure of co-efficient of variation was found to be 43.63 per cent for production, 22.65 per cent for area and 29.22 per cent for yield.

Ravi Srinivas (1996) observed sustainable agriculture is not another technological fix, but involves the nurturing and protection of biodiversity and encouraging diverse agricultural practice, which are ecologically sound. The new trade regimes and dominant trend in bio-technology are emerging as potential threats to sustainable agriculture.

Tripathy and Srinivasagowda (1996), studied the variability of foodgrains production in Orissa using Hazell’s decomposition analysis. The empirical findings of the study suggested the need for area stabilising policy such as price policy for Pulses, Ragi, Millets and Maize and yield stabilising policies for Rice,
Wheat, Jowar and Bajra. The dominance of coastal districts in increased production variability emphasised 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.

Dhindsa and Anjusharma (1997), made an attempt to study the compound growth rates of area, production productivity of Pulses in Punjab for the period 1966-67 to 1991-92. The negative growth of production of Pulses can be mainly attributed to a decline in area and stagnancy in the yield of various Pulse crops. Gram has shown decline in its area and production in most of the regions. The yield of Massar has shown significant positive growth rate in two regions and in the State as a whole during 1966-92. The area under Moong crop has shown a very high growth rate of 13.79 per cent per annum during 1966-92 in Punjab State as a whole. The yield has also shown significant positive rates of growth in two regions of the State.

Kandappa Kumar Barmon (1997) studied the compound growth rates of area, production and productivity of Pulses in Assam for the period 1967-68 to 1989-90. It was found that the compound growth, rates of production of Gram, Tur, other Pulses and total Pulses were 3.75 per cent, 5.03 per cent, 2.84 per cent and 2.85 per cent, respectively. The growth rate of production of Tur was found to be the highest but its yield growth rate was negative being -0.51 per cent per annum. The growth rates of area under different Pulses turn out to be positive in case of Assam and these are much higher than the corresponding growth rates in case of India. He concluded that on production front, special
efforts should be made to generate and transfer appropriate technology for dry farming and limited irrigated agriculture.

Sawant (1997), studied the growth performance of India’s agriculture sector during different periods. Compound annual growth rates (CAGRs) were estimated by fitting a log-linear trend function, namely \( \log y = a + bt \) to the time period specified namely period I (1968-69 to 1980-81) and period-II (1981-82 to 1994-95). The growth scenario for Pulses indicated that from acute stagnation in output in the early part of the green revolution period, the situation improved to a positive significant but low growth in output (CAGR=1 per cent) after 1981. The former was the outcome of low pace of expansion in area accompanied by declines in the yield per hectare of Pulses while in the post 1981 period, expansion in Pulses output was totally induced by growth in their yield per hectare (CAGR=1 per cent). The dismal performance of the two major Pulses, namely, Gram and Tur, was largely responsible for low level of output growth for all Pulses after 1981. By and large, however, Pulses represented a group of slow growing crops throughout the green revolution period.

Singh et al., (1997), while assessing the regional variations in agricultural performance in India, estimated the compound growth rates of area, production and yield of Pulses by fitting log-linear functions of the form \( \log y = a + bt \). The data were analysed for 3 time periods viz., period-I (1960-61 to 67-68), period-II (1968-69 to 1980-81) and period-III (1981-82 to 1992-93). In almost all the States selected for analysis, the growth rates of Pulses were highest during period-II. In Karnataka during the same period, significant growth rates were
observed with respect to area (1.93 per cent), production (1.72 per cent) and productivity (3.66 per cent).

2.2. MEASUREMENT OF TECHNICAL EFFICIENCY:

Bisalaiah (1977), decomposed the output change under new production technology in Wheat farming for various factors of production for the data from Ferozpur district of Punjab and found that the per acre production of Mexican Wheat was about 40 per cent higher than that of the local variety. He concluded that from the same per acre input level of labour, fertilizer and capital 15 per cent more output could be obtained with the Mexican Wheat indicating the effect of technical change.

Bisalaiah (1978), used employment decomposition model to decompose the total changes in employment, per acre into technology, wage rate and complimentary input components and found that new technology Wheat farms absorbs about 41 per cent more labour per acre than an old technology farm. Further, he estimated the contribution of technology alone to total change in employment was about 12 per cent and negative employment effort of normalised wage rate was about 15 per cent. Lastly, the complimentary input effect on employment was about 54 per cent with fertilizer alone contributing 40 per cent followed by irrigation 9 per cent and capital 5 per cent.

Lopez (1980), using an aggregate cost function and an aggregate production function observed the growth in Canadian agriculture being primarily associated with economies of scale rather than with factor-augmenting technical
change. A dual cost function was used to derive explicitly the system of four input demand equations (labour, capital, land and structures and intermediate inputs) using time-series data for the period 1948-77. Estimates of the own-price elasticities and of the hicks-Allen elasticities of substitution among the input pairs were also provided.

Barker et al., (1981), did not find evidence to support the contention that the adoption of modern technology leads to greater production stability. On the contrary, they found a tendency for the absolute variability to increase even though relative variability may in some cases remain unchanged or even decline. This was supported with the fact that the production stabilising components of technology such as plant and land ameliorating are almost invariably accompanied by destabilising components of technology and, on balance, absolute variability in yield tends to increase. In order to minimise the inherent instability associated with new technology, be emphasised to increase the investment in maintenance research.

Mehra (1981), observed that in the decade 1967-68 to 1977-78, the standard deviation and coefficient of variation of production for all the crop aggregates increased as compared with the period 1949-50 to 1964-65. A breakdown of production variability into area and yield variability showed that fluctuation in yield has been the dominant force. It was found that for crop aggregates, the standard deviation of yield increased for crops as a whole and for foodgrains but not for non-foodgrains. Among the foodgrains, Bajra, Maize and Jowar crops, where new technology had played a part, showed large
increases in absolute and relative yield variability. But Wheat and Rice crops, where new technology has been widespread, showed only a small increase in absolute yield variability. Findings of the study highlighted the need for strengthening the elements of new technology that help to reduce variability of yield.

Russel and Young (1983), employed the frontier production function in measuring the technical efficiency of 56 farms in North-West England. The mean efficiency level of the farms was 0.72 and 0.73 for the Kopp and Timer measures of technical efficiency. They pointed out that the mild decreasing returns to scale resulted in the OPP measure for being slightly lower than the timer measure. It was found that approximately 36 per cent of the farms were at least 75 per cent efficient, 75 per cent of the farms were at least 64 per cent efficient and the entire sample was at least 39 per cent efficient.

Thrtle (1985), analysed the productivity for field crops being transformed by the mechanical and fertilizer revolutions in U.S. Since, input data were typically not available by crop, most investigations of productivity were limited to the aggregate levels. This paper developed a simultaneous equation partial adjustment model of the demand for inputs which generated estimates of the technical change parameters for Wheat, Corn, Soyabean and Cotton. These estimates allow comparisons of the factor saving biases in technical change leading to a novel test of induced innovation hypothesis and suggested that productivity slow down may effect agriculture in the United States.
Ranaweera and Hafi (1985), while estimating the technical efficiency of the Maize growing farmers using frontier production function observed that the mean technical efficiency for the sample was 52 per cent which indicated that the total Maize output can be almost doubled if farmers can be encouraged to use the best practice technology and by removing the socio-economic constraints. Nearly one-fourth of the sample farmers were found to be in the technical efficiency range of 51 to 60 per cent and about 58 per cent within the range of 41 to 70 per cent.

Ekanayake and Jayasuriya (1987), adopted the frontier production function analysis to measures the technical efficiency. The study was undertaken in Sri Lanka at two locations which were at the ‘head’ and ‘tail’ of a major irrigation channel. The farmers located at the ‘head’ had access to water throughout the season while access of water to those at the ‘tail’ region was limited. The corrected ordinary least squares estimates of the Cobb-Douglas frontier production function indicated that in the ‘head’ region the mean technical efficiency of the sample farmers was 53 per cent and in the ‘tail’ region it was 50 per cent.

Mclean-Miynesse and Okunde (1988), used divert flexible (dual) cost function to derive a system of conditional factor demand equations for Louisiana Rice producers. Generalised Leontief cost and factor share equations were fitted for the 1955-87 period using Zellner’s share estimation procedure. The Aitken parameter estimates revealed that the optimal input mix of Rice farmers varied with production scale. The factor augmenting technical change was
labour and chemical saving but seed using. The pairwise input substitutions were limited and factor demands were own-price inelastic. An implication based on the study was that Louisiana Rice farmers would not appreciably alter their factor utilizations when relative input prices change.

Jayaram (1988), studying the efficiency of Paddy and irrigated Ragi cultivators of Mandya district using frontier production function approach found the corrected ordinary least squares estimates of technical efficiency for Paddy cultivators to be 97.61 and 97.54 per cent respectively for large and small farmers, while for the irrigated Ragi cultivators it was 94.6 and 92.98 per cent for large and small farmers, respectively. The study of the level of inputs use indicated that large farmers had used their inputs more efficiently than the small farmers in both the crops.

Bouchet et al., (1989), disaggregated the growth of French agriculture among Cereals, non-cereal crops, Milk and Animal products. Shortrun and longrun supply functions were derived from a restricted profit function model in which capital and family labour were assumed quasi-fixed factors adjusted optimally. Technical change as a source of output growth was suggested. Domestic research was identified to be the primary cause of increased Cereals output over the 1960-84 period, while international technology transfers and domestic research efforts were considered important for Milk production.

Castle (1989), opined that measurement of cost-size relationship in farming has been an important area of research in agricultural economics for long time. Much of these research had a farm management and production
economics orientation where firm-industry inter-dependencies were often being ignored. Research results stemming from such an orientation should be interpreted with care when used for policy purposes. Pecuniary externalities were considered of great importance than indicated by research. Treating induced technical change as comparable to a pecuniary externality was suggested. Questions were raised on both theoretical and empirical grounds whether farming in the United States should be considered as a constant cost industry for policy purposes.

Knudson and Larson (1989), stated that technical change as dynamic, recursive and endogenous to the economic system. Further, it was pointed that empirical studies usually treated technology as exogenous and defined technical change in terms of its end results which changed in some production possibilities set. A conceptual framework was developed in which technical change was treated as endogenous. The framework accounted for the dynamic and recursive interactions between research and development activities, the adoption and diffusion of new innovations and the regulatory and institutional environment. As an example, the development of Glyphosate tolerant crops was discussed to show how the framework could be used to identify, organise and understand the important variables and relationships for a specific case of technical change.

Schrader (1989), considered different types of technical change on the farm and their effects at sectoral level evaluated through economical considerations. Impacts on production, input use and farm adjustment were
discussed with regard to biological-chemical, mechanical-electronic and organisational-institutional types of innovations. Quantitative effects of the German agricultural sector since 1950 and changing tendencies in the eighties were analysed. It was shown that the gap productivity between agricultural and other sectors of the economy has decreased, input use in agriculture being stagnating and discrepancies between labour requirements and labour capacity were widening. Finally, the direction of technical progress under changing economic conditions was discussed which should contribute to a solution of conflicts in agricultural policy.

Jain and Singh (1991), estimated the growth rates of different Pulse crops in Punjab during the pre- and post-green revolution phase to examine whether the new Cereal technology had got diffused to Pulses or not. During the pre-green revolution period area, yield and production of total Pulses registered positive but non-significant growth rates indicating stagnancy, whereas in the second period all the three variables gave negative growth rates which were significant in the case of area and production denoting deceleration. Continuous substitution of area under Pulses with HYV Cereal crops was the main reason for the desperate performance of Pulses in the post-green revolution period.

Becker and Guyomard (1991), stated that confrontation of productivity growth theory with reality has led to significant advances in both methodology and theory. The advanced duality theory established linkage between index numbers and production technology. The two concepts of Tomqvist productivity indices and econometric estimation of cost function were applied to French and
German agriculture using sectoral data from 1961-84. For the whole period, the Tomqvist productivity indices documented for France worked out to 2 per cent which was higher when compared to German agricultural sector at 1.6 per cent per annum. The results further indicated declining productivity growth performance for France but accelerated rates for Germany. The econometric cost functions presuming constant returns to scale provided similar results for global technical change to the index number approach. In addition, for the factors considered such as variable inputs, labour, land and capital non-neutral technical change as described by Hicks was found to exist.

Arnade (1992), studied Brazil's agricultural sector which underwent major changes in the past two decades. Though Brazil was abundant in labour, land and animal power, Government subsidies encouraged the use of fertilizer and machines. Since productivity growth arised from technical change Brazil's drive to modernise its agricultural sector should improve agricultural productivity. However, inefficient production practices arose from subsidies can show multifactor productivity growth. Recent removal of agricultural subsidies in Brazil as coincided with increased productivity providing evidence that input subsidies made Brazilian agriculture inefficient.

Byerlee (1992), focussed on dry land Wheat areas of Central and Southern India where Wheat was produced on deep black soils in a fallow Wheat system, which depended heavily on the conservation of monsoon rainfall. Wheat yields increased slowly in dryland areas when compared to irrigated areas yet fetched higher prices. This was due to the fact that more than half of the
dryland Wheat area was planted by improved varieties (durum) which possessed superior drought tolerance, rust resistance and were of high quality grain fetching premium prices. Allocation of resources for research in dryland Wheat appeared to be in accordance with its relative importance in total production. The interaction between favoured (irrigated) and marginal (dryland) areas occurred through food and labour markets.

Sidhu and Byerlee (1992), analysed trends using micro-level farm data to measure productivity growth in Wheat by using an index of total factor productivity. Although farmers initially benefited from green-revolution yet the surplus generated by increased productivity during the 1970s and 1980s resulted in benefiting the Wheat consumers more rather than the producers. The changes calculated in TFP supported these findings, especially with regard to productivity gains arising from land-saving compared to labour-saving technologies. The empirical evidence indicated that future yield gains being high were not readily apparent. A more likely source of future productivity gains was expected from efficient use of inputs including fertilizer and water.

Lo and Huang (1992), used a cross-sectional multi-input and one output translog cost function to analyse the structure of Rice production in Taiwan. Based on cost data obtained from a sample of 55 farms in Taichung county, it was concluded that Rice production in Taiwan was inefficient under the consignment cultivation system and the Government’s Rice support policy. Given the decline in the supply of farm labour, the Government has promoted the use of new technologies and has guaranteed to purchase a given quantity of
Rice at a fixed price. Combined with underlying structure of the agricultural sector, these factors have inhibited farmers ability to improve efficiency. Based on the findings, it was recommended that input prices should be kept variable, mechanization reviewed and an extension programme introduced to improve the overall efficiency.

Neunteufel (1992), used an econometrically estimated translog cost function to investigate factor demand and substitution in Austrian agriculture. The analysis considered the factors such as capital, land, labour, feeding stuffs, fertilizers, energy and other non-specified inputs. After an explanation of the theoretical principles involved, the empirical section used average data for the years 1984-88. The results suggested that technical progress contributed 2.6 per cent per year to the growth of Austrian agriculture.

2.3. USE OF TREND/REGRESSION FOR GROWTH ANALYSIS:

Garg (1964), identified physiographic regions by working out trend of agricultural development in respect of total cropped area, gross irrigated area and food grain production in two districts. The productivity trends in respect of acreage, production and average yield per acre of three important crops, namely Rice, Wheat and Sugarcane were also worked out. To reflect the long term trends, the method of moving averages was adopted. Two districts in eastern region, one district in western region representing the extreme conditions of agricultural development were selected for comparison against the background of the overall figures of Uttar Pradesh.
Gopalakrishna and Rao (1964), measured the variation in output per acre by analysing resource endowment of the district including level of human investment, level of organisation of the resources and demographic pressure which necessitates more intensive cultivation. A multiple linear regression model was used with value of output per hectare as depended variable and percentage irrigated area and percentage area under food and fodder crops as independent variables to estimate the relationships.

Radhakrishna (1964), compared two regions of West Godavari district with respect of productivities of inputs by fitting Cob-Douglas type of production functions. The value of human labour and bullock labour was regressed on the value of output and compared with the marginal value productivities. In the regions where the marginal value productivity of labour was low, projects involving employment of human labour was recommended.

Easter et.al., (1977), found that the restraints to change the level and distribution of agricultural output varying from region to region. For this purpose, it was recommended to measure the contribution of (i) quantity of traditional inputs such as land, labour and fertilizer (ii) quality of certain inputs such as irrigation, technology, environmental factors, soil types and rainfall (iii) infrastructure conditions of transportation and markets to total output. A production function approach was suggested to measure the above relationship.

The growth rate of gross value of agricultural output in Karnataka at 1974-75 prices were estimated to be 3.1 per cent (Anonymous 1978). Nine districts namely; Raichur, Chitradurga, Bidar, Kolar, Shimoga, Mysore, Bellary,
Gulbarga and Mandya registered a growth rate above this level. The remaining ten districts experienced growth rates ranging between 1.3 and 2.8 per cent. The positions of various districts vis-a-vis the State in terms of output per hectare valued at 1960-61 and 1974-75 prices were identified. The average per hectare value of output for the State as a whole in 1960-61 was Rs.1259 and 1974-75 it was Rs.1914. This report also included an analysis of crop and district specialisation based on location quotient. Divergencies were identified between the desirable cropping patterns and the actual practice followed from the point of view of natural advantage and infrastructural facilities.

Mahendradev (1987) indicated in his studies that inclusion of rainfall index in trend equation has improved the value of $R^2$ in most of the States, which indicates that rainfall was able to explain the major part of the variation in food grain production. Growth rate slowed down in most of the States in the decade of 1970's compared to previous decade. The first half of the 1980's, however, witnessed a recovery in the rates of growth in some high growth States of the 1960's. Some hitherto low growth States also (Rajasthan, Madya Pradesh and West Bengal) registered high rates of growth during the period. The trends in instability reveal that it varied from a high declining trend in Punjab to a high increasing trend in Tamil Nadu. The trends in instability for four crops aggregates (Rice, Wheat, Coarse Cereals and Pulses) shows that instability for Rice, Coarse Cereals and Pulses declined in some States. On the contrary, it declined in most States for Wheat. It was shown that the differences in quantity
and quality of irrigation might be the major factor that influenced inter-State variation in growth and instability in foodgrain production.

Green *et al.*, (1992), observed that in the recent years Argentina and Brazil have experienced far-reaching changes in the structure of marketing channels with the development of hyper-markets and super-markets as well as shopping centres. This has coincided with the dawn of new information technologies which are particularly important in large-scale distribution where a large number of quick turnover products have to be managed. This trend is of such an importance that it has created a need to change the way of looking at studying the food sector so as to achieve better understanding and interactions between the various sectors involved farmers, industrial firms, logistics and distributors. An important feature in Argentina and Brazil has been the entry of major European companies such as Carrefour and Makro which have overturned the existing food marketing system (logistics and sales outlets). They have also changed the way the market competition operates.