PUBLIC INVESTMENT AND AGRICULTURAL PRODUCTIVITY: THE CASE OF FOODGRAINS IN INDIA

PUBLIC INVESTMENT AND AGRICULTURAL PRODUCTIVITY: THE CASE OF FOODGRAINS IN INDIA

Dissertation submitted in partial fulfillment of the requirements for the degree of ***Master of Philosophy in Applied Economics*** *of the* ***Jawaharlal Nehru University***

D. Shyjan
M.Phil Programme in Applied Economics
2001-2003

CENTRE FOR DEVELOPMENT STUDIES
Thiruvananthapuram
June, 2003

I hereby affirm that the work for the dissertation, ***Public Investment and Agricultural Productivity: The Case of Foodgrains in India****, being submitted as part of the requirements of the M.Phil Programme in Applied Economics of the Jawaharlal Nehru University, was carried out entirely by myself. I also affirm that it was not part of any other programme of study and has not been submitted to any other institution/University for the award of any Degree or Programme of Study.*

June 30, 2003

D. Shyjan

Certified that this study is the bona fide work of D. Shyjan, carried out under our supervision at the Centre for Development Studies.

K. Pushpangadan
Fellow

M. Kabir
Visiting Scholar

K.P. Kannan
Director
Centre for Development Studies

Acknowledgements

First and foremost thanks to my supervisors, Dr. K. Pushpangadan and Dr. M. Kabir, for their sincere efforts in encouraging me during the time of this dissertation work. Most of the time they had been searching me, the 'missing boy', to at least report the progress. And whenever they caught, efforts began to put ideas of logical thinking and ingenious explanations on me. For that, these words are not enough to express my gratitude to my *Gurus*. Dr. Kabir, rather than a teacher - during my graduation, post graduation and M.Phil - has always been a good guide providing me with the spirit of a wise and gentle personality. The homely atmosphere I enjoyed at Dr. Kabir's house, with the love and affection of Sheela teacher and Jyotsna will always be memorable.

The timely advice about statistical methods from Dr. Vijayamohanan Pillai, who always taught me with extreme clarity and a pleasant face, helped me a lot, without which the study would not have taken its present form. In course of my work, the discussions with Prof. V.S. Vyas, Dr. Sakti Padhi, Dr. Ramalingam and Jose Sebastian also gave me good directions. The occasional visits to Prof. K.N Raj's house gave me an encouragement in learning more about the subject and also the importance of doing authentic empirical research.

The works, which I had done with Dr. John Kurien and Dr. Santha Kumar, helped me very much in getting resources at needy times. Their concern for me deserves special thanks from my heart. My beloved teacher, Achin Chakraborty needs to be acknowledged separately for his inimitable ability of teaching and same is the case with Chandan Mukherjee. I express my gratitude to Dr. K.K George, Dr. Mohanan Pillai, Dr. G.N Rao, Dr. K.N Harilal, Dr.Navaneetham, Dr. Michael Tharakan, Dr. Indrani Chakraborty and all other faculty members, who were encouraging me at the time of this work.

R. Mohan, my classmate, an extremely loving and helping personality, had been with me most of the times when I was feeling down. His pleasing and humorous nature always helped to boost my morale. Our 'Ayyappan' Surjit - a pleasant, caring, loving and above all, a capable friend - also deserves special acknowledgement.

I gratefully remember the moral support given by Rakhee Timothy and Lakshmi Priya in the initial stage of the course work. I also owe Lekshmi R. Nair for teaching me essential statistics during the course work. Sandeep and Aparajitha were of great help during those times whenever I was confused about my work. My love for Sandeep 'Machaan' can never be measured. I acknowledge with love and affection all my other classmates, to mention a few, Rajesh Kumar, Varinder Jain and 'thalaivi' Vaithegi.

Prabhakaran Nair was the only person with me throughout while I was suffering from serious illness. I am also indebted to Poornima Varma, Antonyto Paul, and Indu. K who cared for me at that time. Hari.K.S deserves special mention for his timely help and advice given to me always. The advice given by Sunny Jose time to time gave me more incentive to work. The discussions I had with Rathi Kanta Kumbhar regarding new premises about his thesis helped a lot by reminding me of the basic economic theories. Our senior Venkatesh, who was one of my well-wishers, needs special aknowledgement.

Words are not enough to express my grateful thanks to Anil Edathitta, Rajesh Puliyara and Rajesh K.P for their company. Together with these friends, my company with George Antony, Ajith, Dinesh Lal and Suresh also made my stay in the campus more fun. Jayachandran Annan needs special mention for his extremely helpful nature.

My seniors Reji K Joseph, Shabeer K.P and others also need to be mentioned separately. The immense affection I got from my juniors - V. Dhanya, Aathira, Zakku, Harilal, Francis and Gowri - will always be remembered.

I acknowledge Amir Ali, who is a good comrade rather than a staff member, for joking and being joked in the campus making the annex hostel a 'greener' place to stay. George Kutty, who keeps a treasure trove of beautiful songs, always gave me a chance to listen to the old songs that I love.

The memorable days, though very few, that I spend with Bhaskar, Hari Kurup, Ram Mohan and Khan, at the initial stage of my CDS campus life is noteworthy. My company with S.J Nair, Gopidas, Bahadur and Thankappan was a great relief from my busy academic schedule. Babu and Neetha, Geetha Sathyanarayanan, Sobha Kannan, CDS Library Staff, Soman Nair, Sree Kumari and Geetha and all other well-wishers need to be gratefully acknowledged. The campus kids have to mentioned with my affection.

Time to time encouragement given by my friends, Arun Kumar, Sunil and Rajiv Kashyap always inspired me to get back to my work. I acknowledge my friend Baby Mathew for his wise advice given to me. In this write-up, I would also like to acknowledge my friend, Baby John and his wife. My friend at CDS, Sajitha Beevi, needs to be mentioned with hearty love for bearing my 'madly' manners - singing and disturbing her everytime - and also for her timely help.

I have nothing to write about Anupama. P.K, since anything I write would not be sufficient to address her love for me.

Just giving some words in this acknowledgement to thank my parents and siblings would never be enough as all the credits for whatever I did can be attributed unto them.

D. Shyjan

Abstract of the Dissertation

PUBLIC INVESTMENT AND AGRICULTURAL PRODUCTIVITY: THE CASE OF FOODGRAINS IN INDIA

D. Shyjan

M.Phil Programme in Applied Economics, Jawaharlal Nehru University

2001-2003

Centre for Development Studies

The main objective of the study is to examine the long-run relationship between public investment and foodgrains productivity across the fifteen major states of India. The analysis is confined to the period, 1974-'75 to 2000-'01. In order to examine the long-run impact of public investment on foodgrains productivity, the study uses Koyck's Autoregressive Distributed Lag model (ADL). The same methodology has also been used to test the long-run relationship between foodgrains productivity and investment in irrigation – the major component of public investment.

The study shows that the growth of foodgrains productivity had been positive and significant during the Sixth and the Seventh Plans, but registered no significant growth during the Eighth and Ninth Plans both at the all India level and in the majority of the states. The analysis also shows interstate difference in the average levels of productivity and investment. The study points out that growth of public investment increased during 1974-'75 to 1980-'81, but declined sharply during the next decade both at all India level and in the majority of the states and rose again since 1993-94. The major conclusion of the study is the existence of a positive but lagged effect of public investment on productivity. The lag varies across states; as low as 0.6 years in Maharashtra and as high as more than 12 years in Punjab. Further, the length of the lag is higher in those states where the share of cereals to total foodgrains is higher. The existence of the lag, the study argues, might point to the need for sustained public investment as a means to raise foodgrain productivity in the future.

LIST OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

"Investment in agriculture is a necessary, if not sufficient, condition for increasing agricultural production and productivity and thereby to ensure the availability and accessibility of food to the population" (FAO, 1999:2)

The development of the agricultural sector is an indispensable pre-requisite for overall economic growth in developing agrarian economies. The availability of foodgrains to the population, and for the generations to come, can be assured only through sustained increase in agricultural production. Extension of the area under cultivation as a means to increase agricultural output is out of scope. As Government of India's Economic Survey (1999-2000) observes, " there are limits to increase production through area expansion as the country has almost reached a plateau in so far as cultivable land is concerned". Therefore raising the output per unit of cultivated area shall be the main source for increasing farm production.

Various policy initiatives have already been taken in most of the developing countries to raise agricultural productivity, especially in foodgrains. In India, the so-called 'Green Revolution' was a result of such a policy initiative during the mid-1960s. The new irrigation-seed-fertilizer technology introduced in the country during the mid-Sixties got reflected in substantial increases in food grain productivity. Assured irrigation facilities, High Yielding Varieties of seeds and rural electrification in some of the North-Western states like Haryana and Punjab had bestowed more benefit to these regions during the period of the Green Revolution (Narain, 1988). However, there are many other factors than irrigation, High Yielding Varieties of seeds and rural electrification which play their roles in influencing agricultural productivity. These factors include, besides rainfall and other agro-climatic conditions, availability of institutional credit, subsidies, private investments in tractors, pump sets, tube wells etc., strengthened input delivery system, committed extension services, better marketing facilities, improved water-shed management, efficient education and training activities, research and development and efficient network of various technological inputs. Most of these factors, except rainfall and climatic conditions, directly or indirectly depend upon acts of public investment. In the present study, we attempt to examine the impact of public investment on foodgrain productivity in India and its inter-state differentials.

1.1 Objectives of the Study

The main objectives of the study are to examine:

- the growth in foodgrain productivity at aggregate and disaggregate levels and its variations across states;
- the growth of public investment and its interstate variation; and
- the long-run relationship between public investment and foodgrain productivity across states.

1.2 Coverage of the Study

The study is confined to fifteen major states and ten food crops. The states included are: Andhra Pradesh, Assam, Bihar, Gujarat, Haryana, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Orissa, Punjab, Rajasthan, Tamil Nadu, Uttar Pradesh, and West Bengal. These states, taken together, constitute about 97 per cent of the total area under cultivation of foodgrains. The other states have been excluded from the study because of two reasons - one, the time series data on area and production for these states are not available for all the years under analysis, and two, their contribution to the total food production in the country is negligible. The crops included in the study consist of cereals and pulses. The first one includes rice, wheat, *jowar*, *bajra*, maize, *ragi*, and barley. The second consists of *arhar (tur)*, gram and other pulses.

The period of analysis is from 1974-'75 to 2000-'01. The choice of the period is mainly on the consideration of availability of comparable data. The data on state-wise public investment in a comparable classification is available only from 1974-'75 onwards.

1.3 Sources of Data

The major data that the study makes use of for estimating foodgrains productivity are those relating to area and production of each individual food-crop, provided by the Ministry of Agriculture, Government of India. The same data is also available from www.indiastat.com. For public investment we construct a new series based on the data compiled from various issues of the Reserve Bank of India Bulletin. The method of construction of the series and the limitations of the data set are discussed in detail in Chapter 4.

1.4 Chapter Scheme

The study has been presented in six chapters. Chapter 2 presents an overview of some of the important studies on agricultural investment and productivity. Chapter 3 discusses the growth and levels of foodgrain productivity at all India and state levels. The fourth chapter deals with the growth and interstate variation in public investment. The impact of public investment on agricultural productivity is examined in the fifth chapter. The final chapter gives the major findings and conclusions of the study.

CHAPTER 2

REVIEW OF LITERATURE

2.1 Introduction

Studies on agricultural investment in the Indian economy assumed greater importance since the late Eighties, most of them debating over the issue of complementarity between public and private investments. The issue arose in the context of the decline in public and private investments in the first half of the eighties and the rise in private investment since the mid-Eighties despite the continued fall in public investment. This behavior of agricultural investment made researchers to investigate the true relationship between public and private investments, which were till then considered as complementary. Moreover, some of the studies also debated on the items to be included in the public investment series for analysing the trend in public investment and its relationship with private investment. Though all these studies emphasised on the role of public investment as a major factor in determining agricultural production and productivity, the long-run relationship between the two received very little attention. In this chapter we give a brief review of some of the important studies relating to the impact of agricultural investment in general, and of public investment in particular, on productivity.

The chapter is arranged as follows. Section 2 discusses some of the important studies which argue a case for public investment in agriculture. In Section 3, we look briefly into some of the empirical studies on the role of public investment in determining productivity in Indian agriculture. State-wise studies on the determinants of productivity and the role of public investment in determining productivity are reviewed in Section 4. Section 5 concludes the discussion.

2.2 Public Investment and Productivity: The Theoretical Premise

The role of the State as an agent in raising agricultural productivity began to be seriously discussed at the international level from the 1960s. These discussions emerged mostly in the context of the growth concerns of the newly emerging countries as well as in the context of the demographic pressures and food shortage of the Sixties. Technological revolution in agriculture, commonly known as 'the Green Revolution', gave further impetus to the enquiry into the role of investment, particularly of public investment, in raising agricultural productivity. Writing in 1964, Schultz noted that 'transforming traditional agriculture' warrants investment in physical and human capital. Productivity enhancement is the key to break away from traditional agriculture, the crucial feature of which is the low rate of return to investment that farmers have been using for generations. Significant opportunities for productivity growth in agriculture become available only through changes in technology – new husbandry techniques, better seed varieties, more efficient sources of power, and cheaper plant nutrients. Investment in such activities as agricultural research, leading to the supply of new inputs, and in the education of the farm people who are to use them, provide the basis for technical change and productivity growth in agriculture. Investment in these sectors, Schultz observes, is a matter of social goal, and the existence of spill-over effects necessitates public investments in most of them, especially in research and development, and education.

Taking the cue from Schultz, Hayami and Ruttan (1971) argued that a continuous stream of new technical knowledge and a flow of institutional inputs in which the new knowledge is embodied represent a necessary condition for modern agricultural development. According to them, this stream of new technical inputs must be complemented by investments in general education and in production education for farmers. They also considered an effective system of public research institutions, private agricultural supply firms and markets for factors and products as the critical elements of the growth process. In a similar vein, Nelson (1964) and Feder, et al. (1985) noted that public investment is necessary to promote technology adoption, stimulate complementary on-farm investment and input use and for marketing the agricultural goods produced. Antholt (1994) justified public investment in basic infrastructure, human capital formation and research and development as necessary conditions for private investment.

In the Indian context, a strong case for public investment in agriculture was made by Chakravarthy (1993). According to Chakravarty, the role of the State as an investor is envisaged neither in the simple Ricardian Model nor in the Marxian schemes of expanded reproduction. In the Ricardian schemes, 'capital' largely meant advances to 'labour' along with the 'seed corn' that was planted. The requirement of agricultural growth can be defined in terms of the amount of 'corn' that was directly or indirectly needed for producing a unit of 'corn', the role of fixed capital in agriculture, at least theoretically, being a minor one. Marx allowed for the role of fixed capital in the form of instruments to assist labour. But Marx, Chakravarthy notes, was dealing with a condition of ruthless competition that leads to a situation of growing capital intensification in agriculture with a predominantly labour saving bias. Growth of agricultural output took place through mechanisation which was also correlated with a growth in the size of farms. But in the Indian context, compulsions arising from the existing climatic and demographic characteristics require different types of investment including irrigation, fertilizers, better seeds, etc., and some of these capital inputs often require to be organized on a very large scale, which makes State intervention essential. Along with these yield-increasing investments, there is also the need for investment in infrastructure such as transport and electricity to enlarge the market and to provide suitable energy base for sustainable growth. Moreover, in the Indian case, the inducement to invest on the part of private investors is significantly affected by the behavior of public investment. Therefore, Chakravarthy argued that transforming traditional agriculture means growing public investment involving a suitable mix of directly productive capital and social-overhead facilities.

One point that emerges from these studies is the necessity for public investment as a means to transform traditional agriculture and to raise agricultural productivity, though for different reasons. These reasons extend from the 'market failure' in providing certain important categories of investment due to externalities, to the complementarity of private investment with public investment. Certain items of investment like large-scale irrigation works involve heavy capital expenditure, which would be beyond the ability of the individual cultivator. Education of the farm people, research and development, transport, marketing facilities and electrification, to mention only a few, are indispensable items of investment to enhance productivity and requires direct governmental participation. In what follows we discuss some of the empirical studies which examined the role of public investment in determining agricultural production and productivity in the Indian context. The discussion in the following sections has, however, been limited to the studies from the early Eighties.

2.3 Public Investment and Indian Agricultural Performance: Empirical Evidence

As noted, studies on investment in Indian agriculture from the late 1980s were concerned mostly with the issue of complementarity between public and private investments. The same time, they also highlighted the need for public investment to raise agricultural output and productivity.

Rath (1989), whose interest was to analyse the trend in agricultural output, income and investment from the Fourth to the Seventh Plan at all India level, showed to what extent agricultural output and income had been related to investment in agriculture over time. According to Rath, the annual growth rate of net and gross agricultural production in India had reached its peak during the 5th Five-Year Plan and declined during the subsequent two Plans. The decline had largely been due to the reduction in the growth rate of real fixed capital formation in agriculture. Public investment had declined during the Sixth and Seventh plan periods and private investment was not capable of compensating this. Moreover, Rath noted, private investment, increasingly financed from bank loans, was very unevenly distributed across the states. Because of this, agricultural growth in the vast and poor agricultural regions could have been possible only with increased public sector investment.

Kumar (1992) examined the decline in total agricultural investment during the 1980s and its consequences on agricultural growth and productivity, using the new and old series data on total agricultural investment from the CSO estimates. According to him, the major factor that determines agricultural growth and productivity in the Indian economy is investment in irrigation. The relative neglect of the agricultural sector during the Eighties, evidenced by a marked fall in public investment, according to Kumar, adversely affected the economy as a whole and the primary sector in particular.

The decline in total agricultural investment in the Eighties was also noted by Rao (1994). According to Rao, public investment in Indian agriculture started to decline during the 1980s after its steep rise during the 1970s. Due to the high complementarity between public and private investments, private investment also lost its incentive to show a rising trend in the Eighties[1]. The same time, growth rate of agricultural output experienced an improvement during the Eighties. The reason for the improvement in output growth rate, Rao observed, is the significant lag between investment in infrastructure and the realisation of the potential created. Also, since a large number of projects had existed in the pipeline, some potential from past investment might have become realised during the Eighties. Based on his observation of the lag between investment and realisation of the potential, Rao argued that, the decline in investment during the 80s was likely to generate adverse effect on subsequent agricultural growth.

The fall in public capital formation in agriculture during the Eighties was corroborated by Mishra (1996) and Dhawan and Yadav (1997). But they did not analyse in detail the effect of the decline in public investment on production and productivity in agriculture. However, Dhawan (1998) gave a detailed analysis of determinants of public investment in Indian agriculture, its inducement effect on private capital formation and its effect on agricultural output. To him, besides the availability of institutional loans and the profitability of farmers, public investment in canal irrigation has a very high inducement effect on private capital formation in Indian agriculture. Investment in canal irrigation not only provides protection against failure of monsoon rains, but also substantially raises farm incomes and savings through the rise in land productivity, shift towards more remunerative cropping pattern and improvement in the intensity of cropping. Dhawan noted that a reduction in agricultural investment results in non-creation of irrigation potential and thereby reduces the future crop output and income.

The lag between investment and realisation of agricultural growth, noted by Rao, was confirmed by Murgai et.al (2001) in the context of Indian Punjab. They examined the productivity differential of irrigated agriculture in Indian and Pakistan Punjabs and observed that despite the similar agro-climatic conditions in these two regions, productivity growth in Indian Punjab was higher than its Pakistan counterpart. This,

---

[1] According Rao, the rising subsidies for agriculture and the pre-emption of a major part of state's resources for poverty alleviation programmes had been the reasons for decline in public investment during the 1980s.

they attributed to more rapid growth of inputs in Indian agriculture. Investment was seen to play a central role in productivity growth, but, according to Murgai et al., there was a considerable lag between investment and the realisation of agricultural growth in Indian Punjab.

A close look at the studies show that all of them highlight the role of public investment in raising production and productivity in Indian agriculture. But the exact relationship between public investment and agricultural productivity had been the specific subject matter only in a few studies. An interesting observation that emerges from some of the studies is the lagged effect of public investment on productivity. But, unfortunately, none of them has analysed the duration of the lag, nor have they extended their analysis to the state level.

2.4 Public Investment and Agricultural Productivity: State-wise Studies

Most of the studies at the state-level have been concerned with the determinants of productivity. Very few have examined the long-run relationship between agricultural investment and productivity across the states.

Bhalla and Alagh (1979), in a study on the performance of Indian agriculture that covered all the districts in 13 states and nineteen major crops, compared the performance of the agricultural sector in two time periods, 1962-65 and 1970-73, corresponding broadly to the pre and post Green Revolution periods. The study found that assured irrigation and high rainfall determined high level of productivity. They also found that modern inputs were highly concentrated in the high productivity regions and there existed large-scale variations in the levels of productivity across regions.

Bhalla and Alagh did not go further into productivity variations across states. However the extent of productivity variation was examined by Joshi and Haque (1980) and by Sharma (1992). According to Joshi and Haque (1980), fertilizer, irrigation, HYVs and credit explained more than 50 per cent of the inter-state variations. Sharma (1992) examined the extent of productivity variation across 15 states and seven major crops for the period 1966-'67 to 1988-'89 and found that the productivity ranking of crops in various states had changed noticeably over time. As means to reduce the productivity gap, Sharma advocated for efficient education and training for the farmers and efficient supply network of various technological inputs. Nevertheless, neither Joshi and Haque nor Sharma took up public investment separately as a determinant of productivity variation, though Haque and Joshi had seen irrigation as an important determinant of productivity variation. In fact, the role of irrigation as a factor explaining agricultural productivity was also addressed by other scholars. For instance, Mishra and Bajpai (1994) found that yield per hectare, especially of foodgrains, is positively correlated with expansion of irrigation facility, and fertiliser accompanied by irrigation facility explained more than 82 per cent of the increase in yield.

The effect of public investment on productivity differentials across states was taken up by Singh et.al. (1997). They examined the temporal and spatial performance of important foodgrain and non-foodgrain crops in terms of area, production and yield, and the various factors determining yield and acreage of important foodgrain crops across the states and the country. The analysis was confined to 13 states for the period 1960-'61 to 1992-'93. A multiple regression analysis of various factors affecting the growth rate of yield of foodgrains revealed that increased use of irrigation, fertilizers and HYV seeds explain much of the increase in most of the states. Even though the regression coefficient for public investment was found to be positive, it was not statistically significant, which the authors attributed to the sub-optimal use of the investment.

Factors affecting productivity differentials across states were analysed also by Chadha (1998) and Bhalla and Singh (1997, 2001). Chadha analysed the inter-state variations in agricultural output and productivity growth from 1962 to 1995 covering 17 major states. He examined the expansion of irrigation, technological profile, fertilizer use and other infrastructure growth across states. It was shown that Punjab and Haryana maintained their record of fast productivity growth over the period but many other states achieved fast growth during the nineties. The study also observed that the irrigation-fertilizer-seed complementarity, which has been the essence of the green revolution technology, has worked so far only half way through in the lagging regions. The initial years of the green revolution bestowed extraordinary benefits on those states which had chosen to strengthen their rural economic base in general and agriculture infrastructure in particular, through a planned process of public investment. Chadha argued that public investment and support are inescapable pre-requisites for a smooth transformation of agriculture in India as elsewhere in developing countries.

Bhalla and Singh (1997, 2001) examined 43 major crops for 17 states from 1962-'65 to 1992-'95 for analysing the changes in cropping pattern, growth rate of crop output and productivity changes. The study found that the level of irrigation, fertilizer consumption and use of tractors and pump sets are relatively high in the regions, which experienced high rate of growth of productivity, a conclusion earlier reached by Bhalla and Alagh (1979). According to Bhalla and Singh, disparities in productivity growth across states continue to be very high and are a product of rigid structural factors like variations in the level of infrastructure and technological development in various regions.

Most of the studies mentioned above were based on the data on agricultural investment contained in the National Accounts Statistics of the Central Statistical Organisation. Nevertheless, the investment series of the C.S.O was questioned by scholars like Chand (2000) and Gulati and Bathla (2001, 2002). Chand noted that many items which have a profound influence on agriculture do not find their place in the C.S.O's investment series, requiring revision of the investment series before drawing any conclusion based on that data. Chand (2000), based on data from the Finance Accounts of the states and Union Territories, constructed a new public investment series both at all India and state levels[2] and attempted to explore the relationship between public and private investment in agriculture. He also examined the effect of public investment on productivity. With the help of cross section multiple regression, the study observed a significant positive relationship between public investment and agricultural productivity across the states. Further, Chand refuted any complementarity between public and private investments.

Gulati and Bathla (2002) further redefined the public investment series by Chand. They observed that public capital formation explained more than 90 per cent of the

---

[2] For details see Chapter 4.

variation in private investment and also these two have significant impact on Agricultural Gross Domestic Product. According to them, public sector investments in canals and power do remain important for their inducement effect on private investment. They found that the growth rates of the real value of output of cereals and pulses decreased from 2.16 per cent per annum during the 1980s to 1.84 per cent per annum during the 1990s. The decline in the cereals and pulses during the 1990s, to them, might be due to the fall in public investment during the 1980s. However, the period selected by Gulati and Bathla for creating the public investment series differed across states based on the availability of data. Also, they did not venture into state specific examination of the relationship between public investment and productivity.

Roy and Pal (2002), in their study on investment, agricultural productivity and rural poverty, examined the relationship between investment and productivity for the period from 1965-'66 to 1998-'99 based on the Finance Accounts data. Using a simultaneous equation model the authors observed that both public and private investments have positive relationship with agricultural productivity. They also found that the effect of investment on productivity is stronger than the effect of subsidies.

2.5 Conclusion

The quick overview of the existing literature points to the fact that there are many factors that influence agricultural output and productivity growth. They include, credit, subsidy, rainfall, population, technology, modern farm inputs, private farm investments, public investments in human and physical capital, irrigation, extension services and also infrastructural facilities like rural roads, electrification and marketing facilities. However, most of these factors are in one way or the other related to public investment. Moreover, externalities in certain heads of investment like major and medium irrigation and infrastructure like roads and markets make public investment imperative. In the Indian context, investments on the part of private hands mostly depend upon the behaviour of public investment. However, the long-run relationship between public investment and productivity in relation to the Indian states has not received sufficient attention in the literature. The present study is an attempt to fill this gap. In the next chapter we examine the growth and levels of foodgrains productivity at the state and all India levels.

CHAPTER 3

GROWTH AND LEVELS OF PRODUCTIVITY IN FOODGRAINS: A STATE-WISE CUM PLAN-WISE ANALYSIS

3.1 Introduction

It has been observed that there existed very high inequality in agricultural productivity among Indian states during the initial period of the Green Revolution (Narain, 1988, Panigrahi, 1995, Barman, 1996). It has also been noted that interstate disparity in agricultural productivity narrowed down during the early Nineties (Panigrahi, 1995, Bhalla and Singh 1997, 2001). However, these studies have focused on analysing the interstate disparity in agricultural productivity by taking all the crops - food and non-food crops - together. The specific case of foodgrains, its trend, interstate variation and the role of investment in determining foodgrain productivity across the major states of India have not been analysed in detail. Therefore, in this chapter we take up an analysis of the growth of productivity of foodgrains at all India level and for the fifteen major states.

The organisation of the chapter is as follows. Section 2 discusses the methodology. Section 3 examines the trend and growth rate in foodgrain productivity at all India level. Section 4 analyses the state-wise growth rates of productivity of food grains during 1974-'75 to 2000-'01. In Sections 5 and 6 we look into the plan wise growth rates and average levels of productivity respectively at the state level. The last section concludes the discussion in the chapter.

3.2 Methodology

The concept of productivity adopted here is what has been customary in most of the literature on the growth of agricultural production in India, namely, the gross value of agricultural output in constant prices per hectare of gross cropped area (Narain, 1988). To convert the output series into value terms, we use the average of the whole sale prices of each crop in the fifteen states[1] and to express the series in constant prices we use the average of the prices from 1992-'93 to 1994-'95 as the base[2]. That is, the total value of output equals:

$$\Sigma P_{io} X_{ij}$$

Where, P_{io} is the all India price of i^{th} crop for the base year (average of 1992-'93 to 1994-'95) and X_{ij} is the physical quantity of output of i^{th} crop in j^{th} year.

Exponential growth model has been used for growth rate estimation for the period from 1974-'75 to 2000-'01. We also analyse sub-period growth rates – the periodisation being based on five-year plan periods (from the Fifth to the Ninth Plan[3]). The annual plan periods, 1979-'80, 1990-'91 and 1991-'92, are included in their immediately preceding plan periods. That is, the year 1979-'80 is included in the Fifth Plan (1974-'75 to 1978-'79) and the years 1990-'91 and 1991-'92 are included in the Seventh Plan (1985-'86 to 1989-'90). Thus we examine the plan-wise productivity growth rates for each of the sub-periods - 1974-'75 to 1979-'80, 1980-'81 to 1984-'85, 1985-'86 to 1991-'92, 1992-'93 to 1996-'97 and 1997-'98 to 2000-'01- for cereals and pulses. For the growth rate estimation of sub-periods, we use the kinked-exponential growth rate formula (Boyce, 1986), on the assumption that productivity growth is a continuous series and, therefore, it is important to impose continuity to calculate the growth rates for sub-periods. Here we have five sub-periods and hence four kinks[4]. The kinked-exponential model we use is:

---

[1] The average price has been used in order to neutralise the state-specific price variations.

[2] The whole sale price of each crop is given in 'Agricultural Price in India' for all the markets of every state. To arrive at the price of each crop we have taken the average price in all those markets in each state.

[3] For the ninth plan period, we consider only the first four years of the plan.

[4] We give four kinks in the productivity series to break the series with respect to the Five Year Plans. Therefore, we get growth rates for the Fifth, Sixth, Seventh, Eighth and Ninth plan periods.

$$\ln Y_t = \alpha + \beta_1(D_1t + \sum_{j=2}^{5} D_jK_1) + \beta_2(D_2t - \sum_{j=2}^{5} D_jK_1 + \sum_{j=3}^{5} D_jK_2)$$

$$+\beta_3(D_3t - \sum_{j=3}^{5} D_jK_2 + \sum_{j=4}^{5} D_jK_3) + \beta_4(D_4t - \sum_{j=4}^{5} D_jK_3 + D_5K_4) + \beta_5(D_5t - D_5K_4) + u_t$$

Where $\ln Y_t$ is the logarithm of productivity series, α is the intercept and β_1, β_2, β_3, β_4 and β_5 are the growth rates for the five sub-periods. K_1, K_2, K_3 and K_4 are four kink values given in the model (where $K_1 = 6.5$, $K_2 = 11.5$, $K_3 = 18.5$ and $K_4 = 23.5$). The sub-period dummy variables - D_1, D_2, D_3, D_4 and D_5 - are defined as:

D_1 is **one** for the period 1974-'75 to 1979-'80 and **zero** otherwise,
D_2 is **one** for the period 1980-'81 to 1984-'85 and **zero** otherwise,
D_3 is **one** for the period 1985-'86 to 1991-'92 and **zero** otherwise,
D_4 is **one** for the period 1992-'93 to 1996-'97 and **zero** otherwise and
D_5 is **one** for the period 1997-'98 to 2000-'01 and **zero** otherwise.

and u_t is the stochastic error term.

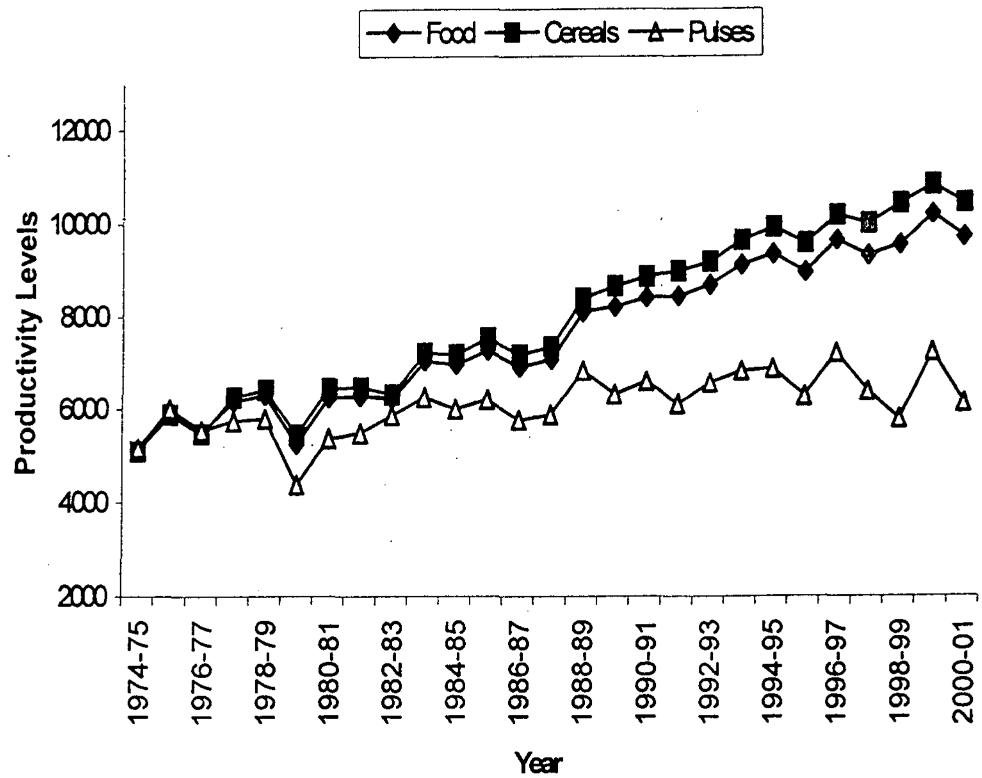
3.3 Trend and Growth Rate of Productivity: All India

In this section, first we examine the trend and growth rate of foodgrain productivity at all India level. Figure 3.1 shows the trend in productivity of foodgrains for the period 1974-'75 to 2000-'01. It may be noted that the trend in overall foodgrain productivity had been positive during the period of analysis[5]. Foodgrain productivity level almost doubled between 1974-'75 and 2000-'01, from Rs.5106 to Rs.9693 per hectare.

[5] However, a sharp decline in productivity can be observed in the year 1979-80. This was because of the severe drought in the Kharif season in some of the states. The total foodgrain productivity in that year declined by 17 per cent, the decline being more pronounced in pulses (by 24 per cent) than cereals (by 15 per cent).

Figure 3.1

Trend in Foodgrains Productivity for the period 1974-'75 to 2000-'01 – All India



At the disaggregate level, the trend in cereal productivity had been similar to that of foodgrains in toto. But in the case of pulses, the trend, though positive, was not as marked as cereals. The differentials in the growth pattern between cereals and pulses is also discernible from the growth rates. Table 3.1 gives the growth rates of foodgrains and its major components, cereals and pulses, at the all India level for the period 1974-'75 to 2000-'01.

Table 3.1

Growth Rates in Foodgrains Productivity for the period, 1974-'75 to 2000-'01 - All India

Crops	Growth Rates
Cereals	2.8* (21.9)
Pulses	0.9* (4.4)
Total	2.5* (21.9)

Note: 1. * Growth Rates are Statistically Significant at 5 per cent level.
2. Figures in Parentheses are Corresponding t-values

As the table shows, the all India growth rate had been significant and positive for cereals as well as pulses for the period 1974-'75 to 2000-'01. But the rate of growth of productivity had been much higher for cereals than for pulses. Though the growth rate was positive and significant for pulses, the major contributor to overall growth in food grains had been cereals.

3.4 Growth Rates of Productivity: State-wise

In this section, we examine the crop-specific growth rates in foodgrain productivity across the fifteen states. Table 3.2 gives the state-wise growth rates of foodgrains productivity for the period 1974-'75 to 2000-'01.

Table 3.2

State-wise Growth Rates of Foodgrains Productivity, 1974-'75 to 2000-'01

States	Foodgrains		
	Cereals	Pulses	Total
Andhra Pradesh	3.6* (19.9)	2.5* (7.9)	3.2* (18.4)
Assam	1.7* (12.1)	1.5* (10.5)	1.7* (12.1)
Bihar	2.4* (8.6)	1.9* (8.7)	2.3* (9.7)
Gujarat	2.6* (5.9)	1.3 (1.8)	2.5* (5.4)
Haryana	3.8* (15.9)	1.3 (1.8)	3.6* (14.9)
Karnataka	1.8* (6.6)	0.07 (0.2)	1.5* (5.6)
Kerala	1.4* (20.2)	3.0* (6.9)	1.4* (19.4)
Madhya Pradesh	2.6* (6.7)	1.9* (7.1)	2.4* (7.3)
Maharashtra	1.5* (4.7)	1.7* (4.1)	1.6* (5.1)
Orissa	1.9* (4.9)	-0.9* (-2.1)	1.7* (4.8)
Punjab	2.8* (15.8)	0.5 (1.4)	2.8* (17.1)
Rajasthan	2.9* (7.7)	0.4 (0.6)	1.9* (4.3)
Tamil Nadu	3.1* (12.8)	1.9* (8.0)	2.8* (12.3)
Uttar Pradesh	3.7* (15.3)	0.6* (2.3)	3.1* (13.3)
West Bengal	2.8* (12.4)	1.3* (6.0)	2.9* (13.0)

Note: 1. * Growth Rates are Statistically Significant at 5 per cent level.
2. Figures in Parentheses are Corresponding t-values

The table shows that the pattern of growth at state-levels had been more or less similar to that observed at all India level. But in the case of pulses, the growth rate had been insignificant in Gujarat, Haryana, Karnataka, Rajasthan and Punjab and was even negative in Orissa. On the contrary, all the states showed significant and positive growth rates in cereals productivity during the period of analysis, but with marked variation across states.

We can classify all the states into two groups with respect to their performance in growth rates – one, states with growth rates above the national level (better performing states) and two, states with growth rates below the national level (poor performing states). With respect to overall foodgrain productivity, Andhra Pradesh, Gujarat, Haryana, Punjab, Tamil Nadu, Uttar Pradesh and West Bengal registered growth rates above the national level and all others had growth rates below the national level.

In the case of cereals, the highest growth rate in productivity was recorded by Haryana and the lowest by Kerala. While Andhra Pradesh, Haryana, Punjab, Rajasthan, Tamil Nadu, Uttar Pradesh and West Bengal had growth rates in cereals above the national level, all other states had growth rates below the national level. In the case of pulses, Andhra Pradesh, Assam, Bihar, Kerala, Madhya Pradesh, Maharashtra, Tamil Nadu and West Bengal registered growth rates above the national level, but the growth rates were below the national level in all other states. Kerala, which was the lowest growing state in cereals productivity, recorded highest growth rate in pulses.

3.5 Growth Rates of Productivity: Plan-wise

3.5.1 Foodgrains: Overall

Table 3.3 gives the plan-wise growth rates of foodgrains productivity for the different states. It shows that the rate of growth at all India level had been significant only during the Sixth and the Seventh Plan periods, but decelerated during the subsequent two plan periods[6].

[6] During the Nineties, the growth rates became lower and insignificant.

Table 3.3

Plan-wise Growth Rates of Foodgrain Productivity

States	1974-'75 to 1979-'80	1980-'81 to 1984-'85	1985-'86 to 1991-'92	1992-'93 to 1996-'97	1997-'98 to 2000-'01
Andhra Pradesh	4.3* (3.3)	3.0* (2.5)	4.1* (4.7)	0.9 (0.8)	3.7 (1.6)
Assam	0.4 (0.3)	1.3 (1.3)	2.7* (3.8)	0.9 (0.9)	2.6 (1.4)
Bihar	-1.5 (-0.8)	5.3* (3.2)	0.6 (0.6)	5.0* (2.8)	0.2 (0.1)
Gujarat	11.0* (3.5)	-4.9 (-1.6)	3.6 (1.7)	5.7 (1.8)	-4.4 (-0.8)
Haryana	5.6* (3.3)	2.7 (1.7)	5.1* (4.5)	0.7 (0.4)	2.4 (0.8)
Karnataka	2.7 (1.8)	-3.6* (-2.6)	3.2* (3.2)	2.9 (1.9)	2.9 (1.1)
Kerala	1.6* (3.4)	0.8 (1.8)	2.3* (7.4)	-0.3 (-0.6)	3.1* (3.8)
Madhya Pradesh	-1.8 (-0.8)	5.7* (2.7)	2.7 (1.8)	2.1 (0.9)	-3.5 (-0.9)
Maharashtra	2.9 (1.2)	-2.3 (-1.0)	4.2* (2.7)	1.8 (0.8)	-2.7 (0.7)
Orissa	1.2 (0.5)	2.9 (1.2)	3.4* (2.0)	-0.9 (-0.4)	4.1 (0.9)
Punjab	5.4* (8.4)	3.9* (6.4	2.4* (5.5)	0.7 (1.1)	2.9* (2.6)
Rajasthan	-0.4 (-0.1)	1.6 (0.5)	1.4 (0.6)	6.9 (1.9)	-5.6 (-0.9)
Tamil Nadu	2.8 (1.7)	0.5 (0.3)	5.5* (4.9)	-0.01 (-0.1)	3.6 (1.3)
Uttar Pradesh	1.4 (0.8)	6.2* (3.9)	2.5* (2.2)	2.2 (1.3)	1.2 (0.4)
West Bengal	-0.3 (-0.2)	3.9* (2.7)	4.5* (4.4)	1.0 (0.7)	1.5 (0.6)
India	1.6 (1.7)	3.0* (3.2)	3.2* (4.8)	1.7 (1.7)	1.2 (0.7)

Note: 1. * Growth Rates are Statistically Significant at 5 per cent level
2. Figures in Parentheses are Corresponding t-values

The state-wise analysis too reveals that, similar to the all India level, all states registered significant growth rates either during the Sixth or the Seventh Plan, but the growth rates became insignificant during the Eighth and the Ninth Plans. The only exceptions to the all India pattern are Bihar, Kerala and Punjab; Bihar registered significant growth rate during the Eighth Plan and Punjab and Kerala during the Ninth Plan. We can note that in Punjab the growth rates picked up during the Ninth Plan after a continuous decline from the Fifth to the Eighth Plan. We can also see from the table that Rajasthan is the only state showing insignificant growth rate in productivity during all the sub-periods[7]. In the next section we examine the crop-wise growth rates in productivity.

3.5.2 Cereals and Pulses

(a) Cereals

Table 3.4 gives the plan-wise growth rates for cereals productivity in the different states.

Table 3.4
Plan-wise Growth Rates of Productivity (Cereals)

States	1974-'75 to 1979-'80	1980-'81 to 1984-'85	1985-'86 to 1991-'92	1992-'93 to 1996-'97	1997-'98 to 2000-'01
Andhra Pradesh	4.9* (3.7)	2.5* (2.0)	5.0* (5.7)	1.1 (0.8)	4.2 (1.8)
Assam	0.4 (0.4)	1.4 (1.3)	2.6* (3.7)	0.9 (0.9)	2.7 (1.4)
Bihar	-1.8 (-0.9)	5.3* (2.7)	0.7 (0.5)	5.6* (2.7)	-0.2 (-0.1)
Gujarat	9.9* (3.3)	-5.3 (-1.8)	4.1* (2.0)	5.7 (1.9)	-1.3 (-0.3)
Haryana	8.0* (6.6)	3.2* (2.8)	4.6* (5.6)	0.9 (0.8)	1.8 (0.8)
Karnataka	3.7* (2.3)	-3.8* (-2.5)	3.7* (3.5)	3.3* (2.1)	2.9 (1.0)
Kerala	1.5* (3.2)	0.7 (1.7)	2.2* (7.4)	-0.1 (-0.2)	3.3* (4.2)
Madhya Pradesh	-0.7 (-0.3)	5.9* (2.3)	2.9 (1.7)	2.2 (0.8)	-5.7 (-1.2)
Maharashtra	4.6* (2.2)	-4.2* (-2.1)	4.8* (3.4)	1.7 (0.8)	-4.1 (-1.1)
Orissa	1.4 (0.5)	2.5 (0.9)	4.7* (2.5)	-1.5 (-0.5)	-4.5 (-0.9)
Punjab	5.9* (9.1)	3.5* (5.7)	2.3* (5.2)	0.7 (1.0)	2.9* (2.5)
Rajasthan	-0.04 (-0.02)	3.3 (1.2)	2.7 (1.4)	5.9* (2.0)	-2.0 (-0.4)
Tamil Nadu	3.1 (1.8)	1.2 (0.8)	6.2* (5.4)	-1.1 (-0.7)	5.2 (1.8)
Uttar Pradesh	2.7 (1.6)	6.6* (4.2)	3.1* (2.8)	2.5 (1.5)	1.3 (0.4)
West Bengal	-0.2 (-0.1)	3.7* (2.4)	4.5* (4.2)	0.9 (0.5)	1.7 (0.6)
India	2.3* (2.4)	2.9* (3.3)	3.6* (5.7)	1.8 (1.9)	1.4 (0.9)

Note: 1. * Growth Rates are Statistically Significant at 5 per cent level.
2. Figures in Parentheses are Corresponding t-values

[7] Rajasthan's growth rate is something different in the sense that this state shows a significant rate of growth in productivity for the whole period (1974-'75 to 2000-'01), but registers insignificant growth rates for all the sub-periods.

Growth rate of cereals productivity shows patterns similar to that for foodgrains in general: increasing from the Fifth to the Seventh Plan period and then decelerating during the Eighth and the Ninth Plan periods. All the states show significant growth rates in cereals productivity during one or the other of the first three sub-periods, but insignificant growth rates during the last two sub-periods. However, the rate of growth of cereal productivity in Punjab had been significant during all the Plans, except during the Eighth. It is interesting to note that in Punjab, the growth rate of cereal productivity increased during the Ninth Plan, after registering continuous decline from the Fifth to the Eighth Plan period. While the growth rates in all the states were insignificant during the Nineties, Bihar and Karnataka showed significant growth during the Eighth Plan and Kerala, besides Punjab, during the Ninth Plan.

(b) Pulses

Table 3.5 gives the plan wise growth rates for pulses productivity across the states. The table shows that the rate of growth for pulses increased at the all India level from the Fifth to the Sixth Plan and decelerated subsequently, and the pattern had been similar in Andhra Pradesh, Bihar, Madhya Pradesh, Orissa, Punjab, Uttar Pradesh and West Bengal. Among the other states, Gujarat and Kerala registered significant growth rates only during the Fifth Plan; the growth rates became insignificant in the subsequent plan periods. It is also interesting to examine whether higher growth rates are related to higher levels of productivity. This aspect is examined in the next section.

Table 3.5

Plan-wise Growth Rates of Productivity (Pulses)

States	1974-'75 to 1979-'80	1980-'81 to 1984-'85	1985-'86 to 1991-'92	1992-'93 to 1996-'97	1997-'98 to 2000-'01
Andhra Pradesh	-1.1 (-0.7)	10.1* (6.7)	0.2 (0.2)	0.3 (0.2)	1.9 (0.7)
Assam	0.4 (0.4)	1.4 (1.6)	0.8 (1.4)	4.5* (5.0)	-1.4 (-0.9)
Bihar	0.5 (0.3)	5.6* (3.6)	0.6 (0.5)	0.8 (0.5)	3.7 (1.3)
Gujarat	13.1* (2.7)	-3.8 (-0.8)	0.9 (0.3)	6.5 (1.3)	-18.6* (-2.2)
Haryana	-3.6 (-0.7)	-0.6 (-0.1)	6.6 (1.8)	0.6 (0.1)	-11.6 (-1.2)
Karnataka	-1.1 (-0.4)	-2.9 (-1.2)	1.2 (0.7)	0.5 (0.2)	5.7 (1.3)
Kerala	7.7* (2.9)	4.4 (1.7)	3.5 (1.9)	-1.2 (-0.5)	-1.2 (-0.3)
Madhya Pradesh	-3.7* (2.0)	5.2* (2.9)	2.2 (1.7)	1.9 (1.0)	-0.3 (-0.1)
Maharashtra	-2.2 (-0.7)	3.5 (1.1)	2.1 (0.9)	2.0 (0.6)	-0.09 (-0.02)
Orissa	1.0 (0.5)	4.7* (2.5)	-1.9 (-1.5)	-6.6* (-3.4)	-0.6 (-0.2)
Punjab	-7.5* (-3.4)	5.2* (2.5)	1.2 (0.8)	-0.2 (-0.1)	-3.2 (-0.8)
Rajasthan	1.1 (0.2)	-0.8 (-0.2)	-0.9 (-0.3)	8.2 (1.8)	-15.3 (-1.9)
Tamil Nadu	2.7 (1.6)	2.7 (1.7)	2.4* (2.2)	-0.8 (-0.4)	1.8 (0.6)
Uttar Pradesh	-1.8 (-0.9)	4.5* (2.3)	-0.7 (-0.5)	0.3 (0.1)	0.1 (0.04)
West Bengal	-3.1* (-2.1)	4.2* (3.0)	1.1 (1.2)	0.4 (0.3)	2.8 (1.1)
India	-1.6 (-1.1)	3.3* (2.4)	0.8 (0.8)	0.5 (0.4)	-1.8 (-0.7)

Note: 1. * Growth Rates are Statistically Significant at 5 per cent level.
2. Figures in Parentheses are Corresponding t-values

3.6 Levels of Productivity across States: Plan-wise

In this section, we examine the average levels of productivity for all the states from the Fifth to the Ninth Plan periods. First we look into productivity levels of foodgrains in general and then of cereals and pulses. We divide the states into two groups – states with levels of productivity above the national average (better performing states) and states with productivity levels below the national average (poor performing states).

(a) Foodgrains: Overall

Tables 3.6(a) and 3.6(b) show the plan-wise average levels of foodgrains productivity for the 'better performing' and the 'poor performing' states respectively.

Table 3.6(a)

Plan-wise Average Levels of Foodgrains Productivity: Better Performing States (in Rs. per Hectare)

States	1974-'75 to 1979-'80	1980-'81 to 1984-'85	1985-'86 to 1991-'92	1992-'93 to 1996-'97	1997-'98 to 2000-'01
Andhra Pradesh	6742	8561	10460	12385	13534
Assam	6870	7526	8187	9443	9984
Haryana	6960	8207	11150	13339	14153
Kerala	11019	11915	12962	14216	14830
Punjab	11194	14230	17124	19182	20410
Tamil Nadu	9494	9763	12814	14860	16801
Uttar Pradesh	5781	7402	9064	10437	11289
West Bengal	8812	9419	12494	14541	15714
India	5702	6549	7774	9143	9678

Source: Ministry of Agriculture, Government of India.

Table 3.6(b)

Plan-wise Average Levels of Foodgrains Productivity: Poor Performing States (in Rs. per Hectare)

States	1974-'75 to 1979-'80	1980-'81 to 1984-'85	1985-'86 to 1991-'92	1992-'93 to 1996-'97	1997-'98 to 2000-'01
Bihar	5809	6304	7575	8579	9676
Gujarat	3986	5558	4724	6445	7014
Karnataka	5475	5591	5343	6928	7456
Madhya Pradesh	4201	4972	5845	7012	6732
Maharashtra	3701	3860	4059	5316	4931
Orissa	5793	6669	7800	8584	7969
Rajasthan	3168	3339	3470	4267	4788
India	5702	6549	7774	9143	9678

Source: Same as Table 3.6(a)

The tables show that almost all the states had been showing an increase in the average levels of foodgrains productivity during all the plan periods from the Fifth to the Ninth. Nevertheless, Gujarat and Karnataka experienced a decline in the average levels of productivity during the Seventh Plan and, Madhya Pradesh, Maharashtra and Orissa during the Ninth Plan. Among the 15 states, Punjab recorded the highest level of productivity during all the plan periods and Rajasthan the lowest. The difference in the productivity level between these two states increased from Rs.8026 per hectare during the Fifth Plan to Rs.15622 per hectare during the Ninth Plan.

For all the plan periods, Punjab, Haryana, Uttar Pradesh, West Bengal, Assam, Tamil Nadu, Andhra Pradesh and Kerala had levels of productivity above the national average. Orissa, which had levels of productivity above the national average during the Fifth to Seventh Plan periods, subsequently fell below the national average. All other states had productivity levels consistently below the national average during all the plan periods.

(b) Cereals

Tables 3.7(a) and 3.7(b) show the state-wise productivity levels of cereals for each sub-period for the 'better performing' and the 'poor performing' states respectively.

Table 3.7(a)

Plan-wise Average Levels of Cereals Productivity: Better Performing States (in Rs. per Hectare)

States	1974-'75 to 1979-'80	1980-'81 to 1984-'85	1985-'86 to 1991-'92	1992-'93 to 1996-'97	1997-'98 to 2000-'01
Andhra Pradesh	7416	9476	11781	14475	15971
Haryana	6643	8893	11570	13801	14508
Kerala	11283	12085	13157	14344	15224
Punjab	11435	14617	17380	19356	20557
Tamil Nadu	10275	10770	15020	16995	19548
Uttar Pradesh	5247	7009	8934	10530	11510
West Bengal	9071	9657	12783	14802	16016
India	5762	6721	8135	9690	10404

Source: Same as Table 3.6(a)

Table 3.7(b)

Plan-wise Average Levels of Cereals Productivity: Poor Performing States (in Rs. per Hectare)

States	1974-'75 to 1979-'80	1980-'81 to 1984-'85	1985-'86 to 1991-'92	1992-'93 to 1996-'97	1997-'98 to 2000-'01
Assam	6962	7656	8331	9578	10136
Bihar	5789	6137	7472	8571	9686
Gujarat	3922	5047	4441	6162	7048
Karnataka	5645	6025	5742	7624	8381
Madhya Pradesh	3880	4738	5678	6924	6360
Maharashtra	3518	3724	3775	4939	4515
Orissa	5946	6700	8344	9223	8529
Rajasthan	2526	2893	3194	4064	4690
India	5762	6721	8135	9690	10404

Source: Same as Table 3.6(a)

The tables show that, except for Assam, states with productivity levels above the national average in the case of foodgrains in general, had higher levels of productivity than the national average in the case of cereals also. We can also note that Uttar Pradesh, which had lower productivity of cereals during the Fifth Plan period, improved its position in the subsequent periods, showing higher levels of productivity. The average levels of cereal productivity had been the highest in Punjab and the lowest in Rajasthan during all the plan periods.

(c) Pulses

Tables 3.8(a) and 3.8(b) give the plan-wise levels of productivity in pulses for the 'better performing' and 'poor performing' states respectively.

Table 3.8(a)

Plan-wise Average Levels of Productivity of Pulses: Better Performing States (in Rs. per Hectare)

States	1974-'75 to 1979-'80	1980-'81 to 1984-'85	1985-'86 to 1991-'92	1992-'93 to 1996-'97	1997-'98 to 2000-'01
Bihar	5914	7365	8277	8587	9604
Haryana	7723	5358	8577	9700	7988
Kerala	5040	7802	8625	11343	9486
Punjab	8405	6926	8659	9475	8065
Uttar Pradesh	8476	9706	9787	9872	9863
West Bengal	6368	6365	7304	7846	8213
India	5440	5791	6231	6744	6372

Source: Same as Table 3.6(a)

Table 3.8(b)

Plan-wise Average Levels of Pulses Productivity: Poor Performing States (in Rs. per Hectare)

States	1974-'75 to 1979-'80	1980-'81 to 1984-'85	1985-'86 to 1991-'92	1992-'93 to 1996-'97	1997-'98 to 2000-'01
Andhra Pradesh	3217	4183	5316	5455	5510
Assam	4707	4992	5255	6249	6535
Gujarat	4575	8378	5944	7406	6835
Karnataka	4823	4210	4022	4625	4706
Madhya Pradesh	4946	5526	6258	7219	7529
Maharashtra	4421	4401	5059	6467	6069
Orissa	5250	6581	6465	5209	4313
Rajasthan	4498	4490	4246	4779	4853
Tamil Nadu	3686	3877	4809	5153	5237
India	5440	5791	6231	6744	6372

Source: Same as Table 3.6(a)

It may be noted that Andhra Pradesh, Assam and Tamil Nadu had been 'poor performers' in pulses productivity during all the plan periods despite their status as `better performers' in cereal productivity. On the contrary, Bihar, though a 'poor performing' state in terms of cereals productivity, had been a 'better performer' in pulses productivity over the sub-periods. The average level of productivity in pulses for all the plan periods had been the highest in Uttar Pradesh. Andhra Pradesh occupied the lowest position during the Fifth Plan, Tamil Nadu during the Sixth Plan, Karnataka during the Seventh and the Eighth Plans and Orissa during the Ninth Plan.

We had seen earlier that Andhra Pradesh, Assam, Tamil Nadu, Uttar Pradesh, Haryana, Kerala, Punjab and West Bengal had above national average level of productivity in foodgrains during all the plan periods. For the first three, this had been due to the high levels of productivity in cereals and in the case of the fourth, it had been due to the high level of productivity in pulses. The other four states had higher level of productivity both in cereals and in pulses.

3.7 Conclusion

The foregoing analysis shows an increasing trend in foodgrain productivity at the all India level over the period 1974-'75 to 2000-'01. But the rate of growth had been significant only during the Sixth and the Seventh Plan periods and insignificant during the Eighth and Ninth Plan periods. The state-wise analysis has shown that the rate of growth of foodgrain productivity decelerated during the Nineties in the majority of the states. During the entire period of analysis, growth rates of productivity had been higher than the national average in Andhra Pradesh, Haryana, Punjab, Tamil Nadu, Uttar Pradesh and West Bengal. These states, along with Kerala and Assam, were also having higher levels of productivity than the national average during all the five-year plans between 1974 and 2001. By implication, states which had higher levels of initial productivity maintained their position throughout and states which had lower levels of initial productivity continued to be so. Further, we find that the rates of growth of cereals productivity have been higher than that of pulses for all India and for majority of the states.

CHAPTER 4

PUBLIC INVESTMENT IN AGRICULTURE: A STATE-WISE ANALYSIS

4.1 Introduction

Studies on agricultural investment appeared with greater importance in the Indian economy during the late Eighties debating on the issue of complementarity between public and private investments[1]. Most of the studies that came out were based on the national level data with very scanty attention on the trend in public investment at the regional level[2]. This chapter discusses the growth and interstate differences in public investment from 1974-'75 to 2000-'01.

The Chapter begins with a discussion on the data coverage. Section 3 discusses the share of investment in irrigation to the total public investment across states. The all India trend and the rate of growth of public investment are analysed in Section 4 and state-wise growth rates in public investment in Section 5. Section 6 deals with the plan-wise average levels of pubic investment across the states and the last Section concludes the discussion.

4.2 Data Coverage

The major data source usually employed to analyse the trend in public and private investments in agriculture at the national level is the National Accounts Statistics (NAS) brought out by the Central Statistical Organisation (CSO). The NAS, however, does not give state-wise data on agricultural investment. Moreover, about 90 percent

---

[1] According to Rath (1989), Shetty (1990), Chakravarty (1993), Rao (1994), Dhawan (1998), Gandhi (1990, 1996), Mishra and Hazel (1996) and Storm (1993) there exists complementary relationship between public and private investment. On the contrary, Mishra and Chand (1995) and Chand (2000) have argued that there is no apparent long-run relationship between the two. To Mitra (1997), there is partial complementarity between public and private investments at the micro level.

[2] See, Purohit and Reddy (1999), Chand (2000), Roy and Pal (2002) and Gulati and Bathla (2002).

of the investment included in this series is constituted by investment on irrigation alone, with the exclusion of important heads of infrastructure investment like storage, rural roads and rural electrification (Rao, 1997; Chand, 2000). Identifying this lacuna, Chand (2000) constructed a new broad series of public investment based on the Finance Accounts of various States and Union Territories. Chand's series includes 23 heads of capital expenditure. But, the inclusion of all these heads in the series was questioned by Gulati and Bathla (2002). According to them, inclusion of the investments such as those in rural development, special area programmes and rural electrification in Chand's new series make the series suffer from either over estimation or under estimation. For instance, what is needed is the inclusion of investment in electricity that goes to agriculture rather than rural electrification as such. They give three alternative concepts of public investment in agriculture. The first concept is the same as the conventional investment series given by the CSO. Under the second one, they include investments under the concept one plus the amount of power supplied to agriculture each year. The third concept covers investments under concept two plus investments made in agriculture and allied activities as defined in the budgetary documents. These include capital expenditure on soil and water conservation, crop and animal husbandry, dairy development, plantations, storage and ware housing, agriculture research and education, co-operation, other agricultural programmes, fisheries, forestry and wildlife.

In the present study we follow the third concept employed by Gulati and Bathla, but with some modifications. We exclude 'power that goes to agriculture' due to the paucity of state-wise data. We also exclude expenditure heads like fisheries and forestry since these have, prima facie, no direct dent on agricultural productivity. Thus, the components of public investment included in the present study are crop and animal husbandry, soil and water conservation, dairy development, plantations, food storage and ware housing, agriculture research and education, co-operation, rural development, other agricultural programmes and major and medium irrigation and flood control. Unlike other studies, we also include loans and advances made by state governments on crop husbandry and soil and water conservation in the public investment series. We restrict our analysis to the period 1974-'75 to 2000-01. The period of analysis starts from 1974-75, because of the non-availability of comparable state-wise data on investment prior to that year[3]. The data we rely are available at current prices. Therefore, we convert them into a constant series at 1993-94 prices, using the deflator derived from the National Accounts Statistics (NAS) of the Central Statistical Organization (CSO)[4]. Due to the difficulty in arriving at state-wise deflator on agricultural capital formation, the all India deflator has been used for all the states.

We follow the same plan-wise periodisation that we have used in the last chapter. The methods for computing growth rates and average levels of investment are also the same as in the last chapter. In order to make allowance for the importance of investment that each state has given to its agricultural sector, we consider the per hectare public investment, derived by dividing the investment figures by net sown area of each state. Before analysing the growth and interstate variations in public investment, we examine the state-wise share of irrigation to the total investment.

4.3 Share of Irrigation in Total Investment

According to the CSO series, about 90 per cent of the total capital expenditure in agriculture is on major and medium irrigation projects. The state-wise percentage share of irrigation in public investment in agriculture with respect to our new series is given in Table 4.1[5].

---

[3] For details, see Chand (2000).

[4] CSO gives time series data on public investment in agriculture at current as well as 1993-'94 prices. We have derived the year-wise deflator from this data to convert our series into constant prices.

[5] The figures are averages of the whole period of analysis (1974-'75 to 2000-'01).

Table 4.1

State-wise Percentage Share of Irrigation in the Total Investment

States	Percentage of Irrigation to Total
Andhra Pradesh	91
Assam	91
Bihar	77
Gujarat	90
Haryana	90
Karnataka	92
Kerala	82
Madhya Pradesh	86
Maharashtra	86
Orissa	95
Punjab	92
Rajasthan	87
Tamil Nadu	61
Uttar Pradesh	77
West Bengal	67
India	84

Source: Reserve Bank of India Bulletin, various issues.

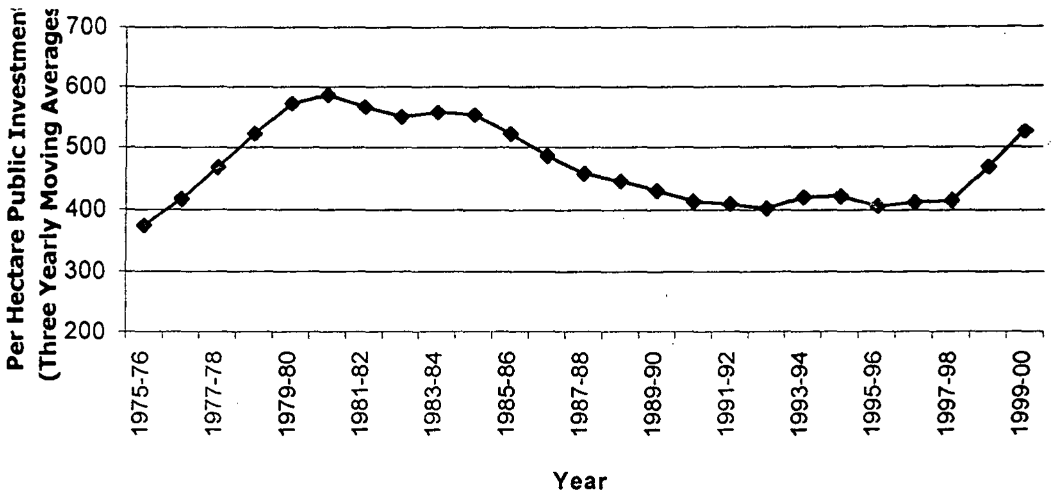
It may be noted that more than 80 per cent of the total investment in Indian agriculture is on irrigation projects. The share, however, varies across states. While most of the states are having more than 80 per cent of their investment on irrigation, in four states - Bihar, Tamil Nadu, Uttar Pradesh and West Bengal - the share of irrigation to total investment is below 80 per cent. Among these states, Uttar Pradesh and Bihar have, however, more than 75 per cent of their total public investment on irrigation. Thus, with respect to either CSO series or the new series, investment in irrigation constitutes the lion's share of total public investment.

4.4 Trend in Public Investment: All India

Figure 4.1 gives the per hectare public investment at all India level for the period 1974-'75 to 2000-'01, based on three yearly moving averages.

Figure 4.1

Trend in Public Investment in Agriculture, 1974-'75 to 2000-'01



The figure shows that public investment at the national level had been steadily increasing till the year 1980-'81 and showing steep decline from 1981-'82 to 1992-'93. After that it tends to move upwards with marginal fluctuations. Therefore, we estimate the growth rates of the series by dividing the whole period into three sub-periods (1974-'75 to 1980-'81, 1981-'82 to 1992-'93 and 1993-'94 to 2000-'01) using the kinked exponential growth model (Boyce, 1986). Hence, the model we have is:

$$\ln Y_t = \alpha + \beta_1(D_1t + \sum_{j=2}^{3} D_jK_1) + \beta_2(D_2t - \sum_{j=2}^{3} D_jK_1 + D_3K_2) + \beta_3(D_3t - D_3K_2) + u_t$$

Where $\mathbf{\ln Y_t}$ is the logarithm of investment series, α is the intercept and β_1, β_2 and β_3 are the growth rates for the sub-periods. $\mathbf{K_1}$ and $\mathbf{K_2}$ are the two kink values given in the model (where $\mathbf{K_1 = 7.5}$ **and** $\mathbf{K_2 = 19.5}$) and the sub-period dummy variables, $\mathbf{D_1}$, $\mathbf{D_2}$ and $\mathbf{D_3}$ are defined as:

$\mathbf{D_1}$ is **one** for the period 1974-'75 to 1980-'81 and **zero** otherwise,

$\mathbf{D_2}$ is **one** for the period 1981-'82 to 1992-'93 and **zero** otherwise and

$\mathbf{D_3}$ is **one** for the period 1993-'94 to 2000-'01 and **zero** otherwise.

$\mathbf{u_t}$ is the stochastic error term.

The results are shown in Table 4.2. It can be noted that from the mid seventies to 1980-'81, the growth rate of public investment had been highly significant and positive. The series shows a perceptible negative growth rate during the eighties, but the growth rate significantly increases from 1993-'94. The rate of growth of public investment during the last sub-period is, however, lesser than that of the initial sub-period.

Table 4.2

Growth Rates of Public Investment

Sub-periods	Growth Rates
1974-'75 to 1980-'81	8.9* (8.5)
1981-'82 to 1992-'93	-4.2* (-8.9)
1993-'94 to 2000-'01	4.7* (5.3)

Note: 1. * Growth Rates are Statistically Significant at 1per cent level.
2. Figures in parentheses are corresponding t-values
Source: computed from R.B.I Bulletin, various issues

In fact, the decline in public investment during the eighties has been observed by other studies on agricultural investment in India. According to Mitra (1996), the decline in public investment between 1980-'81 and 1990-'91 was 4.57 per cent per annum and even higher during the period 1986-'87 to 1992-'93. It implies that with respect to either the CSO series or the broad series that we have constructed, public investment had declined considerably during the eighties. However, whether the pattern of growth rate in public investment at all India level holds true for the states or not is an important query that needs to be addressed.

4.5 State-wise Growth in per Hectare Public Investment

We follow the same periodisation and methodology discussed in the earlier section to estimate the growth rates of public investment for all the fifteen major states. The results are reported in Table 4.3.

Table 4.3

State-wise Growth Rates in Public Investment, 1974-'75 to 2000-'01

States	1974-'75 to 1980-'81	1981-82 to 1992-'93	1993-'94 to 2000-'01
Andhra Pradesh	-1.5 (-0.6)	-0.8 (-0.7)	4.5* (2.0)
Assam	9.7* (3.4)	-4.8* (-3.7)	0.2 (0.9)
Bihar	12.9* (2.0)	-8.8* (3.1)	-2.3 (-0.4)
Gujarat	17.1* (5.2)	-3.4* (-2.3)	11.3* (4.1)
Haryana	21.2* (3.4)	-14.3* (-5.1)	18.9* (3.6)
Karnataka	4.4 (1.6)	-1.4 (-1.1)	7.4* (3.2)
Kerala	15.9* (5.3)	-7.9* (-5.9)	3.4 (1.4)
Madhya Pradesh	4.1* (2.1)	-2.2* (-2.5)	-4.8* (-2.9)
Maharashtra	3.7 (1.7)	1.2 (1.2)	3.2 (1.8)
Orissa	24.9* (9.5)	-7.5* (-6.4)	5.7* (2.6)
Punjab	9.2 (1.2)	-0.2 (-0.1)	6.7 (1.1)
Rajasthan	4.6* (2.2)	-1.1 (-1.2)	3.7* (2.2)
Tamil Nadu	7.8 (1.6)	-14.8* (-6.7)	15.7* (3.8)
Uttar Pradesh	20.9* (4.9)	-10.2* (-5.3)	7.5* (2.1)
West Bengal	5.9* (2.8)	-8.9* (-9.4)	3.5* (2.0)
India	8.9* (8.5)	-4.2* (-8.9)	4.7* (5.3)

Note: 1. * Growth Rates are Statistically Significant at 5 per cent level.
2. Figures in parentheses are corresponding t-values.

Source: Same as Table 4.1

It is clear from the table that all the fifteen states registered negative growth rates in public investment during the eighties (1981-'82 to 1992-'93) and the pattern has been similar to the all India level. But, the growth rates are statistically insignificant for five states (Andhra Pradesh, Karnataka, Maharashtra, Punjab and Rajasthan) though they show negative coefficients. The decline during the eighties was more pronounced in Haryana and Tamil Nadu. For the other two sub-periods - 1974-'75 to 1980-'81 and 1993-'94 to 2000-'01 - the growth rates of public investment in the majority of the states are positive and similar to all-India.

During the first sub-period (1974-'75 to 1980-'81), public investment in the majority of the states had increased, the rate of increase being much higher in Orissa than in any other state. If we divide all the states into two groups - states with growth rates above the national level and below the national level - we see that Assam, Haryana, Kerala, Uttar Pradesh, Bihar, Gujarat and Orissa fall in the first category, while all other states fall in the second category. Among the states with higher growth rates in investment, the last three (Bihar, Gujarat and Orissa) are, however, 'poor performing' and the other four 'better performing' in terms of foodgrain productivity levels[6].

During 1993-'94 to 2000-'01, the growth rates of public investment had been positive and significant for nine states: Andhra Pradesh, Gujarat, Haryana, Karnataka, Orissa, Rajasthan, Tamil Nadu, Uttar Pradesh and West Bengal. The rate of growth of investment had been the highest in Haryana. Though the rate of growth had been positive for Assam, Kerala, Maharashtra and Punjab, the coefficients are not statistically significant. The only state that registered significant negative growth rate in public investment during the Nineties is Madhya Pradesh. We can also see that Gujarat, Haryana, Karnataka, Orissa, Tamil Nadu and Uttar Pradesh are states with investment growth rates above the national level during the Nineties.

Thus, in general, most of the fifteen major states in India experienced a drastic decline in public investment during the Eighties vis-à-vis the increase in the same during the other two periods (from 1974-'75 to 1980-'81 and 1993-'94 to 2000-'01). However, the performance of each state in public investment and its interstate differences can be elucidated by looking into whether the higher growth rates are related to higher levels.

4.6 State-wise Average Levels of Public Investment

In this section, we examine the average level of investment in each state for the five sub-periods outlined earlier. Table 4.4 gives the period-wise average levels of per hectare investment for all the fifteen major states.

---

[6] See section 3.6.

Table 4.4
Plan-wise Average Levels of Per Hectare Public Investment across States

States	1974-'75 to 1979-'80	1980-'81 to 1984-'85	1985-'86 to 1991-'92	1992-'93 to 1996-'97	1997-'98 to 2000-'01
Andhra Pradesh	612	526	512	577	692
Assam	477	658	558	339	440
Bihar	721	979	898	347	532
Gujarat	384	669	487	539	888
Haryana	626	819	416	308	695
Karnataka	446	472	386	571	596
Kerala	933	1144	673	642	625
Madhya Pradesh	334	383	379	264	236
Maharashtra	433	546	504	683	690
Orissa	388	716	516	362	547
Punjab	504	749	466	553	954
Rajasthan	217	246	215	258	268
Tamil Nadu	463	702	211	160	365
Uttar Pradesh	443	603	431	276	424
West Bengal	567	625	325	274	282
India	449	570	447	410	506

Note: Investment Figures are in Rupees per Net Sown Area
Source: Same as Table 4.1

As the table shows, the all India average level of public investment increased from the Fifth (Column.2, Table 4.4) to the Sixth plan (Column 3, Table 4.4) and declined during the subsequent two plan periods. But the level of public investment increased during the last sub-period (1997-'98 to 2000-'01). The pattern is similar in seven states: Assam, Bihar, Haryana, Orissa, Tamil Nadu, Uttar Pradesh and West Bengal.

Among the others, Gujarat, Karnataka, Maharashtra, Punjab and Rajasthan show increase in investment during the Eighth and the Ninth plan periods after recording a decline in the Seventh Plan from the Sixth Plan. But, Kerala and Madhya Pradesh show a continuos decline in investment from the Seventh to the Ninth Plan despite an improvement in the Seventh Plan from the Sixth Plan.

It can be seen from the table that Kerala and Punjab are the only states that maintained their position above the national average during all the plan periods. These two states, for all the sub-periods, had also been 'better performing' in terms of average level of foodgrain productivity. On the contrary, Madhya Pradesh and Rajasthan had been the only states with investment below the national average for all the plan periods and these two states had been 'poor performing' in the case of foodgrain productivity also for the same period.

We observe that seven states - Andhra Pradesh, Assam, Haryana, Kerala, Punjab, Tamil Nadu, Uttar Pradesh and West Bengal - had been ahead of the national average in per hectare public investment levels in one or the other of the initial two sub-periods (the Fifth and the Sixth plan periods). These states, it may be noted, were 'better performing' in foodgrains productivity also during all the plan periods. Therefore, it may be inferred that the better performance of these states in foodgrain productivity might have been due to the higher initial levels of per hectare public investment. However, except in Kerala and Punjab and Andhra Pradesh, the levels of public investment in these states fell below the national average during the last two sub-periods, corresponding to the Eighth and Ninth plans. Tamil Nadu even became the lowest investing state in the Seventh and Eighth Plans[7]. Further, Gujarat, Karnataka and Maharashtra, which had been having productivity levels below the national average during all the plans, had investment levels higher than the national average during the last two plan periods.

4.7 Conclusion

The discussion in this chapter shows that after showing a sharp increase during 1974-'75 to 1980-'81, the growth rate of per hectare public investment in India significantly declined during 1981-'82 to 1992-'93. But the growth rate became positive during 1993-'94 to 2000-01. The state-wise analysis shows that the rate of growth of public investment was not uniform for all the states. Assam, Haryana, Kerala, Uttar Pradesh, Bihar, Gujarat and Orissa were the better performing during 1974-'75 to 1980-'81 and Gujarat, Karnataka, Orissa, Haryana, Tamil Nadu and Uttar Pradesh were the better performing during 1993-'94 to 2000-'01. Further, the decline in investment during 1981-'82 to 1992-'93 was more pronounced in Haryana and Tamil Nadu than in the

[7] For the other Plan periods Rajasthan recorded the lowest average level of investment.

other states. Most of the states having investment growth rate higher than the national average is having higher level of productivity too.

Our analysis of the average levels of investment during the five sub-periods shows that the all India level has increased from the Fifth to Sixth Plan and then declined during the next two plans and it again rose during the last plan. We observe that Kerala and Punjab are the only states having higher levels of investment (above the national average) for all the sub-periods. Whereas, Madhya Pradesh and Rajasthan are the only states having lower levels of investment for all the sub-periods of analysis. This might be an indication of the existence of positive relationship between public investment and foodgrain productivity, which we try to examine in the next chapter.

Further, we have shown that the higher productivity regions - Andhra Pradesh, Assam, Haryana, Kerala, Punjab, Tamil Nadu, Uttar Pradesh and West Bengal - over the sub-periods had registered higher levels of per hectare investment during the initial periods compared to the 'poor performing' states in foodgrain productivity. Therefore, we may infer that the higher initial levels of investment have benefited these states through out the period of analysis to attain higher levels of productivity. However, whether public investment has got a gestation lag in influencing foodgrain productivity across the states needs detailed examination, which is the main concern of the next chapter.

CHAPTER 5

PUBLIC INVESTMENT AND FOODGRAIN PRODUCTIVITY: A STATE-WISE ANALYSIS

5.1 Introduction

In this chapter, we examine the long-run relationship between public investment and productivity in agriculture with reference to foodgrains in the fifteen major states for the period from 1974-'75 to 2000-'01. Since more than 80 per cent of the total public investment in the majority of the states is on irrigation, we also explore the relationship between foodgrains productivity and investment on irrigation.

The chapter is organised as follows. Section 2 deals with the analysis of the impact of public investment on foodgrain productivity. Section 3 examines the long-run relationship between investment in irrigation and foodgrain productivity. Section 4 concludes the discussion.

5.2 Public Investment and Foodgrain Productivity

5.2.1 The Methodology

While examining the long-run relationship between investment and productivity, one should consider the gestation lag in the influence of the former on the latter. According to Rath (1989), the change in public investment during one plan will affect agricultural productivity during the next plan period. Gulati and Bathla (2002) view that investment in irrigation which constitutes a major part of public investment, might have a longer gestation lag - of about ten to twelve years - in influencing productivity. However, these studies suggest the gestation lags (although differently) between investment and productivity at all India level, which need not hold uniformly for all the states. Rather, it may vary across the states depending on the composition of public investment, crop composition, the response of private investment, soil conditions, climate and so on. Since there is no definite gestation lag that can be suggested for investment in influencing productivity in each state, we use the Autoregressive Distributed (Infinite) Lag Model (ADL model) given by Koyck (1954) to catch the lagged effect of investment on foodgrain productivity across the states.

5.2.2 Autoregressive Distributed Lag (ADL) Model

In regression analysis involving time series data, if the regression model includes not only the current but also the lagged (past) values of the explanatory variables, it is called a distributed lag model. If the model includes one or more lagged values of the dependent variable among its explanatory variables, it is called an autoregressive distributed lag model (Gujarati, 2003). There are two kinds of distributed lag models: the **infinite lag model** and the **finite lag model.** The length of the lag is not specified in the former, while it is specified in the latter. We consider the infinite lag model given as:

$$Y_t = \alpha + \beta_0 X_t + \beta_1 X_{t-1} + \ldots + u_t \text{-----------------} (1)$$

From the equation (1), Koyck has derived an ingenious method of estimating autoregressive distributed (infinite) lag model assuming that all the β coefficients decline geometrically as follows:

$$\beta_k = \beta_0 \lambda^k \qquad k = 0,1,\ldots\ldots\ldots\ldots(2)$$

where λ, such that $0<\lambda<1$, is known as the rate of decline, or decay. Koyck's autoregressive distributed lag model replaces all the lagged values of the explanatory variable with a single lagged value of the dependent variable, and therefore, his procedure is known as Koyck transformation[1]. The model can be written as:

$$Y_t = \alpha\,(1-\lambda) + \beta_0\,X_t + \boldsymbol{\lambda Y_{t-1}} + v_t \text{------------------} (3)$$

where, $\mathbf{v_t = (u_t - \lambda u_{t-1})}$, and $\mathbf{(1-\lambda)}$ = the speed of adjustment. Therefore, higher the $\boldsymbol{\lambda}$ value lower will be the speed of adjustment.

Our analysis of the long run impact of public investment and foodgrain productivity across the states relies on this model given by equation (3). With this model we can compute the lag length of the explanatory factor ($\mathbf{X_t}$). Koyck has suggested two ways of computing the lag: one, median lag and the other mean lag, where,

Median lag = log 2/log (λ) and

Mean lag = λ/(1-λ)

The median and mean lags serve as a summary measure of the speed with which Y responds to X. These measures give the time that X takes to accomplish 50 per cent change in Y.

It should be noted that the usual Durbin Watson d-statistic is not enough to check the autocorrelation of the explanatory factor with the stochastic error term. One alternative suggested is Durbin`s ***h*** test. The method of computing h-statistic is:

$$\textbf{Durbin's } h = \rho \sqrt{\frac{n}{1 - n[\mathrm{var}(Y_{t-1})]}}$$

[1] For detailed discussion of the model see Gujarati (2003: Chapter 17)

Where, $\rho \approx$ **1-(d/2)**, **'d'** is Durbin-Watson d-statistic, **'n'** is the number of observations and **var** (Y_{t-1}) is variance of lagged Y_t. However, the computation of the Durbin's h-statistic has its own limitations. If the term in the denominator of the square root becomes negative, then we may not be able to compute the statistic and also it tests only the first-order autocorrelation. Hence, for checking autocorrelation we also report the Lagrange Multiplier autoregression test for overall significance.

5.2.3 Unit Root Test

Before examining the long-run relationship between investment and productivity using this model, we check for the stationarity of the two series for each state and all India. It has been observed that the conventional regression method for examining the relationship between two time series variables that are non-stationary will often lead to spurious regression (Harris, 1995)[2]. Most economic series are non-stationary and contain one or more unit roots. Therefore, in order to establish the true relationship between time series variables one must check for the non-stationarity or presence of unit roots in these variables (Granger and Newbold, 1976). For that we can exercise the standard Dickey-Fuller (DF) and Augmented Dickey-Fuller (ADF) unit root test. Accordingly, if the variable has no unit root, then they are stationary and if it has unit roots, then differencing the variable could make it stationary. Hence, we proceed with testing for the unit root in the case of foodgrain productivity series and the public investment series for each state and all India for the period from 1974-'75 to 2000-'01. The results are reported in Tables 5.1 for productivity series and in 5.2(a) and 5.2(b) for investment series.

[2] Spurious regression means that the results obtained will suggest a statistically significant relationship between the variables in the regression model when in fact all that is obtained is evidence of contemporaneous correlation rather than meaningful causal relation.

Table 5.1
Unit root test for state-wise productivity series

States	t-ADF value (without constant and trend)	t-ADF value (constant included)	t-ADF value (constant and trend included)	Inference
Andhra Pradesh	1.4128 (8)	-0.12187 (8)	-5.5203** (0)	Stationary
Assam	2.4324 (8)	-1.5281 (8)	-4.6818** (0)	Stationary
Bihar	2.3446 (8)	-0.20777 (8)	-4.4392** (0)	Stationary
Gujarat	0.76073 (8)	-0.37039 (8)	-3.7198* (0)	Stationary
Haryana	0.91051 (8)	-0.94147 (8)	-4.7745** (0)	Stationary
Karnataka	1.0992 (8)	-1.2883 (8)	-2.6143 (8)	Difference stationary
Kerala	2.4531 (8)	-0.33515 (8)	-4.5317** (4)	Stationary
Madhya Pradesh	0.72219 (8)	-0.90237 (8)	-4.8014** (0)	Stationary
Maharashtra	0.99583 (8)	-3.0692* (0)	-4.8553** (0)	Stationary
Orissa	0.44401 (8)	-3.2387* (0)	-4.5156** (0)	Stationary
Punjab	0.71829 (8)	-3.3225* (7)	-4.2796* (0)	Stationary
Rajasthan	1.4772 (8)	-3.1279* (0)	-4.1331* (0)	Stationary
Tamil Nadu	1.5686 (8)	-0.19812 (8)	-3.9191* (0)	Stationary
Uttar Pradesh	0.62552 (8)	-2.2603 (8)	-5.2117** (0)	Stationary
West Bengal	1.7394 (8)	-3.5395* (5)	-3.6988* (0)	Stationary
India	0.60237 (8)	-1.4994 (8)	-4.8241** (0)	Stationary

Note: 1. Figures in parentheses denote the optimum number of lags used.
2.* & ** = Significant at 5 and 1 per cent levels respectively.

The above table shows that as per the DF and ADF tests, the foodgrains productivity series for all India as well as for all the states (except Karnataka) do not have any unit root and therefore are integrated of order zero (**I(o)**)[3]. This implies that except for Karnataka, the productivity series for all other states as well as for all India are stationary. The series for Karnataka is stationary at the first difference (integrated of order **I(1)**). The corresponding ADF value (including constant and trend) for Karnataka is -8.929 at zero lag length.

[3] It can be seen that without including any deterministic variables like trend or constant, none of the states are following stationary in productivity series. Some of the states are becoming stationary if we include constant, and all the states (except Karnataka) follow stationary only with the inclusion of constant and trend. Since most economic variables have a trend ingrained, we include a constant and trend in the model for unit root test. Hence, we consider the test of that model only.

Table 5.2 (a)

Unit Root Test for State-wise Total Public Investment Series

States	t-ADF value (constant included)	t-ADF value (constant and trend included)	t-ADF value (without constant and trend)	Inference
Andhra Pradesh	0.047763 (8)	1.8430 (8)	0.59673 (8)	Difference Stationary
Assam	-1.3290 (8)	-1.5709 (8)	-0.52259 (8)	Difference Stationary
Bihar	-2.4933 (8)	-2.3565 (8)	-0.71155 (8)	Difference Stationary
Gujarat	-0.57655 (8)	-1.3072 (8)	0.29196 (8)	Difference Stationary
Haryana	-2.4498 (8)	-0.80514 (8)	-0.65273 (8)	Difference Stationary
Karnataka	-1.3057 (8)	-1.6262 (8)	0.46206 (8)	Difference Stationary
Kerala	-4.7412** (5)	-4.6543** (7)	-3.1294** (5)	Stationary
Madhya Pradesh	-1.9289 (8)	-4.1137* (0)	-1.0020 (8)	Stationary
Maharashtra	0.12040 (8)	-4.5025** (0)	1.1574 (8)	Stationary
Orissa	-3.2852* (0)	-1.3776 (8)	-0.98175 (8)	Stationary
Punjab	-5.1840** (0)	-5.1756** (0)	-2.2568* (0)	Stationary
Rajasthan	-3.2554* (0)	-1.3860 (8)	0.20246 (8)	Stationary
Tamil Nadu	-1.6912 (8)	0.21303 (8)	-0.47539 (8)	Difference Stationary
Uttar Pradesh	-1.3891 (8)	0.86529 (8)	0.89294 (8)	Difference Stationary
West Bengal	-3.5811* (2)	-0.47118 (8)	-2.0274* (2)	Stationary
India	-0.87161 (8)	0.23307 (8)	0.92867 (8)	Difference Stationary

Note: 1. Figures in parentheses denote the optimum number of lags used.
2. * & ** = Significant at 5 and 1 per cent levels respectively.

But, as Table 5.2(a) shows, investment series of only seven states - Kerala, Madhya Pradesh, Maharashtra, Orissa, Punjab, Rajasthan and West Bengal - have no unit root (integrated of order zero) and therefore are stationary. As noted above in all these states foodgrains productivity series also are stationary. The series for the other states as well as for all India are stationary at the first difference (that is, integrated of order one, **I(1)**). Among these states, Karnataka series has stationarity at its first difference in case of both foodgrain productivity and investment series. Hence, the regression analysis using the ADL model (equation 3) can be applied only for these eight states: Karnataka, Kerala, Madhya Pradesh, Maharashtra, Orissa, Punjab, Rajasthan and West Bengal. All other states and all India are integrated of order zero (**I(0)**) in productivity series and of order one (**I(1)**) in investment series (Table 5.2(b)). Hence, statistical analysis using time series technique cannot show the relationship between investment and productivity in these states and for all India, since they might show spurious regression[4].

Table 5.2(b)
Unit Root Test for State-wise Total Public Investment Series
(First Difference (I(1))

States	t-ADF value (constant included)	t-ADF value (constant and trend included)	t-ADF value (without constant and trend)	Inference
Andhra Pradesh	-3.5072* (0)	-3.7309* (0)	-3.5413* (0)	Stationary
Assam	-7.6760** (0)	-7.4997** (0)	-7.8132** (0)	Stationary
Bihar	-5.2706** (0)	-5.1297** (0)	-5.3998** (0)	Stationary
Gujarat	-4.7357** (0)	-4.6408** (0)	-4.7142** (0)	Stationary
Haryana	-5.4004** (0)	-5.2264** (0)	-5.4507** (0)	Stationary
Karnataka	-6.6212** (0)	-6.4700** (0)	-6.6132** (0)	Stationary
Tamil Nadu	-4.5604** (0)	-4.6557** (0)	-4.6645** (0)	Stationary
Uttar Pradesh	-6.4814** (0)	-6.3366** (0)	-6.5268** (0)	Stationary
India	-3.8197** (0)	-3.6808* (0)	-3.7599** (0)	Stationary

Note: 1. Figures in parentheses denote the optimum number of lags used.
2. * & ** = Significant at 5 and 1 levels per cent respectively.

Before examining the relationship between investment and productivity using the ADL model (equation 3), we may examine the cointegration of investment and productivity series using Engle-Granger method. According to Engle- Granger method of cointegration, if the two series are integrated of order one and the residuals follow zero order of integration, then these two series are cointegrated of order (1, 1). We examine the cointegration of investment and productivity only for Karnataka since this is the only state that shows stationarity in investment and productivity at the first difference (I(1)). Other seven states that show same order of integration in investment and productivity are, however, integrated of order zero in both the series, and therefore, no cointegration can be expected in these states. Since we have already seen that the investment and productivity series of Karnataka are integrated of order one, the next step is to check whether the residuals follow zero order of integration. Our examination of the DF and ADF unit root test shows that the residuals follow zero

[4] However, it does not mean that there is no relationship between foodgrain productivity and public investment in these states. But the time series method that we use does not have the scope of estimating such a relationship in these states due to the existence of stationarity problem.

order of integration. The ADF value -2.968 is significant at one-percent level[5]. Therefore, public investment and foodgrain productivity in Karnataka are cointegrated of order (1, 1).

5.2.4 Model Estimation

In this section, we try to examine the long-run relationship between total public investment and foodgrain productivity for all the eight states (Karnataka, Kerala, Madhya Pradesh, Maharashtra, Orissa, Punjab, Rajasthan and West Bengal), each of which are showing the same order of integration (that is, **I(1)** for Karnataka and **I(0)** for other states) both in investment and in productivity series. With respect to equation (3) we can re-write the model in order to examine the long-run relationship between public investment and productivity as:

$$P_t = \alpha\,(1-\lambda) + \beta_0\, I_t + \lambda \mathbf{P}_{t-1} + v_t \text{------------------} \quad (4)$$

where **P** is foodgrain productivity series of each state, **I** is the Investment series and $\mathbf{P}_{t-1}$ is the lagged value of productivity series, which gives the lagged effect of investment series. The results are reported in Table 5.3.

The table shows that the coefficients of current investment series (β_0's) for all the eight states are statistically insignificant. Most of the states show even negative coefficients. This implies that investment in no state has any contemporaneous impact on productivity. But all the states (except Maharashtra) have highly significant coefficients for the lagged variable, which varies across states[6]. While Kerala and Punjab show relatively higher lagged coefficients, Madhya Pradesh, Orissa and Rajasthan are having lesser. This implies that the speed of adjustment or the time that investment takes to accomplish its result on productivity for each state would be varying, which we examine in the next section.

---

[5] The critical values of residuals are -1.955 and -2.656 at 5 per cent and 1 per cent levels of significance respectively.

[6] The Durbin's h-statistic for all the states show that there is no autocorrelation problem in the explanatory variables at 5 per cent level. The residual properties are also satisfied. The AR-1 statistic also shows that there is no residual autocorrelation in any of the states at 5 per cent level except for West Bengal.

Table 5.3

Results of the Relationship between Total Public Investment and Foodgrain Productivity

States	Constant	β_0	λ	Durbin's h-statistic	Residual Analysis					
					AR-1	ARCH	Normality	Xi^2	Xi*Xj	RESET
Karnataka	1219.0 (1.5)	2.3 (1.5)	0.62* (3.2)	#	1.6148 [0.2227]	0.0063487 [0.9372]	0.081356 [0.9601]	0.47468 [0.7538]	0.3818 [0.8543]	2.8812 [0.1037]
Kerala	874.92 (0.71)	-0.14 (-0.37)	0.95* (12.1)	-0.9	1.0283 [0.3749]	0.22144 [0.6428]	0.010516 [0.9948]	0.50388 [0.7334]	0.54329 [0.7411]	0.39691 [0.5352]
Madhya Pradesh	4188.9* (2.6)	-4.8 (-1.7)	0.55* (3.4)	-0.7	0.60431 [0.5557]	0.0062434 [0.9378]	7.6024 [0.0223]	0.29923 [0.8746]	0.24936 [0.9344]	0.37135 [0.5485]
Maharashtra	2086.8* (2.8)	2.2 (1.4)	0.24 (1.0)	#	0.56808 [0.5751]	0.54338 [0.4692]	2.3388 [0.3106]	0.72633 [0.5854]	0.57404 [0.7191]	0.55783 [0.4630]
Orissa	5351.0* (2.9)	-1.5 (-0.9)	0.39* (2.1)	-2.7	1.3871 [0.2718]	1.2309 [0.2798]	0.37004 [0.8311]	1.1844 [0.3511]	0.96204 [0.4679]	2.096 [0.1618]
Punjab	1385.9 (1.8)	-0.89 (-0.38)	0.95* (19.8)	-2.3	3.428 [0.0515]	0.0000727 [0.9933]	0.1955 [0.9069]	1.0358 [0.4160]	0.79859 [0.5657]	0.11489 [0.7379]
Rajasthan	1050.0 (1.1)	4.7 (1.3)	0.43* (2.6)	-1.3	2.388 [0.1163]	0.024073 [0.8782]	0.0023549 [0.9988]	0.6191 [0.6546]	0.52338 [0.7554]	6.2668 [0.0202]
West Bengal	5034.0* (2.2)	-3.9 (-1.9)	0.74* (5.8)	-2.3	8.6621 [0.0018]	0.73282 [0.4016]	1.0744 [0.5844]	4.04 [0.0165]	3.0992 [0.0361]	2.5732 [0.1229]

Note:

1) * significant at 5 per cent level.
2) # Durbin's h-statistic cannot be calculated for these states because of the denominator of the term inside the square root become zero.
3) For β_0 and λ, figures in parentheses are corresponding t-values.
4) For Residual analysis,(AR-1 to RESET), figures in parentheses are corresponding F-values except for Normality – for that the figures in Parentheses are corresponding Chi^2 values.
5) AR-1 is the Lagrange Multiplier Autoregression, ARCH is Autoregressive Conditional Heteroscedasticity, Xi^2 and Xi*Xj are homoscedasiticity one and two and RESET is the Ramsey test for functional mis-specification in the model.
6) The null hypotheses of the residual analysis are: a) there is no autoregression (AR-1), b) there is no autoregressive conditional hetroscedasticity (ARCH), c) there is no heteroscedasticity (Xi^2 and Xi*Xj), d) there is normality and e) there is no functional mis-specification.

5.2.5 The Median and Mean Lags

Koyck has proposed two models for finding the lag: one, median lag model (Median lag = $log\ 2/log\ (\lambda)$) and two, mean lag model (Mean lag = $\lambda/(1-\lambda)$)[7]. We employ the two models to examine the time that public investment takes to accomplish the changes in foodgrain productivity in each state. Since these two models are based on the λ coefficients of each state, one can expect that higher the λ value, lower will be the speed of adjustment. The results with respect to the two models are given in Table 5.4.

Table 5.4

Median and Mean Lag between Public Investment and Foodgrain Productivity

States	Lag length	
	Median Lag	Mean Lag
Karnataka	1.4	1.6
Kerala	@	@
Madhya Pradesh	1.2	1.2
Maharashtra	0.5	0.3
Orissa	0.7	0.6
Punjab	@	@
Rajasthan	0.8	0.8
West Bengal	2.3	2.8

Note: @ = lag length is more than 12 years

The table shows that the duration of the lag between investment and foodgrain productivity varies across states. For Maharashtra, Orissa, and Rajasthan, 50 per cent of the impact in investment is felt on productivity within one or two years, but for Kerala and Punjab it takes more than 12 years. It can be recalled that Kerala and Punjab are the 'better performing' in foodgrains productivity for all the plan periods. Among the other states, while for West Bengal the impact in public investment on productivity is accomplished in two or three years, it takes one or two years in Karnataka. The results imply that public investment in agriculture affects foodgrain productivity with time lag, and, therefore, our analysis extends the earlier hypothesis put forth by Rath (1989), Rao (1994) and Gulati and Bathla (2002) at the all India

[7] see, *supra*. p. 41

level to the state level. In the next section we examine the crop-specific median and mean lag in each state.

5.2.6 Crop Composition and the Lag

In this section, we look into the crop composition of each state (that is, the share of cereals to the total foodgrains) and see whether the states with relatively higher shares of cereals are having higher gestation lags compared to other states. For that we take the percentage share of area under cultivation of cereals to the total foodgrains area and then compare this with the mean and median lag for each state (see Table 5.5).

Table 5.5

Percentage Share of Area under Cereals Cultivation and the Lag

States	Area Share of Cereals	Lag length	
		Median Lag	Mean Lag
Karnataka	77	1.4	1.6
Kerala	95	@	@
Madhya Pradesh	70	1.2	1.2
Maharashtra	78	0.5	0.3
Orissa	78	0.7	0.6
Punjab	96	@	@
Rajasthan	72	0.8	0.8
West Bengal	94	2.3	2.8

Note: @ = lag length is more than 12 years

The table shows that Kerala, Punjab and West Bengal have higher share of area under cereals cultivation - more than 90 per cent - compared to the other states. For the first two states, the share is still higher (≥ 95 per cent). It is evident from the table that these are the states with higher gestation lag or lower speed of adjustment compared to other states. In short, we may note that public investment takes relatively longer time to influence productivity of the states, where the share of cereals to the total foodgrains is higher. In the next section we extend the same ADL model to examine the long-run relationship of the major component of public investment, irrigation, with foodgrains productivity and also the speed of adjustment between the two across states.

5.3 Investment in Irrigation and Foodgrain Productivity: State-wise Analysis

Irrigation is the single largest component of public investment and, according to our series, constitutes more than 80 per cent of the total public investment. Moreover, almost 75 per cent of the total irrigated area under cultivation in India is under foodgrains. Therefore, we shall look into the effect of public investment in irrigation on foodgrain productivity.

5.3.1 Methodology

We apply the same model used in the earlier section to examine the long-run relationship between investment in irrigation and foodgrains productivity for the period 1974-'75 to 2000-'01. The model is:

$$P_t = \alpha\,(1-\lambda) + \beta_0\, IR_t + \lambda P_{t-1} + v_t \text{------------------} (5)$$

Where, **IR** is the investment on irrigation and all other notations denote what they indicated in the preceding section.

5.3.2 Unit Root Test

As the first step in estimating the model, we test for stationarity of the irrigation series based on DF and ADF unit root tests. The results are given in Tables 5.6(a) and 5.6(b).

Table 5.6(a)

Unit Root Test for State-wise series of Investment in Irrigation

States	ADF (constant included)	ADF (constant and trend included)	ADF (Without constant and trend)	Inference
Andhra Pradesh	-3.8796** (1)	-4.0426* (1)	0.64585 (8)	Stationary
Assam	-3.1637* (0)	-3.6497* (0)	-0.78465 (8)	Stationary
Bihar	-1.1429 (8)	-1.9530 (8)	-0.38560 (8)	Difference Stationary
Gujarat	0.62429 (8)	-0.63667 (8)	0.76487 (8)	Difference Stationary
Haryana	-2.1553 (8)	-1.4245 (8)	-1.3076 (8)	Difference Stationary
Karnataka	-0.56773 (8)	-1.3074 (8)	0.73712 (8)	Difference Stationary
Kerala	-2.2957 (8)	-3.9623* (8)	-0.66256 (8)	Stationary
Madhya Pradesh	-1.7467 (8)	-3.7395* (0)	-0.94096 (8)	Stationary
Maharashtra	-3.0167* (0)	-3.9146* (7)	0.62092 (8)	Stationary
Orissa	-3.0903* (1)	-1.4486 (8)	-0.90978 (8)	Stationary
Punjab	-4.351** (0)	-4.6417** (0)	0.18556 (8)	Stationary
Rajasthan	-3.2077* (0)	-1.9254 (8)	-0.63869 (8)	Stationary
Tamil Nadu	-3.4273* (1)	-1.6973 (8)	-0.34508 (8)	Stationary
Uttar Pradesh	-1.7655 (8)	-0.69798 (8)	-0.30734 (8)	Difference Stationary
West Bengal	-3.0275* (0)	-3.7312* (2)	-0.89423 (8)	Stationary
India	-2.9850* (1)	-1.0092 (8)	-0.050628 (8)	Stationary

Note: 1. Figures in parentheses denote the optimum number of lags used.
2. * & ** = Significant at 5 and 1 per cent levels respectively.

Table 5.6(b)

Unit Root Test for State-wise series of Investment in Irrigation (First Difference)

States	t-ADF value (constant included)	t-ADF value (constant and trend included)	t-ADF value (Without constant and trend)	Inference
Bihar	-5.6681** (0)	-5.5429** (0)	-5.8166** (0)	Stationary
Gujarat	-4.6265** (0)	-4.5080** (0)	-4.5980** (0)	Stationary
Haryana	-4.6269** (0)	-4.6531** (0)	-4.7448** (0)	Stationary
Karnataka	-6.4406** (0)	-6.2978** (0)	-6.3311** (0)	Stationary
Uttar Pradesh	-4.4190** (0)	-4.2506* (0)	-4.5117** (0)	Stationary

Note: 1. Figures in parentheses denote the optimum number of lags used.
2. * & ** Significant at 5 and 1 per cent levels respectively.

The tables show that states which follow stationarity in the case of productivity and total public investment series, also follow stationarity in the case of irrigation series. Further, stationarity in the irrigation series exists for all India and for the states of Andhra Pradesh, Assam and Tamil Nadu, which had shown difference-stationary in total public investment. Among the states that show same order of integration in productivity as well as irrigation series, only Karnataka has first order integration and all others have zero order of integration in both series. Hence, we cannot expect a cointegration between public investment and productivity in those states with zero order of integration in both the series. The Engle-Granger cointergation test, therefore, has been done only for Karnataka. The unit root test for residuals in Karnataka shows that it is integrated of order zero (the ADF value of the residuals is −3.739 without including any deterministic variables)[8]. It means that investment in irrigation and foodgrain productivity in Karnataka are cointegrated of order (1, 1).

5.3.3 Model Estimation

Now we proceed to examine the long-run relationship between investment in irrigation and foodgrain productivity for all India and for the states of Andhra Pradesh, Assam, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Orissa, Punjab, Rajasthan, Tamil Nadu and West Bengal using equation (5). The results are reported in Table 5.7.

The table shows that irrigation, like total public investment, has no instantaneous effect on foodgrain productivity in any state except Karnataka. In the case of Madhya Pradesh, the contemporaneous impact of irrigation on foodgrains productivity shows even significant negative coefficient. In all the states (except Maharashtra[9]) investment in irrigation appear to have significant lagged effect on foodgrain productivity like what hold for the total public investment. Durbin's h-statistic does not show autocorrelation of the explanatory variable in any of the states at 5 per cent level except for Assam, where it is significant only at 10 per cent level[10].

---

[8] Critical values are -1.955 and -2.656 at 5 per cent and 1 per cent levels respectively.

[9] In the case of Maharashtra, the coefficient is not significant either for contemporaneous effect or for lagged effect.

[10] The residual analysis reveals that there is autoregression in three states - Andhra Pradesh, Assam, West Bengal - and in all India. But for all other states, the over all specifications are validated at 5 per cent level. Other parameters of the residual analysis like Normality, Heteroscedasticity and Ramsey RESET are well specified in the model.

Table 5.7

Results of the Relationship between Investment in Irrigation and Foodgrain Productivity

States	Constant	β_0	λ	Durbin's h	Residual Analysis					
					AR-1	ARCH	Normality	Xi^2	Xi*Xj	RESET
Andhra Pradesh	803.3	0.15	0.94*	-2.8	5.6586	0.59308	1.8136	0.44009	0.34296	1.1343
	(0.7)	(0.08)	(11.6)		[0.0108]	[0.4498]	[0.4038]	[0.7780]	[0.8797]	[0.2984]
Assam	-563.3	1.6	0.99*	-3.6	7.5694	1.7574	1.5331	2.0117	1.5285	3.2261
	(-0.4)	(1.2)	(7.3)		[0.0033]	[0.1992]	[0.4646]	[0.1359]	[0.2333]	[0.0862]
Karnataka	1737.0*	3.2*	0.48*	#	1.3694	0.03175	0.091097	0.26684	0.24472	2.5112
	(2.0)	(2.1)	(2.3)		[0.2760]	[0.8603]	[0.9555]	[0.8954]	[0.9368]	[0.1273]
Kerala	1317.9	-0.49	0.94*	-0.8	1.0936	0.30773	0.0063662	0.39431	0.484	0.2041
	(1.01)	(-0.8)	(11.9)		[0.3533]	[0.5849]	[0.9968]	[0.8100]	[0.7835]	[0.6559]
Madhya Pradesh	4050.5*	-4.8*	0.54*	-0.2	0.33826	0.067296	5.7831	0.30226	0.2996	0.1179
	(2.9)	(-2.0)	(3.6)		[0.7168]	[0.7978]	[0.0555]	[0.8726]	[0.9063]	[0.7346]
Maharashtra	2175.7*	1.8	0.31	#	0.99632	1.5345	2.9152	0.26164	0.44938	1.0596
	(2.9)	(1.1)	(1.3)		[0.3860]	[0.2291]	[0.2328]	[0.8987]	[0.8079]	[0.3145]
Orissa	5596.2	-2.1	0.38*	-1.9	0.99017	0.92362	0.36858	0.78293	0.76356	2.1322
	(3.3)	(-1.3)	(2.2)		[0.3882]	[0.3475]	[0.8317]	[0.5509]	[0.5884]	[0.1584]
Punjab	1514.0	-1.1	0.97*	-2.5	4.5281	0.051555	1.2994	1.4645	1.1106	0.23107
	(1.9)	(-1.5)	(19.5)		[0.0232]	[0.8226]	[0.5222]	[0.2542]	[0.3913]	[0.6355]
Rajasthan	2274.7	-1.3	0.48*	-0.9	3.2803	0.000090118	0.070486	0.43943	0.40128	1.0538
	(1.8)	(-0.3)	(2.8)		[0.0576]	[0.9925]	[0.9654]	[0.7785]	[0.8412]	[0.3158]
Tamil Nadu	2681.5*	-3.9	0.87*	-1.4	1.4189	0.1519	3.764	2.642	3.2089	0.21562
	(2.1)	(-1.1)	(8.9)		[0.2643]	[0.7007]	[0.1523]	[0.0678]	[0.0320]	[0.6470]
West Bengal	2465.1	-4.6	0.91*	-2.4	11.496	2.4815	0.67671	2.5399	1.9324	0.47438
	(1.6)	(-1.07)	(11.5)		[0.0004]	[0.1301]	[0.7129]	[0.0757]	[0.1415]	[0.4982]
India	1806.3	-2.3	0.91*	-2.2	5.9782	0.057421	1.6935	0.70181	0.53133	0.29124
	(1.7)	(-1.2)	(13.4)		[0.0088]	[0.8129]	[0.4288]	[0.6008]	[0.7497]	[0.5948]

Note:

1. significant at 5 per cent level.
2. # Durbin's h-statistic cannot be calculated for these states because of the denominator of the term inside the square root become zero.
3. For β_0 and λ, figures in parentheses are corresponding t-values.
4. For Residual analysis,(AR-1 to RESET), figures in parentheses are corresponding F-values except for Normality – for that the figures in Parentheses are corresponding Chi^2 values.
5. AR-1 is the Lagrange Multiplier Autoregression, ARCH is Autoregressive Conditional Heteroscedasticity, Xi^2 and Xi*Xj are homoscedasiticity one and two and RESET is the Ramsey test for functional mis-specification in the model.
6. The null hypotheses of the residual analysis are: a) there is no autoregression (AR-1), b) there is no autoregressive conditional hetroscedasticity (ARCH), c) there is no heteroscedasticity (Xi^2 and Xi*Xj), d) there is normality and e) there is no functional mis-specification.

We can also note from Table 5.9 that in most of the states, similar to the effect of total public investment, the effect of investment in irrigation on productivity appears with a lag. But the lagged coefficients are varying across states similar to the case of total public investment and foodgrain productivity. As the results show, the λ coefficients are relatively high in Andhra Pradesh, Assam, Kerala, Punjab, Tamil Nadu and West Bengal and low in Karnataka, Madhya Pradesh, Orissa and Rajasthan. Therefore, for the former group of states, we can expect a relatively low speed of adjustment between investment in irrigation and foodgrain productivity compared to other states. In the next section we examine the duration of lag associated with irrigation in influencing foodgrain productivity across the states.

5.3.4 The Median and Mean Lag

We consider the mean and median lag models explained in section 5.2.2 to examine the time that irrigation investment takes to influence foodgrain productivity in each state. The results are given in Table 5.8.

Table 5.8

Median and Mean Lag between Irrigation and Foodgrain Productivity

States	Lag Length	
	Median Lag	Mean Lag
Andhra Pradesh	11.5	@
Assam	@	@
Karnataka	1.0	0.9
Kerala	10.4	@
Madhya Pradesh	1.1	1.2
Maharashtra	0.6	0.4
Orissa	0.7	0.6
Punjab	@	@
Rajasthan	0.9	0.9
Tamil Nadu	4.9	6.5
West Bengal	7.7	10.6
India	7.1	9.7

Note: @ = lag length is more than 12 years

As we noted earlier, Gulati and Bathla (2002), have suggested about ten to twelve years of gestation lag with respect to investment in irrigation in affecting agricultural productivity. However, our analysis does not show any uniform length of the lag for all the states. Table 5.10 shows that 50 per cent of the total change in foodgrain productivity for the states Andhra Pradesh, Assam, Kerala, and Punjab is accomplished in more than twelve years. But in Karnataka, Madhya Pradesh, Maharashtra, Orissa, and Rajasthan the lag is comparatively less – almost one year. For Tamil Nadu and West Bengal as well as for all-India, it takes about five to ten years for investment in irrigation to affect half of the total change in foodgrain productivity. It can be noted that the states where the speed of adjustment observed to be lower, the average levels of foodgrain productivity are higher than the national average through out the plan periods. In the next section, we discuss about the crop-specific lag effect.

5.3.5 Crop Composition and the Lag

Similar to the earlier section (5.2.6), here also we consider the share of area under cereals cultivation and compare it with the mean and median lag of each state (Table.5.9).

Table 5.9

Percentage Share of Area under Cereals Cultivation and the Lag

States	Area Share of Cereals	Lag Length	
		Median	Mean
Andhra Pradesh	80	11.5	@
Assam	96	@	@
Karnataka	77	1.0	0.9
Kerala	95	10.4	@
Madhya Pradesh	70	1.1	1.2
Maharashtra	78	0.6	0.4
Orissa	78	0.7	0.6
Punjab	96	@	@
Rajasthan	72	0.9	0.9
Tamil Nadu	83	4.9	6.5
West Bengal	94	7.7	10.6
India	81	7.1	9.7

Note: @ = lag length is more than 12 years

Besides Kerala, Punjab and West Bengal, the share of cereals to the total foodgrains is relatively higher in Assam also (more than 90 per cent). It can be observed from the table that for these states, the irrigation investment takes more time to influence productivity compared to the other states, where the share of cereals to the total foodgrains is relatively less. We have already seen that these states had been showing productivity above the national average for all the plan periods analysed. For the states Karnataka, Madhya Pradesh, Maharashtra, Orissa and Rajasthan, the share of cereals seems to be lesser than other states and the irrigation investment in these states takes only about one year to accomplish 50 per cent of the total change in productivity. It can also be recalled that these are the states having productivity below the national average for all the plan periods analysed.

5.4 Conclusion

The results of the foregoing discussion show that for all the states examined there is no contemporaneous effect of public investment on foodgrain productivity, but there exists significantly positive lagged effect of the former on the latter. The length of the lag varies across the states: longer in those states where the productivity levels are higher than the national average. We have also seen that the length of the lag is higher in those states where the share of cereals to the total foodgrain is higher compared to other states. In the case of investment in irrigation also the effect on foodgrains productivity has been the same as for total public investment. The interstate differences in the gestation lag might be explained by the differentials in project implementation, composition of investment in irrigation (between major and minor projects), and delay in the use of complementary inputs besides soil characteristics and climatic conditions. We have not explored these aspects in the present study and needs further probe.

CHAPTER 6

SUMMARY AND CONCLUSIONS

This study aimed at examining the growth of foodgrain productivity and public investment and the long-run relationship between the two in fifteen major states in India for the period 1974-'75 to 2000-'01. In order to examine the long-run impact of public investment on foodgrains productivity, we used the Koyck's Autoregressive Distributed Lag model (ADL). This model was applied to capture the infinite gestation lag of the explanatory variable (public investment) in influencing the dependent factor (foodgrain productivity). We extended the same methodology to test the long-run relationship between investment in irrigation and foodgrain productivity, since irrigation constitutes the major component of total public investment in all the states.

The study showed that foodgrain productivity increased during 1974-'75 to 2000-'01. The rate of growth at all India level as well as in the majority of the states increased during the Sixth and the Seventh Plans, but decelerated during the Eighth and Ninth Plans. But the growth rate had not been uniform in all the states.

Our analysis of the levels of foodgrain productivity across states also revealed significant interstate differences. While some of the states registered productivity levels above the national average during all the plan periods, the others had been below the national average. In other words, states which had higher levels of initial productivity, maintained their position throughout and states which had lower levels of initial productivity continued to be so.

The rate of growth of productivity was found to be higher for cereals than for pulses for the entire period of analysis. The state specific performance varied across crops; while some of the states performed well in cereals, others did so in pulses.

The analysis of growth in public investment showed a sharp decline between 1980-'81 and 1992-'93 after registering a significant increase during 1974-'75 to 1980-'81.

But during 1993-'94 to 2000-'01, public investment showed positive growth both at all India level and in the majority of the states.

Analysis of the levels of investments in the different states showed that Kerala and Punjab had levels of investment above the national average during all the plan periods. In the case of foodgrains productivity too these states stood above the national average during all the plan periods. On the contrary, Madhya Pradesh and Rajasthan registered lower levels of investment than the national average during all the plan periods. These states had also been below the national average in foodgrain productivity during all the plan periods.

Our examination of the long-run relationship between public investment and foodgrain productivity showed that there is no contemporaneous effect of the former on the latter, but there exists significantly positive lagged effect for all the states. The length of the lag varies across the states. The lag had been longer in Andhra Pradesh, Assam, Kerala and Punjab, where the productivity levels had also been higher than the national average, and shorter in Madhya Pradesh, Maharashtra and Rajasthan, where the productivity levels had been lower than the national average during all the plan periods. We have also seen that the length of the lag had been higher in those states where the share of cereals in total foodgrain is higher compared to the other states. In the case of investment in irrigation also the effect on foodgrains productivity had been similar.

One interesting observation is that most of the states, which showed productivity levels above the national average during all the plan periods, were specifically those states which had public investment above the national average in either the Fifth or the Sixth Plan. It may be inferred, given the lag between public investment and foodgrain productivity, that the better performance of these states in foodgrain productivity might have been due to the higher initial levels of per hectare public investment. However, some of these states fell below the national average level of per hectare public investment during the Eighth and Ninth Plans. There was even a decline in the absolute levels of per hectare public investment during the Eighth or the Ninth Plan in some of the states. Further, some other states, which had been having productivity levels below the national average during all the plans, had investment levels higher than the national average during the last two plan periods. They also went up in absolute levels of per hectare public investment. This would imply the possibility of these states showing better performance in foodgrain productivity in the near future, given the shorter lag between public investment and foodgrain productivity in the majority of these states.

The interstate variations in lag length that public investment takes to accomplish its result in productivity might be due to a number of state-specific characteristics, which we have not explored in the present study and needs further enquiry. We put forward the following hypotheses as the possible explanations for the interstate differences in lag length.

- The difference in gestation lag may be due to the difference in the composition of the total irrigation investment, that is, difference in the share of minor irrigation and major irrigation in each state. It might be possible that states with relatively larger share of minor irrigation may register quicker effect in productivity compared to others with relatively larger share of investment in major and medium irrigation. This is because of the fact that investments in major and medium irrigation will take more time in implementation compared to minor irrigation.
- The lag in the completion of public investment, especially irrigation, may cause private investment and other complementary inputs to come delayed, and hence the result of public investment on productivity might get delayed.
- It is possible that the interstate differences in the lag length between public investment and productivity might be due to the difference in the quality of the soil in each state. For states having better quality soil, a little bit of investment would be enough to show its impact on productivity in relatively lesser time compared to states with poor quality soil.
- Lastly, the issue of higher lag in highly productive states may be because of the fact that, once a threshold level or the biologically possible level of productivity[1] has been reached, the response to inputs would be slow. That means, the increase

[1] For example, the maximum biologically possible yield for HYV rice varieties is somewhere around 5 tonnes per hectare.

of yield for paddy from 2 tonnes per hectare to 3 tonnes per hectare may be faster than raising it from 4 tonnes per hectare to 5 tonnes.

Nevertheless, our observation of the positive and lagged impact of public investment implies that the reduction in foodgrain productivity at all India level during the Nineties might have been due to the decline in public investment during the Eighties. Moreover, it highlights the need for sustained and secular increase in public investment. States registering poor performance in foodgrain productivity over the plan periods should give more preference in raising public investment in agriculture. Since the time lag between public investment and productivity has been observed to be low in these states, the results of the investments might be quicker accomplished.

References:

Antholt, C.H (1994), '*Getting Ready for the Twenty-First Century: Technical Change and Institutional Modernisation in Agriculture*', World Bank Technical Paper 217, February.

Barman, K. K (1996): '*Agricultural Breakthrough in India: Some Policy Issues*', in Gupta K.R (ed.), *Issues in Indian Economy*, Atlantic Publishers and Distributors, New Delhi

Bhalla, G S and Alagh, Y K (1979): '*Performance of Indian Agriculture: A District-wise Analysis*', Sterling Publishers Pvt. Ltd. New Delhi.

Bhalla, G S and Singh, G (1997): 'Recent Development s in Indian Agriculture: A State-wise Analysis', *Economic and Political Weekly*, Vol.XXXII, No.13, March 29-April 4.

Bhalla, G. S and Singh, Gurmail (2001), '*Indian agriculture: Four decades of development*', Sage, New Delhi.

Bhalla, G S and Tyagi, D S (1989): 'Special Pattern of Agriculture Development in India', *Economic and Political Weekly*, June 24.

Boyce, James K. (1986): 'Kinked Exponential Models for Growth Rate Estimation', *Oxford Bulletin of Economics and Statistics*, 48, 4.

Central Statistical Organisation, *National Accounts Statistics* (various issues), New Delhi

Centre for Monitoring Indian Economy, *Public Finance* (various issues)

Chakravarty, Sukhamoy (1993): '*Selected Economic Writings*', Delhi, Oxford University Press, Oxford New Delhi.

Chand, Ranesh (2000): '*Emerging Trends and Regional Variations in Agricultural Investments and their Implications for Growth and Equity*', National Centre for Agricultural Economics and Policy Research, Policy Paper.11

Chang, Hui-Shung and Zepeda, Lydia (2001): 'Agricultural Productivity for Sustainable Food Security in Asia and the Pacific: The Role of Investment', in Zepeda, Lydia (ed.) '*Agricultural Investment and productivity in Developing Countries*' Economic and Social Development Paper 148, Food and Agricultural Organisation.

Chadha, G K (1998): 'Regional Variation in Agricultural Development from Sixties to Nineties', in Chatterjee, Biswajit and Harendranath Sur (ed.) *'Regional Dimensions of the Indian Economy'*, Allied Publishers Limited, Culcutta.

Committee on World Food Security (1999), '*Investment in Agriculture for Food Security: Situation and Resource Requirements to Reach the World Food Summit Objective*', Food and Agricultural Organisation, Rome, 31 May - 3 June

Dharm Narain (1988): 'Productivity Growth in Indian Agricultural', in by Raj, K N et al (ed.) '*Studies in Indian Agriculture*', Oxford, New Delhi

Dhawan B D and S S Yadav (1997): 'Public Investment in Indian Agriculture: Trends and Determinants', *Economic and Political Weekly*, April-5 pp.710—714

Dhawan, B D (1998), '*Studies in Agricultural Investments and Rural Savings*', Commonwealth Publishers, New Delhi

Engle R.F and C.W.J Granger (1987), 'Cointegration and Error Correction: Representation, Estimation and Testing', *Econometrica*, Vol.55, No.2, 251-276.

Fan, S., P. Hazel and S.K Thorat (2000): 'Impact of Public Expenditure on Poverty in Rural India', *Economic and Political Weekly*, Vol.35, No.40, September 30

Feder, G., Just R.E and Zilberman, D (1985) 'Adoption of Agricultural Innovations in Developing Countries: A Survey', *Economic Development and Cultural Change*, 33: 255-298.

Gandhi, Vasant P (1990), '*Investment Behavior in Developing Countries: The Case of Agriculture in India*', International Food Policy Research Institute Studies, Vol.22, No.1.

Gandhi, Vasant P (1996): 'Investment Behavior in India Agriculture', *Indian Journal of Agricultural Economics*, Vol.51, No.4.

Gujarati, Damodar N (2003): '*Basic Econometrics*', Mc Graw Hill, 4th International edition.

Gulati, Ashok and Seema Bathla (2001): 'Capital Formation in Indian Agriculture: Re-visiting the Debate', *Economic and Political Weekly*, May 19

Gulati, Ashok and Seema Bathla (2002): '*Capital Formation in Indian Agriculture: Trends, Composition and Implications for Growth*', NABARD, Occasional Paper - 24.

Granger, C and Newbold, P (1976), 'R^2 and the Transformation of Regression Variables', *Journal of Econometrics*, Vol. 4.

Harris, Richard (1995): '*Using Cointegration Analysis for Econometric Modelling*', Prentice Hall, London, New York.

Hayami and Ruttan (1971): '*Agricultural Development: An International Perspective*', The Johns Hopkins University Press, Baltimore, MD.

Hayami, Y (1971): '*A century of Agriculture Growth in Japan*', University of Tokyo Press

Joshi, P K and Haque, T (1980): 'An Enquiry into the Long-term Prospects of Balanced Agricultural Growth in India', *Indian Journal of Agricultural Economics*, Vol.35, No.4

Kumar, A Ganesh (1992): 'Falling Agricultural Investment and Its Consequences', *Economic and Political Weekly*, Oct.17 Pp.2307—2312

Koyck, L. M (1954), '*Distributed Lags and Investment Analysis*, North Holland Publishing Company, Amsterdam

Mishra S.N (1996), 'Capital Formation and Accumulation in Indian Agriculture Since Independence', *Indian Journal of Agricultural Economics*, Vol.51, Nos 1&2, Jan-June

Mishra, S.K and Bajpai, A.D.N (1991), 'Economics of Irrigation and Performance of Agriculture in India', New Economic Policy of India.

Mishra, V.N. and B.R. Peter Hazel (1996): 'Price and Non-price Factors in Agricultural Investments (Discussion)', *Economic and Political Weekly*, Vol. 31, October 20.

Mitra, Ashok (1997): 'Public and Private Investments in Agriculture', in Bhupat M. Desai (*ed.*) '*Agricultural Development Paradigm for the Ninth Plan under New Economic Environment*', Oxford and IBH Pub. Co. Pvt. Ltd. New Delhi.

Murgai, R., Ali, M., and Byerlee, D (2001), '*Productivity Growth and Sustainability in Post-Green Revolution Agriculture: The Case of the Indian and Pakistan Punjabs*', The World Bank Research Observer, Vol.16 No. 2 (pp.199-218)

Nelson, (1964) 'Aggregate Production Functions and Medium-Range Growth Projections', *American Economic Review*, 54(5): 575-606

Panigrahi, R (1995): '*Patterns of Agriculture Growth in India: A State-wise Analysis*', (Mphil Thesis, unpublished), Centre for Development Studies, Trivandrum.

Purohit and Reddy (1999), '*Capital Formation in Indian Agriculture: Issues and Concerns*', NABARD, Mumbai, Occassional Paper-8

Rao, Hanumantha C. H (1994), '*Agricultural Growth, Rural Poverty and Environmental Degradation in India*', Oxford University Press, New Delhi

Rath, Nilakanta (1989), 'Agricultural Growth and Investment in India', *Journal of Indian School of Political Economy*, Jan-June. pp. 64-83

Reserve Bank of India *bulletins* (various issues).

Roy, B.C and Pal, Suresh (2002), 'Investment, Agricultural Productivity and Rural Poverty in India: A State-Level Analysis', *Indian Journal of Agricultural Economics*, Vol.57, No.4, Oct-Dec.

Sawant, S. D (1997), 'Performance of Indian Agriculture with Special Reference to Regional Variations', Keynote Paper on 'Regional Variations in Agricultural Performance in the Last Two Decades', *Indian Journal of Agricultural Economics*, Vol. 52, No.3 September.

Sawant, S. D (2001), '*Indian Agriculture: Past Developments and Policies for Future*', A paper presented at National Seminar on '*Reforms, Institutions and Policies: Challenges Confronting the Indian Economy*', Centre for Advanced Study in Economics, Department of Economics, University of Mumbai.

Sawant, S. D and Achthan, C.V (1995): 'Agricultural Growth across Crops and Regions: Emerging Trends and Patterns', *Economic and Political Weekly*, Vol. XXX, No.12.

Sawant, S. D, Daptardar, V and Mhatre, S (2002), 'Capital Formation and Growth in Agriculture: Neglected Aspects and Dimensions', Discussion paper, *Economic and Political Weekly*, March 16.

Schultz, T W (1964), '*Transforming Traditional Agriculture*', New Haven and London, Yale University Press

Sharma, J L (1992): 'Productivity Variation in Indian Agriculture', *Agricultural Situation in India*, Vol.XLVII, No.2

Shetty, S. L (1990), 'Investment in Agriculture: Brief Review of Recent Trends', *Economic and Political Weekly*, Vol. 25, February 17-24.

Sidhu, D S and Sidhu, R. S (1994), '*Agriculture Productivity in Asia: A Comparative Analysis*', Oxford and IBH Publishing Company, Pvt. Ltd, New Delhi.

Singh, Alka (2000), 'Regional Disparities in Growth and Structure of Public Investment in Agricultural Research and Education', *Artha Vijnana*, Vol. XLII, No. 4, December.

Singh I.J, K. N Rai and J.C. Karwarsa (1997), 'Regional variations in Agricultural Performance in India', *Indian Journal of agricultural Economics*, Vol. 52, No.3, July-Sept. pp374-386

Storm, Servaas (1993), '*Macroeconomic Considerations in the Choice of an Agricultural Policy: A Study into Sectoral Independence with Reference to India*', Averbury, Aldershot, England.

Zepeda, Lydia (2001), 'Agricultural Investment, Production Capacity and Productivity', in Zepeda, Lydia (ed.) '*Agricultural Investment and productivity in Developing Countries*' Economic and Social Development Paper 148, Food and Agricultural Organisation.