POLICY PAPER 22

CHANGING PATTERN OF RICE PRODUCTION SYSTEMS AND TECHNOLOGY IN ASSAM

A SPATIO-TEMPORAL ANALYSIS OF PERFORMANCE AND PROSPECTS

B.C. Bhowmick
B.C. Barah
Sushil Pandey
N. Barthakur

राष्ट्रीय कृषि आर्थिकी एवं नीति अनुसंधान केन्द्र
NATIONAL CENTRE FOR AGRICULTURAL ECONOMICS AND POLICY RESEARCH

NCAP has been established by the Indian Council of Agricultural Research (ICAR) with a view to upgrading agricultural economics research through integration of economic input in planning, designing, and evaluation of agricultural research programs and strengthening the competence in agricultural policy analysis within the Council. The Centre is assigned a leadership role in this area not only for various ICAR Institutes but also for the State Agricultural Universities. With a view to making agricultural research a more effective instrument for agricultural and rural change and strengthening the policy making and planning machinery, the Centre undertakes and sponsors research in agricultural economics relating to the problems of regional and national importance.

Changing Pattern of Rice Production Systems and Technology in Assam:

A spatio-temporal analysis of performance and prospects

B.C. Bhowmick

B.C. Barah

Sushil Pandey

N. Barthakur

Policy Paper 22

भाकृअनुप
ICAR

National Centre for Agricultural Economics and Policy Research (NCAP)
Indian Council of Agricultural Research
New Delhi 110 012, India

Policy Paper 22

Changing Pattern of Rice Production Systems and Technology in Assam

A spatio-temporal analysis of performance and prospects

B.C. Bhowmick, B.C. Barah, Sushil Pandey and N. Barthakur

Published by
Dr. Ramesh Chand
Acting Director, NCAP

Printed at
Chandu Press
D-97, Shakarpur
Delhi - 110 092

Contact Address: Dr. B C Barah, Principal Scientist, NCAP, New Delhi 110 0012
Email: bcbarah@yahoo.com

Collaborating Institutes

LEAD CENTRE

National Centre for Agricultural Economics
and Policy Research (NCAP)
(Indian Council of Agricultural Research)
New Delhi 110 012, India

COLLABORATING CENTRES

Assam Agricultural University,
Jorhat, Assam

International Rice Research Institute (IRRI)
Los Banos, Manila, Philippines

CONTENTS

LIST OF TABLES

LIST OF FIGURES

APPENDIX STATISTICAL TABLES

FOREWORD

This policy paper is based on a research study on rice production system in Assam carried out by team of researchers from Assam Agricultural University, Jorhat, National Centre for Agricultural Economics and Policy Research (NCAP), New Delhi, and International Rice Research Institute, Manila, Philippines. The project was implemented from NCAP and coordinated by Dr. B.C. Barah. Dr. Barah has singnificantly contributed to prepare this Policy Paper from the project report. I thank him for this effort. The paper analyses dynamics of rice production system and technology which dominates economy of the state of Assam. The authors have followed the approach of using macro data at state and district level and grassroots data at farm household level. This helped them in explaining changes in rice area, production and productivity and other socio economic variables in terms of the changes and undercurrents seen at the ground level.

Despite its dominance rice cultivation is found to be inadequate to meet various household requirements. This underscores the need for raising productivity and production of rice and also diversification of some area towards high value alternatives. The paper indicates technological, policy and infrastructural interventions for different district and typologies. Agricultural R & D is found to be in a state of neglect in the state. The state is reported to best exemplify the vicious cycle of low productivity leading to low agricultural income which leaves low or no resources for private investments, reinforcing low productivity.

The paper makes general and specific recommendation to raise rice output and to ameliorate economic conditions of farmers, particularly of small and marginal one who forms overwhelming majority of cultivators in the state of Assam. I hope the study would fill the pending gap to understand and address causes for low growth in rice production and farmers' income in Assam. I appreciate the efforts put up by Dr. B.C. Bhowmick, Dr. B.C.Barah, Dr. Sushil Pandey and Dr. Nilotpal Barthakur to prepare this paper.

July, 2005

Ramesh Chand
Acting Director

ACKNOWLEDGMENTS

This paper on changing pattern of rice production systems in Assam is a part of larger project on socio economic study of rice production of eastern India, which benefited from the advice of a peer group comprising of researchers from ICAR institutes and state agricultural universities (SAU) in the eastern India, experts from the International Rice Research Institute, Manila, policy makers and representatives of the state government. Authors are grateful to them for insightful suggestions.

At the time of project formulation, several discussions on technology-related issues were also held with the rice breeders, policy economists and other biological scientists in SAUs and ICAR institutions as well as the International Rice Research Institute. During the operation of the project, an elaborate farm survey was conducted involving 150 farming households in two selected districts of Assam. Authors wish to record gratitude and appreciation to each and every one who participated in the discussions.

The National Agricultural Technology Project (ICAR) critically examined the proposal and funded the project generously. But for the constant interest and encouragement of the members of the Scientific Advisory Panel headed by Dr. J.S. Kanwar, Scientist Emeritus, ICRISAT, the implementation of the project would not have been possible. We are grateful to Dr. Kanwar and all the members of SAP (RFS) including Prof. Ratan Lal, Iowa State University, USA, Dr. N.G.P. Rao, former Chairman ASRB (ICAR), Dr. Dayanatha Jha, National Professor ICAR and former Director of NCAP, Dr. I.C. Mahapatra, former Vice Chancellor of the Orissa University of Agriculture and Technology and Dr. S. Bislaiah, Chairman Peer Review Committee and former Vice Chancellor of the University of Agricultural Sciences, Bangalore for their support. We express sincere acknowledgement to the International Rice Research Institute (IRRI), Manila, who also provided generous funding support for a part of the project.

During various stages of the project, the research team has been benefited tremendously from the advice and suggestions from a number of policy experts and researchers. Authors are particularly thankful to Dr. C.H.H. Rao whose expert advice and suggestions enriched our understanding of the problems and perspectives of the eastern India. We are also thankful to Drs. V.S. Vyas, C. Ramaswamy, S.S. Acharya, Mahabub Hossain, T.M. Thagyarajan, Norman Uphoff, P.C. Deka, A.K. Pathak, Dinesh Marothia, and S.L. Mehta. The team is grateful to Dr. Mruthyunjaya, former Director, National Centre for Agricultural Economics and Policy Research (NCAP), New Delhi, Dr. R.K. Singh, IRRI, Delhi and Dr. B.N. Singh, former Director of CRRI, Cuttack for their encouragement and advisory role, almost on a continuous basis during the project period. We are particularly thankful to Dr. A.K. Neog, a senior member of the Indian Economic Service, who took keen interest in the study and offered a number of valuable suggestions besides pointing out the omissions and commissions in the paper. Authors thank Dr. Ramesh Chand, Principal Scientist and Acting Director and Dr. P S Birthal, National Fellow, NCAP for various discussions, suggestions and analytical help for improving the paper. The findings were presented and discussed in a national symposium sponsored jointly by the National Centre for Agricultural Economics and Policy Research, New Delhi, IRRI, Manila, Philippines and the Indian Society of Agricultural Economics. We are gratreful to Dr. Mangala Rai, Director General, ICAR, Dr. Ronald Cantrell, former Director General, IRRI, Manila, Prof. A Vaidynathan, Emeritus Professor, MIDS, Chennai, Professor E A Siddiq, former National Professor, ICAR and other luminaries for their valuable comments at the symposium. We are highly grateful to the paper reviewers for their insightful comments and suggestions on the paper.

The views expressed in the paper do not pertain to that of the organizations. The usual disclaimers apply.

Finally, we are thankful to the ICAR and the IRRI, Manila for the funding support

Research Team

EXTENDED SUMMARY

(1) Assam, the gateway of the North East India, is one of the backward states in the country. Despite, relatively lower growth rate of the 26 million population, the poverty has been a severe problem in Assam. The economy of Assam was primarily a rural-based where more than 87% of the population lives in the rural areas. The small and marginal farmers accounting nearly 70% of the total cultivators, dominated the agricultural sector. But this small farmer-oriented agriculture is stuck with low productivity and stunted growth. Agriculture contributed about 40% to the state GDP, grew at the rate of 1.82% during the period of 1990-99. Among the agricultural crops, rice occupied a major position accounting nearly 67% of gross cropped area and 91% of net cropped area. Rice has been the major staple food in the state, which was grown almost entirely on rainfed condition. The availability of irrigation was less than 10% of the total cropped areas. Another critical characteristic of the rainfed rice in Assam was the fluctuating but decelerating growth rate. Traditionally, a variety of crops were grown in the upland areas, though their share used to be negligible. More importantly, rice has been an important source of household income. But, rice has been susceptible to the risk of floods, particularly the winter rice. Historically, agricultural scenario in the state has been highly disappointing till the early 1980s. But, later the growth pattern improved and variability has also declined. Therefore, in spite of the dismal performance, some positive changes occurred in the agricultural economy. Such a discernible change in the traditional rice production system has broken the stagnation in agricultural production, which has been most desirable in a chronic food-deficit state like Assam. These changes however, occurred in isolated manner, which lack uniformity. The inter-regional and inter-temporal variation in agricultural performances has been matter of concern.

(2) The main goals of the study have been to identify the factors affecting the technological change in the production system and the role of rice

in Assam. Some policy interventions for improvement in agricultural practices to stabilize rice productivity, household income and improve the rural livelihood were also suggested. The analysis of time series of disaggregate district level data captured the changes in rice production systems and identified the factors affecting adoption of production enhancing technology and productivity of rice. An in-depth farm-level primary village survey has been conducted in two districts representing two distinctly contrasting ecosystems, viz. Nagaon district (a flood-prone district in the Central Brahmaputra Valley Zone) and Golaghat, a flood-free district of Upper Brahmaputra Valley Zone. A sample of 150 farmers was selected from the 24 villages, which represented marginal, small, medium and large farmers. Winter *Sali* paddy (*kharif:* June-October) was the major crop covering two-thirds of total rice area, followed by autumn *ahu* paddy (*pre-kharif: February-June*) with 25% area and the summer (*rabi: November-May*) *Boro* paddy covered 6% of total rice area. The survey captured the seasonal differences in rice culture as it was conducted in all the three seasons. Winter paddy was grown to both medium land and lowland, which was the largest areas, autumn paddy to medium land and summer paddy was grown in typical Boro paddy areas having assured irrigation.

(3) Agriculture in Assam has been dominated by rainfed production system, which covered 79% of total cropped areas. The rainfed areas were further classified into upland and shallow land, which occupied 60% of total rice area, deep water 14% and areas with intermittent water (30-100 cm) was 26%. Rice in Assam has a dubious distinction, having grown to diverse land types in three seasons in a year. This diversity of production ecosystems made the understanding of rice production system more complex.

(4) Among the changes in the agriculture economy in Assam, the change in seasonal allocation of area under different rice culture has been noticeable. The rice culture and its internal dynamics have been peculiar aspects of agriculture in the state. At the aggregate state level, the share of area under the main winter rice (*Sali*) was 72% in 1970s, which decreased to 67% in 1990s, although at district level, the picture has been more sharpened. In four out of ten districts, the

share of area of winter rice increased marginally during the past three decades, but the rest of the districts experienced deceleration in area, which varied from 3% in Kamrup to 16% in Nagaon. Among the different rice cultures, the change in summer rice was more dramatic, prominently in the flood-prone districts. The decrease in area share of winter rice, due to regular floods in these districts, has been compensated by substantial increase in area under summer rice. In particular, summer rice area in the perennial flood-prone district of Nagaon jumped from 5% in 1970s to the highest of 29% of total rice area in the 1990s, the corresponding percentage were 2% to 16% in Kamrup and in Goalpara from 3% to 19% and in Lakhimpur the same were from less than 1% to 13%. Such a changing pattern in area allocation has been an important signal to the agricultural R&D system for developing need-based alternative options as flood proofing mechanism.

(5) The picture of decadal growth of area, production and yield has been vibrant. It depicted that on the overall, growth of area under winter rice decelerated fast and in many instances even showed negative growth, while, the production growth has been positive all through. The yield growth however, continued to be sluggish. At the district level, the yield growth also turned negative in some cases. In contrast, the summer rice showed a phenomenal changing pattern of decadal growth. As a result there was an overall upsurge in growth rate of summer rice area, especially in the 1980s and the 1990s. It has grown at the rate of nearly 10% per annum and the yield at more than 3%. In few districts, the growth rate exceeded 4% too. A remarkable recovery of the performance of rice during past couple of years appeared to be a silver line in the dark cloud of agricultural economy. The question therefore has been that could summer rice be the main driver of future growth in rice economy in the state? Or was there unequal emphasis on R&D on summer rice rather than the more important winter rice?

(6) The analysis showed that introduction of the promising *Boro* rice cultivation has contributed towards increase in the overall rice yield. With adequate crop management care, the farmers achieved yield of *Boro* rice at least double the winter yield. Rapid increase in adoption

of summer rice has resulted in higher yield relative to winter and autumn rice. The highest average yield of more than 4 ton/ha (TE 1999-01) was achieved in Nagaon, which was at least 1.27 ton higher than the yield of winter rice and over 2.30 ton higher than the autumn rice yield. A similar pattern was observed in other districts (viz, Kamrup, Goalpara and Lakhimpur) also. This signified that the Boro rice was an appropriate alternative to the risky winter rice in these districts, which helped escaping the severity of the flood havoc. This success has been made possible due to some policy support in recent years, which accelerated the adoption of *Boro* rice in the flood-prone areas.

(7) As this new rice type has been input intensive, the sustainability of its productivity hinged on appropriate policy interventions and assured support infrastructure. Sustainable productivity of *Boro* rice is the path-way to overcome the scourge of food deficiency in the state. It is to be noted here that the productivity of rice increased, even with less than 10% of irrigated area. This indicated that irrigation development would further enhance the productivity.

(8) The winter rice, however, enjoyed some direct benefits of the past research and other indirect spillover effects. Despite low irrigation, past agricultural R&D helped in increase in adoption of modern varieties. It is another that many of the varieties developed for irrigated ecology also spread into the rainfed areas. The popular modern varieties at the farmers' fields were *Ranjit, Mahsuri, Bahadur, Pankaj* and improved *Manohar Sali,* although their adoption required to be accelerated evenly across the districts for greater impact. Interestingly, traditional varieties have also performed better in the survey areas under improved management practices. The traditional varieties (TVs) have high adaptation capability and several built-in biological properties such as tolerance to biotic and abiotic stresses, sturdy stem, consumer preference, etc. Apart from these desirable merits, TVs had been the first choice of the small and marginal farmers, due to their low inputs requirement. Despite some yield advantage, higher cost of production of MVs often outweighed the gain in net return over the TVs. Therefore, farmers followed a strategy of mixing both modern varieties and traditional varieties depending

on production conditions. This synergy between modern and traditional varieties at farmers' fields, contributed significantly to the household food security. The pertinent questions, thus arose (i) Whether the existing modern varieties of rice were targeted for the diverse ecosystems, (ii) Did the policy interventions on agricultural Research and Development system adequately address the issues of demand-driven technology and agro ecological specificity in the region?

(9) The relationship between fertilizer, albeit very low level, and rice yield was found positive. In order to strengthen this relationship, improvement in irrigation facility along with fertilizer network has been necessary requirements, which is likely to accelerate the rate of adoption of modern inputs and thereby increase productivity. The use of tractors and other technologies were also rare.

(10) The differences in the socio-economic factors, support infrastructure and technological changes and their effects were examined. It has been observed that, apart from the inter-district differences in socio-economic factors (including literacy and farm labour use), the biophysical factors influenced the adoption of modern varieties significantly. Among them, the land types (as classified on the basis of soil hydrology and soil quality) and access to irrigation were the most important decision variables. This finding has direct R&D implications in agriculture.

(11) Due to its pivotal role in the farming system, rice has been important not only because it provided food but also helped reducing the household income inequality. The estimated marginal effects, derived from decomposition of gini inequality, showed that the farm income (particularly rice income), rather than salary income, **reduced income inequality** to the extent of 10 to 13%. That is, the household income inequality could be substantially higher in the absence of rice income. Therefore it has been imperative that more of high yielding modern varieties and cost-effective rice technology accompanied by the guaranteed access to market information would have greater impact on household income. The market imperfections including the output prices, often realized below the minimum support price at the farm level was considered severe constraint to agricultural production system in the study areas.

(12) The income decomposition procedure further showed that despite income equalizer role, the agriculture in general and rice in particular had not **contributed adequately to household income,** to improve the household livelihood. Hence, along with rice, the improvement of the existing crop diversification has been felt essential.

(13) The **management of vast fallow areas in *rabi* season** has been a major policy challenge in Assam. Because, over 80% of cultivable areas as fallow in rabi season, adversely affected the cropping intensity and deteriorated rural livelihood. Fallowing of vast cropped areas during the rabi season is a common practice in Assam. This practice of keeping cropped areas idle in most period of the year, also affected resource use efficiency in agriculture and thereby the land productivity. In this context, a carefully designed intervention is needed for the management of the large-scale fallowing of productive cropped land and enhanced the cropping intensity. The issues of reforms on land system, marketing of agricultural produce, resource conservation, ground water utilization, promotion of agro-processing and post harvest care, storage, credit supply, flood risk, remunerative pricing policy and agricultural diversification were also important. With the rich human capital and abundant natural resources, appropriate infrastructure support and policy interventions on technology development could help tapping the agricultural potential further. Therefore, it necessitated the proper identification of the constraints and careful prioritization strategies for accelerated balanced growth.

(14) The analysis has brought out that **a group of four out of ten districts** (Kamrup, Goalpara, Darrang and Lakhimpur), were classified as a developmental-lagged group. The agriculture performance during the past three to four decades, has been consistently low productivity of rice in these districts, hence the group deserved developmental priority urgently. Incidentally, these districts occupied a very high proportion of total cropped area (56%) in the state but contributed only 47% of rice production. The poor infrastructure facility was responsible for the poor performance. It has been observed that the overall infrastructure development (as measured by the index of infrastructure development indicator) in these districts was the poorest as compared

to other districts. It implied that the inter-district disparity in infrastructure facility directly affected productivity.

(15) The predominantly **small farmer-oriented monocrop farming practice** in Assam required to be supported by enhanced public investment to ensure the availability of basic infrastructure, health care and education. Evidences generated in the study showed that such a huge investment on the infrastructure development could hardly come from the private sources. It is largely because, a meager per capita income of the majority of the farmers, as little as Rs.15 per day (about Rs.5200 per annum), not to speak of **generating investible surplus in the hands of farmers**, even the minimum basic requirements could rarely be met. Accumulated evidences further indicated that consistent under-investment in agriculture resulted in the farm sector with a state of severe infirmity. Under the circumstance, the rural areas also required more opportunities in non-farm, off-farm activities, services and other means of employment generation to supplement total household income. Otherwise, the economic forces would further compel the small and marginalized farmers to abandon farming and migrate to urban areas.

(16) Production infrastructure and support services explained the **yield gap** at the farmers' fields. Lack of support services (irrigation, fertilizer supply and market etc.) has restricted the adoption of yield enhancing modern varieties (say *Boro* rice varieties). The study showed that the rice yield could be increased under the existing technology by providing improved crop management care.

(17) The most worrying aspect is that the winter rice, which though occupied the major share of area, but its **performance has been staggering year after year**. The growth rates of production during the 1990s, was less than 1% in almost all the districts and that of area was even negative. A pertinent question thus aroused that, could *Boro* paddy with less than 10% of the area share, promising though, increase the total rice production? Another relevant question has been that why was the existing technology and R&D innovation on winter rice failed to translate into growth opportunity?

(18) To ensure sustainability of rice production system, a discernible breakthrough in the productivity of winter rice is most essential. It

would require a radical change in rice research and development paradigm targeting eco-regional specific issues and *inter-alia*, addressing the problems of biotic and abiotic constraints. The policy innovation must be accompanied by renewed emphasis and effective public investment on socio-economic infrastructures (road, transport, marketing, storage, post harvesting technology and management, remunerative pricing policy and product quality improvement). The persistently **meager investment on agricultural research and development (R&D) system** affected the agricultural production system adversely in the state. Over the years, the public investment on agricultural R&D has become ineffective and the system of monitoring, mid term evaluation and correction almost non-existent. The worst has been the steadily declining rate of investment on agricultural research and extension. Therefore, this declining trend in public investment has to be reversed emphasizing on issue-based re-casting of the existing R&D system, to meet the requirements of demand-driven technology.

(19) Lack of **quality seed** has been a major hindrance to adoption of modern varieties of rice. The long and time-consuming process of supply of seed has been the retrograde factor, which discouraged farmers to adopt modern varieties. The seed replacement rate in the study area has been as low as 5 to 10% only. But, the farmers expressed willingness to adopt newer varieties and other improved practices, if the constraints are addressed properly.

(20) The analysis also showed that if assured access to information on modern variety, crop management practices are guaranteed and problem of weather and other sources of agricultural risk addressed, then the performance of the existing system could be improved adequately. **Access to information** has been crucial for rice production. Unfortunately, the farmers derived required information on newer methods and innovative agricultural practices from own experiences, relatives and neighbours. The availability of institutional sources has been negligible. A strategy for strengthening the role of these agencies is necessary for greater impact of technology adoption at farmers' fields. This would enhance the reaching out to the targeted beneficiaries more effectively.

(21) While the importance of rice research could hardly be overemphasized, there has been urgent need to look at **the rice plus** policy as alternative source of household income security. Based on the calculations of profitability and income share, **rice-only system** has been found inadequate to meet the household needs, yet the cultivation of rice could hardly neglected. Rice has been important for household food security, but livelihood security of farming households required proper utilization of the vast fallow land and unexploited resources such as ground water. Seasonal unemployment has been a tricky matter in the planning for rural development in the state. Renewed interventions are required to strengthen and promote more realistic diversified systems like rice (winter/*Boro*)-livestock-fishery-horticulture system for enhancing income. Such initiatives could potentially solve the perennial problem of *rabi* fallow and of cropping intensity. The instances of increasing adoption of modern technology as a softer instrument, as against the most critical and risk-minimization option such as *Boro* paddy in the flood-prone areas, required more closer policy attention. Actually, the lesson derived from rapid adoption of *Boro* rice in the neighboring West Bengal and Bangladesh, could be useful for Assam too, which has already set a transition path from winter rice to summer rice. To emulate such a process on a wider scale in Assam, the State requires to build a strong foundation ensuring an un-interrupted availability of supporting infrastructure through the enhanced public investment.

INTRODUCTION

Agricultural Economy of Assam: A Profile

Assam, situated in the eastern part of the country, is the gateway of the North Eastern India. The state is surrounded by the hill states of Arunachal Pradesh and Sikkim in the north, Nagaland and Manipur in east and Mizoram and Meghayalay in the south, which are popularly known as “seven sisters”. Assam occupies a strategically important position. Its economy is termed as “corridor economy”, as the state is connected to the rest of the country by a small strip of land in its western border (Bardoloi, G., et al, 1986). The total population of Assam was 26 million in 2001, which was 2.6% of All-India population and occupied the 13^{th} rank in the country. As against the exponential growth rate of 1.93% in the country, the population of the state grew at the rate of 1.73% during the period of 1991-2001. The literacy rate increased to 64% in 2001 from 54% in 1991. Nearly 87% of the population of the state lives in rural areas.

The economy of the state is primarily a rural-based where more than 87% of the population dependent on agriculture. Although agriculture is the backbone of the economy of Assam, but the production system is yet to be developed fully, which has been predominantly a rainfed system. Nearly 80% of total cropped area was rainfed signifying that dependency of agriculture on vagaries of nature and vulnerability to risk (Goswami, P.C., 1989). The average annual rainfall in the state was 2300 mm, of which nearly 60 to 70% received within a span of 3 to 4 months (May to August). The state is endowed with abundant water resource, which is also to be developed properly (Baishya, P. D., et al. 1997).

The inter-regional and inter-temporal variation in agricultural performances has been matter of concern in Assam. However, the state has undergone some structural changes in the agricultural sector during the past couple of years (Barah, B.C., et al., 2000). The transition from low and stagnating productivity to acceleration is a fascinating development. Rice occupied a vital position in the agricultural economy of the state. Of the total foodgrain production of 3.89 million tons in 2002-2003, rice contributed nearly 96% at 3.74 million tons (Economic Survey of Assam 2005). But, the productivity of this important crop has been stagnant and growth sluggish. However, the productivity of rice improved considerably in the recent years due to the some innovative production practices. The introduction of summer (*boro*) rice has contributed tremendously in this regard. This changed scenario has improved food production and elevated the state from a chronic food-deficit to a surplus status in rice production. An objective assessment is required to understand the nature and significance of the changes and their impact on the livelihood of the common people in the rural areas.

The main objectives of the study were

- To characterize rice production systems in Assam
- To suggest strategies for future rice technologies and policies those are likely to be appropriate to production systems undergoing different patterns of changes.
- To suggest policy intervention options for improving food security of rice farmers and household income.

Changing pattern of rice production, productivity and the growth rates were analyzed and the impact of change on socioeconomic status has been examined. The study identified the determinants of the sluggish rice economy and gained more insight into rural economy of the state.

Chapter - 2

METHODOLOGY

The change in agricultural production system has been captured in the analysis of time series data pertaining to past three decades. Data on area, production and productivity of various crops, fertilizer usage, irrigation and other related variables were collected at the disaggregate district level for the period 1971–2001. Since a number of newer districts were created in the past decade, for the sake of data consistency, the newer ones have been aggregated as par the erstwhile districts[1] . The time series data was supplemented by an in-depth farm-level primary village survey, conducted during the *kharif* and *rabi* seasons in 1999-2000 and 2000-2001. Two representative districts were selected purposively for in-depth investigation. The selected districts represented two distinct ecological situations, viz., Nagaon district of Central Brahmaputra Valley Zone, which was a flood-prone district and Golaghat of Upper Brahmaputra Valley Zone; a flood free district. Both the districts also had high concentration of rainfed rice areas. The selected districts thus, depicted a comparative picture of two important agro-ecological situations viz “flood-prone” and “flood-free”. Two administrative blocks were selected from each of the districts. These blocks were selected in such a way that they together cover more than 25% of the total rainfed rice area in the district. A total of 150 farmers from 24 villages (14 from Nagaon and 10 from Golaghat) were selected by using stratified random sampling procedure. A structured questionnaire was designed to elicit in-depth information on the farming households. The survey recorded detailed information at plot and parcel level.

The plots or parcels, often termed synonymous, are the tiny pieces of non-contiguous scattered land belonging to a household. The subdivision of the landholdings into tinier plots is of special significance in production management particularly for the resource poor and lesser well-to-do farmers. The detailed plot information was useful as the location and

---

[4] Assam had ten districts originally; some of the districts are segregated to form newer districts, carved out of the original districts. Currently there are 23 districts in Assam.

other biophysical characteristic of the scattered plots influence the farmer's preference and adoption of crops and varieties within the socio-economic milieu they live in.

The analysis of the rice production system was carried out at three levels:

(i) The state level analysis (macro analysis) provided broader pattern of change perspectives.

(ii) The district and zonal analysis (meso analysis) characterized the production systems and classified the districts into improved and lagged districts for future policy perspectives.

(iii) The farm and plot/parcel level analysis (micro analysis) characterized the on-farm production conditions and provided more analytical rigor to the cause and effect relationships.

Chapter - 3

SOCIO ECONOMIC DYNAMICS OF RICE PRODUCTION SYSTEM

3.1: Macro-Economic Indicators (State Level Analysis)

Over the years, there has been tremendous inter-sectoral shift in the economy of the state. This has resulted in more fluctuating shares of various components of State Domestic Product (SDP). The share of the primary sector declined during the period 1980 to 1996 by 11%, while those of secondary and tertiary sector have gained by 9% and 12% respectively (Planning Commission 2002)[1] . The overall annual compound growth rate of netSDP during the period worked out to 3.54% at constant price (base=1980-81). But, despite favourable growth rate of population, the per capita income of the state continues to lag behind the national average, which has been a matter of concern. The worrying feature is that the growth rate of per capita gross state domestic product in Assam has declined to 1.0%, pushing it to the position of one of the lowest performing states in the country.

Table 1: Growth of Agricultural GDP and rural population in Assam (in percent)

Period	Rural Population	Ag_GDP	Per Capita AgGDP
1980-89	1.98	2.31	0.33
1990-99	1.94	1.82	-0.12
1980-99	2.03	2.28	0.25

The decadal growth of agricultural GDP has been not smooth either. The growth of agricultural gross domestic product declined from 2.31% in the 1980s to 1.82% in the 1990s, though the long term growth rate has been 2.28% during 1980-99 (Table 1). The growth of the per capita AgGDP has not only been consistently low but more worrying phenomenon is that it has dipped to negative rate in the 1990-99.

[5] Planning Commission, 2002, An approach paper on Xth Five Year Plan, New Delhi

3.1.1: Vulnerability to Flood Risk

Due to high intensity-rainfall, the incidence of floods has been atypical in Assam, making the state highly vulnerable to risk and uncertainty. Between 1957 and 1996, floods affected an average of 200 thousand hectares of the cropped area annually. It rose to as high as 1100 thousand hectares, which is nearly 40% of the total cropped area (the latest such severest flood occurred year in 2004). Such a high-intensity flood has destroyed the economy severely. The multiple waves of flood during the monsoon caused extensive damage to crops, lives, other properties and infrastructure, disrupt economic activities and the worst being the permanent loss of cropped areas due to heavy siltation. Nearly 73% of the total flood-prone area falls in the chronically flood-prone category. The zonal distribution of flood-prone areas showed that the highest share of flood-prone area of 39% lies in North Bank Plain Zone, followed by 32% in Lower Brahmaputra Valley Zone and 17% in Upper Brahmaputra Valley Zone.

3.1.2: Agro-Ecological Zones in Assam

Assam has been divided into six distinct agro-ecological zones, viz. Upper Brahmaputra Valley Zone (UBVZ), Lower Brahmaputra Valley Zone (LBVZ), North Bank Plains Zone (NBPZ), Central Brahmaputra Valley Zone (CBVZ), Barak Valley Zone (BVZ) and Hill zone (Fig 1).

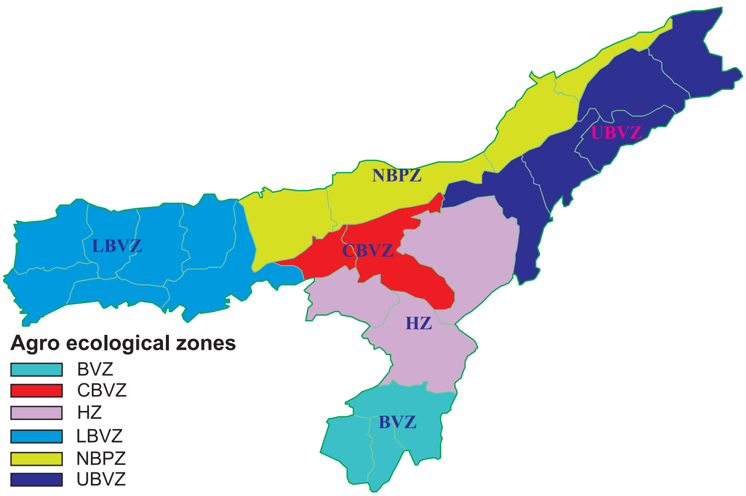


Fig. 1 Agro ecological zones in Assam

The CBVZ is densely populated with 302 persons per sq. km. and the Hill zone is thinly populated with only 37 persons per sq. km (Table 2). The agro-ecological zones are highly diverse and hence the pattern of adaptation of crop production system differs across the zones.

The soil quality also varied significantly, which has been the mix of ulfisol, entisol, alluvial soil and new alluvial soil. Highly diverse topographical situations within zones demand wide ranging technological options and thus called for appropriate policy interventions. Rice dominated the agriculture in all the zones, covering more than two thirds of total rice planted area.

The Lower Brahmaputra Valley Zone has been the largest zone, which occupied 35% of total rice area in the state, with seasonal share of winter rice at 50%, autumn rice at 30% and summer rice at 45%. The lower Brahmaputra Valley Zone together with the north bank plains zone occupied more than 58% of total rice area. Like area, the share of production has also been the highest in the LBVZ at 28% of total production. But, comparatively, the UBVZ has been more productive zone as it contributed about 22% of total rice production in the state with 18% area.

Table 2: Zone-wise distribution of districts and share of rice area and production

Zone	District (original)	Soil type	Rainfall (mm)	Area share (%)	Production (%)	Rice Area (%)	Population Density
Lower Brahmaputra valley	Goalpara, Utlisol	Kamrup	1778-2347	35	28	77	225
Central Brahmaputra valley	Nagaon	Entisol	2000	13	15	62	302
Upper Brahmaputra valley	Sibsagar, Dibrugarh	Alluvial	2650	18	22	67	241
North bank plains	Darrang, Lakhimpur	New Alluvial	1700	20	18	67	388
Barak valley	Cachar	Alluvial	2000	9	11	93	245
Hill zone	N C Hills, Karbi Anglong	Hill soil	2000	5	6	70	37

Among the remaining zones, the central Brahmaputra valley occupied 13% of the total area and 9% in Barak valley. The smallest zone is the hill zone with 5% area and 6% production. The average rainfall pattern is also highly variable ranging from 1700 mm in the LBVZ to the highest rainfall of 2650 mm in the Central Brahmaputra Valley Zone.

3.1.3: Agriculture at a Glance

The economy of Assam has been predominantly an agricultural-based. Agriculture contributed about 47% to the state GDP in 1970-71 and only 40% in 1997-98 at current price. The agricultural GDP of the state grew at the rate of 1.82% during the period of 1990-99. But the poverty has been a severe problem in the state, which has been more acute in the rural areas (nearly 40% in 2000). The proportion of people living below poverty line (BPL) has been at least 10 percentage points higher than that of the All-India. That is, while the All-India poverty level was 26.1% in 2000, it was 36.1% in Assam. Two out of five people in rural areas were under the poverty line (Assam Human Development Report 2003).

Agriculture in Assam has been basically cereal-based, where around 80% of total area was devoted to foodgrain production. Rice was the major food crop and a staple food to the entire population of Assam. But, the small and marginal farmers accounting nearly 70% of the total cultivators, dominated the agricultural sector. This small farmer-oriented agriculture has been characterized by low productivity and stunted growth. Among the agricultural crops, rice occupied a major position accounting nearly 67% of gross cropped area and 91% of the net cropped area. Rice was grown almost entirely in rainfed condition in Assam. Traditionally, a variety of crops have been grown in the upland areas, though their share has been negligible. As a result, rice contributed significantly to food production in the state. But, production of rice has been highly risky as the main winter rice is affected by risk of floods during the growing period.

Historically, the performance of agriculture in Assam has been highly disappointing till the early 1980s. But, later the production growth improved and variability has also declined (Pandey, S., 2000). It has been observed that in spite of the dismal performance, the recent years experienced some positive changes. Such a discernible change in the traditional rice production system seemed to have broken the stagnation in agricultural production. This has been most desirable in a chronic food deficient state like Assam, which however, occurred in isolated manner, and thus lacked uniformity. The vulnerability to natural disaster also made agriculture more riskier, which endangered household income security.

Rice was not only the major crop, but also has a dubious distinction of being a three-season crop. That is, rice was grown in winter, summer and autumn season. But despite the predominance and prominence of rice, the agricultural productivity remained much below the national level.

3.1.4: Rice Ecosystem in Assam: Land type

Before getting into in-depth analysis of rice economy, it is essential to understand the production systems confronting the farmers. Rice was mainly grown in rainfed ecosystems. The percentage of irrigated area was 22% of total cropped areas, of which wet season irrigation was 17% and in dry season 5% (Table A1). The remaining bulk of rice area was rainfed (about 79% of total rice area). Of the total rainfed area of 1.96 million ha, the combined share of upland and shallow land (which is defined as medium land) was 60%, lowland (having intermittent water) was 26% and 14% of area was under deepwater. It was this diversity of production system, which made the rice economy in Assam more complex and challenging.

3.1.5: Cropping Pattern

Agriculture in Assam was primarily a cereal-based system, where rice accounted for a lion's share. During past three decades, the share of total cereal remained unchanged at around 80% of the grossed cropped area, while the share of rice was constant at 77% (Table A3). The allocation of area under different crops witnessed dynamism in the recent years. The normal *ahu* paddy was substituted to an extent by early *ahu*, summer rice and jute. The area under jute expanded, especially in Kamrup, Goalpara and Nagaon districts. Among other cereals, wheat and maize was gaining some popularity among the farmers in Assam. Oilseed was next to rice in area coverage, and then the fibres and pulses. Pulses, oilseeds and jute jointly accounted for 16% of area coverage. Over the years, the share of oilseeds improved marginally at the cost of pulses and fibre crops. Among the other crops sugarcane, potato, linseed sesamum, tumeric and banana etc were also grown.

3.1.6: Importance of Rice in Assam

Rice was the principal crop of Assam, which occupied more than three-fourths of the gross cropped area. The area under rice was hovering around 2.5 million hectare with an average productivity of 2.03 ton/ha[1] . Being the main item of food basket, the rice was of crucial importance to the agricultural economy. But its production has been subjected to multiple risks. Low and uncertain yield, slow technical change and negligible support infrastructure including surface irrigation facility, hampered the growth of rice production system. Low input use also affected production. The use of chemical fertilizer was lower than the national average.

3.1.7: Rice Culture

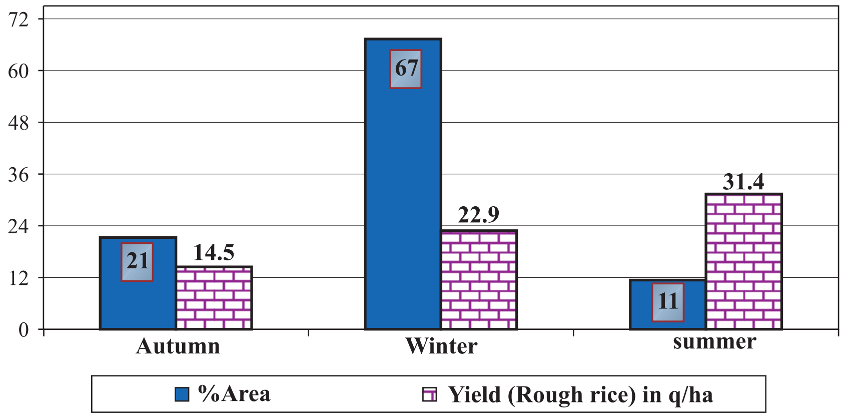
Rice in Assam was unique as it has been grown in all the three seasons in a year viz, kharif (winter or sali), *rabi* (summer or *Boro*) and pre-kharif or autumn (Ahu). Of these rice cultures, winter rice is grown during the period of June to October. Early *Ahu* (autumn rice) is grown during February to June and *Boro* rice (summer rice) during November and May. Autumn rice was grown as normal *ahu* crop under rainfed condition and the same as early *ahu* under irrigated condition.

Area Allocation: On the overall, the share of winter rice was 67% of total rice area, 22% for autumn and 11% for summer rice during triennium 1998-2000.

As more irrigation facility made available, the early *ahu* expanded in the districts of Cachar, Nagaon, Dibrugarh, Kamrup and Goalpara. Medium land and lowlands were suitable to *ahu* and *sali* rice. While *Boro* rice was grown in rainfed low-land as 'typical' *Boro*, which utilized the residual

[1] All production and yield data for rice are in terms of rough rice, not milled rice.

Fig 2: Share of rice area by culture and yield (Triennium 1998-2000)

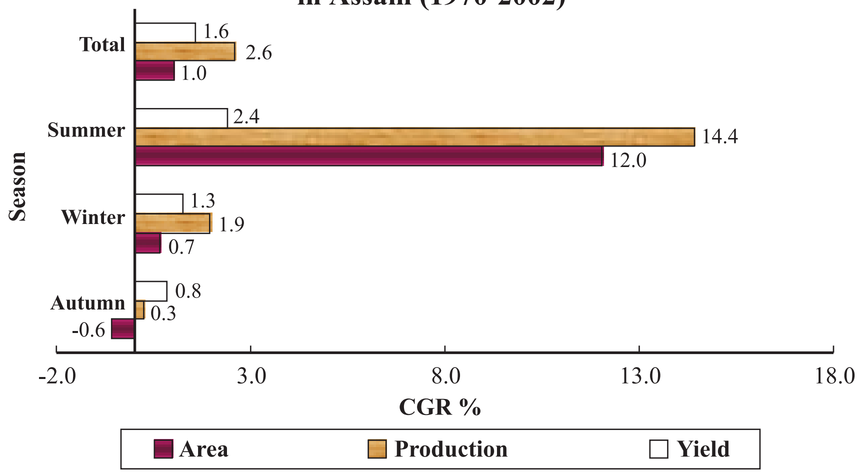


soil moisture. The main *Boro* rice grown under irrigated conditions was known as the irrigated *Boro*. While the 'typical' *Boro* was limited to some pockets, the area under irrigated *Boro* has been increasing gradually since 1980. Among the intra seasonal rice culture, the *Boro* rice emerged as the fastest growing alternative. The yield of summer rice was generally the highest followed by winter and then the autumn. Under this changing scenario, it was necessary to characterize various production conditions and to identify the factors affecting the production system.

Rice Yield: Average rice yield was around 1.65 ton/ha of rough rice till the 1980s, which increased to 2.38 ton/ha in the 1999-2001. Over the past two decades, overall rice yield increased by 30 kg/ha per year, winter rice by 25 kg/ha and summer rice increased by 59 kg/ha per year. This increase in yield was primarily due to 19 points increase in area under modern variety during the period. Rice yield thus found positively associated with the adoption of modern technology. However, the adoption needs to be further accelerated. It became essential because at the current rate of increase in area under HYV, the state would take at least two decades to achieve complete adoption level.

Emergence of *Boro* Rice: While both area and production of winter rice and autumn rice were stagnating, the summer rice showed the prospect for rapid growth. From barely 36 thousand ha under summer *boro* rice in the early 1970s, it expanded to as high as 293 thousand ha in 1998-2000. The rate of increase accelerated more rapidly after the 1980s. At the aggregate level, the summer rice area increased from 2% to 13% during the past 20 years. The area expansion when juxtaposed by productivity increase, enhanced the importance of *Boro* rice in rice economy in Assam. Comparing the winter and autumn rice, yield of summer rice of 3.14 ton/ha was at least a ton of additional rice/ha during the triennium 1998 2000. Higher yield of summer rice may have contributed to the growth of total rice production in the state. Not only the productivity level, but also its growth rate of summer rice was higher. The highest growth rate of summer rice yield was recorded at 3.50% during the period of 1980-90, as compared to that of total rice yield at 1.56% annually. The growth rate for summer rice area was exceptionally high at 9.88% and that of production was also impressive at 12.63% (Table A4). The growth of productivity has been even more sharper at the district level particularly in the flood-prone districts, which grew at the annual rate as high as 6% in Lakhimpur and 5.4% in Nagaon. Such a high growth was attributed to the implementation of suitable irrigation policy during recent years, which facilitated adoption of modern variety for summer rice. This growth performance, if sustained, likely to improve the rice economy of the state. More importantly, summer rice was also relatively less riskier option as it was gown in flood free season.

Fig 3: Relative growth pattern of various rice culture in Assam (1970-2002)



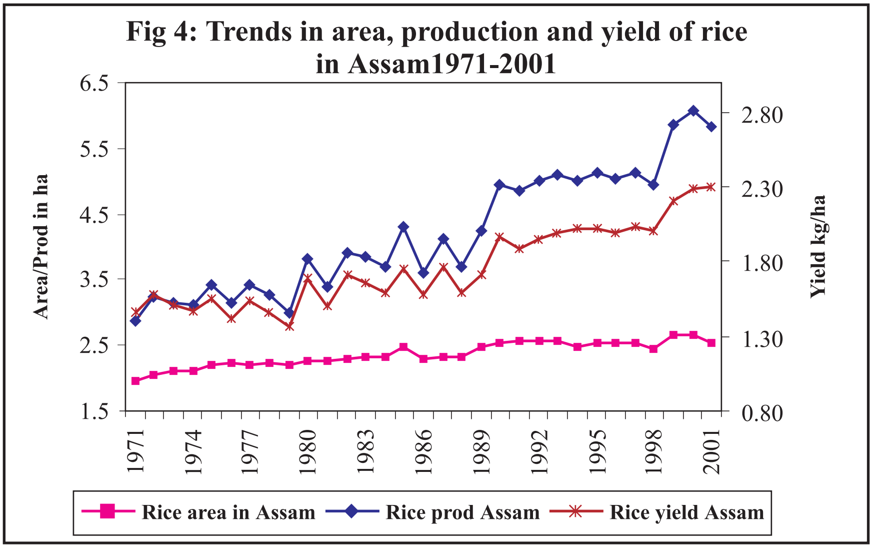
3.2: Trends and Decadal Growth of Area, Production and Productivity of Rice in Assam

The winter rice occupied the highest share of nearly 71% of the total rice area during the triennium 1989-91 (ie. 1.8 million hectare of total of 2.5 million hectare), while its output share accounted for 79% of foodgrain production in the state (Table 3). The autumn and summer rice accounted for 25% and 4% of the total rice area respectively while the corresponding production share was 16% and 5%. However, autumn rice area declined to 21% in the 1998-2000 and its production declined to 14%. Similarly, share of winter rice has also declined. On the other hand, area and production of the summer (boro) rice increased; while area gained additional 7%, the production gained 11% during the period of 1989 to 2000.

Table 3: Changing share of area and production of rice in Assam by rice culture

	Area share			Production share		
TE	Autumn	Winter	Summer	Autumn	Winter	Summer
1989-91	25	71	4	16	79	5
1995-97	24	69	7	16	75	8
1998-2000	21	67	11	14	70	16

The annual average growth of productivity of rice increased by half a percent from a negative growth rate of (-) 0.91% in the 1970s to 0.41% in the 1980s and then to 1.56% in the 1990s. Similarly, production growth increased from 0.66% to 1.07% and then to 1.68% in the respective period (Table A4). The improvement in the production growth, in general, was mainly due to yield-led growth, indicating the impact of technical change. However, this growth rate of yield required to be accelerated further to enhance the production. The long term overall growth rate in area, yield and production of total rice in the state was estimated at 1.01%, 1.58% and 2.59%, respectively (1970-2001). During the 1970s, the expansion of area under rice influenced the production growth and but later its effect weakened, in favour of yield effect, which increased to 61% in 1990s from 38% in 1980s.



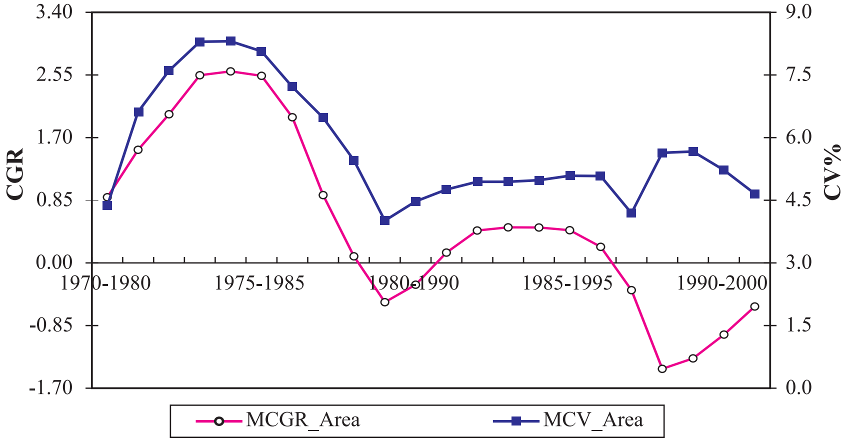
However, most worrisome aspect is that while the aggregate growth of area slowed down considerably over the decades, the productivity growth also staggered at a rate lesser than the population growth rate. Hence, there was urgent need to diffuse and spread the rice technology adequately particularly in the laggard districts. The adoption of improved technologies was however, hampered by the natural calamities like floods and other climatic risk, particularly of winter rice.

Although the winter rice accounted for a major share of the total rice but due to lackluster performance, its growth remained subdued. The pattern of changes in area was more disappointing too, which declined from 1.6% in 1970s to a subzero level in 1990s. Probably due to lack of technical change, winter rice failed to make any breakthrough in production and productivity, even in the less flood risk areas.

3.2.1: Sensitivity Analysis

The growth rate is sensitive to the choice of period of growth. A single outlier such as high intensity flood may drastically affect the production and productivity growth. Therefore, in order to understand the impact of outliers on growth, a moving growth rate series is generated, which traces the intra period change in the growth path.

Fig 5: Moving Compund growth and Coefficient of variation of total rice area in Assam



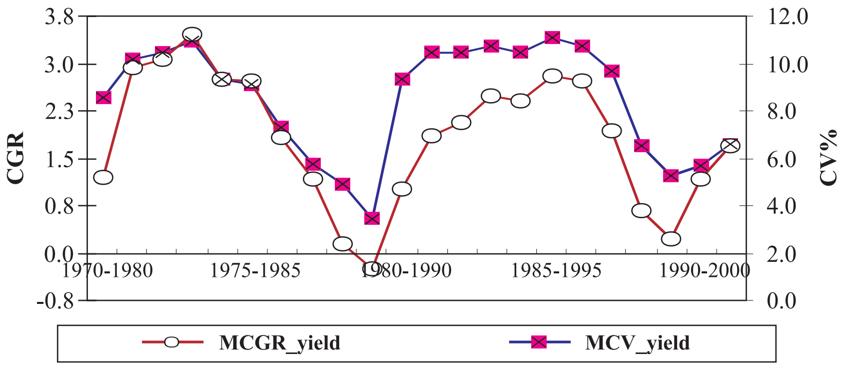
Figures 5 and 6 depict the estimated moving growth rates and coefficient of variation (cv) of area and yield of rice in Assam.

Unlike the long term growth rate, which usually confound the intra-year variation, the moving growth rate is more flexible and revealing. The value of growth rate changes as the period changes, reflecting the influence of fluctuation in climate.

The figures depict an interesting pattern of the inter-year variation and the high and low in the long term spectrum. The movement along the growth path shows that growth rate rice area increased from a low of about 0.60% in the 1970s to a high of around 1.20% in the 1980s, which continued until the decennial period ending in 1995. Thereafter it collapsed. The lowest growth rate was observed in 1989-98. The pattern is found to be similar for coefficient variation (Fig 6).

But, the growth shows a sign of recovery during the past couple of years as demonstrated by the upward trend in rice production. If this increasing pattern of yield growth sustained, the rice production system in the state will be benefited enormously. <u>A relevant question has been that how to maintain the upward tempo in area and yield of summer rice to sustain the overall yield?</u>

Fig 6: Moving CGR and CV of rice yield in Assam



3.3: Relative Importance of Rice Production system across Agro-Ecological Zones

Heterogeneous ecological situations resulted in diverse behavioural pattern of agriculture. The seasonal pattern of area allocation has been highly uneven across different agro-ecological zones. The area share by rice culture (across the seasons) shows that winter rice occupied as high as 91% of total area in Upper Brahmaputra valley zone during the triennium 1999-2001 while the lowest share was observed at 54% in the Central Brahmaputra zone (Table A6). The autumn rice covered a substantial area in LBVZ at 30%, in NBVZ at 26% and in CBVZ at 19%. At the same time, *Boro* rice area jumped from almost negligible area about a decade ago, to the highest share 27% in the CBVZ. Fig 8 shows a clear pattern of share of summer rice area in different agro-ecological zones.

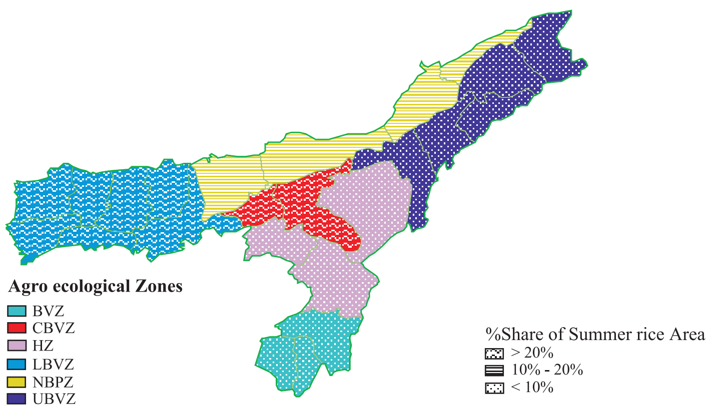


Fig 7: Percentage share of summer rice area

Table 4 summarizes the growth scenario by rice type as defined by the growing seasons. The analysis classified the agro-ecological zones into two distinct groups, viz, high-growth and low-growth category for each of the rice cultures. The autumn rice has been almost static over the years, therefore not considered in this table. Similarly the growth rate of winter rice area was also very low. In contrast, the area under summer rice shows a fantastic growth rates across the zones. Except in Barak valley, its area growth was more than 4% per year in all the zones.

Behavioural pattern across the agro-ecological zones and rice culture has been highly complex. On the overall, UBVZ, CBVZ and hill zone showed high growth of area of all three rice type; total rice, summer rice and winter rice. NBPZ showed low growth rates in total rice and winter rice but high growth for summer rice. BVZ and LBVZ showed low growth rates for all three types of rice except for summer rice in LBVZ. However, the yield growth in all the rice types was high in BVZ with winter rice having the highest rate at 2.44%. But except summer rice, yield growth rate of other rice was low in most of the zones. As the stagnating area and sluggish growth of yield adversely affected the production, therefore those zones having very low productivity growth required more policy attention.

Table 4: Highest and the lowest growth rates of area and yield of rice by zones (1970-2001)

	Area		Yield	
Rice culture	**High growth**	**Low growth**	**High growth**	**Low growth**
Total rice	UBVZ, HZ, CBVZ	BVZ, LBVZ & NBPZ	BVZ & CBVZ	HZ, LBVZ, NBPZ & UBVZ
Summer	UBVZ, HZ, CBVZ, LBVZ & NBPZ	BVZ	CBVZ & UBVZ	HZ, LBVZ, NBPZ & BVZ
Winter	UBVZ & HZ	BVZ, LBVZ, NBPZ & CVBZ	BVZ	HZ, LBVZ, NBPZ, CBVZ & UBVZ

The deceleration in some zones and stagnation in others, was caused by the disparity in infrastructure, as reflected by the positive correlation between agricultural infrastructure index and rice yield. Top performing zones with higher level of infrastructure had higher average yield, contrary to low yields and low infrastructure in the rest of the zones. The value of Agricultural Infrastructure Index (AII) for the top three zones, viz. UBVZ, BVZ and HZ being 69, 59, and 51 respectively (against All India=100) was associated with corresponding higher average productivity of 1.63 ton/ha, 1.60 ton/ha and 1.53 ton/ha respectively (Table 5).

Table 5: Relationship between agricultural infrastructure index (AII) and rice yield

Agro ecological zones	AII	AII Rank	Yield ton/ha	Yield Rank
Upper Brahmaputra Valley	69	1	1.63	1
Barak valley	59	2	1.60	2
Hill zone	51	3	1.53	3
Central Brahmaputra valley	45	4	1.41	4
North Bank Plains	40	5	1.34	5
Lower BrahmaputraValley	35	6	1.22	6

Source: NIRD 2000, India Rural Development report, Hyderabad

While Lower Brahmaputra valley zone showed the lowest productivity as the lowest value of AII being at 35.

3.4: Trends and Growth in Rice Production System (District level analysis)

Five largest districts out of the ten original districts, viz., Kamrup, Goalpara, Darrang, Nagaon and Sibsagar, together accounted for more than 73% of rice area, which contributed 72% of production in the state (Table A8). Kamrup was the largest district within this group accounting for 20% of the total rice area of the state. Table A9 shows the changes in share of area by rice culture over the decades. It was observed that while both winter rice and autumn rice gained 5% area in 1999-01 over the 1980s levels, the summer rice area gained about 11% during the period. At the aggregate level, the summer rice area increased from 2% to 13% during the past 20 years. The summer rice area witnessed rapid increase at individual district level, notably in Darrang (from 1% in 1980s to 8% in 1999-01), Goalpara (3% to 19%), Kamrup (2% to 16%) and in Lakhimpur (less than 1% to 13%). But the highest and significant increase took place in Nagaon (from 5% to 29%). It is to be noted that three out of above four districts of Goalpara, Kamrup and Nagaon are the flood-prone districts, which affected the winter rice regularly. Therefore, the introduction of summer rice was a useful compensating alternative.

3.4.1: Cropping Pattern at district level

Table A10 shows the detailed account of the cropping pattern by districts. Like the state aggregate, the share of foodgrain at district level hovered around 82% of gross cropped area, of which cereals covered more than 80%. The foodgrains dominated agriculture, within which rice occupied the major share, consistently in all the districts. The average share of rice was more than 75%, which varied from 62% in N.C.Hills to 93% in Goalpara. In the hill areas, other crops like wheat and maize was grown along with oilseeds, fibre crops, banana, potato, sugarcane and turmeric. Pulses were grown to about 3-5% of the area. Jute was an important crop in Darrang, Kamrup and Nagaon. But its area declined during the past two decades.

3.4.2: Inter-district Variation in Rice Yield

Although, the winter rice has been the major rice culture, its yield did not show appreciable improvement. The yields hovered around 2 ton/ha in almost all the districts. The highest winter rice yield of 3.19 ton/ha has been found in Cachar and the lowest of 1.94 ton/ha was in Kamrup and Gaolpara (Table A9), while overall state average yield was 2.38 ton/ha. Judging by the average yield of winter rice, the Cachar and Sibsagar seem to have most productive and favourable rice environment. The yield in rest of the districts was medium.

Due to simultaneous area expansion and yield increase, the production of summer rice in Nagaon increased rapidly after mid-80s contributing nearly 40% of the total rice production with 29% area in the TE 2001-2002. Fig 8 shows that except Lakhimpur, Cachar and K.Anglong, summer rice yield is more than 2.5 ton/ha in rest of the districts. The yield of summer rice was higher because the entire summer rice was grown to modern variety under irrigated condition. Compare to other rice, summer rice gave at least a ton/ha additional yield.

Table 6 below summarizes the growth scenario of the major rice across the districts. More detailed estimates of compound growth rates are given in the appendix table (Table A11)

The growth of area and yield for total rice and summer rice was significant in Kamrup, Cachar, Darrang and Sibsagar. However, the weirdest aspect was that growth rates of winter rice were not only low but also non significant. The growth rate of summer rice area was encouraging, which was also highly significant in Darrang, Sibsagar, Goalpara, Nagaon, K. Anglong, Lakhimpur and Dibrugarh. As summer rice was grown entirely to modern variety and under assured irrigation, the availability of more modern varieties will further boost the production.

Table 6: Pattern of growth of area and productivity of rice in Assam 1990-2001

	Total		**Summer**		**Winter**	
	Area	**Yield**	**Area**	**Yield**	**Area**	**Yield**
Kamrup	√	√	√	√	√	√
Cachar	√	√	ns	√	ns	√
Darrang	√	√	√	√	ns	ns
Sibsagar	√	√	√	√	ns	ns
Goalpara	ns	√	√	√		ns
Nagaon	ns	√	√	√	ns	√
K Anglong	ns	ns	√	ns	ns	ns
Lakhimpur	ns	ns	√	√	ns	ns
Dibrugarh	ns	√	√	√	ns	ns
NC Hills	ns	√	ns	√	ns	√
Assam	√	√	√	**ns**	√	√

Note:P denotes statistical significance, ns Non significant

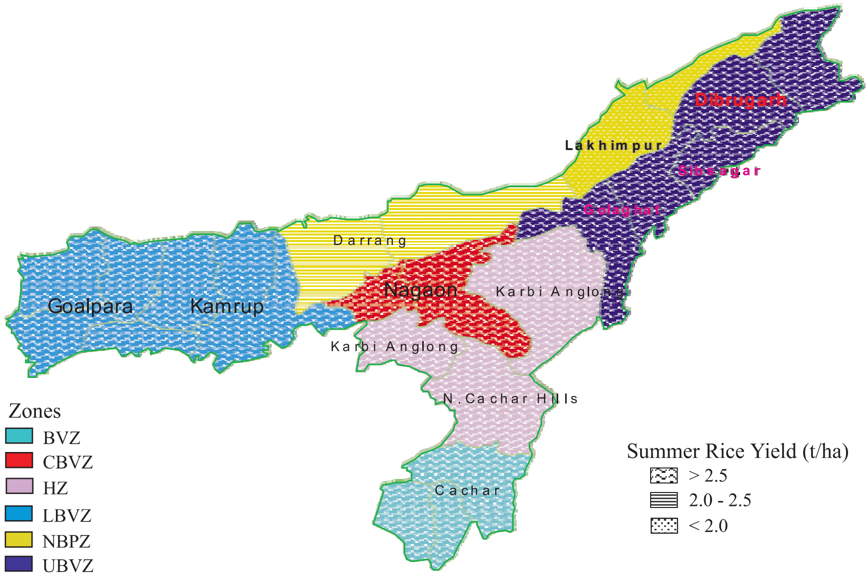


Fig 8: Summer rice yield by districts and zone boundary

3.4.3: Rice Productivity Based Classification of Districts

On account of extreme inter-district variation in production practices, it became essential to identify the hotspot of disparity, which was important for rice improvement policy interventions. Considering the time series of rice yield, the group of districts comprising of Kamrup, Goalpara, Darrang and Lakhimpur was classified in the low-yield category, which also had low growth. These districts covered 56% of the state rice area, but contributed only 46% to the total production in the state. During the last three decades, the productivity of total rice in this group of districts has been stagnant by and large. These districts were also highly susceptible to frequent and multiple floods, which affected the winter rice adversely and blurred the prospect of total rice production. Obviously these districts required more developmental initiatives and policy prioritization for rice improvement. On the contrary, Sibsagar, Dibrugarh, Cachar and Nagaon have been high performing districts and in high growth path as well, which required different interventions for improving resource use efficiency and sustainability. These districts occupied 38% of rice area and contribute substantially at more than 48% of the total rice production in Assam.

SOURCES OF INTER-FARM DIFFERENCES IN PRODUCTION PRACTICES: AN ON-FARM SURVEY

4.1: Micro Level Analysis at Farm and Plot Level

The micro level farm survey is a useful instrument to explain the changes in crop production system, which was captured in the analysis of district level aggregative time series data. Apart from the detailed farm level information, the survey, *inter-alia* provides the information on inter-plot difference within the family farm. The plot level difference arises due to the location of the plots/parcels in different land types and land qualities.

4.2: Demographic Characteristics

The demographic characteristics of the population play important role in modernising agriculture and the knowledge management. The sample districts viz., Nagaon and Golaghat occupied approximately 22% of the state geographical area. The combined population share of these districts was nearly 23% of the total population of the state. Compared to Nagaon, the district of Golaghat was thinly populated, but also had more educated population (Table A13). Table 7 gives the distribution of the sample households into various farm size categories.

Table 7: Distribution of sample households in various farm size category

	Marginal	Small	Medium	Large	Small & marginal
Golaghat	15	43	23	20	58
Nagaon	19	41	32	8	60

Another important characteristics of the survey villages was that the marginal and small farms constituted nearly two-thirds of total farmers and 67- 91% of households were dependent on rice cultivation for their livelihood.

In the sample villages, the education level was uniform across age-sex groups. However, the proportion of illiterate farmers among the small and marginal was found high and so was the poverty. The head count ratio showed that poverty level was relatively higher among the marginal farmers in Nagaon (0.667), as compared to Golaghat (0.429). Interestingly, despite relatively better performances in agriculture, the poverty was more in Nagaon, probably due to higher population pressure. Therefore, poverty, low income and low productivity syndrome seemed to afflict the rural population severely.

4.3: Analysis of Landholding and Tenancy

The farmers have been grouped into four categories according to the land ownership pattern. Nearly 60% of the farmers were small and marginal farmers followed by the medium farmers 32% and large farmers of 8% in Golaghat, while the corresponding percentages in Nagaon were 58%, 23% and the large 20% (Table 7).

The average size of land holdings was relatively larger in Nagaon as compared to that of Golaghat (Table 8).

Table 8: Average size of ownership landholdings and operational landholdings

	Owned land (ha)	Operated land (ha)
Golaghat	1.83	2.13
Nagaon	2.34	2.65

But, due to the presence of tenancy market, the pattern of landholdings became more equitable; i.e. operational landholdings were more equitable than the ownership landholdings. It also indicated the presence of common practice of lease-in and lease-out in the villages. The land transaction and the nature of land market thus influence landholding status.

The average size of the ownership holdings was 1.83 ha which varied from 0.64 ha for marginal farmers to 5.60 ha for large farmers in Nagaon and the corresponding figure in Golaghat was 2.34 ha varying from 0.55

ha to 5.67 ha. But, the size of the operational holdings was larger than ownership holdings at 2.13 ha in Nagaon and 2.65 ha in Golaghat. The landholdings were not only small in size but also fragmented into as many as 8 to 10 parcels, due to subdivisions on account of breakdown of the joint family system and law of inheritance. Such scattered tiny plot of land is a deterrent to productivity and the agricultural operations. The distribution of both types of landholdings is studied with the help of Lorenz curve and inequality of landholdings as measured by *gini* coefficient (Figures 9 and 10).

Figure 9: Lorenz curve showing inequality in ownership land holding in Nagaon (1999)

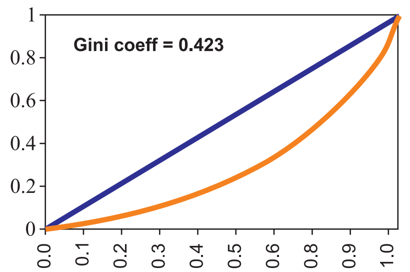
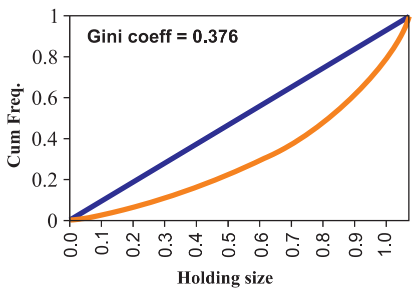


Figure 10: Lorenz curve showing inequality in Operational holding distribution in Nagaon



The *gini* coefficient of operational holdings was in general smaller than that of the ownership landholdings in both the districts (Table 9).

Table 9: Coefficient of inequality for ownership holdings and operational holdings in Assam

	Ownership landholdings	Operational landholdings
Golaghat	0.62	0.54
Nagaon	0.42	0.38

Therefore, it reaffirmed that the tenancy market has positive impact on inequality of land distribution, particularly as an equalizer of landholdings. Among the study districts, the inequality was more in Golaghat than Nagaon as was reflected in *gini* coefficient. The Lorenz curve depicted the visual picture of inequality. This means larger proportion of small and marginal farmers possessed smaller land area as compared to fewer large and medium farmers possessing larger areas in Golaghat.

4.4: Landholdings as Differentiated by Land Type and Quality:

The farmers classify land types as upland, medium land and low land according to their perception on soil hydrology and the relative positions of land in the toposequence. Five land types were found in the region viz., upland bunded, upland unbunded, medium land, low land and very low land. The combined area under lowland and medium lands dominated the land type in both the districts of Nagaon and Golaghat. These two land types were considered favourable for rice cultivation. The medium land and lowland together occupied almost equal share in both the districts at about 83% of total land, while the percentage of bunded upland was 9% in Nagaon and 6% in Golaghat (Table A15). In Nagaon, small and marginal farmers possessed a high proportion of medium land (68% each), and the large and medium farmers possessed the rest. The opposite was true in the case of more productive lowland. The proportion of lowland was more in Golaghat while, in Nagaon both medium land as well as lowland was of almost equal share. In other words, the large and medium farmers owned most of the better quality lowland. Hence rather than quantity, quality of land explained the farm size variation across the farmer groups. Unlike land type, the land quality per se was difficult to measure as it represented many characteristics such as texture and fertility of soil, field hydrology and irrigation facility etc. Yet, farmers differentiated the soil type according to their own conventional wisdom. The clay loam, sandy clay loam and sandy loam soil occupied the highest proportion in Golaghat (81%) while clay and sandy loam dominated in Nagaon (76%) (Table A16). It has been found that the disparity in landholding was reflected not only in quantity of land but also in land quality as large farmers possessing better quality land and the small and marginal farmers the others.

4.5: Cropping Pattern

Rice was the dominant crop in the cropping pattern. The survey showed that share of rice was as high as 80% with negligible inter-group variation (marginal farmers 89%, small farmers 84%, medium farmers 84% and large farmers 86% in Golaghat and the corresponding figures in Nagaon are 86%, 85%, 85% and 85%) (Table A18). Sugarcane was the second important crop in Golaghat, having about 10% area share among the medium farmers, while jute was the second important crop in Nagaon, which occupied 6% area, followed by rapeseed and mustard (5%). Among the rice cultures, the winter (*Sali*) rice was the major rice covering 70%; autumn *ahu* crop 24% and summer *Boro* covers 6% of gross cropped in the sample areas. This finding of the primary survey also conformed the findings of the aggregate level analysis. Despite recent expansion of area under *ahu* and *boro* rice, their share was relatively small, which signified the existence of large-scale fallow in *rabi* season in both the districts.

4.6: Intensity of Fallow Land

The common practice followed in the region has been that after harvesting kharif rice, the *ahu* rice and summer rice were grown in pre kharif season and rabi season in Assam. However, cropped area was found to be around 25-30% of the total cultivable area in pre-kharif and rabi season. Thus, despite the introduction of summer rice in *rabi* season, nearly 70% area was kept fallow in *rabi* season (Table 10). It has been noted that the expansion of tube-well irrigation in recent years, improved the prospect of increase in area under summer rice and hence further expansion of irrigation seems likely to reduce fallow area in rabi season. It has been found that proportion of fallow was more among the medium and large farmers in rabi season. And, it was of lesser proportion among the small and marginal farmers, which indicated that these farmers utilized their land more intensively. Some fallow land was also found in kharif season also primarily due to floods and other uncontrollable factors.

Table 10: Extent of land fallow in various seasons in Assam (%)

	Marginal	Small	Medium	Large	All
Golaghat					
Kharif	0	0	28	35	17
Rabi	41	68	78	66	70
Nagaon					
Kharif	0	9	29	15	13
Rabi	0	60	72	83	70

4.7: Cropping Intensity

Cropping intensity was fairly low in the selected areas, mainly due to large-scale fallowing of cultivable areas. Within the limits of *kharif* dominated cropping pattern, the cropping intensity was relatively higher in Nagaon than Golaghat, as land type in Nagaon was suitable for cultivation of more crops such as jute, pulses and other oilseeds. Newer crops such as pulses and oilseed have entered into the crop production system, although their presence was thin and contribution negligible. The crop diversification and expansion of summer rice area seem to improve the cropping intensity to some extent in recent years.

4.8: Varietal Diversification in Rice

The varietal diversification, rather than crop diversification, in rice has been a common practice. Higher value of Simpson Varietal Diversification Index (SVDI) indicated the presence of more number of varieties (Table 11). Among the rice varieties, the SVDI was relatively low for modern variety than that for traditional varieties. This implied that the modern varieties were fewer in number as compared to traditional varieties. But, in case of summer rice being wholly dependent on modern variety in rabi season, the picture is reversed.

Table 11: Varietal diversification (Simpson diversification Index by variety)

		Modern Variety (MV)	Traditional Variety (TV)
Goalghat	Kharif	0.926	0.973
	Rabi	0.704	0.450
Nagaon	Kharif	0.906	0.978
	Rabi	0.840	0.732

4.9: Rice Production Method: Crop Establishment

There are two different production methods of rice production viz., transplanting method and dry seeding method. Of these two methods of crop establishment, transplanting rice (TPR) has been the dominant practice, which covered on an average of 84% of planted area. The dry seeding rice (DSR) was rare in Assam except few instances of autumn (*ahu*) rice.

From the pooled data, it has been found that transplanting method was most common in lowland (covering 75-85% of the planted area across farm size) and medium land (65-92%). Transplanting rice was practiced also in medium land as rainfall was abundant during the *kharif* season. The dominant *sali* rice (*kharif*) was best suited to lowland and medium land under rain-fed conditions, which was totally transplanted. The transplanted rice had yield advantage as compared to the DSR *Ahu*, the highest being 3.87 ton/ha. The yield under transplanted method of rice cultivation increased with increase in the farm size.

4.10: Adoption of Modern Varieties

The adoption of a variety or a technology was measured as percentage of planted area. In Assam, the farmers grew both the modern varieties and traditional varieties simultaneously. The farmers followed the strategy to allocate land between MVs and TVs as par the home consumption needs, desired grain quality and stability of production. The traditional varieties have been particularly preferred due to variety of reasons such as food security and resistance to biotic and abiotic stresses. As much as 43 traditional varieties were found in Nagaon and 30 in Golaghat, in contrast to a fewer than seven modern varieties in the survey areas. Table A19 shows the adoption of modern varieties by season and district. The area under traditional varieties varied from 40-56% in Golaghat across the farm size categories, while the same has been 46-70% in Nagaon (Table A20). The marginal farmers preferred more traditional varieties, as compared to the large farmers in Nagaon. The modern variety has been adopted in uplands in Golaghat and in both upland and lowlands in Nagaon (Table A21). The detailed variety-wise area allocation information, although difficult to obtain from the published sources, but the survey data revealed that modern varieties of which top four most popular varieties (*Biplab*, *Masuri*, *Ranjit,* and *Prasadbhog*) had area share of 78% in Golaghat while *Masuri, Ranjit, Bahadur* and *Pankaj* occupied 83% in Nagaon. At the same time, large number of traditional varieties viz, *Bora, Latasali, Laxmanbhog, Jahinga, Gethu, Badalbao, Dhusuri, lucky, Kajalchuk* and *Solpona* were thinly spreading across the villages (Table A22).

4.11: Rice yield by land type and variety

The rice production in Assam confronted the stagnant growth and almost static accompanied by low and unstable yield till the early 1980s. But the productivity improved later to reach a level of around 2 ton per hectare. It is intriguing that even with relatively low level of adoption of modern HYV, the overall rice yield had increased. Emergence of newer practices like *boro* rice seems to have contributed largely towards the increase.

Among the survey districts, rice yield was higher in Nagaon than in Golaghat. Apart from inter-district variation, there was difference in yield between the variety within a district too. The weighted average yield was 4.6 ton/ha and 3.9 ton/ha for modern variety and traditional variety respectively in Nagaon and the corresponding yield in Golaghat was 3.7 ton/ha and 2.7 ton/ha. The yield of modern variety was about a ton/ha more than that of the traditional varieties in Golaghat, but the difference was half in Nagaon. In Nagaon, average yield of traditional varieties itself was higher at 3.9 ton/ha as compared to 2.7 ton/ha in Golaghat. The production environment appeared to be more suitable for rice in Nagaon than in Golaghat. Apparently, in a situation where the yield of traditional varieties was low, the modern variety has clear edge over the traditional variety as in Golaghat as compared to areas with higher yield of traditional variety. On account of improved management practices and crop care, the yield difference between the modern and traditional varieties was very marginal in Nagaon, but substantial in Golaghat. In general, the small farmers harvested slightly higher yield than the large farmers.

As land type and soil quality found to differ from location to location, so was the performance of production system. Most rice varieties performed better in upland and lowland. The medium farmers achieved the highest yield of 5.58 ton/ha (rough rice) in bunded upland in Nagaon mainly due to efficient water control and other favourable factors (Table A23). The medium and small farmers achieved higher yield of MVs in almost all the land types in Golaghat. The promising variety such as *Biplab*, performed extremely well under irrigated condition.

4.12: Input Usages

Labour use and gender participation :Rice was the largest employment provider in rural areas, although sugarcane also utilised more labour. On the whole, the utilization of total labour days in rice was 140 person days/ha in Nagaon and 133 person days in Golaghat (Table A27).

Operation-wise breakup shows that the highest share of labour use was found in crop establishment and harvesting (71 days/ha of 140 days in Nagaon and 70 days/ha in Golaghat). The labour use also differed from crop to crop and operation to operation, particularly in the context of gender participation. The female labour use was 54 days/ha in Nagaon and 43 days/ha in Golaghat. Proportion of female labour was higher in crop establishment at 17 of total of 30 person days/ha, harvesting 14 of 29 person day/ha, weeding 8 of 16 person days/ha in Nagaon. Similar pattern was observed in Golaghat. Therefore, it may be inferred that transplanting, harvesting, weeding and threshing were more woman-friendly operations and employ more of female labour as compared to the operations such as land preparation, crop establishment, fertilizer and chemical application. In both the sample districts, land preparation was done only by male labour (about 31% of total labour use in Nagaon and 48% in Golaghat) while the entire transplanting operation was performed by female labour in Golaghat (Table A28). . On the whole, the employment of female laborer in rice cultivation was more than other crops. The difference in labour use between modern varieties vis-a-vis traditional varieties, was 49 person days/ha in Nagaon and 20 person days/ ha in Golaghat. The total labour use by different farm size groups varied from 128 person days/ha to 139 person days/ha

Fertilizer Use : The use of fertilizer in rice was generally low in both the districts. But among the rice varieties, as expected, the fertilizer application was more in modern varieties than in traditional varieties. About 26 kg/ha of NPK was applied to traditional varieties as compared to 69 kg/ha for modern varieties in Nagaon, where as, it was 15 kg/ha and 67 kg/ha respectively in Golaghat (Table A27). This indicated that, not only the production environment was suitable for rice in Nagaon, input use intensity was also relatively high (use of fertilizer, irrigation and tractor). Fertilizer use in jute was at 38 kg/ha and 26 kg/ha in Rapeseed Mustard. The use of phosphatic fertilizer was more in Golaghat due to easy availability of DAP (Di-Ammonium Phosphate) while in Nagaon, the SSP (Single Super Phosphate) was used as a main source of phosphorus. The difference in use of nitrogenous fertilizer in modern and traditional varieties was substantial in both the districts.

4.13: Determinants of Inter-farm and Inter-plot Variation

The factors determining the adoption of modern varieties were analyzed with the help of the probit model. A selected set of plot-specific variables, farm-specific variables, socio-economic and biophysical factors were used in the model.

4.13.1: Probit Model

The Probit model has been a useful tool to explain the inter-farm and inter-parcel/plot differences in adoption of modern varieties. Model took into account the agro-biological and climatic factors and crop management practices, which influenced the inter-farm variation in adoption of modern technology. The climatic factor such as rainfall, land type and soil types characterizing the natural production condition, were normally not subjected to management controls. Whereas, crop management practices reflect the human adaptations to agro-climatic situations as well as the socio-economic conditions of the farmers. Farmers allocated favourable plots to modern varieties and the other plots to traditional varieties. This implied that the probability of adoption of modern variety was high in favourable land type and quality soil type, which were the important plot-specific characteristics. Thus, the detailed information on plot or parcel was found extremely useful for farm planning.

The general functional form of the model is given by equation (1)

$$Y = f(X, Z, W), \qquad \text{——— (1)}$$

Where,

Y = The variety dummy, 1 for modern variety and 0 otherwise.

X = A vector of bio-physical factors such as land type and soil type. These are used as dummy variables.

Z = A vector of socio economic factors

W = error term

A linear probit model used the following identified variables:

(i) <u>Plot/Parcel characteristics:</u>

Land type dummy: Two dominating land types viz, Medium land and lowland were considered against the rest

X_1 = Dummy for medium land

X_2 = Dummy for lowland

Soil quality dummy: Two dominating soil types were considered against the rest

X_3 = Dummy for clay loam

X_4 = Dummy for sandy loam

(ii) <u>Household characteristics:</u>

Z_1 = Farm size in hectares

Z_2 = Education of the head of the household (in number years of schooling)

Z_3 = Age of the head of the household in years; The younger farmers are expected to be more informative and interested to adopt modern methods but the elders may be more efficient in management matters.

Z_4 = Workforce within a family measured as a ratio of number of active members per hectare landholdings

The variables were grouped into socio-economic (family members, farm size), environmental (rainfall, flood, land and soil type), technological (chemical fertilizers, HYV, other inputs), management factors (cropping intensity), and infrastructure (road, credit, markets). But the problem of multicolinearity and the data limitations, restricted the specification of the full model. Moreover, the variables like HYV and fertilizers tended to be highly correlated as farmers applied more fertilizers to HYV and less to traditional varieties, which gives rise to the problem of multicollinearity. The use of fertilizers also tended to be correlated with irrigation infrastructure. Fertilizer was also considered to be a good proxy variable to represent several other factors; adoption of HYV, irrigation and infrastructure. Under the circumstances, a careful selection of representative variables was needed to specify a model.

A number of variables were tried but final analysis used a set of selected variables. The analysis of agro-climatic zones rather than rainfall was preferred as the former measured the joint effect of soil, crop and climate (say, rainfall and its distribution).

The estimates of the probit model shows that compared to age, education, workforce (labour-land ratio) and farm size, the land type and soil quality emerged as important factors. The education did not show visible impact as its level was low as in Nagaon. In Golaghat, the coefficient of education was positive but not significant. Therefore, the effect of these factors varied across the districts depending on social and economic infrastructure, access to input and output markets etc (Tables A28).

The bio-physical variables such as favourable land type and quality soil, and man-land ratio (workforce) were found to increase the probability of adoption of modern variety. That is, the chance of adoption was high if the farmers possessed superior land type and soil quality along with other favourable factors. Also, among the land types, the probability of adoption was high in bunded upland and lowland with clay soil. In general, while the modern variety was adopted in better quality land, the traditional variety was grown to marginal and lesser productive land. Hence, it was not surprising that the yield of traditional variety was low.

4.13.2: Yield equation

Mere adoption of modern variety did not adequately guarantee the increase in yield as its performance was governed by a set of additional factors. Yield equation considers such a set of favourable factors as given below:

A simple specification of the linear yield equation was given by equation (2)

$$Y= \alpha + \beta_1 X_1 + \beta_2 X_2 + B_3 X_3 + B_4 X_4 + B_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8 + \text{error term} \quad \text{—— (2)}$$

Where Y = Rice yield; ton/ha

(i) Household characteristics:

X_1= Farm size in hectares

X_2= Fertiliser (NPK in kg/ha)

X_3 = Modern variety dummy

X_4= Age of the head of the household in years

X_5= Pre-harvest labour days per hectare

(ii) Plot/Parcel characteristics:

X_6= Percentage area under (bunded) Upland

X_7= Percentage area under medium land

X_8= Percentage area under clay loam

X_9= Percentage area under sandy loam

The estimated equation shows that yield response to fertilizer was positive but varied across the farms and districts. An additional kilogram of fertilizer gave around 15 kilogram of additional yield per hectare (Table A30). The positive coefficient also implied that fertilizer enhanced yield, though the current level of fertilizer use was low. Another important factor of yield improvement has been the modern variety. The estimated coefficient of variety dummy was positive and significant indicating direct impact of modern variety on yield. The modern variety could increase the yield as high as 1.40 ton/ha as compared to traditional varieties. Therefore, the varietal adoption and fertilizer (as a proxy for a host of qualitative as well as quantitative factors), along with other socio economic factors explained the difference in rice yield to a considerable extent. The irrigation did not show encouraging result with the present data, because of very low level of irrigation. On the other hand, negative coefficient of farm size indicated the inverse relationship between productivity and farm size.

4.14: Analysis of Cost and Return to Rice

The cost of cultivation and return was calculated separately for modern variety and traditional variety. For the sake of simplicity, paid-out cost of material inputs including wages was considered first and then added the imputed value of family-owned inputs to total cost. The family-owned resources were valued at prevailing market price, because the estimation of shadow prices for various components was more difficult. Moreover, this could also be justified on the ground of low opportunity cost of the family-owned resources. The estimated values showed that among the individual components, the cost of seed of MVs was higher than that of TVs. Usually, the seed of traditional rice varieties was treated as a non traded item, therefore it seemed likely that imputed value may appear overestimated. Next critical input was fertilizer and manures. Cost of fertilization of modern variety was two to three times higher than that of the TVs. On average, it was Rs.164 for TVs as against Rs.629/ha for MVs in Golaghat, whereas, the corresponding cost estimates were Rs.256/ha and Rs. 635, respectively in Nagaon (Table A31). Between labour and material, cost of the former was relatively higher. On the whole, total paid-out cost of material input was Rs.4849/ha and Rs.3044/ha for MV and TV, respectively in Nagaon, while the corresponding costs were Rs.4159/ha and Rs.2878/ha in Golaghat. Table 12 shows the total paid-out-cost and sum of paid-out-cost and imputed cost. It shows that difference in paid-out cost between MV and TV was about 16% and the same was about 3% of the total cost in Golaghat, therefore, in the context of cost differntil, the farmers in Golaghat had fewer options to choose from. The corresponding differences were 31% and 41% respectively in Nagaon. This again re-ascertained that favourable production condition in Nagaon helped getting higher yield of traditional varieties with relatively lower cost of production.

Table 12: Total Paid out cost and total cost of cultivation of rice

Cost Rs./ha	Modern variety	Traditional variety
Golaghat		
Total paid-out cost	7273	6288
Total cost	11430	11166
Nagaon		
Total Paid-out cost	7847	5990
Total cost	12696	9034

The detailed cost of cultivation and returns from rice cultivation were also analysed separately for variety, ecosystem and season as shown in Table 13, while the detailed break up of paid-out cost and imputed cost is given in Table A31.

Generally, intensity of resource use in rice cultivation was comparatively high in Nagaon than in Golaghat, in which fertilizer and labour were the important to total cost. Labour cost (family and hired) constituted a bulk of cost of cultivation in rice in both the districts. It has been observed that total paid-out cost of labour was Rs.2661/ha and the imputed cost of Rs.4247/ha for MV in Golaghat and the same were Rs.2665 and Rs.4540 in Nagaon. The imputed cost of material inputs and labour together caused the difference in total cost among the varieties. The fertilizer cost was as high as 3 to 5 times more for modern variety as compared to the same for traditional variety in both the districts.

The net return over the paid-out cost was Rs.10651/ha for MVs and Rs.8581/ha for TVs in Nagaon, while the corresponding returns were Rs.9118/ha and Rs.5757/ha in Golaghat (Table 13). The difference in net return between modern variety and traditional variety was about 24% in Nagaon as against 58% in Golaghat.

Table 13: Cost of cultivation by variety in various districts (Rs/ha)

	District Nagaon		**District Golaghat**	
	Traditional varieties	**Modern varieties**	**Traditional varieties**	**Modern varieties**
Material inputs				
Seed	19	107	10	53
Fertilizer	256	635	164	629
Insecticide	8	76	-	-
Manure	112	121	113	116
Bollock	391	323	248	319
Tractor	290	570	253	258
Irrigation	-	352	-	122
Total Material inputs	**1065**	**2184**	**778**	**1496**
Total Labor cost	1979	2665	2050	2661
Total paid-out costs	**3044**	**4849**	**2828**	**4157**
Gross return	11625	15500	8585	13275
Net returns above paid-out cost	8581	10651	5757	9118

The relatively higher proportional return to modern variety in Golaghat was primarily due to very low productivity of traditional variety.

Again, between the districts, the difference in net return to MV was about 17% higher in Nagaon than Golaghat, while the same was over 50% for TV. The overall return to rice was however nearly double in Nagaon, as against the same in Golaghat (Table A33).

4.15: Analysis of Total Household Income

This section highlights the findings of the analysis of income distribution, inequality and poverty implication. The share of various sources to total household income was examined with a special focus on rice (Table 14).

Total household income was computed as the sum of on-farm net return (net of production costs) and income from off-farm and non-farm activities. The income from various other sources that supplements the household income was also estimated.

Table 14: Share of various source income to total household income (%)

Source	Nagaon	Golaghat	Both
On-farm Income	62	57	60
Non-farm income	38	43	40
Total	100	100	100

The household deployed several sources of income including the family-owned resources such as land, labour and other production inputs. The value of produce net of cash cost of production was defined as the on-farm income. The wage income of the labourer from the outside farm activities was treated as off-farm income. Non-farm income usually accrued from non-agricultural activities such as salary income, income from retailed shop, petty vendor and services also estimated. The income from livestock and livestock products was separately counted under livestock income. The income derived from sale of vegetables and other produce in kitchen garden (homestead), forest, orchard product and other miscellaneous sources were included in the “other” income.

4.15.1: Average Income Shares by source

The average annual per capita total household income of Rs.12008 was comparatively higher in Nagaon as against Rs.11060 in Golaghat (Table A34).

The household income inequality was decomposed into various components and their shares estimated. The contribution of individual source towards income inequality was measured by estimating the marginal effect in the decomposition procedure. The detailed analytical methodology of decomposition of *gini* income inequality is given in the endnote in the paper (Pandey, S. et.al, 2000).

The decomposition analysis revealed that the on-farm income occupied a major share as compared to non-farm and off-farm sources income in both the districts (Table 13). The ratio of on-farm income and non-farm income was found as 60: 40. The overall share of rice was the highest at 58% of on-farm income, remaining 37% from non-rice and 5% from livestock income. The shares of various components of on-farm income by individual districts show that share of rice income was 62%, non-rice crop income 33%, livestock and homestead garden income was 5% in Nagaon. While in Golaghat, the same was 54%, 41% and 6% respectively. The non-farm income composed of share of remittance (49%), salary (43%) and others 8% in Nagaon and in Golaghat the same were 14%, 80% and about 1% each from forest product and handicrafts, respectively.

4.15.2: Income Distribution

The pattern of income distribution was interesting and identical in both the selected districts. The analysis of income distribution revealed that around 41% of the farm households were in the bottom 40% income level irrespective of farm size categories, 26% of the farmers in the next 40% income level, while 10-15% of households fall in the top 10% income level. The value of *gini* concentration ratio of total income was calculated, which varied inversely to farm sizes, that is the inequality was lesser among the large farmers (gini coefficient is 0.31) and relatively more for marginal farmers (0.47).

4.15.3: Decomposition of Income Inequality and Contribution of Source Income

The share of rice in household income was found to be higher in Nagaon as compared to Golaghat. The salary and off-farm income components figured significantly in the household income in Golaghat. The contribution of these components to overall income inequality, varied across the farm size categories and districts. In order to assess the contributions of various source income, total income inequality was decomposed and the marginal effect estimated. In the decomposition procedure, the relative marginal effect of source income reveals the nature of change in (amount increasing or decreasing) inequality for a unit change in source income. The estimated marginal effect shows that rice reduced the total household income inequality by 13% in Nagaon and 10% in Golaghat. Off-farm and livestock income reduced to the extent of 8% each in Golaghat as against 3% in Nagaon (Table A35). Thus, rice was not only a provider of food but it also acted as an income equalizer. Livestock income also has an inequality reducing effect. The salary income, however, increased inequality as in Golaghat (27%) implying that the opportunity for salaried job was highly skewed and thus added to the total inequality.

4.16: Production Constraints

Based on perceptions, the farmers considered drought and floods as major constraints to agricultural production in Assam. It was interesting to note that in a high rainfall area like Assam, drought has been an important constraint to agriculture. To an opinion and perception question, 53% farmer respondents gave first rank to drought as a critical production constraint followed by flood (47%) in Golaghat. Diseases and non-availability of quality seeds were reported the third and fourth constraints in order of importance. As the district of Nagaon falls in the flood-prone area, a high proportion of the respondents expressed that floods, rainfall and diseases simultaneously affect the crop production (according to 82% respondents). Other production constraints such as access to information and resources (credit, technology information and markets) were also cited to be crucial for rice production.

4.17: Pattern of Changes

The opinion of farmers in the study area was obtained on the nature of changes in agricultural production systems, including socio-economic conditions, health, education facility, standard of living and general welfare that had occurred during the past 10 years.

4.17.1: Levels of Living

An overwhelming majority of the farmers expressed that there were improvements in number of areas contributing to the level of living during the past decade. These include the availability of more food, health care and sanitation, employment within farm sector, over all income level and general welfare. But, the rise in school enrolment, productivity of foodgrains, cash crops, livestock and homestead gardens was not palpable. The farmers in Nagaon opined that there was no improvement in off-farm employment (Table A36).

4.17.2: Innovation in Agricultural Activities (Crops and Varieties)

It was found that the farmers adopted a number of crops and other innovative activities in the last decade. Among these, a rapid increase in area under *Boro* rice was the most prominent (40% farmers responded) in both the districts (Table A37). Changes also occurred in crop establishment methods particularly in *ahu* rice. Crops like potato, jute, rapeseed and mustard and vegetables were among the newer entries. Sugarcane area had increased, as about 7% to 16% additional farmers had started growing it in Golaghat.

4.17.3: Rice Technology

The changes had occurred in the agricultural portfolio of the farmers in the study area, remarkably in the choice of newer rice technology. Therefore, even with limited number of modern rice varieties, adoption of newer and modern varieties of rice had increased over time. Among the notable newer varieties were: *Ranjit*, *Mashuri*, *Bahadur* and *Biplab*. The introduction of modern varieties has driven away many traditional varieties; prominent among those were *Badal Sali, Harkona, Bardhan, Jahigna and Doria*. Yet, the traditional varieties still dominated in considerable extent in the planted areas (Table A37).

In the case of rice production practices, there was no visible change, except that the irrigation under shallow tube wells increased in the selected areas. Fertilizer use had increased but not yet reached the desired level.

4.18: Reasons for Change

Most farmers strongly felt that land market played an important role in bringing about changes in landholdings and farm income. As discussed earlier, the prevalent tenancy system changed the size of the landholdings, *ipso facto*, reduced the inequality of landholdings. On the other hand, fragmentation of farm holdings into tiny plots adversely affected the agricultural productivity.

4.19: Access to Information

The information is a useful carrier of modern technology to the door steps of the farmers. But, it was intriguing that most farmers learnt about newer rice cultivation practices including animal husbandry, and soil nutrient management etc., from their own family sources and neighbours, rather than from the formal channels. The role of the institutional sources such as extension workers, farmers' organizations, NGOs and local schools was negligible in providing the information to the farmers. Thus strengthening and sensitizing these agencies, were essential for improving the production pattern.. These organizations could potentially help in popularizing modern varieties, methods of pest and disease management etc, amongst the anxious-to-learn farmers (Table A39).

4.20: Fertilizer Management

Rather than picking up, the fertilizer usage in the study areas was found to lagged behind the national level. Instead of fertilizer, the farmers applied manure (about 5-6 ton/ha) in the rice field. The existing level of fertilizer use also appeared unbalanced. For example, it has been observed that in

Nagaon, the DAP was used more frequently due to easy availability of this brand, which resulted in over-dose of phosphate. On the other hand, SSP was commonly used as a source of phosphorous in Golaghat, although it supplied comparatively lower quantity of the nutrient.

Chapter - 5

CONCLUDING REMARKS AND POLICY INTERVENTIONS

Assam is strategically an important state having the largest population among the constituent states of the North East India. The population with about 26 million grew at a rate lower than that of the country. But, despite the favourable population growth, the poverty has been a severe problem in the state. The poverty level in Assam has been at least 10 points higher than that of all India. The economy of the state has been primarily rural-based where more than 87% of population lives in rural areas. Agriculture is the main source of livelihood for majority of the population. Nearly 60-70% of the total cultivators in the state are small and marginal farmers. But, the low productivity and stunted growth have been the characteristics features of this small farmers-dominated agriculture.

- Agriculture in Assam has been dominated by rainfed rice-based production system. The rainfed areas accounted for as high as 80% of total cropped area, having dependent on rainfall. This monsoonal-based agriculture has been subjected to vagaries of nature. Rice, not only, occupied a pivotal position in agriculture in Assam, but also has a dubious distinction of being a three-season crop viz, winter rice, autumn rice and summer rice. Winter rice is the main crop, which occupied the largest share of 72% of total rice area. Winter rice, (though occupies major share), has been susceptible to the risk of multiple floods, therefore, the pattern of growth became highly unstable. On the whole, agriculture in Assam has been plagued by a number of adversities, namely low productivity, stagnation, risk-prone and diversity of production system.
- Notwithstanding the dismal performance, the pattern of growth responded positively to some policy interventions in the recent years. Such a discernible change in the rice production system had broken the stagnation in agriculture in the chronic food deficit state like Assam. These changes however, occurred in isolated manner lacking

uniformity. The inter-regional and inter-temporal disparity has been matter concern to the policy makers.

- The main goals of the study were to understand the genesis of the technological change in the production system, to assess the role of rice in Assam and to identify the factors affecting the change. Attempt was also made to suggest policy interventions for improvement in agricultural sector, to stabilize rice productivity and household income as a means of livelihood. The analysis of time series district level data captured the changes in rice production systems and identified the factors affecting technology adoption. An in-depth farm-level primary survey was conducted in two districts representing two distinctly contrasting ecosystems, viz., flood-prone Nagaon and flood-free Golaghat, district. The survey covered all the three seasons viz Winter *Sali* paddy (*kharif:* June-October), autumn *ahu* paddy (*pre-kharif: February-June*) and summer (*rabi: November-May*) *Boro* paddy. It also captured more finer details of the plot level variation within the selected households.

- The production environment has been highly diverse particularly in the sphere of biophysical and socio-economic and infrastructure. Five land types viz., upland bunded, upland unbunded, medium land, lowland and deepwater land were found in the study areas. The land types were classified on the basis of the location of the land/plots in the toposequence and the hydrological situation as perceived by the farmers. Among these land types, prominent ones were the upland and shallow land, which occupied 60% of total rice area, and the rest being the medium land (intermittent water of 30-100 cm) and deepwater land. Rice was grown to all land types and seasons. Thus, this diversity of production ecosystems made the understanding of rice production more complex.

- Among the changes taken place in rice production system in Assam. over the years, the change in seasonal allocation of area to different rice culture has been noticeable. At the aggregate state level, the share of area under the main winter rice (*Sali*) decreased from 72% in 1970s to 67% in 1990s. The pattern of declining to negative growth of winter rice area adversely affected the production growth, but the weirdest one has been the sluggish yield growth. However, as compared to overall stagnating winter rice, the rapid changes in summer rice have effectively contributed to the overall improvement in rice production system. Summer rice popularly known as *Boro* rice, has demonstrated a high growth potential, which also has certain distinctive features viz., a safer crop as grown during the flood fee period and higher productivity. These favourable features helped to adopt this innovative practice swiftly. This resulted in unprecedented upsurge in its growth pattern, which reached a level as high as 10% per annum especially in the 1990s. The emergence of *Boro* rice cultivation in summer season and its fast spread could be termed as return of renaissance in rice economy in Assam. Another important distinction is that changes in summer rice occurred in the flood-prone areas to contribute to household food security. It was observed that with adequate crop management care, farmers achieved yield of *Boro* rice at least double the winter yield (about 4 ton/ha). The sustainability of its productivity, however, hinged on appropriate policy interventions and assured support infrastructure. It could be inferred that sustainable productivity of *Boro* rice could be the path-way to overcome the scourge of food deficiency in the state. But, this yield improvement has not been uniform across the zones. The instances of increasing adoption of relatively a softer instrument and less risky option such as *Boro* paddy in the flood-prone areas, require more closer attention. Therefore, having demonstrated the usefulness of the desired change in summer rice particularly in unfavourable production environments, it posed a challenge to the agricultural R&D system for developing a need-based alternative technology as flood proofing mechanism. Therefore, the questions aroused that could summer rice be the main driver of future growth of rice economy in the state? Alternatively, should there be more R&D emphasis on summer rice rather than on the most vital winter rice, which has been stagnating for decades? Another question related to the impact of the existing R&D has been that why the improvement in winter rice failed to translate into growth opportunity?

- The analysis revealed that the area under summer rice has expanded rapidly (prominently in lower Brahmaputra valley, north bank plains and central Brahmaputra valley), but the productivity increased only in few areas viz., CBVZ and LBVZ. To achieve a uniform yield improvement, there is urgent need for more of ecosystem specific modern varieties. Such innovation would be helpful to flood vulnerable areas, as the production condition for summer rice, has been relatively risk-free. The success of *Boro* rice depended on more pro-active R&D, which should address the problems of development of appropriate varieties supported by adequate infrastructures and support services.

- The winter rice, however, enjoyed some direct benefits of the past research initiatives along with other indirect spillover effects. That is why, despite low irrigation, overall adoption of modern varieties increased in the state. It is another matter that many of the varieties developed for the irrigated ecology might have spread in the rainfed areas.

- The yield response to fertilizer for modern variety was found to be positive, albeit very low level of current utilization. Therefore, enhancing the existing irrigation facility along with fertilizer network is most essential to accelerate adoption and increase productivity.

- Interestingly, many traditional varieties continued to be popular among the farmers, due to high adaptation and in-built desirable biological properties such as tolerance to biotic and abiotic stress, sturdy stem, and consumer preference, etc. Farmers followed a strategy to mix both the varieties as par the production condition. Apart from these safety net merits, the small and marginal farmers also prefer the cultivation of TVs, due to its responsiveness to low inputs. The synergy between modern and traditional varieties at farmers' fields has contributed to the household food security. The pertinent questions have been (i) whether the existing modern varieties of rice were adaptable to diverse ecosystems in Assam, (ii) Were the policy interventions on agricultural Research and Development system in the past adequately addressed the issues of demand-driven technology and agro-ecological specificity in the region?

- In order to understand more about the changing production pattern and gain insights, the differences in the socio-economic factors, support infrastructure and technological changes in rice variety were examined. The analysis showed that, apart from inter-district differences in socio-economic factors, the spatial differences in the biophysical factors, influenced the adoption of modern varieties significantly. Among them, the land type, soil hydrology and soil quality, irrigation appeared the most important factors. This causal relationship reinforced the need for ecosystem specific research prioritization.

- Due to its pivotal position, rice has been important not only because it provided food but also helped reducing the total income inequality. The estimate of the marginal effects derived from the decomposition of gini inequality showed that the farm income (particularly rice income), rather than the salary income, reduced income inequality in rural areas to the extent of 10 to 13%, of which rice was the major component. In other words, the income inequality could be substantially higher in the absence of rice income. Therefore, development of cost-effective rice technology accompanied by the guaranteed access to market information will have greater impact on household income.

- The income decomposition analysis further shows that the agriculture in general and rice in particular, provided lesser scope for income generation to meet the household livelihood needs. As a matter of fact, rice provided sustenance need rather than household income. Therefore, improvement in the existing crop diversification is necessary to supplement the rice income. Utilization of vast fallow land could also be instrumental in income enhancement.

- The management of vast fallow areas in *rabi* season has been a major policy challenge in Assam. Because, over 80% of cultivable areas as fallow had affected resource use efficiency, land productivity, and cropping intensity. Hence a carefully designed intervention is needed for the management of large scale fallowing of productive cropped land. Land reform, agricultural marketing, resource conservation techniques, ground water utilization, agro-processing (including post harvest care, storage), credit supply and remunerative pricing policy were also important for further tapping the agricultural potential in the state.

- Therefore identification of the constraints and careful prioritisation of the policy strategies were essential to accelerate agricultural growth. For example, the analysis identified a group of four out of ten districts viz., Kamrup, Goalpara, Darrang and Lakhimpur, as low productivity and development-lagged group. These districts occupied a very high proportion of total cropped area (56%) but contributed only 47% of the production. During the past three to four decades, the performance of the group has been very poor consistently, which deserved urgent developmental priority.

- The predominantly small farmer-oriented monocrop farming situation in Assam, also required enhanced public investment to ensure basic infrastructure facilities, health care and education. The analysis revealed that such investment would not come from the private sources. Because, the meager per capita income in rural areas, as little as Rs.15 a day (about Rs.5200 per annum), speaks of the magnitude of investible surplus at the hands of the farmers. Moreover, over the years, the public investment on agricultural R&D has declined and at the same time monitoring, mid term evaluation and correction almost non-existent. The meager existing investment on agricultural research and development (R&D) system affected the agricultural production system adversely in the state. Continuation of this trend will have serious implication for agriculture in Assam. Therefore this trend must be reversed and needed to convert it into growth opportunity of demand-driven technology by re-casting the existing R&D system. Because, further continuation of situation is also likely to result in the farm sector with a state of severe infirmity. Another serious apprehension has been that, if the investment policy continued neglected, the economic forces would further compel the small and marginalized farmers to abandon farming and migrate to urban areas. The sustainable rice production system thus, required a radical change in rice research and development paradigm targeting eco-regional specific issues and addressing *inter-alia*, the problems of biotic and abiotic problems and infrastructure for transfer of technology.

- Lack of quality seed is a major hindrance to adoption of modern varieties of rice. The long and time-consuming process of supply of seed by the government agency has discouraged the farmers to use modern varieties. Presently, the seed replacement rate is very low in the range of 5 to 10% only. But, the farmers expressed willingness to adopt newer varieties and other improved practices for future improvement of production, if the constraints are addressed properly.

- The ensuring access to information on modern varieties, crop management practices, including weather and other sources of agricultural risk had been important policy requirement in the rural areas. Unfortunately, farmers rarely benefited from the institutional source on such matters, rather they derived most information on newer methods and innovative agricultural practices from informal sources like own experiences, relatives and neighbours. The strategies for strengthening the role of institutional agencies has been a felt need for knowledge sharing and enhanced the impact of technology. This would help reaching out to the targeted beneficiaries more effectively.

- While the importance of rice research could hardly be overemphasized, there has been urgent need to look at the rice plus policy to ensure household income security. Based on the calculations of profitability, rice-only system was found inadequate to meet the household needs. Hence, appropriate intervention was felt necessary to strengthen and promote more realistic diversified systems like rice (winter/*Boro rice)*-livestock-fishery-horticulture system for more effective income supplement. To emulate such innovative practices on a wider scale in Assam, the State requires to build up a strong foundation ensuring un-interrupted availability of supporting infrastructure through the public investment.

Certain policy measures (as listed below) implemented by the Government of Assam in recent years, have provided rich dividend to the agriculture sector. But, to make the state self-sufficient and sustainable in rice production, concerted efforts are needed to widen the impact of policy interventions and to "reach out" to the farmers.

- A crash programme for increasing the use of fertilizers was launched in the year 1990-91 and the year was observed as "Fertilizer Year" in the state.

- Assam Seed Corporation Ltd. undertook procurement, distribution and sale of high-yielding varieties to bridge the gap in quality seed supply.

- Following landmark decision by the government to implement plans and programmes in respect of irrigation such as surface irrigation and groundwater irrigation project in the Fifth and Sixth Five Year Plans are considered significant breakthrough for productivity.
- Realizing the poor utilization of irrigation, the State Government (Department of Agriculture), in its recent effort, installed one lakh shallow tubewells for cultivation of autumn and summer rice under "Samridha Krishi Yojana". The impact of this policy on rice productivity has been spectacular.
- Technical change in respect of newer rice varieties developed for improved grain quality, resistant to lodging and pests and diseases gradually made in-road towards modernization of agriculture. Modern varieties such as Mashuri, Bahadur and Ranjit have found more acceptability among the farmers and were already adopted by 49 per cent of sample farms

REFERENCES

Baishya, P. D. Bhorali, G., Bordaloi, A. K. Neog and T. N. Saikia, 1997; *Development Issues in North East India*; Essays in honour of P. C. Goswami, Lawyer's Book Stall, Guwahati.

Barah, B.C. and Rajiv Betne, 2000, *Rice in Assam, in Prioritisation of Strategies for Agricultural Development in North eastern* India, Barah B.C. (ed), Proc series, National Centre for Agricultural Economics and Policy Research, New Delhi.

Barah, B. C. and A. K. Noeg; 1997, *Prospects of Agricultural Development in Flood-prone Ecosystem*, Journal of Agricultural Economic Research, Vol 10, pp 65-77.

Barah B C et al, 2003, *Final report of Socio Economic Dynamics of Rice Production Systems in Eastern India*, submitted to the AED (NATP), CRIDA, Hyderabad.

Bardoloi, G. and A. K. Neog, 1986; *Economy of North East India*, B N Press, Guwahati.

Bhowmick, B.C. and Borthakur N., 2002, *Final Report on Socio Economic Dynamics of Changes in Rice Production System in Assam*, NATP (RRPS 2), Department of Agricultural Economics, Assam Agricultural University, Jorhat-785013.

Bhowmick, B.C., B.C. Barah, and N. Borthakur, 2003, *Socio Economic Dynamics of Rice Economy in Assam: A 3-tier Disaggregates Level Analysis*. (Report on RRPS2) submitted to PIU, CRIDA, Hyderabad.

Birthal, P. S., 1995, *Structure of Rural Income Inequality: A Study of Western Uttar Pradesh*; Indian Journal of Agricultural Economics, vol 50, pp168-175.

Hossain, Mahbub and J. Thakur, 2002, *Impact of Modern Rices in Irrigated and Rainfed Environments*; paper presented at the International Conference in "Impact of Research and Development", San Jose, Costa Rica, 4-7 Feb 2002.

Huke, R. and E. H. Huke, 1997; *Rice Area in South, South Asia and East Asi*a; a revised and updated data base, IRRI, Manila.

Government of Assam; 2003; *Assam Human Development Report*, Guwahati, Assam

Government of Assam; 2005; *Economic Survey of Assam*, Chapter 4, Guwahati, Assam

Goswami, P.C., 1989; *Agriculture in Assam,* Assam Institute of Development Studies, Guwahati.

Pal, S. and A. Singh, 1997, *Agricultural Research And Extension in India: Institutional Structure and Investments,* National Center for Agricultural Economics and Policy Research, New Delhi, India, Policy paper No.9.

Pal, S. and D. Byerlee, 2003; *Funding and Organisation of Agricultural Research in India; Evolution and Emerging Policy Issues*, Policy Paper No. 16, NCAP New Delhi.

Pandey, S and Pal S., 2000, *The Nature and Causes of Changes in Variability of Rice Production in Eastern India: a District -level Analysis*. In: Proc. Risk Analysis and Management in Rainfed Rice Systems, Eds: S. Pandey, B.C. Barah, R.A.Villano and S. Pal, International Rice Research Institute, Los Baños, Philippines. Manila, Philippines, p 73-96.

Pandey, S., B. C. Barah and R.A. Villano, 2000, *Socio Economic Dynamics of Rice Economy in Assam: A methodological note*, RRPS 2, NATP, New Delhi.

Planning Commission, 2000, *Expert Group on Poverty Estimate,* Govt. of India, New Delhi (June).

Singh, V.P., and R. K. Singh (ed), 2000, *Rainfed Rice: A Source Book of Best Practices and Strategies in Eastern India*, IRRI, Philippines.

[i] Assam policy paper revised at NCAP March 7 05, 4/15/05

APPENDIX STATISTICAL TABLES

Table A1: Rice Area by Ecosystems in Assam

	Ecosystem	Area (000 ha)		% total share
Rainfed rice		1971	% of rainfed area	
Upland		544	28	22
Shallow (medium land)	(0-30 cm)	629	32	25
Intermittent (lowland)	(30-100 cm)	514	26	21
Deep water	(>100 cm)	272	14	11
			100	
Irrigated rice				
Wet season		412		17
Dry season		117		5
Total Rice Area		2490		100

Source: Huke R and E H Huke 1997; Rice Area by Type of Culture: South Asia and East Asia; A revised and updated data base, IRRI

Table A2: Trends in average share of area and production by season in Assam (in per cent)

	1970-1979	1980-1989	1999-2001
Share of Rice Area			
Winter	71	72	68
Autumn	27	26	20
Summer	22	13	
Total	100	100	100
Share of Rice Production			
Winter	79	80	70
Autumn	19	17	13
Summer	23	17	
Total	100	100	100

Table A3: Decadal trends in cropping pattern in Assam (in per cent)

	1970s	1980s	1990s
Cereals (Rice wheat, maize)	80.6	79.4	80.6
Rice only	77.0	75.6	77.5
Pulses	3.5	4.1	2.9
Fibres	6.1	3.9	3.0
Oilseeds	6.3	10.0	8.1
Others	2.1	3.3	4.4

Source: Estimated from time series secondary data

Table A4: Decadal compound growth rates of Area, Production and Yield

(in percent)

Season	Period	Area		Production		Yield	
Autunm							
	1970-1979	1.29**	(2.05)	-0.16	(0.09)	-1.45	(1.06)
	1980-1989	-0.13	(0.20)	-1.17	(0.78)	-1.04	(1.07)
	1990-2001	-1.83***	(4.38)	-0.56	(0.77)	1.27**	(1.98)
Winter							
	1970-1979	1.58***	(9.35)	0.82	(1.46)	-0.75	(1.54)
	1980-1989	0.68***	(2.62)	1.25	(1.62)	0.57	(0.91)
	1990-2001	-0.36**	(1.59)	0.57	(1.36)	0.93***	(3.58)
Summer							
	1970-1979	1.79	(1.66)	-3.93	(1.06)	-5.72	(1.59)
	1980-1989	8.14***	(8.25)	11.65***	(4.80)	3.5**	(2.03)
	1990-2001	9.88***	(8.74)	12.64***	(8.23)	2.75***	(5.23)
Total							
	1970-1979	1.51***	(5.61)	0.6	(0.81)	-0.91	(1.61)
	1980-1989	0.66**	(2.30)	1.07	(1.35)	0.41	(0.69)
	1990-2001	0.13	(0.67)	1.68***	(4.04)	1.56***	(5.63)

Note: Bracketed value indicates t-value

*** indicate level of significance at 1% prob. Level, ** at 5% prob. level and * at 10% prob. Level

Table A5: Relative share of rice area in different Agro-ecological Zones (% of state area by season in 1999-2001)

Agro-ecological zones	Total	Autumn	Winter	Summer
Hill Zone	5	3	7	1
Barak Valey	9	4	11	5
Central Brahmaputra valley	14	12	11	32
Upper Brahmaputra valley	17	6	22	2
North Bank Plains	20	25	20	15
Lower Brahmaputra valley	36	50	30	45
ALL	100	100	100	100

Table A6: Relative importance of rice by culture across the agro-ecological zones (% rice area) (TE 2001-2002)

	Winter	Autumn	Summer	Total
Hill Zone	86	13	1	100
Barak Valey	84	10	6	100
Central Brahmaputra valley	54	19	27	100
Upper Brahmaputra valley	91	8	2	100
North Bank Plains	66	26	9	100
Lower Brahmaputra valley	56	30	14	100

Table A7: Long term compound growth rates of Area, production and yield of rice by zones (1970-2001)

Zones	Rice	Autumn	Winter	Summer	Total
Barak valley	Area	-3.01	0.78	0.85	0.18
	Production	-1.91	3.31	2.2	2.31
	Yield	1.17	2.44	1.28	2.08
Central Brahmaputra valley	Area	1.62	0.12	10.82	1.57
	Production	4.27	1.64	13.68	3.75
	Yield	2.31	1.45	2.59	2.15
Hill zone	Area	-0.23	1.85	4.19	1.64
	Production	0.09	2.45	5.65	2.22
	Yield	0.32	0.59	1.4	0.57
Lower Brahmaputra Valley	Area	-0.15	0.01	8.71	0.45
	Production	1.1	1.15	10.06	2.01
	Yield	1.39	1.17	1.05	1.57
North Bank Plains	Area	1.29	0.49	12.6	0.96
	Production	2.59	1.45	13.76	1.98
	Yield	1.3	0.96	0.98	1.02
Upper Brahmaputra Valley	Area	1.71	1	12.35	1.09
	Production	3.9	2.2	14.79	2.37
	Yield	2.15	1.18	2.17	1.27

Table A8: Percentage state total of Area, production and yield of Rice in Assam 1999-01

District	Area share %	Production share %	Av. Yield t/ha
Low yield districts	**61**	**52**	**1.98**
K.Anglong	5	5	2.17
Lakhimpur	8	6	1.78
Darrang	14	12	1.97
Goalpara	15	13	2.01
Kamrup	20	17	1.94
High yield districts	**39**	**48**	**2.74**
N.C.Hills	1	1	2.50
Dibrugarh	6	6	2.45
Cachar	8	12	3.15
Sibsagar	11	14	2.87
Nagaon	13	16	2.75
ASSAM	2591	5949	
	(000 ha)	**(000 ton)**	**2.30**

Table A9: Relative importance of rice in Assam (%Share of Area & production of rice by season)

		Area %			Production (%)			Yield (t/ha)		
District	**Rice**	**1980s**	**1990s**	**1999-01**	**1980s**	**1990s**	**1999-01**	**1980s**	**1990s**	**1999-01**
Cachar	Winter	78	82	82	78	84	84	1.93	2.54	3.19
	Autumn	17	12	11	18	11	11	2.00	2.34	3.10
	Summer	5	6	7	4	5	6	1.43	2.02	2.52
	Total	**100**	**100**	**100**	**100**	**100**	**100**	**1.92**	**2.50**	**3.15**
Darrang	Winter	69	65	61	80	72	67	1.80	2.01	2.18
	Autumn	30	31	32	20	23	24	1.02	1.39	1.46
	Summer	1	4	8	1	5	9	1.72	2.16	2.38
	Total	**100**	**100**	**100**	**100**	**100**	**100**	**1.56**	**1.83**	**1.97**
Dibrugarh	Winter	86	87	88	90	88	90	2.04	2.33	2.51
	Autumn	14	12	11	10	12	9	1.47	2.25	2.02
	Summer	0	0	0	0	0	1	1.78	2.75	3.08
	Total	**100**	**100**	**100**	**100**	**100**	**100**	**1.96**	**2.32**	**2.45**
Goalpara	Winter	59	54	53	69	62	50	1.51	1.78	1.94
	Autumn	38	38	28	27	26	18	0.91	1.17	1.36
	Summer	3	8	19	4	13	31	1.77	2.52	3.03
	Total	**100**	**100**	**100**	**100**	**100**	**100**	**1.29**	**1.67**	**2.01**
K. Anglong	Winter	92	90	90	93	92	92	2.01	2.22	2.24
	Autumn	10	9	9	7	7	7	1.31	1.72	1.59
	Summer	0	1	1	0	1	1	1.81	2.53	1.81
	Total	**100**	**100**	**100**	**100**	**100**	**100**	**2.00**	**2.17**	**2.17**
Kamrup	Winter	63	62	59	73	68	59	1.59	1.83	1.94
	Autumn	36	32	25	24	22	17	0.92	1.17	1.39
	Summer	2	6	16	3	10	24	1.88	2.85	2.73
	Total	**100**	**100**	**100**	**100**	**100**	**100**	**1.36**	**1.68**	**1.94**
Lakhimpur	Winter	80	77	72	86	83	80	1.92	1.97	1.97
	Autumn	20	19	15	14	14	10	1.22	1.24	1.14
	Summer	0	4	13	0	3	10	1.73	1.97	1.41
	Total	**100**	**100**	**100**	**100**	**100**	**100**	**1.78**	**1.81**	**1.78**
N.C.Hills	Winter	53	56	59	61	64	69	2.13	2.81	2.95
	Autumn	47	44	41	39	36	31	1.48	2.01	1.86
	Summer	0	0	0	0	0	0	1.82	2.65	3.68
	Total	**100**	**100**	**100**	**100**	**100**	**100**	**1.82**	**2.46**	**2.50**
Nagaon	Winter	69	56	53	75	55	49	1.77	2.20	2.49
	Autumn	26	24	18	18	17	11	1.13	1.55	1.47
	Summer	5	21	29	7	28	40	2.02	3.19	3.76
	Total	**100**	**100**	**100**	100	100	100	1.62	2.31	2.75
Sibsagar	**Winter**	**89**	**90**	**92**	**92**	**93**	**95**	**2.22**	**2.69**	**2.94**
	Autumn	10	9	6	8	6	4	1.61	1.71	1.95
	Summer	0	1	2	0	1	2	1.84	2.78	2.88
	Total	**100**	**100**	**100**	**100**	**100**	**100**	**2.16**	**2.61**	**2.87**
ASSAM	Winter	72	69	67	80	75	70	1.84	2.17	2.38
	Autumn	26	24	20	17	16	13	1.11	1.35	1.53
	Summer	2	7	13	2	9	17	1.79	2.66	3.08
	Total	**100**	**100**	**100**	**100**	**100**	**100**	**1.65**	**2.01**	**2.30**

Table A10: Trends in cropping pattern (% Area to gross cropped area) in Assam by district

	Triennium ending				Triennium ending			
Crop	**1982**	**1985**	**1991**	**1998**	**1982**	**1985**	**1991**	**1998**
Kamrup						**Darrang**		
Total cereal area	**76**	**73**	**77**	**78**	**73**	**74**	**75**	77
Rice Total	**70**	**78**	**74**	**76**	**66**	**69**	**73**	75
Maize	4	6	3	3	4	5	2	2
Wheat	0	0	0	0	0	1	0	0
Total pulses	5	7	5	5	4	4	3	4
Total foodgrain	**82**	**77**	**82**	**83**	**77**	**78**	**78**	81
Oilseed	7	12	9	9	9	11	12	10
Total fibre	4	5	3	3	5	4	4	3
Banana					1	1	1	1
Potato	1	2	3	3	1	2	2	3
Sugarcane	1	1	0	0	1	1	1	1
Turmeric	0	0	0	0				
GCA	100	100	100	100	100	100	100	100
Goalpara						**Sibsagar**		
Total cereal area	**77**	**93**	**94**	**94**	**81**	**88**	**86**	86
Rice Total	**74**	**91**	**93**	**93**	**78**	**104**	**84**	85
Maize	0	0	0	0	1	1	2	1
Wheat	4	2	1	1	0	0	0	0
Total pulses	4	2	2	1	3	2	2	3
Total foodgrain	**81**	**95**	**96**	**95**	**83**	**90**	**88**	88
Oilseed	7	2	2	2	10	6	8	6
Total fibre	7	2	1	1	1	1	0	0
Sugarcane	0	0	0	0	3	3	2	1
GCA	100	100	100	100	100	100	100	100
Nagoan						**Cachar**		
Total cereal area	**70**	**68**	**79**	**78**	**93**	**91**	**93**	91
Rice Total	**68**	**64**	**74**	**76**	**91**	**91**	**93**	91
Maize	4	4	5	2	0	0	0	1
Wheat	0	0	0	0	0	0	0	0
Total pulses	5	5	3	3	1	1	1	1
Total foodgrain	**75**	**78**	**82**	**81**	**93**	**92**	**94**	93
Oilseed	9	9	8	9	1	2	2	1
Total fibre	7	6	4	4	0	0	0	0
Potato	1	1	1	1	1	2	2	2
Sugarcane	2	3	2	2	3	2	1	2
Turmeric					0	0	0	0
GCA	100	100	100	100	100	100	100	100

Crop	**1982**	**1985**	**1991**	**1998**	**1982**	**1985**	**1991**	**1998**
K Anglong						**Lakhimpu**		
Total cereal area	**77**	**80**	**80**	**78**	**71**	**72**	**78**	**84**
Rice Total	**65**	**73**	**73**	**73**	**74**	**71**	**76**	83
Maize	1	1	1	1	1	1	1	1
Wheat	7	6	7	5	0	0	0	0
Total pulses	2	2	2	2	4	4	1	2
Total foodgrain	**78**	**82**	**82**	**80**	**75**	**77**	**79**	86
Oilseed	10	10	11	12	14	17	16	9
Total fibre	2	2	2	2	1	1	1	0
Potato	0	0	1	1	1	2	2	3
Sugarcane	4	3	2	3	1	1	0	0
GCA	100	100	100	100	100	100	100	100
N C Hill						**Dibrugarh**		
Total cereal area	**72**	**70**	**69**	**68**	**77**	**76**	**84**	83
Rice Total	**67**	**65**	**63**	**62**	**74**	**73**	**82**	82
Maize	0	0	0	0	4	2	1	0
Wheat	4	4	5	6	3	1	1	0
Total pulses	2	4	4	5	4	6	1	3
Total foodgrain	**75**	**74**	**72**	**72**	**81**	**82**	**85**	86
Oilseed	9	12	12	12	9	12	11	9
Total fibre	7	7	5	2	0	0	0	0
Banana	1	1	2	2				
Chillies	1	1	1	1				
Potato	1	1	1	1	1	2	1	2
Sesamum	1	2	2	2				
Sugarcane	1	1	4	6	3	2	1	0
Turmeric	1	1	1	1				
GCA	100	100	100	100	100	100	100	100
ASSAM								
Total cereal area	**76**	**77**	**79**	**79**				
Rice Total	**72**	**74**	**76**	**75**				
Maize	1	1	1	1				
Wheat	4	3	3	3				
Total pulses	4	4	3	3				
Total foodgrain	**80**	**81**	**82**	**82**				
Oilseed	11	10	9	7				
Total fibre	4	3	3	4				
Banana	1	1	1	1				
Potato	2	2	2	1				
Sugarcane	2	1	1	1				
GCA	100	100	100	100				

Table A11: Compound growth rates of Area, production and yield by season (1970-2001)

(in percent)

District	Rice	Autumn	Winter	Summer	Total
Cachar	Area	-4.98 ***	0.25	-0.21	-0.42 ***
	Production	-2.74	2.53 ***	4.09 **	1.99 **
	Yield	2.36	1.98 **	4.03 **	2.18 **
Darrang	Area	1.35 **	0.14	16.27 ***	1.06 ***
	Production	2.44 **	0.95	19.54 ***	2.00 ***
	Yield	1.10	0.8	3.01 *	0.94 **
Dibrugarh	Area	-1.7 ***	0.08	11.62 ***	-0.1
	Production	-1.26	0.59	14.38 ***	0.45
	Yield	0.44	0.48	2.75 ***	0.52 *
Goalpara	Area	-2.41 ***	-0.9 ***	15.32 ***	0.20
	Production	0.31	-0.71	20.39 ***	2.87 ***
	Yield	3.39 **	0.33	4.01 ***	2.73 ***
K. Anglong	Area	0.07	-0.15	21.83 ***	0.01
	Production	0.92	0.49	19.94 ***	0.64
	Yield	0.85	0.63	-1.89	0.64
Kamrup	Area	-1.10	-0.46 **	12.58 ***	0.47 ***
	Production	0.91	0.59	14.31 ***	2.49 ***
	Yield	2.57 **	1.05 **	1.13 *	2.00 ***
Lakhimpur	Area	-2.45 ***	-1.22	41.94 ***	0.03
	Production	-3.29	-1.43	34.62 ***	-0.58
	Yield	-0.73	0.13	-6.9 ***	-0.26
Nagaon	Area	-2.87 ***	-0.66	4.45 ***	0.06
	Production	-1.67	1.05	8.32 ***	2.91 ***
	Yield	-0.36	1.37 **	3.9 ***	2.88 ***
NC Hills	Area	-1.12 ***	-0.04	2.08	-0.49
	Production	-1.09	2.45 **	6.1	1.2
	Yield	0.02	2.5 **	4.01 ***	1.69 **
Sibsagar	Area	-9.64 ***	-0.33	36.81 ***	-0.9 **
	Production	-8.94 ***	0.15	39.06 ***	-0.08
	Yield	1.41	0.51	2.23 ***	0.84 *
Assam	Area	-0.58	0.68 **	12.02 ***	1.01 ***
	Production	0.26	1.94 **	14.41 ***	2.59 **
	Yield	0.84	1.26 *	2.39	1.58 **

*** Significant at 1% prob. Level, ** Significant at 5% prob. level

* Significant at 10% prob. Level

Table A12 : Compound growth rates of Area, production and yield by season

Decade	District		Area	Autumn Producti	yield	Area	Winter Producti	Yield	Area	Summer Productio	Yield	Area	Total Product
1970s	Cacher	b	244 *	-2.63	-5.07 **	1.96 ***	-0.18	-2.14	1.15 *	-4.7	-5.85	1.98 ***	-1.1
		t	(1.79)	(1.02)	(2.30)	(5.36)	(0.09)	(1.25)	(1.42)	(0.67)	(0.79)	(6.43)	(0.81)
1980s		b	-6.58 ***	-10.01	-3.43 *	0.76	4.22 *	3.46 *	6.69 ***	1.15	4.84	-0.22	1.81
		t	(2.49)	(3.24)	(1.73)	(1.43)	(1.84)	(1.70)	(6.05)	(1.54)	(0.69)		(0.86)
1990s@			-4.979 ***	-2.737	2.355	0.254	2.528 ***	1.979 **	-0.214	4.091 **	4.028 **	-0.420 ***	1.985**
			(5.03)	(1.29)	(1.54)	(1.21)	(2.88)	(2.22)	(0.21)	(2.02)	(2.33)	(3.89)	(2.17)
	Darrang												
1970s		b	3.15 ***	-0.78	-3.93	1.96 ***	0.12	-1.84 *	-7.82 **	-15.9 ***	-8.08 ***	2.26 ***	-0.19
		t	2.94	(0.28)	(1.73)	4.34	0.12	(2.04)	(2.32)	(2.78)	(2.58)	3.77	(0.15)
1980s		b	3.31 ***	3.99 **	0.68	0.91	3.18 **	2.27 **	15.13 ***	12.12 ***	-3.01	1.7 ***	3.41 ***
		t	(4.48)	(2.15)	(0.50)	(1.43)	(2.25)	(2.20)	(3.93)	(2.51)	(1.26)	(2.90)	(2.72)
1990s		b	1.350 **	2.444 **	1.103	0.144	0.955	0.796	16.266 ***	19.543 ***	3.009 **	1.057 ***	2.002 ***
		t	(1.71)	(2.13)	(1.28)	(0.28)	(1.31)	(1.60)	(4.20)	(4.31)	(1.89)	(2.62)	(3.19)
	Dibrugar	h											
1970s		b	-0.02	-0.72	-0.71	2.99 ***	3.14	0.15	-33.20 **	-37.46 **	-4.26	2.74 ***	2.86 *
		t	(0.01)	(0.17)	(0.29)	(4.38)	(2.15)	(0.12)				(3.40)	(1.79)
1980s		b	0.83	0.66	-0.17	0.3	0.9	0.6	-9.98	-7.02	2.95	0.37	0.91
		t	(0.38)	(0.21)	-0.10	(0.44)	(1.25)	(0.68)	(0.64)	(0.44)	(1.47)	(0.46)	(1.14)
1990s		b	-1.703 ***	-1.265	0.439	0.080	0.592	0.482	11.622 ***	14.380 ***	2.754 ***	-0.099	0.450
		t	(2.66)	(0.97)	(0.38)	(0.38)	(1.56)	(1.33)	(3.51)	(4.06)	(5.29)	(0.56)	(1.25)
	Goalpara												
1970s		b	0.51	-2.03	-2.54	0.87 *	-0.2	-1.07	-2.05	-7.64	-5.6 ***	0.66	-0.96
		t	1.09	(0.92)	(1.34)	(1.97)	(0.19)	(1.01)	(0.68)	(1.60)	(2.05)	(1.56)	(0.76)
1980s		b	-1.56 ***	-2.58 **	-1.02	-0.1	0.16	0.26	7.23 ***	7.55 ***	0.32	-0.45	-0.3
		t	(3.60)	(1.92)	(1.00)	(0.21)	(0.15)	(0.37)	(4.26)	(3.32)	(0.20)	(1.43)	(0.38)
1990s		b	-2.412 ***	0.314	3.394 **	-0.897 ***	-0.705	0.331	15.324 **	20.387 ***	4.011 ***	0.205	2.870 ***
		t	(3.70)	(0.20)	(2.28)	(2.55)	(0.82)	(0.42)	(9.01)	(6.81)	(2.84)	(0.81)	(3.88)

	K												
1970s		b	-3.18	-4.68	-1.5	6.31 ***	6.42 **	0.11	-18.60 **	-25.96 ***	-7.36 *	4.96 ***	5 **
		t	(1.00)	(1.33)	(1.15)	(2.93)	(2.43)	(0.09)	(2.43)	(4.86)	(1.91)	(2.54)	(2.08)
1980s		b	-0.15	-6.97 **	-6.82 **	2.15 ***	-0.82	-2.97 **	14.41 ***	17.83 ***	3.43 *	2.52 **	-1.23
		t	(0.05)	(2.45)	(2.40)	(6.09)	(0.61)	(2.32)	(3.17)	(3.07)	(1.94)	(2.59)	(0.89)
1990s		b	0.072	0.922	0.580	-0.148	0.486	0.634	21.828 ***	19.943 ***	-1.885	-0.004	0.369
		t	(1.19)	(0.82)	(0.80)	(0.45)	(0.59)	(0.91)	(3.36)	(3.08)	(1.17)	(0.01)	(0.81)
	Kamrup												
1970s		b	1.22 **	3.15	1.93	1.15 ***	0.09	-1.06	-1.57	-7.73	-6.16 *	1.13 ***	0.73
		t	(2.12)	(1.42)	(0.91)	(7.14)	(0.08)	(0.90)	(0.66)	(1.52)	(1.76)	(6.17)	(0.66)
1980s		b	-2.15 **	-3.41	-1.26	2.16 ***	2.94 *	0.79	9.57 ***	12.69 ***	3.12 **	0.77	1.6
		t	(2.07)	(1.03)	(0.49)	(4.38)	(1.92)	(0.65)	(5.22)	(4.27)	(2.05)	(1.53)	(1.21)
1990s		b	-1.099	0.914	2.575 **	-0.463 **	0.587	1.047 **	12.578 ***	14.305 ***	1.133 *	0.470 ***	2.485 ***
		t	(1.14)	(0.64)	(2.23)	(2.32)	(0.94)	(2.17)	(7.76)	(8.58)	(1.73)	(2.94)	(4.31)
	Lakhimp												
1970s		b	3.29 *	1.36	-1.94	1.07 *	0.55	-0.52	30.63 ***	26.98 ***	-3.65	1.43	0.6
		t	(1.96)	(0.49)	(0.98)	(1.77)	(0.45)	(0.60)	(5.77)	(6.00)	(1.01)	(3.21)	(0.55)
1980s		b	5.63 ***	5.11 ***	-0.52	2.61 ***	2.03 ***	-0.58	-7.28 **	-0.73	6.55 **	3.2 ***	2.42 **
		t	(8.12)	(2.89)	(0.43)	(5.96)	(2.07)	(0.69)	(2.56)	(0.43)	(2.06)	(9.35)	(2.51)
1990s		b	-2.449 ***	-3.288	-0.731	-1.222 *	-1.432	0.128	41.935 ***	34.621 ***	-6.896 ***	0.025	-0.575
		t	(4.91)	(1.23)	(0.32)	(1.65)	(1.51)	(0.26)	(14.04)	(11.02)	(5.64)	(0.04)	(0.55)
	N C Hill												
1970s		b	-3.82 **	-7.65 ***	-3.82 ***	4.1 **	2.39	-1.72	26.86 ***	32.82 ***	86.55 ***	-0.62	-2.97
		t	(2.14)	(5.22)	(3.77)	(2.61)	(0.77)	(0.95)	(2.78)	(2.78)	(2.78)	(0.41)	(1.52)
1980s		b	0.24	0.13	-0.11	-0.83 ***	-0.52	-1.35	22.28 ***	25.63 ***	3.35 *	0.57 *	-0.24
		t	(0.42)	(0.06)	(0.06)	(2.64)	(0.33)	(0.85)	(2.93)	(3.07)	(1.86)	(1.88)	(0.14)
1990s		b	-1.117 ***	-1.094	0.023	-0.043	2.454 *	2.497 **	2.083	6.097	4.015 ***	-0.495	1.199
		t	(2.82)	(0.92)	(0.03)	-0.05	(1.63)	(2.22)	(0.28)	(0.85)	(4.90)	(0.91)	(1.05)

Table A13: General household characteristics in sample areas

Characteristics	Nagaon	Golaghat
Number of respondents	75	75
Average household size	6.3	6.5
Average age of household head (years)	54.8	44.5
Av No. of years in school of household head	8.0	7.8
Household composition (%)		
Male	58	53
Female	42	47
Age group (%)		
< 16 years old	20	24
16 to 50 years old	64	62
> 50	16	14
Education		
Illiterate	17	17
Government training	-	17
Primary	24	20
Secondary to High School	42	52
College/University	17	11
Occupation (%)		
Agriculture	57	70
Salaried job	10	10
Service	9	9
Private business	9	8
Others	15	3
Poverty % (head count; BPL=Rs.11800)		
Marginal farmers	67	43

Note: * students are excluded from the work force.

Table A14: Average size of landholdings and respective percentage in different farm size categories(ha)

District	Marginal	Small	Medium	Large	All
Ownership holdings					
Golaghat	0.55	1.22	2.41	5.67	1.83
Nagaon	0.64	1.33	2.44	5.60	2.34
Operational holdings					
Golaghat	1.03	1.62	2.56	5.67	2.13
Nagaon	1.31	1.60	2.64	5.87	2.65

Table A15: Area under various land type across farm size (in Percent)

Land type	Marginal	Small	Medium	Large	Total
Golaghat					
Medium	47	34	34	41	37
Lowland	45	43	46	53	46
Upland Bunded	6	6	9	0	6
Upland Unbunded	2	8	8	3	7
Very lowland	0	9	3	3	4
Nagaon					
Medium	68	68	37	38	49
Lowland	30	19	48	40	35
Upland Bunded	2	10	6	11	9
Upland Unbunded	0	3	9	10	7
Very lowland	0	0	0	1	1

Table A16: Area under different soil types (in Percent)

	Marginal	Small	Medium	Large
Golaghat				
Clay	13	2	4	0
Clay loam	32	39	43	10
Sandy clay loam	17	8	9	2
Sandy loam	26	47	43	70
Loamy sand	12	0	1	12
Loam	0	4	0	6
Sandy	1	0	0	0
Nagaon				
Clay	7	39	29	60
Clay loam	0	6	20	12
Sandy clay loam	5	9	16	8
Sandy loam	88	42	28	17
Loamy sand	0	2	7	0
Loam	0	2	0	0
Sandy	0	1	1	3

Table A17: Area under land types and soil types (in Percent)

	Lowland	Medium	Upland (B)	Upland (UB)	Total
Golaghat					
Loamy sand	3	8			5
Clay	5	2	0	0	3
Loam	5	1		1	3
Sandy clay loam	13	5		4	8
Clay loam	28	17		55	30
Sandy Loam	45	67		37	51
Nagaon					
Clay	58	30	23	44	40
Sandy Loam	15	52	49	13	36
Clay loam	19	3	6	11	10
Sandy clay loam	6	12	17	7	10

Table A18: Cropping pattern by farm size (% area)

Crops		Category		
	Marginal	Small	Medium	Large
Golaghat				
Rice	89	84	84	86
Jute	4	0	0	0
R&M	2	1	2	4
Potato	0	3	1	3
Pea	2	0	0	2
Sugarcane	1	8	10	2
Vegetable	3	3	2	3
Nagaon				
Rice	86	85	84	85
R&M	4	4	4	4
Jute	5	5	5	4
Sugarcane	0	3	5	6
Potato	1	1	0	0
Pea	0	1	1	0
Lentil	0	1	0	0
Vegetable	3	1	1	0

Table A19: Adoption of Modern rice Variety by season (% Total rice area, # plots) by farm size

Season	Marginal		Small		Medium		Large		Total	
	Golaghat									
Autumn	77	(8)	84	(19)	77	(7)	84	(4)	81	(49)
Winter	45	(15)	63	(66)	54	(51)	49	(16)	55	(376)
Summer	23	(1)	45	(3)	66	(5)	16	(3)	40	(12)
	Nagaon									
Autumn	54	(7)	45	(12)	41	(2)	26	(4)	41	(52)
Winter	43	(8)	62	(48)	62	(28)	67	(54)	64	(259)
Summer	21	(4)	78	(19)	71	(12)	55	(7)	61	(76)

Bracketed values denote the number of plots

Table A20: Area under different rice variety by farm size (in Percent)

District	Variety	Marginal	Small	Medium	Large	Total
Golaghat	Modern variety	45	60	59	47	55
	Traditional variety	56	40	41	53	45
Nagoan	Modern variety	30	52	50	54	51
	Traditional variety	70	48	50	46	50

Table A21: Adoption of modern rice variety by land type and farm size (in percent)

	Marginal		Small		Medium		Large		Grand Total	
	Golaghat									
Upland B	90	(1)	-	(2)	56	(2)	-		83	(5)
Upland U	59	(1)	-	(14)	60	(6)	-	(2)	82	(23)
Medium	41	(9)	62	(34)	67	(28)	23	(4)	54	(75)
Lowland	43	(14)	68	(56)	63	(38)	60	(18)	62	(126)
	Nagaon									
Upland B	-	(1)	73	(7)	70	(3)	45	(5)	58	(16)
Upland U	-	0	27	(2)	30	(1)	49	(3)	40	(6)
Medium	35	(14)	64	(49)	45	(13)	75	(27)	61	(103)
Lowland	45	(4)	61	(21)	75	(25)	62	(30)	65	(80)

Note: Bracketed values denote the number of plots

Table A22: Popular rice varieties in Golaghat and Nagaon

	Duration	% Area	Yield (t/ha)
Golaghat	**Modern varieties**		
Biplab	150-180	29	4.5
Masuri	130-140	20	2.3
Ranjit	145-155	14	3.7
Prasadbhog	140-150	15	2.2
Nagaon			
Masuri	130-140	37	4.4
Ranjit	145-155	29	4.3
Bahadur	145-155	14	4.6
Pankaj	130-140	3	5.2
Golaghat	**Traditional Varieties**		
Solpana	130-140	22	1.2
Bora	145-155	16	1.8
Gethu	135-150	11	2.0
Jahinga	130-150	4	0.3
Nagaon			
Laxmanhbog	140-150	16	3.9
Badal bao	180-200	8	3.6
Dhusuri	135-145	6	3.4
Boroi	140-150	3	1.8
Lucky	-	13	3.8
Kajalchuk	-	11	3.0

Table A23: Rice yield by land type and variety

Variety	Land type	Marginal	Medium	Small	Large	Total
	Golaghat					
Modern	Upland B	3.70	4.47	5.42	5.16	4.69
	Upland UB	5.42	3.71	5.92		5.02
	Medium land	2.96	3.15	3.15	1	2.57
	Low Land	4.17	3.5	3.22	3.23	3.53
	Very lowland		4.08	3.70		3.89
Traditional	Upland B	2.07	1.83			1.95
	Upland UB		1.48			1.48
	Medium land	2.75	1.8	2.1	1.24	1.97
	Low Land	1.68	2.22	1.55	1.24	1.67
	Very lowland		2.86	1.13		2.00
	Nagoan					
Modern	Upland B		5.58	4.99	4.63	5.07
	Upland UB		4.3	4.59	4.54	4.48
	Medium land	4.69	3.58	4.56	3.93	4.19
	Low Land	4.37	4.29	4.98	4.69	4.58
Traditional	Upland B		3.05	4.36	2.72	3.38
	Upland UB		3.08	4.16	2.75	3.33
	Medium land	3.22	2.43	3.6	3.95	3.30
	Low Land	3.52	3.58	3.91	3.92	3.73
	Very lowland				2.29	2.29

Table A24: Weighted rice yield (ton/ha)

District	Modern Variety	Traditional Variety
Golaghat	3.7	2.7
Nagaon	4.6	3.9

Table A25: Yield of paddy by farm size category and variety

Variety	Marginal	Small	Medium	Large	Total
	Golaghat				
Modern	3.4	4.0	3.7	3.3	3.8
Traditional	2.4	3.3	2.2	2.6	2.7
Difference	**1.0**	**0.7**	**1.5**	**0.7**	**1.1**
Total	2.8	3.7	3.1	3.0	3.3
	Nagoan				
Modern	4.4	4.8	4.5	4.5	4.6
Traditional	4.5	4.0	3.7	3.8	3.9
Difference		**0.8**	**0.8**	**0.6**	**0.7**
Total	4.5	4.5	4.1	4.2	4.3

Table A 26: Yield and input use by modern and traditional variety

Item	Units	Nagaon				Golaghat			
		Traditional Varieties (1)	Modern Varieties (2)	Difference (2-1)	All	Traditional Varieties (3)	Modern Varieties (4)	Difference (4-3)	All
Yield	t/ha	3.52	4.60	1.08	4.07	2.30	3.64	1.34	3.08
Material inputs									
Seed	Kg/ha	47	45	2	47	46	44	2	45
Fertilizer	Kg/ha	**26**	**69**	**43**	**53**	**14**	**67**	**53**	**48**
N		15	42	27	34	6	33	27	25
P		1	10	9	6	5	19	14	13
K		10	17	7	12	4	16	12	10
Insecticide	Kg/ha	0	0	0	0	—	—		-
Manure	t/ha	6	4	-2	3	2	3	1	2
Bullock	hrs/ha	142	154	12	147	267	281	14	272
Tractor		3	9	5	7	2	2	0	2
Irrigation		-	31	31	31	-	11	11	11
Labor inputs	Days /ha								
Land preparation		20	30	10	28	34	36	2	35
Crop establishment		25	35	10	32	26	32	6	29
Fertilization		2	6	4	4	1	8	7	5
Weeding		14	18	5	17	5	10	5	8
Irrigation		-	7	7	7	-	2	2	2
Harvestg/Threshing		33	41	8	39	42	42	-1	41
Winnowg/Hauling		11	15	5	13	15	14	-1	14
Total labor		103	152	49	140	123	143	20	133

Table A27: Labour use in cultivation various crops (in percent)

Crop	Total labour input (person days/ha)	Male	Female
	Nagaon		
Rice	139	58	42
Wheat	-	67	33
Jute	103	70	30
Oilseeds	50	70	30
Pulses	-	65	35
Vegetables	-	74	26
	Golaghat		
Rice	133	58	42
Wheat	-	66	34
Oilseeds	-	68	32
Pulses	-	60	40
Sugarcane	143	69	31
Vegetables	-	72	27

Table A28: Total labour use for rice production by operation and gender in Assam (person days/ha)

Operation	Male	Female	Total
	Golaghat		
Land preparation	34	-	34
Crop Establishment	2	22	28
Fert. Application.	5		5
Weeding	4	1	7
Irrigation	1		1
Harvesting	11	12	27
Threshing	10		14
Winnowing	0	8	8
Hauling	3	3	6
Total labor	73	43	130
	Nagaon		
Land preparation	23	3	26
Crop Establishment	12	17	30
Fert. Application.	3		3
Weeding	7	9	16
Irrigation	7		7
Harvesting	13	14	28
Threshing	7	4	11
Winnowing	1	6	7
Hauling	4	3	7
Total labor	78	54	135

Table A29: Factors determining adoption of modern rice variety (Probit Model) in Golaghat and Nagaon

Golaghat		
Variables	**Co-efficient**	**t-ratio**
Household characteristics		
Constant	-0.184	-0.29
Age	0.008	0.99
Education	0.045 *	2.35
Farm size	-0.101	-1.25
Labour-land ratio	-0.007 ***	-1.76
Parcel characteristics		
Clay loam	0.037 *	2.90
Sandy loam	0.005	0.45
Upland (B)	0.031	1.10
Medium land	0.011	0.97
Log likelihood function	-127.15	
Chi-square	20.1	
No. of Obs.	198	

Nagaon		
Variable	**Coeff.**	**t-ratio**
Household Characteristics		
Constant	0.454	0.78
Farm size	-0.005	-0.12
Education	0.002	0.61
Age	-0.006	-0.67
Labour-land ratio	-0.003	-0.72
Parcel characteristics		
Medium land	-0.535 ***	-1.56
Lowland	0.676 *	2.23
Clay Loam	0.102	0.37
Sandy Loam	0.715 *	2.12
Log likelihood function	-88.64	
Chi-square	12.98	
No. of Observations.	138	

*, ** and *** Indicate probability level of significance at 1%, 5% and 10%, respectively

Table A30: Yield Regression Equation for Golaghat and Nagaon

	Golaghat		Nagaon	
	Coeff.	**t-ratio**	**Coefficient**	**t-ratio**
Household Characteristics				
Constant	1.33 ***	1.76	4.15 *	7.98
Age	0.003	0.35	0.0014	0.92
Farm size	0.061	0.65	-0.047	-1.27
Pre-harvest labour	0.002	0.53	0.0002	0.07
Fertilizer	0.006 *	5.31	0.0018	1.14
Variety dummy	1.47 *	6.41	0.47 *	2.26
Parcel characteristics				
Upland (B)	0.686	1.13	0.720 *	1.24
Medium land	-0.084	-0.35	0.083	0.39
Clay loam	0.176	0.61	0.028	0.93
Sandy loam	0.117	0.37	-1.358 *	-4.97
Adj R-squared=	0.32			0.21
# Observations	279		178	

Table A31: Cost of cultivation of rice cultivation by variety (Rs./ha)

District	Modern Variety		Traditional Variety	
	POC	**IC**	**POC**	**IC**
Golaghat				
Seed	53		10	468
Fertilizer	629	591	164	-
Insecticides	0	-	113	-
Manure	116	1230	778	1180
Total Material cost	1496	3026	2050	2848
Labour	2661	4247	2828	3440
Nagaon				
Seed	106	499	19	335
Fertilizer	635	-	256	-
Insecticides	75	-	7.5	-
Manure	121	1761	112	1570
Total Material cost	2184	3307	1065	2544
Labour	2665	4540	1979	3446

POC= Paid out cost, IC= Imputed cost

Table A32: Summary of cost and return of rice cultivation by variety (Rs./ha)

	Material inputs	Labour. cost	Imputed labour cost*	Total costs	Gross revenue	Net revenue	Return over paid out cost
Golaghat:	Modern	varieties					
Marginal	3791	3381	3017	7171	13432	6260	9278
Small	4099	3256	2531	7355	14847	7492	10023
Medium	5032	3409	2787	8442	16490	8048	10835
Large	5250	3321	2646	8571	17742	9171	11817
	Traditional	varieties					
Marginal	3958	3245	2797	7203	9974	2772	5568
Small	4210	2869	2303	7079	10455	3376	5679
Medium	4407	3197	2580	7604	11899	4296	6876
Large	2980	2624	2043	5603	11290	5687	7730
Nagaon:	Modern	varieties					
Marginal	3598	3316	1534	7472	14823	7351	9443
Small	2136	2446	1005	5714	21517	15803	17940
Medium	2076	2344	797	5461	18123	12661	14500
Large	1124	2166	852	5095	21485	16391	19047
	Traditional	varieties					
Marginal	3967	5027	2913	8995	16304	10223	10223
Small	3961	3418	1565	7379	19025	13211	13211
Medium	5492	2570	1513	8062	14580	8031	8031
Large	1131	1706	839	2838	17655	15656	15656

*: Imputed cost was derived at market price

Table A33 : Profitability of rice by district and farm size category

District/Farm size category	Gross returns (Rs)	Paid-out costs (Rs)	Imputed costs (Rs)	Returns above-paid out costs	Net returns
	Nagaon				
Marginal	15578	4719	7956	10859	2903
Small	25838	7719	12300	18120	5819
Medium	37145	11741	18868	25404	6537
Large	68445	21472	35217	46973	11757
All farms	36067	11324	17726	24544	6812
	Golaghat				
Marginal	6550	2054	3655	4896	741
Small	13170	3950	7861	9221	1360
Medium	20627	5959	10831	15568	2038
Large	40800	12337	23854	28463	4609
All farms	20671	6160	11118	14510	3392

Source: Survey

Table A34: Average annual household income by sources

(Rs/household)

Source of income	Nagaon	Golaghat
On-farm		
Rice	29159	21870
Non-rice	15518	16500
Livestock	2194	2322
Sub-total	46873	40693
Off-farm		
Hired labour	440	192
Non-farm		
Remittances	13973	4227
Forest products	—	187
Handicraft	—	111
Salary	12186	25032
Others	2380	1558
Sub-total	28540	31115
Total income	75413	72000
Average income/capita	12008	11060

Source: Survey

Table A35: Decomposition of Income inequality and their marginal effects

Income source	Income share [S]	gini of source[G]	Relative Income [R] inequality	Component contribution [RGS/G]	Relative marginal effect
					(5)-(2)
(1)	(2)	(3)	(4)	(5)	(6)
	Golaghat				
Rice	0.41	0.310	0.658	0.308	-0.104
Non Rice crop	0.08	0.585	0.230	0.038	-0.040
Off-farm	0.10	0.248	0.328	0.0316	-0.072
Livestock	0.10	0.492	0.130	0.024	-0.078
Salary	0.17	1.365	0.510	0.449	0.272
Non farm	0.08	0.834	0.468	0.113	0.034
Homestead	0.05	0.691	0.313	0.037	-0.010
Total Income	1	0.274	1	1	0
	Nagaon				
Rice	0.61	0.337	0.763	0.490	-0.127
Non-rice	0.17	0.596	0.490	0.159	-0.017
Livestock	0.03	0.831	0.273	0.021	-0.009
Homestead	0.03	0.848	0.270	0.023	-0.010
Non farm	0.14	0.892	0.781	0.306	0.163
Total income	1	0.324	1	1	0

Source: Survey

Table A36: Changes in the levels of living (% of respondent s)

Factors	Nagaon			Golaghat		
	I	D	C	I	D	C
Food availability	71	8	21	83	3	14
School enrolment of children	51	3	47	53	4	42
Health and sanitation	75	1	24	75	7	18
Employment outside farm	21	9	69	16	7	77
Employment within farm sector	35	9	56	31	15	53
Production of food crops	67	8	25	92	4	4
Production of cash crops	24	43	33	74	6	20
Livestock Production	36	23	41	16	10	74
Production of home garden	48	15	37	10	14	76
Overall income	77	4	19	89	2	9
Overall welfare	76	1	23	80	-	20

I=Increased, D=Decreased, C=Constant

Table A37: Changes in rice varieties in Nagaon and Golaghat

Varieties	Nagaon		Golaghat	
	Percentage area planted	Percentage of farmers	Percentage area planted	Percentage of farmers
Varieties STARTED growing				
Masuri	10.7	17.3	21.2	28.9
Pankaj	5.7	9.3	8.4	12.8
Bahadur	13.5	28.0	5.3	20.1
Ranjit	38.8	65.3	24.5	32.4
Biplab	4.5	9.3	9.9	31.2
Lachit	-	17.3	10.5	35.4
Jaibangla	5.7	-	3.1	10.2
Ch-63	4.1	13.3	-	-
Others	16.6	46.6	16.8	40.1
Varieties STOP growing				
Badal Sali	13.5	10.6	-	-
Harkona	28.0	25.3	-	-
Others	58.4	46.6	-	-
Bardhan	-		22.1	23.2
Jahinga	-		30.5	33.8
Doria	-		14.1	13.3
Others	-		33.1	45.2

Table A38: Changes in crop planted in Nagaon and Golaghat

Crop	Nagaon		Golaghat	
	Av. Area (%)	No. of farmers (%)	Av. Area (%)	% of farmers
Name of crops started growing				
Boro rice	44	35	34	40
Potato	3	21	2	25
Jute	6	13	4	13
Lentil	4	11	3	14
Ahu rice (Transplanting)	28	28	11	12
Rapeseed & Mustard	9	16	9	10
Chilli	0.7	15	6	12
Sunflower	0.5	3	0.5	3
Khesari	1	1	2	18
Cole crops	3	4	5	29
Brinjal	0.4	3	1	28
Pumpkin	0.4	1	0.2	20
Name of crops withdrawn				
Sugarcane			7	16

Table A39: Farmer's Access to information (% of respondents)

District	Rice cultivation	Soil nutrient manage-ment	Animal husbandry	New varieties	Pest control	Aqua-culture
Nagaon						
Own experience	56	11	48	4	4	25
Other family members	31	25	21	6	4	15
Neighbors	7	45	29	17	21	11
Extension workers	5	13	-	51	33	15
Farmer organization/	1	4	-	15	13	12
NGO		1	-	4	23	16
Golaghat						
Own experience	43	90	60	6	10	32
Other family members	35	-	24	6	4	25
Neighbors	-	2	3	10	22	15
Extension workers	18	4	3	77	55	4
Farmers	-	-	-	2	17	3
organization / NGO /School	4	5	10	-	3	4

APPENDIX: Note on Decomposition of Income inequality by source income

gini measure also quantifies income inequality and can be extended to identify the sources of inequality. In rural areas, total household incomes compose of more than one source, whose contributions vary widely depending on large number of factors. Thus effectiveness of the equity-oriented measures requires in-depth analysis of sources of inequality to counter the problem of inequality. Studies on nature and significance of the sources of inequality are important for prioritization of policy.

The method allows the decomposition of total *gini* coefficient is into various components in terms of shares of source income. The estimated component is used to find the impact of marginal increase in particular income source on total income inequality.(Kakwani (1977) and Shorrock (1982), Lerman and Yitzhiki (1985)[1]). The total income inequality is equal to the product of contribution of sources income in terms of weighted pseudo *gini*. The pseudo *gini* is the product of share of income share and the ratio of covariance of income source and rank of source income to the covariance of source income and rank of total income.

1 Kakwani N C 1977; Application of Lorenz curve in economic analysis, Econometrica vol 45 pp719-727

Shorrock A F 1982; Inequality Decomposition by factor components; Econometrica vol 50 pp193-211

Lerman R and S Yitzhiki 1985; Income inequality effect by income sources: A new approach and application to the US, Rev econ & Stat vol 67 pp151-156

Pyatt G, C N Chen and J Fei 1980; The distribution of income by factor components; quarterly jr. of economics, vol 95 pp 451-473

The methodology is widely used to assess the impact of various income sources (Fei J C H et al 1978, Adams and Adelman 1992, Aheam, Johnson and Strickland 1985, Sharma 1982, Birthal PS 1995, Thakur J et al 2001, Hussain M et al 2002, Janaiah A 2001)[2] ..

The basic derivation of the decomposition algorithm is given as follows;

The half of gini's mean deviation is the area under the Lorenz curve and the diagonal representing the line of equality (ie. Line of 450). The mathematical expression is given as

$$A = \int_a^b F(y)[1 - F(y)]\,dy \qquad (1)$$

where y is income, (a,b) income limits, F is the cumulative distribution of income.

Assuming y as inverse function of F(y) and F is uniformly distributed between (0,1) with mean ½, the expression A can be written as

$$\mathbf{A = 2\ cov(y\,k, F)} \qquad \mathbf{(2)}$$

2 Fei J C H, G Ranis and S W Y Kuo 1978; Growth and income distribution of family by factor components, quarterly jr. of economics 92(1), pp17-53
Adam R H and H Adelman 1992; Sources of income inequality in rural Pakistan; Oxford Bulletin of Econ and Stat, vol 54 pp591-608
Aheam M, J Johnson and R Strikland 1985; Distribution of income and wealth of farm operator households; Am Jr. of Agr Economics vol 67, pp1087-1094
Sarma J S 1982; Agricultural Policy in India; Growth and Equity; IDRC, Otawa
Birthal P S 1995; Structure of rural income inequality: a study of western Uttar Pradesh; Ind Jr. of Agr Economics, vol 50, pp168-175
Thakur J, M L Bose and M Hossain 2001, Rural income distribution and poverty in Bihar: Insight from a village study, Eco & Pol Weekly, vol 35 (No.52&53)
Hossain M, F Gascon and E B Marciano 2001, Income distribution and poverty in Philippines: Insight from repeat village study, Econ & Pol Weekly, vol 35 (No.52&53)
Janaiah A, M L Bose and A G Agarwal 2001, Poverty and income distribution in rainfed and irrigated ecosystems: Village study in Chattisgarh, Econ & Pol Weekly vol 35 (No.52&53)

Making appropriate transformation and assuming y1,y2,…yk as sources of total income, equation (2) is written as

$$A = 2\sum \text{cov}(y_k, F) \tag{3}$$

Dividing LHS of (3) by mean of total income,(m)

$$\frac{A}{m} = \sum \left[\frac{\text{cov}(y_k, F)}{\text{cov}(y_k, F_k)}\right]\left[\frac{2\,\text{cov}(y_k, F_k)}{m_k}\right]\left[\frac{m_k}{m}\right] \tag{4}$$

or $G = \Sigma R_\kappa G_\kappa S_\kappa$ (5)

Where R_κ , G_κ ,S_κ are gini correlation, pseudo gini and source income share for the kth source. Lerman et al 1985 tastefully illustrated the statistical properties of these components of total gini measure.

Using (5) the marginal effect on total inequality for a small changes in individual source income is calculated. The marginal effect of the kth source income is obtained by dividing partial derivative of the decomposition function by total gini. It gives the comparative importance of sources of total income inequality.

$$\frac{\frac{\partial G}{\partial e_k}}{G} = \frac{(S_k R_k G_k)}{G} - S_k \tag{6}$$

NCAP Publications

Policy Papers

9. Birthal, P. S., Anjani Kumar, A. Ravishankar and U. K. Pandey. 1999. Sources of Growth in the Livestock Sector.
10. Sulaiman V., Rasheed and V. V. Sadamate. 2000. Privatising Agricultural Extension in India.
11. Chand, Ramesh. 2000. Emerging Trends and Regional Variations in Agricultural Investments and Their Implications for Growth and Equity.
12. Pal Suresh, Robert Tripp. and A. Janaiah. 2000. The Public-Private Interface and Information Flow in the Rice Seed System of Andhra Pradesh (India)
13. Haque. T. 2001. Impact of Tenancy Reforms on Productivity Improvement and Socio-Economic Status of Poor Tenants.
14. Selvarajan, S., A. Ravishankar, and P. A. Lakshmi Prasanna. 2001. Irrigation Development and Equity Impacts in India.
15. Birthal, P. S., P. K. Joshi, and Anjani Kumar. 2002. Assessment of Research Priorities for Livestock Sector in India.
16. Pal, Suresh and Derek Byerlee. 2003. The Funding and Organization of Agricultural Research in India: Evolution and Emerging Policy Issues.
17. Adhiguru, P. and Ramasamy, C. 2003. Agricultural-based Interventions for Sustainable Nutritional Security.
18. Birthal, P. S. 2003. Economic Potential of Biological Substitutes for Agrochemicals.
19. Chand, Ramesh. 2003. Government Intervention in Foodgrain Markets in the New Context.
20. Mruthyunjaya, Pal, Suresh and Saxena, Raka. 2003. Agricultural Research Priorities for South Asia.
21. Dastagiri, M.B., 2004. Demand and Supply Projections for Livestock Products in India.

Policy Briefs

9. Sulaiman V., Rasheed and A. W. van den Ban. 2000. Agricultural Extension in India- The Next Step.
10. Ravishankar, A. and Sunil Archak. 2000. IPRs and Agricultural Technology : Interplay and Implications for India.
11. Ravishankar, A. and Sunil Archak. 2000. Plant Variety Protection Technology: Interplay and Implications for India.
12. Gill, Gerard J., Diana Carney and Suresh Pal. 2000. Improving Competitive Agricultural Research Funding in India.
13. Andy Hall, Norman Clark, Rasheed Sulaiman V., MVS Sivamohan and B. Yoganand. 2000. Coping with New Policy Agendas for Agricultural Research: The Role of Institutional Innovations.
14. Chand, Ramesh and Linu Mathew Philip. 2001. Subsidies and Support in World Agriculture: Is WTO Providing Level Playing Field ?
15. Selvarajan, S. 2001. Sustaining India's Irrigation Infrastructure.
16. Sulaiman. V., Rasheed and Andy Hall. 2002. Beyond Technology Dissemination-Can Indian Agricultural Extension Re-invent itself?
17. Sulaiman. V., Rasheed and Andy Hall. 2003. Towards Extension-plus Opportunities and Challenges.
18. Adhiguru, P. and Mruthyunjaya. 2004. Institutional Innovations for Using Information and Communication Technology in Agriculture.
19. Selvarajan, S. and B.C. Roy. 2004. Irrigation Equity: Impacts, Sources and Strategies.
20. Chand, Ramesh. 2004. Agricultural Growth During the Reforms and Liberalization: Issues and Concerns.
21. Hall, Andy , Rajeswari Raina, Rasheed Sulaiman V., Guru Naik, Norman Clark and Shambu Prasad. 2005. Institutional learning and change: a review of concepts and principles.
22. Pal, Suresh, Prasoon Mathur and A K Jha. 2005. Impact of Agricultural Research in India: Is it Decelerating.?
23. Chand, Ramesh. 2005. Post WTO Agriculture Trade and Agenda for Negotiations on Agriculture

राष्ट्रीय कृषि आर्थिकी एवं नीति अनुसंधान केन्द्र
NATIONAL CENTRE FOR AGRICULTURAL ECONOMICS AND POLICY RESEARCH
(Indian Council of Agricultural Research)
POST BOX No. 11305, LIBRARY AVENUE, PUSA, NEW DELHI-110012.
Phone : 91-11-25847628, 25848731 Fax : 91-11-25842684 E-mail : director@ncap.res.in
http: // www.ncap.res.in