CHAPTER 8

Summary and Conclusion of the Present Study

8.1 Introduction

The present thesis focuses on the growth performance of a few selected major crops and crop-categories of the state in West Bengal for the period 1980-81 to 2002-03. Six major crop categories — like Rice, Cereals, Pulses, Foodgrains, Fibres and Oilseeds and eight major crops — like Aman (winter paddy), Aus (autumn paddy), Boro (summer paddy), Jute, Wheat, Gram, Potato and Rapeseed- Mustard have been selected for the analysis. The objectives of the present study are—

- To understand the process of growth in agriculture through the examination of area, production and yield of different crops and crop categories in West Bengal. We have also examined whether there have been shifts in the growth path of major crop categories and individual crops between pre- and post - Liberalisation period, in the state of West Bengal. In addition, an attempt has been made in the present study to determine the factors affecting the yield of various crops.

- For analysing the growth process empirical studies mostly relied upon the traditional approach of Time Series Analysis. However, the traditional approach based on deterministic trend curve fitting and dummy variable analysis is criticized by the modern approach of Time Series analysis which relies upon the concept of stochastic trend. Theoretical development about the unit root test took place as an alternative to the traditional concept of
characterization of most macroeconomic series as Trend Stationary process. Unit root test enables us to say whether a series is Difference Stationary or Trend Stationary. A Trend Stationary process implies that the effect of a random shock is temporary around a stable trend. On the other hand, a Difference Stationary process implies that the random shock has a permanent effect. Besides, for a DS process the variance of the relevant series is a function of time. Later modifications of unit root tests with respect to both exogenous and endogenous structural break further enriched the time series analysis.

At this point, the second important objective of the present thesis is to see if there exists any structural break in the growth path of area, production and yield of major crops and crop-categories in West Bengal due to liberalization. Both exogenous and endogenous structural break approach of Modern Time Series Analysis have been considered in the study.

- To find out a long-run equilibrium relation between area under a crop and other relevant variables like price or net income of a crop. Another related objective is to see whether any deviation from the long-run relationship gets corrected through a series of partial short-run adjustments towards long-run relation.
- To measure the levels of technical efficiencies in production of different crops grown in the state and to identify the specific factors responsible for variations in inefficiencies or efficiencies of a crop.
- To measure Total Factor Productivity Growth (TFPG) in agricultural production in the state involving seven major crops — Aus, Aman, Boro, Jute, Wheat, Mustard, and Potato. Other related objectives of the present study are to decompose of the TFPG into a technical
change component, an efficiency change component and a scale change component and to analyse the factors behind the movements TFPG in the state.

The major findings of the study are summerised below.

8.2 Major Findings of the Study

8.2.1 Findings of the Growth Analysis Based on Traditional Approach

Chapter 3 of the present thesis focuses on the growth performance of area, production and yield of major crop categories and individual crops along with determination of the factors influencing the yield of various crops using traditional regression technique. A sub-period analysis has also been carried out with two sub-periods viz., the pre-Liberalisation period (1980-81 to 1990-91) and the post-Liberalisation period (1991-92 to 2002-03), using 1990-91 as the break point, to take account of the effect of economic liberalisation. The presence of inter-crop disparities is evident in the context of movements in the growth path of area, production and yield and also regarding the yield determinants.

Following observations can be made on the basis of the results from the present study.

- Considering the growth rate of area for all crop-categories, it is seen that the highest growth rate is achieved for the Oilseeds (2.12%) while the lowest positive growth rate is noticed for the Foodgrains (0.51%). The highest growth rate in production is recorded for the Oilseeds (3.82%) and the lowest positive rate is noticed for the Foodgrains (3.14%). Pulses is the only crop category which has experienced negative trends in both area (-3.43%) and production (-2.23%). The aggregate area and production growth rates are 0.82% and 3.65%, respectively. The highest yield growth has been recorded for Fibres (6.1%) followed by Rice (2.98%). Pulses (1.19%) has the lowest rate of yield growth. The aggregate yield growth has been around 2.88%.
Among the *individual crops* Boro has the highest expansion in area (6.14%) while Jute has the lowest (positive) growth rate in area (1.09%). So far as the output growth is concerned, the highest growth is recorded for Boro (6.72%) and Aus has the lowest (positive) growth rate (1.10%). Negative area growth rates are recorded for Aus (-2.52%) and Gram (-4.04%). The output growth of Gram is also negative (-3.09%). The highest rate of yield growth is noticed for Aus (3.65%) while the lowest rate is found for Wheat (0.64%).

- A period wise analysis reveals that in case of *crop-categories*, the growth rates of area, output and yield of Foodgrains, Cereals, Rice, and Oilseeds, and of yield of Pulses declined significantly in the post-liberalisation period i.e., 1991-92 to 2002-03. Statistically significant acceleration in period II is noticed for the rate of growth of area under Fibres and under Pulses.

Similarly, among the *individual crops*, the series of (i) area, production and yield of Aus, Boro, Rapeseed-Mustard and Potato, (ii) yield and production of Aman and (iii) yield of Jute have registered statistically significant decline in the latter period. On the other hand, (i) area under Jute and (ii) area and production of Gram have recorded a statistically significant increase in the post-reform period.

- An analysis of the *contribution of growth of area and growth of yield* revealed that for the entire period of analysis, significant increases in both area and yield of all *crop-categories* except Pulses have contributed to the output growth. For Pulses, the decline in area exceeded the increase in yield and the declining area has contributed significantly to the negative rate of output growth for this crop. In period I area and yield of all the categories except Pulses and Fibres have increased while these have undergone a decline in period II.
Inter-period differences become even more prominent for the individual crops. Output growth of Aus is mainly attributable to the yield improvement for the entire period and also for sub period I. For Aman, the effect of area expansion on the growth of its output can be taken to be almost zero as the output and yield rates are almost same for this crop. For the remaining crops output growth in the entire period is attributable to both area expansion and yield improvement. In period I, the output growth for Boro, Rapeseed-Mustard and Potato too, came from both area expansion and yield improvement. For Gram the decline in area has exceeded the decline in output for the entire period as well as for period I. In period II, the rates of growth of area, yield and also of output are negative and significant for Aus, Boro, Rapeseed-Mustard and Potato. In the same period, the rates of growth of output and yield of Aman being close to each other indicate that the output growth is mainly due to the yield growth. For Jute though area growth rate is positive and significant and the yield growth rate is negative and significant, the resulting output growth is found to be positive and insignificant. For Gram area expansion has remained significant whereas the yield effect has been negative and insignificant. So, the output growth for this crop in period II is mainly caused by the expansion of area.

- To explain the yield determining factors, the present thesis tested for the effect of some crop-specific variables (like, human labour, price, pesticides, fertiliser and price risk), some infrastructural variables (like Warehouse, Roads, Regulated Markets and irrigation) and also, some policy variables (like, State plan expenditure on irrigation & flood control, State plan expenditure on agriculture & rural development, expenditure on education & research in West Bengal, credit facilities such as the loan advances from the Agricultural Credit Societies
in West Bengal and the existing inequality in the distribution of operational land holding as reflected by the Gini coefficient).

There exist noticeable inter-crop variations with respect to the yield explaining factors. The price factor has emerged as an important regressor for Aus, Boro, Jute and the aggregate yield. The human labour factor has significant effect on the yield of Aman, Boro and Mustard. The price risk has adversely affected the yield of Jute and Potato. Fertiliser has been a significant variable for Boro yield and Potato yield whereas pesticides have shown positive influence on Mustard yield only. The study highlighted the importance of government expenditure on education & research in explaining the growth rate of yield for Boro and Mustard. The plan expenditure on agriculture & rural development has positive effect on Aman yield, Potato yield and the aggregate yield. The plan expenditure on irrigation & flood control has significant positive effect on Wheat yield. Irrigation as an input, has appeared to be an important parameter for Aman, Aus, Jute, and aggregate yield. The inequality in the distribution of land holding as represented by the Gini ratio is an important explanatory variable for Aman, Aus, Mustard and aggregate yield. It is to be mentioned in this context that the present thesis found a negative relation between yield and the inequality in the distribution of land holding. Thus land reforms aiming at reducing the inequality in the distribution of land holding can foster the yield growth. Loan advances from the agricultural credit societies has positively influenced Aus yield. Among the infrastructural variables, the length of roads has been positive and significant for Aman yield while the warehouse facility has appeared as a significant variable for Jute yield.

To put in a nutshell, the results from the present study reveal price responsiveness of yield for four out of eight included crops and also the significant effects of price risk and fertilizer
on yield of various crops. Other important results that follow from the study are the indispensable role of various forms of public expenditure like plan expenditure on agriculture & rural development, expenditure on education and research & variables like less inequality in the distribution of land holding, irrigation facility.

8.2.2 Findings of the Test for Exogenous and Endogenous Structural Break using the Unit Root Tests in Area, Production and Yield of Different Crops

Chapter 4 caters to the analysis of exogenous and endogenous structural break with the help of unit root tests in area, production and yield for six major crop-categories—Foodgrains, Rice, Cereals, Pulses, Oilseeds, and Fibres and eight major crops—Aman, Aus, Boro, Gram, Jute, Wheat, Potato, and Rapeseed - Mustard. The exogenous structural break analysis arbitrarily selects the break point while in the endogenous structural break analysis the break point is determined within the system. The exogenous structural break analysis considers testing of the null hypothesis of unit root, the alternative being trend stationary with the break period chosen at 1990-91. The reason for choosing 1990-91 as the break point is that due to the economic reforms various changes in economic policies began to take place around this point.

The analyses of exogenous and endogenous structural breaks using unit root analysis consider three model specifications with i) break in the level, ii) break in the growth rate and iii) break in both level and the growth rate of the series. The analysis highlights the sharp contrast that exists among various crops and crop-categories either regarding the nature of the trend process or regarding the presence of break.
• Findings of the Test for Exogenous Structural Break only in Level of the Series of Area, Production and Yield

Among the selected *crop-categories*, all series other than Pulses yield, Fibre yield and Foodgrains production have Difference Stationary Process (DSP). These three series follow Trend Stationary Process (TSP). Among these three series, Foodgrains production and Pulses yield have positive and statistically significant coefficient of time which implies that, among the selected crop-categories only these two categories show increasing trend overtime from 1980-81 to 2002-2003. The series of Production & yield of Rice and of Cereals, area & yield of Foodgrains and production of Oilseeds have positive and statistically significant coefficients of time implying that these series show increasing trend. However, as these series are DSPs, such trends are stochastic in nature and also, they are subject to increasing variability overtime. Levels of area of Foodgrains, Oilseeds & Fibres, the levels of production of Foodgrains, Rice & Cereals and the levels of yield of Rice, Pulses, Cereals & Oilseeds have a drift term in the series. Rice yield, Cereal yield and Oilseed area have positive and statistically significant structural break dummy coefficient suggesting a significant jump at the break point and in the positive direction for the respective series. The positive & significant coefficients of post-break dummy for Pulses yield and Cereals yield imply a positive significant change in the drift parameter of each series after the break point. The negative & significant coefficient of post-break dummy for Oilseeds yield ensures that there is a negative significant change in the drift parameter of the series in the post break period. However, as all series except Pulses yield, Fibre yield and Foodgrains production are of DS type they are subject to fluctuations around stochastic trends. So, any changes (whether it is
about structural break or change in drift) with respect to all the above mentioned series, except Pulses yield, Fibre yield and Foodgrains production, are not sustained in nature.

For the selected individual crops, all the series follow DSP. Among these series, production and yield of Aman and of Rapeseed- Mustard, area and production of Boro and production of Potato show increases in variability overtime while Wheat area and Boro yield show decline in variability overtime. The series like area & yield of Boro, of Aus and of Wheat, production & yield of Aman, yield of Rapeseed - Mustard and production of Potato have significant intercept term and hence, these are series with a drift term. The coefficient of the structural break dummy (D(TB)_t) did not turn out to be statistically significant for any crop. Hence, it follows that there is no evidence of one time structural break at 1990-91 in the level of area or production or yield for the crops. The positive & statistically significant post-break dummy coefficient for Wheat area and Boro yield indicates a significant positive change in the respective drift parameters in the post-break period while the negative and statistically significant estimated value of the same parameter for yield of Rapeseed – Mustard implies a significant negative change in the drift parameter, of the series, in the post-break period. However, these series being of DS type, the changes in the drift parameter of these series after 1990-91 do not reveal any sustained change.

- **Findings of the Test for Exogenous Structural Break only in Slope of the Series of Area, Production and Yield**

For the crop-categories, the results show that except the series for Fibre area, Fibre yield and Oilseeds yield, the underlying series for all other cases follow DSP. Among these DSP series, area, production & yield of Foodgrains, Cereals and Rice, area under Oilseeds and yield of Pulses have positive and statistically significant time coefficient. So, it follows that
there has been increase in variability overtime for these series. Among the TSP series, the time coefficient is positive and statistically significant for Oilseeds yield and negative and statistically significant for Fibre area. So, there exists an upward trend in Oilseeds yield for the entire period 1980-81 to 2002-03 while the series for Fibre area has a downward trend and also such trends are deterministic in nature. All series except area and production of Rice, Pulses, Cereals, production of Oilseeds and Fibre yield have drift terms. The structural break coefficient is positive and significant for Foodgrains yield, Fibre area and Fibre production implying that an increase in slope occurs for these series after 1990-91. On the other hand, a negative and statistically significant structural break coefficient for Oilseed area, Oilseed yield, Cereal area and Rice area implies a fall in slope or the growth rates for these series after the point of break. The series of yield of Cereals, Foodgrains and Rice have positive and statistically significant coefficients of post-break dummy while Oilseeds yield has a negative and statistically significant post-break dummy coefficient. However, as all the above mentioned series except Fibre area and Oilseeds yield have DSPs, the associated changes cannot be taken to represent any sustained movement overtime.

Among the individual crops, only area and production of Wheat and area under Rapeseed-Mustard follow TSP. Among all other series (which are DSPs), production and yield of Aman, area and yield of Boro, Rapeseed-Mustard yield, Aus production, Potato area and Gram yield have positive and significant time coefficient while area and production of Gram have negative and significant time coefficient. So, it follows that the series of production & yield of Aman, area & yield of Boro, yield of Rapeseed-Mustard, production of Aus, area under Potato and yield of Gram have increase in variability overtime while the series of area and production of Gram have declining variances with time. On the other hand, for TSPs like
Rapeseed-Mustard area and production of Wheat, the time coefficients are positive and significant and negative and significant, respectively. Hence, increasing trend is seen for the series for Rapeseed-Mustard area while production of Wheat shows a receding trend. It is worth mentioning that these trends are of deterministic type. All series except production and yield of Aus, Jute, Potato, area & production of Boro, and Jute production contain a drift term. Series like area, production & yield of Gram, area & production of Jute and of Wheat and production of Boro have positive and statistically significant coefficients of the structural break dummy which indicates increase in growth rates for these series in the post-break period. On the other hand, a few series like area under Rapeseed-Mustard & under Aman and area & production of Aus have negative and statistically significant values of the parameter implying a fall in growth of these series after 1990-91. Area and production of Wheat experience a positive break in slope while for Rapeseed-Mustard area we have a negative break in slope. Aman yield and Rapeseed-Mustard area have positive and statistically significant coefficient of post-break dummy while Wheat area & production, Gram area and Rapeseed-Mustard yield have negative and statistically significant coefficient of the parameter. However, as all series except area & production of Wheat and area under Rapeseed-Mustard follow DSP the apparent changes with respect to these series are stochastic in nature.

- **Findings of the Test for Exogenous Structural Break in both Level and Slope of the Series of Area, Production and Yield**

Among the *crop-categories*, all the series except Fibre area are DSP. Since, the DSPs like the series of area, production & yield of Cereals, Foodgrains and Rice, area & yield of Oilseeds, production of Fibre and yield of Pulses have positive and statistically significant
time coefficient, it implies increasing variability overtime, for these series. A negative and statistically significant time coefficient for the TSP like Fibre area implies downward trend for the series. A significant intercept term for all series except area, production & yield of Foodgrains, Pulses yield, area & yield of Oilseeds, area & production of Fibres implies presence of drift in all series except these eight series. The series of Cereal yield and of Rice yield have positive and statistically significant structural break dummy coefficients signifying a sudden upward jump in the series, at the break point. Rice area, Pulses yield and Oilseed yield have positive and significant coefficients of post-break dummy variables while area and production of Fibre have negative and significant values of the above parameter. So, it follows that while there are positive changes in the drift parameter in the post break period for the former three series, the changes in the drift parameter are negative for the latter two series. For Fibre area, there is a decline in the magnitude of drift in the post break period. The time dummy coefficient turned out to be positive and statistically significant for production of Fibre signifying a higher growth path after 1990-91 and negative and statistically significant for area under Cereals, Rice & Oilseeds and also for yield of Oilseeds signifying a lower level of growth for these series. Area under Fibre also has positive and statistically significant time dummy coefficient. As this series is a TSP it follows that it has a sustained increase in the growth rate after 1990-91. However, the changes mentioned above are not of much importance for series other than Fibre area as this is the only TSP that we have.

For *individual crops*, all series except area and production of Wheat follow a DSP. Among these DS series, positive and statistically significant time coefficients for area, production & yield of Boro and of Rapeseed-Mustard, production & yield of Aman, production of Aus, yield of Gram and area under Potato imply increasing variability
overtime, for these series. On the other hand, negative and statistically significant time
coefficient for DSPs like area and production of Gram means a decrease in the variability
overtime. A negative and statistically significant time coefficient for TSP like Wheat
production implies decreasing trend for this series overtime. From the negative and
statistically significant structural break dummy coefficient it appears that there is a downturn
in area under Aus and in production of Rapeseed-Mustard at the break point. The significant
intercept term for all series except production & yield of Aman, of Aus and of Potato, area &
production of Boro, production of Rapeseed-Mustard and yield of Jute implies presence of a
drift term in all series except these ten aforesaid series. The coefficients of post- break
dummy are positive and significant for series like area under Aman, under Aus and under
Rapeseed- Mustard implying increase in the drift parameter and negative and statistically
significant for series like area & production of Jute, of Gram, and area under Potato implying
a fall in the drift term after 1990-91. For TSPs of area and production of Wheat, negative and
statistically significant post- break dummy coefficient implies a drop in the drift parameter.
Positive and statistically significant time dummy coefficient for area & production of Jute, for
area, production & yield of Gram and also for Potato area shows increase in growth for these
series after 1990-91. On the other hand, negative and statistically significant time dummy
coefficient for area under Aman and Rapeseed- Mustard implies a fall in the growth after the
break point for these series. For TSPs like area and production of Wheat, positive and
statistically significant time dummy coefficient implies increase in growth after 1990-91.
However, as all series except area and production of Wheat are DSPs, on the basis of
stochastic trend in all these series, one cannot claim that the associated changes in the series
having a DSP are deterministic in nature.
The results from the exogenous break analysis reveal that for most of the series, the data do not support the existence of sustained structural break at the arbitrarily specified point, i.e., 1990-91. Given this observation a relevant question is: whether the nature of the series supports the break at 1990-91 in case of endogenous determination of the break points from within the system? To seek answer to this question the present study focuses on endogenous structural break analysis with the help of unit root tests.

- **Findings of the Test for Endogenous Structural Break in the Series of Area, Production and Yield**

  For the *crop-categories*, all the series, except Pulses yield, have DSP. For DSPs like area under Rice, area & yield of Cereals and of Foodgrains, production of Fibres and area, production & yield of Oilseeds positive and significant coefficients of time show increasing variance for these series. On the other hand, negative and significant coefficient of time for DSPs like production & yield of Rice, area & production of Pulses, production of Cereals show decreasing variance for these series. The series of Pulses yield, which is a TSP, has positive and significant coefficient of time signifying increasing trend for this series. In the endogenous model, one time structural break found i) in level for Pulse yield, Fibre yield, Foodgrains area and area & yield of Cereal, ii) in the growth rate for production & yield of Rice, area & production of Pulses and production series of Cereals, of Foodgrains & of Fibres, iii) in both level and slope of the series for area, production & yield of Oilseeds, Rice area, Food grain yield, area under Fibre. It deserves mentioning that as the break point is determined from within the system in the endogenous model the points of break vary not only among the crop-categories but also between different model specifications. However, all these above series except Pulses yield follow DSPs. Thus, one time structural break which
occurs in the level for Pulse yield is of sustained nature while changes in all other series are volatile. Positive and significant time dummy coefficients for Foodgrains yield and Fibre area signify a higher growth path for the respective series in the post-break period, while negative and significant time dummy coefficients for area, production & yield of Oilseeds indicate a lower growth path for these series, after the respective break points. However, the changing growth path of these series carries very little significance as these are DSPs and thus possess stochastic trend.

All crops are found to have Difference Stationary Process. The crop series with positive and significant coefficient of time and thus showing increasing variance (as these follow DSPs) are area & yield of Aman, yield of Aus, of Gram and of Wheat, area, production & yield of Boro, of Potato and of Rapeseed – Mustard, production & yield of Jute. Aman production, area under Aus, area & production of Gram, and production of Wheat have negative and significant coefficients of time and thus show decreasing variance. All series except the series of Rapeseed – Mustard production have a non-zero drift term. One time structural break found i) in level for yield of Aman, of Boro and of Jute, for Aus area and for area & production of Potato, ii) in slope or growth rate for area & production of Aman and of Boro, area under Gram, production series of Wheat & of Jute and yield of Potato and iii) in level as well as in slope of the series for Jute area, production & yield of Aus and of Gram, area, production & yield of Rapeseed - Mustard and area and yield of Wheat. Like the crop categories, for individual crops also, the break points differ among the crops and also between different model specifications. As is evident from the positive and significant time dummy coefficient, yield of Aus, area under Jute & Wheat and production & yield of Gram followed a higher growth path after their respective break points. On the other hand, yield of
Wheat, production of Aus, yield of Potato and area, production & yield of Rapeseed - Mustard had negative and significant time dummy coefficient and so these series have a lower growth path after their respective break points. However, as all series for the crops follow DSPs, the changes associated with them cannot be taken as sustained ones given the stochastic nature of the trend of the series.

The comparison between the endogenous and exogenous models reveals a few important facts. First, except Pulses yield all other series for the crop-categories, followed a DSP in the endogenous model. In case of model with exogenous break in level, all series except Pulses yield, Fibre yield and Foodgrains production depict DSPs. Notwithstanding, the differences in results between the two analyses, the endogenous structural break analysis, just as the exogenous structural break analysis, also could not find any statistical evidence for the presence of deterministic trend in series, as a general phenomenon. The same is observed for individual crops, too. In the endogenous break analysis none of the series for the selected individual crops follows a TSP. This result bears resemblance to the result from the model of exogenous break in level. However, except the series for i) area and production of Wheat, and area under Rapeseed- Mustard, in case of the model of exogenous break in slope and ii) area and production of Wheat, in case of the model of exogenous break in both level and slope, all other series follow DSP.

Second, one cannot find sustained structural break for any crop-categories after 1990-91 either using the model of exogenous break in level or the model of exogenous break in both level and slope. For the model of exogenous break only in slope, breaks exist for Oilseeds yield and Fibre area after 1990-91. On the other hand, in the endogenous analysis, a sustained
one time structural break is found in level for Pulse yield, after the relevant break point i.e., 1987-88.

Regarding the *individual crops*, though one time structural break is found to be present for some series, but as none of the series is a DSP these changes are not considered as sustained ones. Therefore, results from the endogenous analysis fail to provide evidence for break in series on a sustained basis. Similarly, no structural break could be found for any series for the individual crops in the model of exogenous break in level and also in the model of exogenous break in both level and slope. In the model of exogenous break in slope though a few series show change in slope after 1990-91, but as all series except area & production of Wheat and area under Rapeseed-Mustard follow DSP these changes cannot be regarded as sustained ones.

It deserves mentioning that, in case of Pulses yield, the only TSP that emerged from the endogenous analysis, one has a sustained one time structural break and the break point is determined at 1987-88 which is much earlier to 1990-91. As in the rest of the cases, the series are DSPs, no definite conclusions can be made about the break points. What follows is the nature of the series for either crop- categories or crops in case of endogenous determination of break points also does not support the occurrence of 1990-91 as the break point.

**8.2.3 Findings of the Supply Response Analysis within the Vector Error Correction Framework**

Chapter 5 analyses the supply response behavior of the farmers within the vector error correction framework in West Bengal. The analysis is basically concerned with finding out a stationary long- run equilibrium relation or a cointegrating relation between area under a crop and three alternative variables —viz., the absolute prices of a crop and of its competing crops,
relative prices of a crop with respect to its competing crops and the net income over paid-out costs of the crop — provided these are non-stationary series and are cointegrated of the same order. In addition to the long-run analysis the study also incorporates a Vector Error Correction (VEC) analysis which basically means an analysis of partial short-run adjustments towards long-run relation that take place following any deviation from the long-run relationship. As prior to the search for the cointegrating relation one needs to determine the order of integration of the relevant variables, the first stage of the analysis, involves a stationarity test which is done by using a Dickey Fuller unit root test. In the next stage, the cointegrating relationship is obtained by finding out the number of cointegrating vector with the help of rank test. The final stage involves an analysis of short-run adjustments towards the long-run equilibrium relationship following any deviation from the equilibrium.

As revealed by the test results, all the relevant series, except the relative price of Aus, contain unit root, implying that the variables for six crops viz., Aman, Boro, Jute, Wheat, Potato and Rapeseed-Mustard are integrated of order 1, viz. I (1) processes. As the series for relative price of Aus is a stationary series, viz. an I (0) process, the subsequent cointegration analysis and the VEC analysis are not carried out for this crop. The rank tests led to the acceptance of the hypothesis of one cointegrating vector for the remaining crops.

Long-run price responsiveness for the six aforesaid crops is revealed by the statistically significant long-run price elasticities between i) area and absolute price for Aman, Boro, Jute & Potato and between ii) area and net income for Rapeseed-Mustard & Wheat. For Aman and Wheat, the Vector Error Correction results with respect to the error correction terms (ECT) do not produce feasible values for convergence towards long-run equilibrium. Hence, while finding out the short-run acreage elasticities and drawing policy conclusions, these two crops
are not taken into account. For Rapeseed- Mustard, the ECT is significant; however, the relevant model has no difference term of either area or income of the crop.

The error correction terms or the speeds with which adjustments in area take place in response to a deviation from long-run equilibrium is moderate for Boro; however, the rates are slow for Jute and Potato. These short-run adjustments take place through i) adjustments in area for Boro and Jute, and ii) adjustments in both area and absolute price for Potato.

Presence of inter-crop disparity is evident with respect to the short-run acreage adjustments. The short-run price elasticities of area under cultivation are significant for Potato. But for area under Boro and under Jute, the short-run price elasticities are insignificant. Thus area under Boro and Jute imply low price response while Potato acreage adjustments show significant price response.

The present study reveals significant price responsiveness of Potato acreage. Now, given the fact that wide variations in price are quite common for Potato, there is an urgent need for formulating a price support system for this crop.

8.2.4 Findings of the Technical Efficiency Analysis

Chapter 6 carries out an efficiency analysis focussing on seven major crops viz., Aus, Aman, Boro, Jute, Wheat, Mustard and Potato, of West Bengal for the period 1980-81 to 2002-03. The methodological framework used is one of the stochastic frontier production function with two inputs, namely human labour and fertiliser. The level of technical efficiency and its determinants are estimated simultaneously.

The presence of disparity in efficiencies among the selected crops is evident from the results. The highest average technical efficiency is recorded for Aman while Mustard has the lowest average efficiency. On the average level, farmers have failed to utilize about 21%, 8%,
19%, 20%, 27%, 66%, and 27%, respectively of the potential output of Aus, Aman, Boro, Jute, Wheat, Mustard and Potato. In order to find out the determinants of efficiency some general parameters which are outside the farmer’s direct control but are expected to affect the overall production frontier are incorporated in the model. Factors like state plan expenditure on agriculture and rural development, advances from land development banks, the proportion of area under small and marginal farmers and advances from scheduled commercial bank are selected in the final estimating equation. The elasticities of output with respect to two inputs viz., human labour and fertiliser are positive and statistically significant.

A detail analysis of factors influencing technical efficiencies of the selected crops reveals that factors like the plan expenditure on agriculture & rural development, advances from land development banks and proportion of area under small & marginal farmers have a significant negative effect on mean inefficiency levels. That is to say these factors have significant positive influences on the level of technical efficiency.

The results suggest that increasing public expenditure on agriculture & rural development and increasing credit flow to the rural sector are necessary to meet the gap that arises due to technical inefficiency, between observed output and frontier output of the selected crops. Also, the positive relation between efficiency and the proportion of area under small & marginal farmers points out that the changes that took place in the size of holding in the State as a result of Land Reforms have been conducive to technical efficiency changes at least for the selected major crops. However, as the relation between advances from scheduled commercial banks and efficiency has turned out to be negative, special emphasis is to be given to proper utilisation of credit in the agricultural sector.
8.2.5 Findings of the Total Factor Productivity Analysis

Chapter 7 elaborates a Total Factor Productivity (TFP) analysis for seven major crops – Aus, Aman, Boro, Jute, Wheat, Mustard, and Potato – of West Bengal. The present study decomposes total factor productivity growth into the technical change, the technical efficiency change and the scale efficiency change, that might have taken place in West Bengal agriculture over 1980-81 to 2002-03. The methodology used in the study is the Data Envelopment Analysis which is a Non-Parametric method of measuring productivity growth.

With the help of the Malmquist productivity index it is found that all the selected crops taken together have an annual average productivity growth of about 2.6%. The crop wise analysis reveals that all selected crops except Aus and Jute experienced positive productivity growth. Boro registered the highest productivity growth of 6.6%. Next to Boro, Mustard recorded around 5.5% growth in productivity followed by Potato and Wheat which have recorded around 4.7% and 4.5% productivity growth, respectively. Aman recorded the lowest positive productivity growth of about 0.023%. The productivity rates for Aus and Jute are around, -1% and -1.9%, respectively. Thus the rates of TFP growth differ remarkably across the selected crops.

The negative productivity growth rate for Aus is attributable to the technical regress together with negative rates of technical efficiency change. The rate of scale efficiency change is also negative for Aus. For Jute, the negative productivity growth rate is mainly explained by technical regress, the rate of technical efficiency change being zero. The rate of scale efficiency change is also zero for Jute. For Aman the rate of technical progress is the main contributing factor of productivity growth as the rate of technical efficiency is zero. Aman also recorded a zero scale efficiency change. Boro has recorded the highest
productivity growth rate and this is attributable to positive rates of technical progress as well as of efficiency change. The rate of scale efficiency change has been positive for this crop. For Wheat the positive productivity growth rate is explained by the technical efficiency change component and also the rate of technical progress. However, the rate of technical progress is much less in comparison with the rate of the technical efficiency change. The improvement in scale efficiency is also high for Wheat. Actually, the rate of scale efficiency change has been the highest for this crop among the selected crops. For Potato, the positive productivity growth rate is explained mainly by the efficiency change, the rate of technical progress being very low. The rate of scale efficiency change has been positive, though low, for this crop. For Mustard, the rates of technical progress and of efficiency change together contribute to the positive rate of productivity growth. Improvement in scale efficiency is also noticeable for this crop.

The above discussion reveals that crops other than Aus and Jute have experienced technical progress and also an efficiency gain (the level of efficiency being at least 100%). Given the high level of technical efficiency no further improvement in efficiency is possible for crops other than Aus and Jute. On the other hand, Aus and Jute show technical regress. At the same time the level of efficiency is close to 100% for Aus and it has reached the 100% mark for Jute. It seems that an efficiency gain has taken place for these two crops; however, the actual reason for this improvement in efficiency is the downward shift of the frontier itself (as manifested through technical regress).

A regression analysis was carried out to identify the factors affecting TFP growth. For this purpose a number of infrastructural variables like, the number of regulated sub-markets (agricultural) in West Bengal, proportion of area irrigated through sources other than
government canals, area irrigated through government canals and policy variables like, expenditure on education & research in West Bengal, State plan expenditure on agriculture & rural development, State plan expenditure on irrigation & flood control, the inequality in the distribution of operational land holding in the state as captured by the Gini ratio, loan advances by the land development banks in West Bengal, loan advances from scheduled commercial banks to the rural area in West Bengal, are incorporated. In addition to these factors, number of borgadars in the state and consumption of fertilizers in the state are also included as factors explaining the TFPG.

For Aus the important explanatory variables are fertiliser consumption, advances from commercial banks, and the Gini ratio. As none of the explanatory variables has appeared to be significant for Jute, this crop is not retained in the regression analysis. The TFPG of Aman depends on the real value of plan expenditure on irrigation & flood control and the Gini ratio. For Boro the only relevant explanatory variable is the real value of plan expenditure on irrigation & flood control but lagged by three years. For Mustard the real value of the expenditure on Education & Research in the state, loan advances by the land development banks, advances from commercial banks, the Gini ratio and the number of regulated markets have significant effect on the rate of productivity growth. Factors like the state plan expenditure on agriculture & rural development and the state plan expenditure on irrigation & flood control arise as significant explanatory variables in the model for Potato. In the regression for Wheat, the significant variables are the expenditure on Education & Research lagged by three years and loan advances by the land development banks. TFPG on an average is found to depend significantly on real and lagged value of expenditure on Education & Research, loan advances by the land development banks, advances from commercial banks,
fertiliser consumption, number of regulated markets and the proportion of area irrigated through sources other than government canals.

The regression analysis reveals that compared to irrigation through government canals, other sources of irrigation is more effective in fostering the productivity growth. The results also emphasize the roles played by the public sector (as revealed through statistically significant regressors like different forms of government expenditure), credit (as explained by advances of the scheduled commercial banks and advances of land development banks), the infrastructural variables (as explained by the regulated markets) and also, equality in distribution of operational land holding, in augmenting the TFP growth.

8.3 Connection among different aspects of growth

The results from the present study reveal the superiority of modern time series techniques over the traditional methods in addressing the growth analysis. A few points can be noted in this respect.

- Comparing the growth rates of area, production and yield of the crops for the entire period 1980-81 to 2002-03 reveals a few facts. Boro having the highest area and output growth also registered the highest total factor productivity growth. Aus has the highest rate of yield growth but a negative TFPG rate and Wheat has the lowest rate of yield growth but a higher rate of TFPG. So, it is established from the results that having high yield does not necessarily mean high rate of TFPG and vice versa. However, so far as the average level of technical efficiency (TE) is concerned, Aman has the highest average TE while the lowest average TE is recorded for Mustard.
• Relying on techniques like the Data Envelopment Analysis enables us to decompose the TFP into technical change (progress or regress), technical efficiency change and scale efficiency change. From the analysis it is seen that Boro has the highest rates of technical progress and also of technical efficiency change while Jute has the lowest (negative) rates of productivity growth and also of technical change. Aus also has negative rates of productivity growth, technical change, technical efficiency change.

• A few important points can be highlighted regarding the explanatory variables included in different analyses. Growth analysis in Chapter 3 suggests that price is an important determinant for yield of crops. The importance of price factor is once again highlighted in the Supply Response analysis where all the crops, except Aus, show long-run price responsiveness. Factors like public expenditures and the Gini coefficient of operational land holding, which are two important determinants of yield of the crops, also emerge as significant factors explaining total factor productivity. Public expenditure also appeared as a significant factor in explaining technical efficiency. And though the Gini coefficient is not found to bear any meaningful relation with technical efficiency, the proportionate area under small & marginal farmers reflecting the effect of land reform is found to have significant positive effect on efficiency. Besides, we also found infrastructural variables like road, warehouse & various forms of irrigation as yield determinants and like regulated market & different forms of irrigation as factors affecting TFP. Credit also appears, though in different forms, as important factor in explaining yield, productivity as well as efficiency.
8.4 Policy Suggestion

Based on the above analysis the following policies seem to be relevant. i) Formulating a price support policy for Potato could be a better option for the policy makers; ii) Other results from the study suggest that factors like public expenditure, credit, infrastructural variables like irrigation, regulated markets, length of roads etc. and institutional factors like Gini ratio of operational land holdings and the proportion of area under small and marginal farmers, play catalytic roles for agricultural growth in general. So, developing the infrastructures and improving the credit facilities can, in general, assist the overall agricultural growth of the state. But above all the indispensable role of public expenditure should be acknowledged in the sense that this policy variable seems to be an important determinant of growth rate of yield, efficiency change and total factor productivity growth. As squeezing the public sector’s share in gross capital formation has hampered the agricultural growth, public investment in agriculture needs to be encouraged. Also, emphasis should be on institutional factors like, reducing the inequality in the distribution of land holding as reflected through the Gini ratio and sustaining the effects of land reforms which gets reflected through the increasing proportion of area under small and marginal farmers.

Our analysis shows presence of inter-crop disparities not only with respect to area, production and yield growth rates and rates of TFPG but also with respect to the factors explaining yield or TFPG. Hence, while taking policy decisions for enhancing growth and productivity, crop-specific policies are likely to yield better results than any general policy.
8.5 Future Research Scopes

The study is based on the state-level data for six major crop-categories and eight major crops as our emphasis has been to study the performance of major crops grown in the state. However, with respect to the analyses of supply response for different crops, technical efficiency (TE) & its determinants for different crops, and total factor productivity growth (TFPG) & its determinants for different crops we can identify some issues which have not been taken care of by the present study and future research can effectively address these issues.

In the context of the supply response analysis within the vector error correction framework, the present study is does not include any exogenous variable. An attempt can be made to specify some non-price variables and incorporate these in the models to improve the speeds of adjustment. Also, carrying out a sub-period analysis to capture the effects of reforms on supply response of various crops can also be done.

With respect to the analysis of TE and the TFPG analysis, a farm-level analysis is expected to provide a more disaggregated picture of inefficiency analysis and productivity analysis, respectively, in crop production in the state. This will help in better specification of the variables affecting inefficiencies and total factor productivities at the farm level. But due to paucity of data the present study could not carry out a farm-level analysis. Also due to a short span of the post- liberalisation period (almost a decade) any sub-period analysis could neither be done as this would adversely affect the degree of freedom. So, the future research can focus on the farm-level TE analysis and farm-level TFPG analysis and can also take care of the developments in the post- liberalisation period.