Review of Literature on Productivity

2.1. Introduction

The review in this study is restricted mainly to literature on productivity in agriculture. There are studies at international level comparing the level and growth trend of countries, developed as well as developing, studies at national and regional level. However, with respect to the time frame, the methodology employed, the nature of data used, the number of variables examined and the estimation procedure adopted, the conclusion of the studies vary widely. The studies reviewed are arranged in chronological order so that it enables us to trace the historical evolution of the methodology used, the improvement in data coverage and estimation procedure and the contribution of each piece of research to the stock of knowledge.

2.2. International Studies

A significant impetus in understanding the factors influencing international agricultural productivity was provided by Hayami (1969, 1970), Hayami and Ruttan (1970), with updating by Nguyen (1979), Kawagoe and Hayami (1983), and Kawagoe, Hayami and Ruttan (1985). They stressed the influence of education and human capital on productivity growth. By conducting a separate analysis for developed and developing countries, Hayami and Ruttan (1970) implicitly assumed that technology might change with the level of development. This raises the question of how agricultural productivity varies across countries.

In an attempt to explain cross-country differences in agricultural productivity, Evenson and Kislev (1975) emphasized the role of research. using a Cobb-Douglas production function. Antle. J.M (1983) focused on the effect of transportation and communication infrastructure on aggregate agricultural productivity for the period 1965-66 for 66 countries comprising 47 less developed and 19 developed nations for all crops using secondary data and Cobb-Douglas function. The variables used in the study are land, labour and livestock variables that
represent the country’s resource endowments of these inputs. The fertilizer variable is used as a proxy for ‘modern’ inputs. The education variable as a measure of the country’s human capital stock in 1965. The research variable was included to capture the effect of investments in agricultural research on the Hicks-neutral productivity level of each country’s agricultural sector. The study tested Hayami-Ruttan hypothesis that production function coefficients are equal across the developed and less developed country groups. The hypothesis was not rejected for a model that accounts for variation in the Hicks neutral productivity levels due to difference across countries in human capital, research and infrastructure.

Using an econometric approach, Nehru and Dhareshwar (1994) examined sources of TFP growth in 83 industrial and developing countries for the period 1960-1990. They found that human capital formation was three to four times more important than raw labour in explaining output growth. Using human capital as a separate variable, they found that the countries with the fastest growing economies have based their growth on factor accumulation (human capital, labour and physical capital), not growth in efficiency or technology.

Developing a non-parametric approach to production analysis Chavas (2001) investigates international agricultural productivity. The analysis develops productivity indexes based on Shephard's (1970) input distance function and non-parametric representation of technology. The approach is applied to FAO annual data of inputs and outputs for twelve countries for the period 1960-1994. It estimates separate production frontier for each country and therefore it does not require the assumption that the production technology is similar across countries. It was found that technical efficiency was decreasing in most of the countries during the late 1960s probably due to environmental degradation.

Data Envelopment Analysis to derive Malmquist productivity indices was utilised by Rao, and Coelli (2004) to examine level and trends in agricultural output and productivity for 1980 – 1995 for 97 countries treating crops and livestock as output variable. Time series data provided by the FAO and the ILO have been used to estimate Total Factor Productivity. The study found that TFP was growing at rate of 2.7 percent annually. China witnessed spectacular performance recording 6.8 percent TFP growth. India posted a Total Factor Productivity growth of 1.6 percent.
Asia is the major performer with TFP growth rate of 3.1 percent and Africa registered the weakest performance with 0.9 percent growth.

2.3. National Level Studies – Rest of the World

Numerous studies were conducted on the productivity theme in the United States and other Western European countries. The present review does not touch up on these studies, as they will be used in the context of methodology. Only a few studies are taken up for review.

On the sources of productivity gains in Japanese agriculture as compared with the U.S experience for the period 1952-54 and 1959-61 Kaneda (1967)\textsuperscript{13} used the output elasticity estimates derived from Cobb-Douglas production function as the weights for land, labour and capital in the computation of total productivity index. The annual growth rate of residuals (rate of technical change) is found to be 2.9 percent. Land productivity and mechanization are the two factors that contributed 95 percent of productivity gain in labour.

Wen G. J (1993)\textsuperscript{14} examines the performance of the successive rural institutions in China in terms of changes in Total Factor Productivity for 1952-89 using Secondary time series data for crop and non-crop output. The study estimates PFP and Total Factor Productivity using TT index. The study concluded that Household Responsibility System (HRS) was more efficient in resource allocation than the commune system in increasing Total Factor Productivity. In more than 20 years the commune system succeeded in improving land productivity but worsened labour productivity. In the context of HRS both rose.

Using farm level cross-sectional survey data Wadud and Ben (2002)\textsuperscript{15} measured farm-specific technical inefficiency of rice farmers in Bangladesh. Technical inefficiency effects are modelled as a function of environmental factors, irrigation infrastructure and farm-specific socio-economic factors.

The study estimated a Translog stochastic frontier production model with the specification of technical inefficiency effects model which included farm-specific factors like age, education of farmers, land fragmentation, irrigation infrastructure and land degradation, using the single stage formulation applying maximize likelihood techniques. The study revealed that technical inefficiency effects tend to
be significantly influenced by the factors measuring environmental degradation and irrigation infrastructure. Younger farmers, who adopt new technology, are educated and those who have easier access to credit are most likely to operate farming activities efficiently. Moreover, larger the land plot size the greater is the technical efficiency. Land management and land tenure policies in reducing the land fragmentation remain critical to improving technical efficiency and hence household welfare.

2.4. National Level Studies – India

Relatively large volume of literature on productivity is available in Indian Agricultural economics. Majority of studies conducted at all India level compute partial productivity measures, particularly land productivity. Mukherjee and Vaidyanathan (1980)\textsuperscript{16} used econometric technique and fitted two models to study the effect of rainfall on yield variation and alternatively the effect of rainfall, inputs, the interaction between their effects and sustained changes in output due to productivity changes for the period 1950-51, 1975-76 using time series data. As regards the use of inputs Kerala’s input index showed 13 percent fall over the period considered.

Bhalla & Alagh (1983)\textsuperscript{17} made an attempt to examine the levels and changes in labour productivity in agriculture in 281 districts of India during 1962-65 to 1970-73 and to statistically explain the inter-district variation in labour productivity in these regions by factors like intensity of use of capital and other important inputs. The variation in male worker productivity is explained using double log regression analysis. The study found that tractor alone was able to explain fairly large variation in labour productivity in both periods. Since high growth districts were the predominant users of available tractors and tube wells, capital intensity per worker was the main determinant of labour productivity in these districts. Fixed capital alone was important, but additional variables like gross cropped area and fertilizers resulted in significant increase in the explanation of variation in labour productivity. As investment in modern equipment like tractors and tube wells was limited and even the working capital requirements were quite low in traditional agriculture, labour productivity depended more on the vagaries of monsoons than on quantum of fixed and variable capital.
Bhatia (1992)\textsuperscript{18} tried to understand the changes in input efficiency in the production of wheat in the major growing states of India during post-green period, 1970-71 to 1990-91. Using time series data on wheat for Punjab, Haryana, U.P, and M.P the partial Factor Productivity of land, labour, fertilizer and total factor productivity are computed using multiple linear regressions. The study found improved input use efficiency over the years; labour productivity and land productivity have improved resulting in the reduction in unit cost due to the use of land saving technologies of high yielding variety seeds, fertilisers, insecticides, etc. and the marginal productivity of fertiliser came down particularly in Punjab due to its over use.

Roségrant and Evenson (1992)\textsuperscript{19} tried to assess Total Factor Productivity growth, traced the sources of productivity growth and estimated the rate of return to public investment in research and extension in India for 1956 –1987 using cross section and time series data at district level. Törnqvist -Theil index was computed for 271 districts in 13 states in India for the said period. To assess the determinants, Total Factor Productivity index was regressed as a function of variables such as investment in research, extension, human capital and infrastructure. Altogether, 15 independent variables were used in regression. Dummy variables were used for agro-climatic zones. The study found that main sources of productivity growth were public research and extension and private research. The rate of return to public research and extension were high indicating continued profitability of public investment in agricultural research and extension.

Dholakia and Dholakia (1993)\textsuperscript{20} aimed to estimate the sources of growth of Indian agriculture for three sub-periods during 1950-51 to 1988-89 for all crops. It also estimated the contribution of adverse weather conditions and intensity of resource use to total factor productivity growth. The analysis was developed in growth accounting framework, worked out the growth rates of output and inputs, land, labour and capital using time series data. Principal component analysis was used to identify the determinants of TFP growth so as to avoid the problem of multi co-linearity, which is unavoidable in time series data. The study confirmed the hypothesis that modern agricultural inputs like fertilizer, HYV seeds and irrigation determine the TFP corrected for weather.
In order to address the issues like the contribution of growth to total output growth, the sources of productivity growth and the returns to agricultural research, Kumar and Rosségrant (1994) attempt to assess Total Factor Productivity growth for rice in different regions in India and examine the sources of productivity growth. Index number approach to growth accounting has been used. Divisia -Törnqvist index for TFP was calculated. To estimate the impact of probable variables on TFP, the TFP index was treated as the dependent variable and regressed by nine relevant variables. Time series data from different regions were pooled and dummy variables are included for regions, keeping the eastern region as the reference region. Estimation was undertaken using a fixed effects approach for the pooled cross section time series regional level data set for 1970-71 to 1988-89. The study revealed that increase in area and production of crop was highly associated with their relative profitability Rice area increased slowly since 1980s mainly through substitution from coarse cereals. Market infrastructure, research, canal irrigation, balanced use of fertilizers were found to the important source of TFP. Future productivity gains in rice production would have to be achieved from the eastern and the southern regions of India.

Panigrahi, Ramakrishna (1995) analysed the growth pattern and identified factors affecting productivity levels across states and examined the role of population in land productivity growth for the period 1967 – 68 to 1991-92 in India during the post green revolution period for principal crops divided into food crops and non-food crops. Secondary time series data was used and multiple regression method was applied.

Bhalla and Singh (1997) examined the contribution of Indian agriculture in the productivity frame for the period 1980-83 to 1992-95 for the states in India. The contribution of area to the output growth has drastically diminished; the expansion of gross cropped area through double cropping has increased. Cropping pattern changes were positive since low yield and low value coarse cereals were replaced by high value oilseeds as well as rice and wheat, without adversely affecting food grain output. A rise in labour productivity was another striking feature during 1980-83 to 1992-95.
On studying the relationship between farm prices and aggregate agricultural production, as well as agricultural productivity in 20 Indian districts belonging to seven states taking into account seventeen harvests, Schafer (1997) examined whether changes in farm prices were an important, or even the sufficient factor in effecting changes in cultivated area or in aggregate agricultural production. Regression method is employed. The expected price at time $t$ was estimated by Nerlovian Model. The study could find only a weak positive correlation between farm prices and agricultural area. No statistically significant relation could be established between farm prices and agricultural productivity. No significant relationship between agricultural production and farm prices was found. However, there is relationship between infrastructure, proxied by irrigation or length of roads, and agricultural production. This supports the view that prices do not have a proven short-term effect on aggregate agricultural production but infrastructure plays a good role. Policy implication is that non-market factor, including provision of better infrastructure and socio-economic environment influences productivity rather than the accepted wisdom of market factors.

Mittal and Kumar (2000) used Total Factor Productivity as a measure of quality of inputs and technology. Using cross section and time series data for 1973-95 for wheat and rice Törnqvist-Theil index is worked out. The period was subdivided into 1973-90: pre-trade liberalization; 1990-95: short term liberalized economic environment; 1973-95: long term perspective. In order to examine the impact of literacy on TFP simultaneous equation model was utilised. The study found that literacy was positively related to crop productivity and strongly linked to farm modernisation.

Assessing the TFP growth, measuring the changes in real cost of production, identifying the sources of productivity and estimating marginal rate of return to public investment on wheat production in different states (Punjab, Haryana, UP, MP and Rajasthan) in India were the aims of Mittal, Surabhi & Lal, R.C (2001). Secondary data on inputs, their prices were collected for the period 1971-72 and 1995-95. State level time series data on area, yield, production, irrigation, HYVs, rural literacy rate, village electrification, sources of irrigation etc. were taken from
published reports of GOI. Using the accounting framework the Divisia-Törnqvist index is used to compute the total output, input and input price indices.

Cross section time series data were used in the estimation of TFP decomposition model using three stage least squares (3SLS) estimation framework. The study found that the TFP index for wheat rose at the rate of 0.9 percent per annum and contributed about 24 percent to the output growth. Research investment, quality of inputs and rural infrastructure are the most important determinants of TFP growth. There is a need to target public investments to agricultural research, ground water irrigation, electrification to areas where the yield levels are still low.

Long run relationship between land productivity of food grain and government investment in agriculture in India was the thrust of Shyjan (2003) using secondary data of food grains for the period 1974-75 to 200-01. The study found that growth rate in productivity was not uniform through out. Growth rates of productivity were higher for cereals than for pulses. Kerala and Punjab had levels of investment higher than the national average during all the plan periods. They stood above for food productivity too. Lag in food grains productivity and investment is more than 12 years in Kerala and Punjab. The lag is more in those states where share of cereals is more in food grains.

For analysing the temporal and spatial variations in the sustainability status of the crop sector in Indo Gangetic Plane (IGP) and identifying sources of Total Factor Productivity of food crop sector in the region Kumar, et. al (2004) used district wise secondary data for the period 1980 – 81 to 1996 – 97 for the states, Punjab, Haryana, U.P, Bihar, and W. Bengal. Growth accounting approach was adopted for computing TFP growth. Divisia-Törnqvist index was used. To find the determinants of TFP, its index was regressed on a number of variables. In order to find the impact of infrastructure on total factor productivity an Infrastructure Index was computed using six major infrastructural facilities – transport, energy, irrigation, banking, education and health. Energy, transport, irrigation, and finance are economic infrastructural facilities while education institutions and health facilities are considered as social infrastructure. The major findings of the study are: The TFP index of the crop sector in IGP rose by 1.2 percent annually during 1981 to 1987; productivity alone contributed 1/3 of the increase in output; productivity growth attained in 1980s was
not sustained in 1990s and The public policies such as investment in research, extension, education and infrastructure (road, electrification, educational institutions, health facilities, banking etc.) have been the major sources of TFP growth.

2.5. Regional Studies –other than Kerala

In this section, we deviate from the chronological approach generally followed hitherto in reviewing earlier studies. The studies here are clubbed state wise so that region wise comparison of the studies is possible.

Majority of regional studies during the 1960s and 70s focussed on testing the Shultzian hypothesis that traditional farmer utilises resources efficiently. Reddy (1967)\textsuperscript{29} tested the hypothesis and approved it for Andhra Pradesh. Agricultural production in India may not be increased simply by increasing all inputs in the traditional state of art but should introduce a modern technology package. The package should consist of new inputs, agricultural education, special skills, and techniques, and guidance in farm planning. Primary data for 1957-58 in West Godavari district for rice and tobacco in 3 villages were collected and used CD function to estimate the marginal factor cost and the marginal value product. Efficiency is defined in terms of marginal factor cost and marginal value product, \( \frac{MFC}{MVP} \leq 1 \).

Iqbal and Azeemuddin (1993)\textsuperscript{30} assessed and evaluated the impact of tube well irrigation on input utilization in the paddy crop and to find out its relationship with output and assessed the productivity and profit of paddy growers in Tribal and Non-tribal area of AP. Using Cross-section data for 1992 the study could find that variables like season, seeds, fertilizers, pesticides and hired labour components were significant in influencing the value per acre of paddy crop. Manures and acres were found to be nonsignificant.

The objective of Kumar et. al (1984)\textsuperscript{31} was to estimate the yield per hectare of wheat in the three agro-climatic zones (low hills, mid hills and high hills) so as to determine the levels of land productivity in different soil and climatic conditions of wheat in Himachal Pradesh. Average yield for three years was computed as a combined average of yield of individual years. Sample data for three years from 1979-80 to 1981-82 were analysed. The yield of irrigated wheat is highest in the low hills. The yield of irrigated wheat has been found to fall as the altitude increases.
Joyal. R.K (1987) was to enquire into the effect of health on productivity, using district level aggregate data in respect of 54 districts of Uttar Pradesh. Scores of variables affect productivity such as labour related, like literacy, type of employment, health. Others relate to non-labour or physical variables, like urbanization, roads, consumption of electricity, fertilizers. A set of 17 variables was included. And, stepwise regression was run. It was shown that among the variables concerned with attributes of labour, health variable has positive and significant contribution toward productivity.

Sau (1990) analysed the productivity differentials in rice across the major rice producing states of India and in rice and food grains across the districts of West Bengal. It uses econometric method. Productivity in agriculture as measured by the output per hectare depends mainly on two factors: the level of inputs used and resource base and infrastructure development of the region. The indicators of inputs used are: Percentage of gross area irrigated to gross cropped area; Fertilizer used per hectare of cropped area; Percentage of HYV area to gross cropped area and credit availability per hectare or per capita. Infrastructure, in its broad sense covers the items that provide external economies to the farmers as a whole. Its indicators are: Road mileage per square kilometer; percentage of electrified villages and Literacy rate.

Pillai (2001) focuses on the role of input utilization in paddy cultivation during the 80’s and early 90’s. The exercise is carried out for West Bengal and Orissa by examining a) changes in aggregate, state level factor productivity growth b) the extent of technical inefficiency, and difference if any, across seasons, crop varieties, status and overtime and c) whether there is perceptible shift in production technology overtime in the case of west Bengal. The upsurge in agricultural productivity in general is attributed to two major factors: 1) Role of institutional changes and 2) Wider adoption of new technology, better utilization of fertilizers, credit and so on. Using time series data for 1971 to 92 for West Bengal, for 1971 to 93 for Orissa and farm level study (cross section data) is carried out for 1986-87 for West Bengal and 1990-91 of Orissa separated by season and crop variety. Growth accounting method is used and Divisia-Törnqvist index is computed. The study
found that input productivity played an important role in the growth performance in 80’s and 90’s. The performance of West Bengal was better than Orissa.

Ahmed and Bhowmick (1991) attempted to examine: the extent of variability in area, yield and price; the nature of price, productivity and acreage movement over the period in relation to technology; and the factors responsible for determining the area under the principal crops. Price, productivity (kg/hect), productivity of competing crops are the factors influencing the variation of acreage of a crop in Assam. The study is based on five principal crops, rice, rapeseed & mustard, jute, wheat, and potato in Assam. Time series data were used. Time period variable was used as a proxy for technology. Simple linear model was used for the purpose with $P, Y, A = f(t)$. Supply response function was fitted in line with the Nerlovian type. Both linear and double log form of the function were fitted and linear form was found to be more representative. The study concluded that acreage under the principal crops in Assam is influenced by the yield of the crop, lag acreage and area under irrigation. Farmers in Assam were not at all price responsive for the crops considered here with respect to allocation of acreage. It means that farmers in this area are yet to take farming as a business.

Sarma (1999) analysed the impact of mechanisation on land productivity in the Jorhat district of Assam for 1991-92 covering the crops: Rice, Mustard, and Potato. Field level data was used and multiple regression was run. The study found that mechanisation improved productivity. Borbora and Mahanta (2001) examined the factor intensity in agriculture of Assam. To examine the impact of fertilizer and rainfall on agricultural productivity for the period 1990 – 1999 in all the 23 districts of Assam Time series data was utilised to estimate marginal productivity of land specifying Cobb-Douglas production function. The parameters were estimated by using least squares method. Borbora and Mahanta (2002) tried to identify inter-district disparities in the agricultural sector in 23 districts of Assam. The period of study is:1998-99. Crops are not specified. Secondary data, cross-section was used for estimating land productivity. The method of analysis is: Principal component method used to determine factors influencing production. To measure inter-district disparity in agricultural development in the state 13 indicators were developed. The
study found that inter-district disparity existed in proportion to the area under cultivation.

Patil and Kalyankar (1992) studied the impact of research on productivity of major crops grown in Marathawada region of Maharashtra. Time series data on area, production and productivity per hectare was collected from 1970-1990 and trend analysis was done using regression. Production and productivity of crops included in the study increased during the period covered.

Singh and Kaur (1992) attempted to study the growth in productivity in different districts of the Punjab during the 70s and 80s; to examine the inter-district gap and variation in agricultural productivity in Punjab; to study the relationship between incremental productivity and incremental capital investments and type of capital investments. Growth rates were worked out. Rank method was adopted to compare the productivity differential among districts. Agricultural productivity in Punjab was increasing at the rate of 4 percent per annum during the 70s and 80s.

Sidhu and Byerkee (2001) tried to find out the major sources of growth in wheat productivity in the post green revolution period after HYVs were widely adopted; the prospects for continuing to exploit these sources of growth; slower growth in productivity reflect changing input-output ratio that provides a disincentive for investing in improved technology; increased yields and changing practices reflected in changes in costs of production and TFP in wheat; extent of increase of productivity in wheat been captured by producers or passed on to consumers in the form of lower prices. Data collected from the Comprehensive Scheme for the Study of Costs of Cultivation of Principal Crops in Punjab has made use of. Total productivity index has been worked out. This index is superior to the usual approach in India of equating productivity with yield per unit of land area, which does not account for increasing importance of purchased inputs in substituting for land in wheat production. More over, the TFP index has been proposed as way of measuring sustainability. The study concluded that important source of productivity has been labour saving technology. The use of Bio-chemical technologies has only modestly increased TFP. Further productivity gains in wheat production could be achieved by more efficient use of inputs such as fertiliser and water.
Adams and Bumb (1993)\textsuperscript{42} tried to know the sources of district wise agricultural productivity in Rajasthan for 1971 covering all crops. Seventeen variables were included. Land Productivity was estimated using Factor analysis. The result of the study showed that land productivity depended directly upon three things: supplies of conventional inputs, the cropping pattern and cropping intensity, and the use of modern mechanical and chemical technologies. Infrastructure and institutions are facilitative or intermediary variables.

Singh and Singh (1993)\textsuperscript{43} examined the growth rates of area, production and productivity of gram in different districts of Bihar; estimate the factors affecting the area, production and productivity of gram. Based on the district wise secondary time series data on area, production, productivity, prices, irrigated area, and annual rainfall from 1960-61 to 1989-90. Compound growth rates have been estimated. In order to study the impact of various factors on yield a Cobb Douglas type function was fitted using the output per hectare as the dependent variable and annual rain fall, area under irrigation, current year prices (Rs./qtl.) and one year lagged prices (Rs./qtl.) as independent variables. Conclusion was that though the area under pulses were mostly pre-determined and as the area under irrigation increased it was gradually substituted by cereal or cash crops; the production could be increased either by motivating the farmers of non-traditional pulses growing area or by introducing pulses crops in no-traditional crop seasons.

Nanavati and Patel (1994)\textsuperscript{44} examined the relative position of districts after the green revolution for 1970-71 to 1984-85 taking food and non-food crops in Gujarat. Land productivity was estimated using secondary cross-section data. The method of analysis was simple in that coefficient of variation of output among districts was worked out. It concluded that the share of food and non-food crops in SDP remained 50:50; govt. policy towards agriculture should be on the basis of agro-climatic zones. Shiyani and Maurvi (2002)\textsuperscript{45} estimated total factor productivity growth for 4 major oilseed crops viz., groundnut, castor, mustard and sesame in Gujarat. TFP is measured as an index of total output to index of total factor inputs and encompasses the impact of technical change and change in the level of all inputs. Time series data on area, production and yield per hectare of four oil seeds have been collected. Data on crop inputs included human labour (man days), bullock labour.
(days/hectare), seed (kg/hect.), insecticides/pesticides (Rs/hect.), miscellaneous cost which includes the cost of transportation and other paid out expenditure (Rs/hect.), depreciation cost of farm buildings and implements (Rs./hect.), and rental value of owned land (Rs./ha.). The Tornquist Theil index was used for computing the total output index, total factor productivity index. The growth rate of total output indices, total input indices and total factor productivity indices were worked out. The acreage and yield per hectare of all the crops improved substantially during the 40 year period. Positive rate of growth was found in the case of castor, while others showed negative growth rate.

Singh and Nandal (1995)\textsuperscript{46} examined the effect of land degradation on agricultural productivity and its magnitude for the period 1989-90 covering all crops. Primary data were used to compute land productivity. Cobb-Douglas production function was estimated using regression technique for Haryana. It found that appropriate choice of technology like surface and sub surface drainage, improved crop varieties etc. could reverse the process of degradation and improve productivity.

Jain and Idnani (1996)\textsuperscript{47} was to envisage the cost return structure according to size of holding; determine the resource productivity of rainfed paddy in different size of holding and; to suggest measures to improve the productivity of rainfed paddy. Secondary data on 80 cultivators in Chatisgarh region of Madhyapradesh was collected. A Cobb-Douglas production function was fitted for human labour, bullock labour, capital inputs and fixed inputs on paddy production. Estimating land productivity the study concluded that rainfed cultivation was profitable only for medium and large scale farmers. Kawadia (2000)\textsuperscript{48} was to decompose labour productivity to identify the factors contributing it. As cultivators and agricultural labourers cannot be distinguished average product of workers is termed as labour productivity for all crops. The method used by Bhalla and Alagh (1983) was employed. Labour productivity growth is decomposed into growth rate of land productivity, cropping intensity and land labour ratio.

Mythili and Shanmugam (2000)\textsuperscript{49} measured farm level technical efficiency for rice in TamilNadu using farm level data for 1990-91, 91-92, 92-93. Frontier Production Function Technique was applied using the Cobb-Douglas production function type applying Maximum Likelihood method of estimation. Total output in
quintals is regressed on human labour in man hours, area in hectares, fertilizer in kg., capital expenditure incurred on bullock labour, machinery and pesticides in money terms. It concluded that technical efficiency ranged between 46.5 and 96.7 mean TE being 82 percent. Extension services and training programmes do contribute to TE. Govindarajan et. al (2004) analysed the productivity variation over time and space effects using error component model and to suggest suitable policy measure for improving the rice productivity. It covered the period: 1980-2002. The area of study was Cauvery Delta region consisting Kumbakonam of Tanjore district, Mannagudi taluk of Nagapattinam district of Tamil Nadu. Both primary and secondary data were used to estimate land productivity. Productivity is hypothesised to depending on inputs, time, region and other random factors. Time effects are changes in technology, management efficiency, soil quality, climate, status of management, input quality such as water, labour skill and the level of service provided in the region. The productivity variation can be decomposed into input effect, regional effect, time effect and stochastic effect. The variation in output due to changes in the level of input used is the input effect on output. The regional difference in output due to variation in availability of say water, quality water, management services is the spatial effect. The variation in output due to change in time period was termed as the regional effect. Productivity decomposition is carried out by the CD form of Time Varying Stochastic Frontier Production Function (TVSFPF). The study found that except for seeds, all other inputs contributed positively to productivity. There is very little space for improving productivity as majority of sample farmers have reached more than 80 percent efficiency levels. Farmers should be taught to adopt modern practices of farming by intensifying the extension activities of the State Department of Agriculture.

2.6. Regional Studies – Kerala

There are studies focusing on one or more crops or on the agricultural sector as such. Invariably all studies attempt to estimate land productivity defined as the output per hectare. One earlier study on Kerala economy on productivity theme was that of Oommen (1962). Defining productivity as yield per acre the author worked out land productivity of important crops except rubber in Kerala during 1950-51 to 1960-61. A simple linear regression was fitted for time to find the growth rate. The
study found that though productivity of cereals and pulses generally showed a rising trend, many other crops especially cash crops, did not show a steady rise in productivity. Factors behind productivity are identified as irrigation, improved seeds, fertilizer consumption, and disease controls.

Pillai (1969) was analysing the impact of irrigation on rice production in Kerala using aggregate data for the period 1952-53 to 1965-66 for rice using secondary data. Using OLS method of regression and treating irrigating and un-irrigated area as exogenous variables the author estimated land productivity. The study concluded that irrigated farms yield more output than un-irrigated farms.

George (1979) worked out land productivity for food and non-food crops. Simple linear growth rate was used to estimate the trend in output and area of crop cultivation. The period covered is 1952-53 and 1974-75. Time series data was utilised. Growth rate in agriculture was contributed more by increase in area under cultivation than by increase in productivity during the period. The price non-price factors responsible for increase in productivity were examined and found that price relations have adversely affected the cultivators in respect of most of the crops. Large increase in the growth rate of area under non-food crops, accompanied by negative growth rate in productivity should be a matter of serious concern. The stagnant growth rate of food production especially rice, despite large increase in the supply of irrigation, calls for closer look at our irrigation projects. In view of favourable response of individual crop areas to price, there is need for evolving a long-term input-output price policy consistent with the land use capability and the requirements of overall economic growth. Long-term policy agricultural research is called for it will enhance technological progress and thereby agricultural productivity.

Jeemol Unni (1981) analysed the reason for the shift in cropping pattern away from rice to coconut for the period 1960-61 to 1978-79 using secondary data. Land productivity was computed by simple statistical values like ratios, percentages etc. The result of the study was that coconut was substituting for rice in wetlands because of relative profitability of coconut single cropped paddy land than double cropped converted faster. Higher labour fertiliser cost in paddy while paddy prices fluctuated.
A first comprehensive study on Kerala agriculture economy is that of Pillai (1982). The aim of the study was to analyse in summary measures the growth of agricultural output in Kerala during the period from 1952-53 to 1978-79 as against the overall performance of the state economy. It also looked at (i) whether the green revolution in Indian agriculture brought any noticeable impact on Kerala’s agriculture, (ii) whether this sector was yet poised for sustained growth with stability and (iii) whether agricultural growth started decelerating in the recent past. Time series data has been used to construct index of area, production and partial productivity of all crops, food crops and non-food crops separately. Annual compound growth rates as a summary measure of growth and range and standard deviations as measures of variations to examine the stability or otherwise in the growth were used. The study concludes that there has been a gradual decline in the share of agriculture in the total SDP, particularly from the mid-sixties. During the mid sixties per worker contribution to SDP of the primary sector has been on the decline and that of the secondary sector on the increase. There has been a shift in the cropping pattern in favour of plantation crops. Among the food crops, increase in the production of tapioca has been substantial. Pulses, pepper, cashew nuts and coconuts declined. Sugarcane and banana experienced moderate gains in yield. Rice, tapioca, rubber and tea recorded impressive increase in yield.

In Indian agriculture the general performance of agricultural production and yield was better during the 70’s than in the 60’s. However, it was the other way round in Kerala. In Kerala’s agriculture the 60’s witnessed a period of accelerated growth and after the 70’s a period of decelerated growth. Kerala’s agriculture witnessed during the sixties much higher growth rates in area as well as output, but not in productivity. The growth of productivity in Kerala’s agriculture always lagged behind that in Indian agriculture. As arable land is limited in Kerala and, the only way to increase production is to concentrate on productivity. Sivanandan (1985) attempted to know the nature of variation among crops, seasons and regions and to identify factors influencing such variations for the period 1960-61 to 1982-83. The method of curve fitting was effectively used; growth curve of second degree was fitted. Since 1970-71 was taken as the base year for calculation, 1977-78 gives the year in which growth rate is zero and turns to be negative. It was in 1975-76, the new system of land utilization survey was introduced. Area classification was
according to agro-climatic zones. The study found that determinants of growth or decay of production could be identified as variations in land capability, effectiveness of irrigation, use of fertilizers, spread of HYVs and availability of credit.

George and Mukherjee (1986)\textsuperscript{57} analysed the changes in the growth pattern of rice in Kerala over and across time (between 1960-61 to 1974-75, I period and 1975-76 to 1983-84, period II), across seasons (autumn, winter and summer), and across space (major rice growing districts), irrigation and relative prices in explaining the changes in area, yield and production of rice. Regression is run to estimate compound growth rate of area, yield and production. Additive decomposition model was used to identify the contribution of area, yield in explaining the changes in production over the period following Minhas and Vaidyanthan (1965), Dharam Narain (1977) and Vidya Sagar (1980). The study concludes that it is unlikely that the area under paddy in the state could be increased. While maintaining the parity between paddy prices and wage rates might prevent farmers from keeping land fallow, price incentives are unlikely to induce a shift in the cropping pattern in favour of paddy. There is scope, however for increased production through changes in technology, particularly HYV and fertiliser application. However, this can be effective only if irrigation facilities, both surface and ground water are utilised efficiently. Thus, the strategy for increased rice production in Kerala should be based on improved utilisation of irrigation facilities, use of HYV and efforts to maintain farm level income either through remunerative output prices or through stable cost of production. It is important to explore the possibilities of increasing yield through institutional mechanism, particularly consolidation of holdings as proposed by Raj (1985).

Kannan and Pushpangadhan (1988, 1999)\textsuperscript{58} explained the agricultural stagnation that set in Kerala since the mid 70s. The study covers the period between 1962-63 and 1985-86, which seems to show that there has been two distinct phases in terms of agricultural growth. During the sixties and up to the mid 70s (1962-63 to 1974-75) there has been an over all increase in the rate of growth of area, production and yield for all the crops while in the following period 1975-76 to 1985-86 there has been a near stagnation in the growth rate of aggregate area, production and land productivity.
Index numbers were constructed for each crop with 1962-63 as the base in order to overcome the problems of different units of physical output. A measure of aggregate output was obtained on weighting index number of output of each crop by its share in the total gross cropped area for the year 1962-63. These aggregate measures are then used for the analysis of the performance of Kerala’s agriculture.

The overall performance of the agricultural sector can be measured by the growth rate of output and its components, namely, area and yield. Two methods are used: the decomposition method pioneered by Minhas and Vaidyanathan (1965) and the second is a statistical estimation method using various functional forms. A second-degree exponential function is used for measuring growth rate. The period wise growth rate is based on kinked exponential function.

The study concludes that the decline in agriculture during the 70s has wiped out the gain in growth during the 60s. The stagnation in Kerala’s agriculture is attributed to the inadequate as well as ill conceived development of critical factors such as water management and land development and increasing environmental degradation taking place in Kerala since mid 70s.

To test the hypothesis statistically that though in general Kerala agriculture was stagnant, it was severe for individual crops, Pushpangadan (1988) studied land productivity of tapioca using secondary data for the period 1963-64 to 1974-75 and 1975-76 to 1985-86. District wise analysis of the growth rate of tapioca using the 2nd degree function in terms of area, yield and output was conducted. The result of the study reveals that state level finding is not valid even for single district. Causes of stagnation of tapioca are identified as: demand constraints, low profitability compared to competing crops; and relative price of and income from competing crops, rubber.

Thomas et. al (1991) analysed the trend in area, production and land productivity and estimated the output response behaviour of tapioca in the state. Secondary data supplied by GOK, Statistics for Planning for the period 1960-61 to 1986-87 is used for the analysis. Trends are estimated by a semi logarithmic function. Area and yield response are studied by alternative linear forms of Nerlovian type function. The lagged adjustment model proposed by Nerlove postulates that actual acreage under a crop in each period is adjusted in proportion to the influence between
the desired area and actual area in the previous period. The result of the study is summarised in the table below.

The acreage showed a declining trend. The positive growth rate of productivity offset the decreasing trend in area. 1960s witnessed increasing rate of growth of area, output and productivity. 1970s witnessed negative trend in all the three. 1980s showed a slight increase in productivity coupled with a fall in area and output. The area under tapioca declined and that of natural rubber has increased. It is at the expense of tapioca. Natural rubber was considered as the competing crop with tapioca for area. The acreage under tapioca is determined mainly by its harvest price. The factor that determines yield variation is found to be rainfall. Through advancement of technology and diversification market higher level of output of tapioca could be attained.

Lelithabhai (1993)61 studied sources of production of paddy and coconut in Kalliassery panchayat using primary data. The sources of production were identified as: yield, area, cropping pattern, and interaction of area, and cropping pattern. The result of the study showed that yield is positively correlated with size of land. Larger size enjoys greater advantage. Density of plants in smallholdings is higher that results in low yield. Three major constraints identified are:1) Drainage problems in coastal plains caused by change in cropping pattern, infrastructural development and spread of human habitation; 2) Increasing problem of salinity as a result of unrestricted ground water utilization in the coastal plane and siltation of valley rises causing floods in monsoon and water scarcity in summer. Extension work in cultivation practices and community intervention are suggested for improving productivity. The social milieu is such that agriculture is considered to be a subsidiary occupation. Social institutions have to be developed to create better utilisation of land and water resources.

On evaluating the economic impact due to technical innovations in paddy cultivation in Kerala using district wise secondary data Shoba Varghese (1995)62 identified technical change as TFP. Divisia index has been worked out. TFP and TFPG index from 1961-1992 has been computed. Taking HYV seeds as embodied technical change the study estimated 55-63 percent growth in TFP from 1961 to 1992 with an average annual growth of 1.79 percent. The study found declining trend in
agricultural production since 1970s. Technical change in agriculture is due to fertilizer (embodied/chemical technology). There is continuous neglect of extension activities. Spread of HYV technology is shrinking – spread effect is low and lab to land linkage is missing.

Sathees Babu et al (1996) attempted to analyse the trends in area, production and productivity of pepper and to identify research needs and constraints in the cultivation of pepper. Time series data for 1956-57 to 1989-90 has been made use of. Exponential growth function is fitted for getting growth rate. The factors influencing land productivity were identified by step-wise multiple linear regression. Independent variables are climatological, technological and economic factors. The growth rate of area, production and average productivity are tabled below: The monthly rainfall and monthly variation in average farm harvest prices of pepper on productivity were examined by a linear regression model. May rain in summer contributed to more pepper productivity while January and July rains had negative impact. It was found that average farm harvest prices prevailing during January had influence on pepper productivity.

Thomas (1996) examined trends in area, productivity of paddy in Kerala and economic causes of decline in paddy cultivation and tried to identify current problems of paddy for the period 1960-61 to 1991-92 using both secondary time series data and primary data to study current problems. - 10 villages were collected, 5 in each Kuttanad regions in Alapuzha and Kottayam districts in June 1996. Land productivity was computed. Growth rate calculations were made to examine performance of area and productivity. Additive decomposition scheme was used to measure the change in output.

The study found that none of the sources of productivity had affected productivity of paddy. HYV seeds, chemical fertilizers, rainfall, plant protection measures are identified as the determinants that influence productivity. Productivity in Kerala since mid 70’s is attributed to the sustained decline in area under paddy, a process in which marginal paddy lands with comparatively lesser productivity had been going out of cultivation. Growing pressure on land, land price differentials and rise in paddy fields for non-agricultural purposes have resulted in the area under paddy.
Job and George (2002)\textsuperscript{65} assess technical efficiency in rice production of the State using primary data collected from Kuttanad for 1996. Maximum Likelihood Estimation is resorted. Farm specific Technical efficiency is worked out as the ratio of the production function per hectare of the $i^{th}$ farm to the frontier production per hectare of the same farm. Mean efficiency is found to be 85.01 for puncha, 84 for Virippu. Extension service and training programmes are recommended to increase farm level Technical efficiency.

Job and Nandamohan (2004)\textsuperscript{66} attempts to analyse the changes in the growth pattern of rice in Kerala across time and across seasons; between the period 1975-76 and 1998-99, and for autumn, winter and summer. Secondary time series data on area, production and productivity were compiled. Methodology is based on the computation of compound growth rate, decomposition of growth, and measures of instability. Compound growth rates of area, production and productivity or rice in the three crop seasons for the state was estimated using exponential growth model. Rice production was decomposed into area and yield effect. Area effect and yield effect were computed using a multiplicative model. Result of the study reveals that area under rice and production showed significant negative trend and positive trend in productivity. The factors responsible for the decline in area are weather, which is a short run phenomenon and price of rice. Before mid 70s rice was one of the profitable crops that got reversed on the combined effect of falling price and rising cost of production. As rice production is labour intensive, labour cost is the most important item of cost and more than 90 percent of labour used in rice cultivation is hired labour. Apart from the above, rising land value for housing and brick making industry and increasing urbanisation have contributed for the contraction of rice producing area. Rising labour cost coupled with the unmanageability and unavailability of labour had also prompted the relatively resourceful farmers to convert rice lands to be used for other relatively labour non-intensive crops.

Subash \textit{et. al} (2004)\textsuperscript{67} measured farm specific technical efficiency (TE) among rice growers in Kumarkam village of Kuttanad area in Kottayam for the period 2002. Using primary data technical efficiency was computed. Econometric method was used– Translog stochastic frontier production function estimation using the computer package Frontier 4.0. Result of the study showed that TE varied.
between 60 to 98 percent. Mean efficiency being 92 percent. The factors that
determine TE are: age, which means experience counts, education. The variables that
determine TE regressed are: raw materials, family and hired labour, fertilizer, usage
per acre tractor use, irrigation, electricity charges, extension services, sources of
credit, farm size in acres, quantities of farm output, infrastructure and data relating to
schooling, age, size of house hold.

2.7. Concluding Observations

We have reviewed important studies relating to agricultural productivity
conducted in international, national and regional perspective. Probably because of
the easiness of computations, majority of the studies seem to have measured land
productivity, which is only a partial measure that does not reveal the relationship
among variables in agricultural production. Of course, some of the recent macro
level studies conducted by using aggregate data at all India level focus on total factor
productivity. Even micro level studies in different regions of India attempt to
measure total factor productivity. In Kerala the scene is quite different. The review
of studies spanning for over 64 years from 1962 to 2004 in Kerala convincingly
show the fact that not a single study attempted to estimate the Total Factor
Productivity Growth of the agricultural sector in Kerala but relied on conventional
measure of partial productivity, particularly land productivity. Many studies have
shown that the only way out for Kerala agriculture from the stagnated state to growth
path is through technological improvement [Pillai, 1982; Kannan & Pushpangadan,
1988]. Since TFP is a measure of technical change, the primary concern in this
context is to identify factors contributing to TFP changes.

Only a few studies have taken into account the variety of crops covered in
this study. Similarly analysis based on a longer period, extending 45 years from
1960-61 to 2004-05 as we proposed to cover in this study is not seen in other studies.
Further, the methodology of analysis, particularly the cointegration approach, which
is the contemporary technique used for time series data analysis and the cost function
approach undertaken for estimating TFP and its decomposition into technical change
and returns to scale were not undertaken by any studies so far. The present study is
an endeavour in this direction


