सामयिक निबन्ध
Occasional Paper - 47

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EXECUTIVE SUMMARY

- Beginning at the advent of introduction of dwarf and new dwarf high yielding variety of rice and wheat, the food production in India has increased manifold. The innovation alleviated the status of food deficit to a net food surplus country.

- Rice is the most important crop in India, which plays a critical role in food security. More importantly, it is a choice crop of the millions of poor and small farmers not only for income but also for household food security. However, the rice sector has witnessed rapid dynamism in production processes. After climbing a height of four-fold increase in production during past four decades, the production curves have started showing downward trend and productivity decelerating since the later half of the 1990s. Is it the beginning of the agrarian impasse (particularly in the rice system), not only in the core green revolution state of Punjab, but also in several other states such as Tamilandu, Andhra Pradesh and Kerala etc. The productivity decline is experienced in other states also including the rainfed areas. Therefore, an in-depth understanding of the changing production and productivity pattern is essential.

- The paper analysed spatio-temporal rice related data from secondary sources pertaining to rice growing areas and studied the trends and growth pattern over the decades 1950-51 to 2001-2002. It covered the information at country level, state level as well as at the disaggregate district level.

- The regional dimension of rice production systems assumes significance, as it depicts an interesting picture. A historical analysis shows that over the decades, the phenomenal pace in increase in rice production has been uneven and the regional disparity highly pervasive among the States as well as across the diverse ecosystems. Clearly, the gain due to modern rice technology has been discriminatory against the resource poor areas, which is also dominated by small and marginal farmers. The analysis also brings out a distinct production divide between irrigated tracts and rainfed areas, which substantiated the inter-regional disparity in production and productivity in rice. The paradox is that the un-sustainability of intensive system of agriculture (eg. Rice-wheat system in North-western India), gradually pushing the ostracised green revolution out of stream and at the same time, the performance of the rainfed areas continue to be dismal. The core green revolution-states like Punjab, Tamilnadu and Andhra Pradesh resorting to pro-agriculture diversification policy, may create an unexpected vacuum in the food production frontier. The apprehension that if Punjab diverts a million hectares from rice-wheat system in favour of crop diversification, as envisaged in next 4-5 years, the rice production may be reduced by about 5 million tonnes at the current level of productivity. This is an important pointer to desired shape of future rice production system. Apparently in order to compensate the loss of total production in such an event, the onus automatically falls on the lesser performing rainfed areas. It would require at least three times additional area at the given level of productivity of rice or to increase the productivity itself by 2 to 3 times. How to break the productivity barrier in the rainfed areas? Can the green revolution bypassed region and the less developed rice production system in eastern India play more innovative role in future.

- Focussing on the rice productivity at disaggregate level (district), the analysis shows a clear productivity divide with a sharp contrast between the prosperous areas on one hand and lesser developed areas on the other. This disconnect between irrigated area and rainfed areas, has direct implication on future food security. About 36 percent of the districts covering 44 per cent total rice area in the country achieved productivity level of more than 2tonnes/ha (approx 3 tonnes/ha of rough paddy). These districts contributed a major share of 63 per cent of production. On the contrary, the major junk of remaining 64 per cent of the districts covering 57 per cent of total rice area have been contended with dispassionately low productivity at less than 1 tonnes/ha. Obviously, this group of districts contribute barely 37 per cent of production. Incidentally, most districts of the later group belonging to the rainfed areas are the victim of neglect and deprivation of modern technology.

- Notwithstanding poor performances, agricultural sector in eastern India showed considerable degree of dynamism in the recent years. However, the pace of growth has been variable both in spatio-temporal dimensions. The growth of productivity was impressive during the 1980s, but slackened considerably during the 1990s (Fig 3). The only way to accelerate productivity growth will require a concerted effort in several key dimensions. A new wave of technology and investments in increasing rice productivity is needed to keep the rate of output growth above the rate of population growth. Therefore, a desired paradigm shift in research and development strategies for eastern India, must be cognizant of the evolving characteristics and new challenges that have arisen during the 1990s.

- Recognising that more than half of the poor people of India now live in eastern India (as many as 142 million of total 260 million population below poverty line), therefore a further reduction in the national poverty level is dependent largely on the success in eastern India.

- The typology of rainfed rice production systems shows that the agriculture in rainfed area is characterised by the domination of small and marginal farmers, whose proportion is growing at an alarming rate. Interestingly, the proportion of this group of farmers is bulging out over the years, which has already reached 81 per cent mark in 2003. Therefore, research and development efforts on productivity enhancement should keep into consideration the growing preponderance of small and marginal farmers in eastern India, that might unleash the technological solution to poverty. The implication of the small and marginal farmer-oriented agriculture for research and development system is that the future technology should suit the small farms and farmers. As the capital requirement for developing water resource and soil, mechanisation and seed technology is enormous, therefore, these resource-starving farmers are unlikely to be able to make lumpy investments in farm inputs and machinery. The public sector institutional investment is critical, where the role of financial institutions such as NABARD is important.

- Apart from income inequality, which is conspicuous in the rural areas, the distribution of modern rice varieties across the ecosystems is also skewed favouring the irrigated environment. The inequitable distribution is more severe at the sub-ecosystem level in the rainfed areas, which affected the low productivity. Slower pace of adoption of the existing modern variety has also caused the low productivity in the region. In addition, lack of variety resilient to biotic and abiotic stresses aggravates the production fluctuation. Notwithstanding the problem of availability, in the course of time, some varieties transgressed from irrigated ecology to rainfed areas. Therefore while adoption has occurred as farmers saw an opportunity to obtain a modest increase in yield compared to their own traditional varieties, but these non-targeted improved varieties adapted specifically to rainfed environments are required to fully exploit the potential that exists.

- Persisting yield gap has been a vexed issue in productivity improvement in rice. Yield gaps analysis in the eastern India classifies the areas into low yield low gap, the low yield high gap, and the high yield low gap category and derive the policy implications for each categories. The table below briefly summarises the policy implications.

  - Low average yield and low yield gap category consists of Parts of Assam, Chattisgarh, Coastal Orissa: Policy implication is *Yield-increasing technology*

  - High average yield and low yield gap category consists of Uttar Pradesh, West Bengal: Policy implication is *Higher input efficiency and Agricultural Diversification*

  - Low average yield and high yield gap category consists of Most Plateau regions: Policy implication is *Appropriate technology, Adaptive research, and"Reaching out to farmers"*

- Eastern India is also known for low rate of seed replacement in rice. As compared with the all India average of 14 percent seed replacement rate, Bihar, Madhya Pradesh and West Bengal have a much lower rate of seed replacement. Farmers basically keep their own seeds and use them from year to year, which might have hampered the adoption of new technology.

A targeted approach to agricultural research and development

- Based on the patterns of productivity growth and the current average yield of rice, the states of eastern India is categorized into two distinct groups. The first group includes eastern Uttar Pradesh and West Bengal. The second group includes the other states. The agricultural research and development strategy for the first group have to be somewhat different from the other group where rice yields are much lower. Without an efficient marketing system and other institutional support, farmers in this area will not be able to benefit from improved technology and the gains that have been made so far may be lost. Rice technologies that facilitate crop diversification are needed so that food production is not compromised as agriculture becomes diversified. For the second group of states, the average yields are still low and the growth in productivity has been modest. Drought is a major constraint that reduces productivity. Research to increase the productivity of the drought-prone areas is strongly needed to generate the required impact. Drought management in these areas will also require interventions that go beyond a single crop and include the whole of the watershed.

- The practices of leaving vast agricultural area fallow also add to the overall low productivity. Low land use intensity is due mainly to lack of irrigation. Watershed based approach complemented by traditional tanks and dugwells may provide some opportunities for intensification of land use. A number of institutional constraints such as low level of infrastructure, limited credit availability and poor extension of technologies prevent farmers from having access to modern inputs. Growth in these areas will remain sluggish without active involvement of the public sector in the provision of these public goods.

- The major challenge, thus is to enhance the productivity of rice and rice-based systems by focusing and prioritising the eco-regional based rice research in eastern India. This is likely to reduce the existing yield gap. It however, requires a well articulated design of system research in the following theme areas as lauded by the International Year of Rice 2004 declaration: Genetic improvement in rice variety for higher yield and stability, better crop management and crop care techniques, effective post harvest technology, and to strengthen the capacity building of the stakeholders. Not only developing modern and new technology but also imbibing the traditional knowledge base on the rice production systems is essential. Therefore, the participatory innovations, information revolution, knowledge dissemination and education quadrangle is likely to play key role.

- A small farm size also means that rice production constitutes a small proportion of the gross household income. Hence, there is need for moving away from "rice only" policy towards the "rice-plus" policy, keeping rice production in the centre stage. Reforms on input-output delivery institution (say development of rental markets, market for water pump, power tiller, etc.) are likely to make significant impact on farm production. The mechanical technologies that are purely labor-displacing, may also be less appropriate in areas with abundant surplus labour as in eastern India.

The paper also discussed some prognosis in rice production systems:

- *Next Generation Green Revolution :* In view of wide-spread agricultural growth in eastern Uttar Pradesh and West Bengal and improved performance of rice productivity in Assam, there is huge untapped potential in eastern India for the next green revolution targeted in rainfed areas.

- *Public Expenditure in Infrastructure and Agricultural R&D investment :* Following economic reforms, the fiscal compression forced further reduction in public expenditure in infrastructure. The agricultural R&D grew, but at a slower pace. The spill over effect of agricultural technology supported by ground water irrigation seems to have exhausted in some areas and other areas require more new technology.

- *Innovative Variety, Seed Multiplication & Delivery System :* Innovative mechanisms are required for variety release as well as seed multiplication and delivery system. Inadequate supply and scarcity of seed of modern variety is crucial cons-traint to adoption.

- *Pro-active Policy Interventions :* The multiplicity options and diverse production conditions in eastern India demand more critical policy interventions in regard to yield barrier, cutting edge technology, support infrastructure, access to information and delivery systems.

- *Rice Biodiversity :* As rice is the crop of the millions, eroding its genetic base could have serious consequences to sustainable livelihood. Maintaining rice biodiversity and utilizing its merits should have sustainable impact in increasing productivity in future. Rice is life, as it not only provides subsistence but also a source of income to meet the other household requirements in India. Rice is actually life sustaining.

Acknowledgement

The author is grateful to NABARD for assigning the task of preparation of this occasional paper **"Dynamics of rice economy in India: Emerging Scenario and Policy options"**. NABARD has recognised the impending situation in rice economy and felt it necessary to understand the changing pattern. Needless to say that rice continues not only as an important food provider, but also a major source of rural livelihood, particularly of the millions of poor. On account of wide diversity and adaptability, the rice research is a challenge and a prime mover for food security. Insight into the complexity requires wider stakeholders' participation. The occasional paper analyses changing scenario and suggest certain policy imperatives. In the preparation of the paper, I am benefited immensely while interacting with Dr. Sushil Pandey, Agricultural Economist, IRRI Manila, Philippines who collaborated in implementation of an elaborate survey of rainfed rice in eastern India. I am particularly grateful to him for intense research interactions. Author is indebted to several friends and colleagues, who provided constant support and encouragement in writing this monograph. I am grateful to Dr. Dayanatha Jha, former Director NCAP and National Professor, Dr. Arun Bandopadhaya, Chief General Manager, Dr. K V Raghavulu, Chief General Manager and Dr. T.N Jha, General Manager, NABARD, Mumbai for their insightful comments and suggestions. I am also grateful to Dr. Mruthyunjaya, National Director, National Agricultural Innovation Project (ICAR) and former Director NCAP, and the consultancy cell, NCAP for encouraging me to undertake the preparation of the paper. I acknowledge the help and support of Dr. Mohinder Kumar, AGM and Ms. Pankaja Borah, NABARD, Mumbai.

Dynamics of rice economy in India : Emerging Scenario and Policy options

Abstract

Most of 726 million rural populations in India is dependent on agriculture. Rice is the staple food of nearly 65% of the total population in India. The production of rough rice reached 135 million tonnes (89 million tonnes of clean rice) in the TE 2002 from 32.3 million tonnes (20 million tonnes clean rice) in 1950-52, primarily due to the fact that agriculture is in the dynamic path in transforming traditional mode of production to modern agriculture. The country earned a huge accolade as it ushered the input-intensive green revolution in agriculture, where the yield improvement is ingrained in it. Yet this phenomenal pace in increase in rice production and productivity has been uneven, and the disparity is highly pervasive among the states and across the diverse ecosystems. Moreover, the yield curves have started showing decelerating trends in the later half of the nineties and has been continuing thereafter, which seems to have induced the unsustainability. The paper traces the growth path of rice production along the time scale and analyses the trends and growth at disaggregate level. It shows that the inverted bowl shaped pattern of production growth experienced in during past couple of decades has been a matter of concern for sustainable and likely to threaten the food security. Clearly, the gain due to modern rice technology has been discriminatory against the resource poor areas, which is also dominated by small and marginal farmers. Productivity ranges from a less than 2 tonnes/ha in rainfed areas to as high as 5.85 tonnes/ha in irrigated tract in Punjab. This disparity is caused as the research achievement failed to fulfil the requirements of demand-driven technology and "reaching out" to the target groups for wider adoption. Should it be the beginning of an alarming agrarian impasse in the core green revolution areas?

Notwithstanding, the overall disparity and poor performance in several areas, rice production systems experience considerable degree of dynamism in recent years. The paper attempts to characterize the typology of the change and argues in favour of a likely shift of production base from well-endowed irrigated areas to less well-to-do rainfed areas in India.

The shift is justified as the recent changing policy environment designed to divert prime cereal crop lands in favour of crop

diversification in several prosperous areas, is likely to affect food security in the country. The evidences suggest that declining rice production in recent years seems to have been pushing the core green revolution areas out of rice production stream, which is also a threat to household food security of the poor millions.

Therefore enormous untapped production potential in the rainfed area has gained its prominence. The recent pattern of production growth in eastern Uttar Pradesh and West Bengal, improved performance of rice productivity in Assam and other parts of the rainfed areas has been widespread. Further utilisation of huge untapped potential in eastern India could pave the path for next generation green revolution. Therefore, a paradigm shift in policy and production environment is necessitated to prepare the ground for increasing production in the rainfed areas.

The reform is also essential in agricultural R&D investment. A new look regionally differentiated R&D policy on rice-plus system (as against the rice-only system) is advocated with special emphasis on resource-rich but poor utilisation areas. Development of modern varieties resilient to biotic and abiotic stresses should be supported by policy intervention to ensure its equitable distribution among the stakeholders. The strategies recommended for the rainfed areas include that the region with low yield and low yield gap requiring *"Yield-increasing technology"*, for the low yield and high gap areas the strategies on *"Appropriate technology, adaptive research and Reaching out to farmers"* while the *"Higher input efficiency and agricultural diversification"* is needed in the high yield and low gap areas. Appropriate intervention on efficient implementation of the developmental programmes, is likely to accelerate the desired growth rate of rice production at a level higher than that of population growth, else the problem of food insecurity will loom large.

1. Introduction

Green revolution was initiated during the mid sixties at a time when the country was whirling through the tyranny of food deficit. Beginning at the advent of introduction of dwarf wheat germplasm and cultivars from CIMMYT, Mexico in 1964-65, and later the new dwarf high yielding variety of Rice (IR8 released in 1966) from the International Rice Research Institute (IRRI), Manila, the food production increased manifold, which transformed the status from food deficit to a net food surplus country. About four-fold increase in food production was achieved when it climbed the height of 213 million tonnes of food grains in 2001-02. During the period, food production grew at a rate of about 100 percentage point every decade from barely 50 million tonnes in 1950-51. But, unfortunately, the achievement seems to have short-lived, because the food security in the country has raised doubts on its sustainability and anxiety in the production front in the recent years.

Rice is the most important crop in India, which played a critical role in food security. It is the important staple food for more than half of the world population and provides 60-70 per cent body calorie intake to the consumers. Rice is a supreme commodity to mankind, because rice is truly life, culture, tradition and a means of livelihood to millions. In recognition to these important traits, the United Nations General assembly, in a resolution declared the year 2004 as the International Year of Rice. The resolution very eloquently upheld the need to heighten awareness for the role of rice in alleviating poverty and malnutrition[1]. The global perspective of rice is relevant to agricultural development in India (Appendix Box 1: FAO provides an excellent outlook for rice in 2004). Rice is specifically important to India as it is grown on more than 44 million hectares, the highest area ever occupied by a single crop. Globally, rice occupied the largest area among the million (hectare) plus countries in the world, although China topped the position in production. Nevertheless, rice is a choice crop of the millions of poor and small farmers not only for income but also for household food security. The FAO data shows that while many countries show declining trend in production during past couple of years, India's production remained relatively stable.

But, the regional dimension of rice production systems depicts an interesting picture in India. The inter-regional disparityin production

1. United National General Assembly; A/Res/57/162; dated 16 December 2002; www.rice2004.org

and productivity as well as technology support is conspicuous. Focussing on the rice productivity at disaggregate level (district), the rice production system showed a clear production divide with a sharp contrast between the prosperous region and lesser developed areas. Disconnect between irrigated area and rainfed areas, has direct implication on future food security. About 36 percent of the districts covering 44 per cent total rice area in the country achieved productivity level of more than 2 tonnes/ha (approx 3 tonnes/ha of rough paddy). These districts contributed the lion share of 63 per cent of production (Table 1). On the contrary, the remaining 64 per cent of the districts covering 57 per cent of total rice area seems to have contended with dispassionately low productivity at less than 1 tonnes/ha. As a consequence, this group of districts contribute barely 37 per cent of production. Incidentally, most districts of the later group belong to the rainfed areas and is the victim of neglect and deprivation of modern technology.

Table 1 : Classification of the rice growing districts based on various productivity groups during 1998-2000

Productivity groups	Districts (No.)	Area share (%)	Production share (%)	Productivity (t/ha.)
High Productivity (>2.5 t/ha)	110	26.9%	42.8%	3.10
Medium Productivity (> 2.00-2.50 t/ha)	81	17.3%	20.0%	2.25
Subtotal	**191**	**44%**	**53%**	**2.75***
Medium-Low Productivity (> 1.50-2.00 t/ha))	94	16.8%	15.3%	1.78
Low Productivity (1.00-1.50 t/ha))	155	25.8%	16.3%	1.23
Very-Low Productivity (< 1.0 t/ha))	94	13.2%	5.6%	0.8
Subtotal	**343**	**56%**	**37%**	**1.26***

* weighted average,
Source : Directorate of Rice Development 2004, Govt. of India, Patna

Therefore, the potential areas to sustain the food need of the increasing population in the country lies in the less developed bypassed areas. The paper thus focuses on the rainfed areas of eastern India, where ample unexploited opportunities to increase production are awaited. Not only the productivity enhancement, but there is also scope for horizontal expansion in rice area in rabi season. Fortunately, the concerted strategy of the government in recent years has improved the scope for production in rabi season to an extent. Being flood free, given assured irrigation, production in rabi season could be more stable. The productivity of rabi (summer) rice is fairly higher than that of main winter rice, yet barring West Bengal, the summer rice area has not picked up in other states (which is presently, less than 10 per cent).

The phenomenal pace in increase in rice production has been uneven and the regional disparity is highly pervasive among the states and across diverse ecosystems. Clearly, the gain due to modern rice technology has been discriminatory against the resource-poor areas, which is primarily dominated by preponderance of small and marginal farmers. The poor performance of the productivity of rice in the rainfed areas requires in-depth examination of the causal relationship. While the irrigated rice is progressive, the rice in rainfed areas confront diametrically opposite situation, depicting a highly disparaging picture. But, the paradox is that the un-sustainability of intensive system of agriculture; rice-wheat system, which contributed significantly to production growth in north-western India, appears to have been gradually pushing the ostracised green revolution out of stream. In the same time, the outlook of rainfed rice is not bright too, as it is grown with negligible irrigation, minimal chemical inputs and the lowest level of mechanisation. Unfortunately, the productivity in the traditional mode of production has been one of the lowest in the country. Studies have shown that the declining trends in production and productivity endanger the food production and threaten the sustainability of food security at large (Sinha 1997, Siddiq 2000). Moreover, with the recent pro-agriculture diversification policy followed in the prosperous states, the food production scene may be gloomy. The core green revolution-States resorting to this newer path may create unexpected vacuum in the food production frontier, if timely care is not taken. The major rice growing states like Punjab when withdraws a million hectare of rice wheat area (as envisaged in next 4-5 years) in favour of crop diversification, then to compensate the loss of total production to the tune of over 5.5 million tonnes of rice, the onus automatically fall on the lesser performing rainfed areas (Appendix Box 3: Punjab model of agricultural development and change is a relevant example to emulate elsewhere). Given the existing policy apparatus, this changing scenario implies that the shortfall in food grain is likely to make a significant dent in the central pool of foodgrain. In order to meet such a shortfall, there will be a demand for at least three times additional planted area at the current level of productivity or to increase the productivity itself by 2 to 3 times. Of the above two options, which one is achievable at ease is a matter of concern. Apparently as the former is untenable, the future production increase must come from productivity enhancement only, which is basically technology dependent. Hence, there is need to develop appropriate technology package to break the productivity barrier in the rainfed areas, which is a major research challenge (Appendix Box 2: The quote provides essential elements in the rice systems, which are necessary for designing future research model for rice).

Another dialectic is that while combined areas under wheat and rice is stagnating around 69 million hectares (accounting about 57 per cent of area under foodgrains), at the same time, the productivity of rice in over two-third areas got stuck at less than 2 tonnes per hectare. Low productivity affects the household food security of the millions of small and poor farmers, a phenomenon, likely to reach an un-manageable situation in future. Studies show that the situation is particularly frightening while reckoning the historical production performance in eastern India (Pandey S et al 2000)[2].

Accumulated evidences suggest that gap in research challenges and goals achievement has been bulging out, which also created more demand for rice research in the region (Jha D et al 2005). The unequal distribution of gain due to rice research achievement and growing nutritional insecurity has created escalating demand for appropriate and location specific research.

Notwithstanding the regional disparity and dismal performances, the rice production system has undergone tremendous changes over the decades. Proper diagnosis of the changes and their characterisation, is essential to formulate regionally differentiated targeted policy interventions. In-depth understanding of the synergy among the varieties (modern variety and traditional variety) as a determinant of system resilience and likely future demand for rice research requires more insights into the on-farm dynamics of the existing production systems and the pattern of change (Barah BC and S. Pandey 2005).

The paper attempts to generate required information base and analytical supportive evidences in this understanding.

2. Paper draws upon some materials from Pandey S, B C Barah and L Velasco, 2000.

The major objectives of the paper are the following:

- To characterize the typology of rice production systems
- To suggest strategies for future rice technologies and policies undergoing different patterns of changes.
- To suggest policy intervention options for improving food security of rice farmers and household income.

The paper deals with policy perspectives for strengthening sustainable food security. It has been felt that unlike wheat, studies on sustainability of rice production are relatively sparse, and rarely integrate micro and macro dimensions, which is a necessary requirement for a national policy. Rice is a complex crop to research due to its wide adaptability in diverse fragile ecosystems and socio economic settings, hence the location-specific perspective is more important. Emphasizing on the supply-side aspects of rice production system, the analysis attempts to generate empirical evidences by integrating the disaggregate parameters, which are necessary for a macro perspective. The paper utilised the secondary district level rice related data pertaining to the period 1950-51 to 2002-2003. The country is divided into four arbitrary zones; northern zone, southern zone, eastern zone and western zone. The zonal performance and growth analysis is also carried out. For disaggregate analysis, the study covered almost the entire 511 newly formed districts in the major rice growing states in India. However, the eastern Indian districts are considered for in-depth analysis. An useful panel data set on rice is generated, which is required to understand recent changes in production systems and the trends thereby. The analysis utilizes some simple statistical tools including moving averages, compound growth rate, multiple regression techniques and graphical analysis.

Organisation of the paper

Chapter 2 gives a brief description of the recent development in the rice sector both in global context as well as its relative importance in India. Next chapter analyses the status of rice production system in the present context. Chapter 4 and 5 draw inferences on the findings of aggregate level as well as disaggregate district level trend and growth analysis, which is essential to identify and prioritise strategy for two sets of districts, viz., the laggard and well off districts, by adding an important dimension for need-based and regionally differentiated policy strategy. The typology of inter-regional variation in rice production systems is also suggested. Chapter 6 deal with the regional disparity in production and productivity and the changing pattern of rice production system. The pattern that emerged necessitated dynamic structural adjustment in production system among the zones. The opportunity for exploiting enormous untapped potential of rice production in eastern India is specifically discussed in Chapter 7. Some flavour of diversity of production conditions and implication of small farmer-oriented agriculture is discussed in Chapter 8. Modern technology is a kingpin to agricultural improvement, but its adoption has been constrained in most part of the rice growing areas as discussed in Chapter 9. Chapter 10 portrays an analysis of historical perspectives of rice R&D and the distribution of modern rice varieties across the ecosystems. Rice production is also subjected to number of adversities such as vulnerability to production risk, impact of rice quality and trade and the problem of buffer stock management, which are discussed in Chapter 11. The Chapter 12 presents concluding remarks and the policy issues. Lack of timely and uninterrupted flow of information is a limitation of the data. Therefore, development of a networking of the rice-growing states would be suggested to facilitate and ensure continuous flow of rice information.

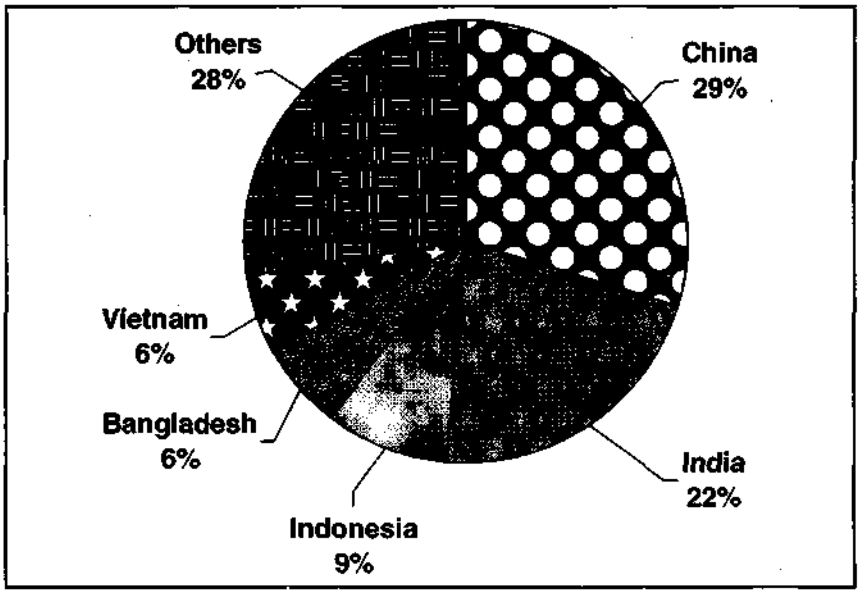
The detailed understanding of the issues related to the rice production system in India and focus on the policy interventions, are necessary to convert the high potential rainfed rice systems into a major source of future growth, a growing concern in years to come.

2. Recent Developments in the Rice Sector

a. Importance of rice in global context:

Rice is grown in 44 million hectares in India, which is the highest area occupied by a single crop in the million-hectare plus countries in the world. Rice production has a long history of

Fig. 1 : Global share of production rice 2001-2003



evolution in India, which enabled wide adaptability in diverse ecosystems. A large gene-pool and land races also enabled building up large stock of rice biodiversity (Rai M 2004). But, India lagged behind in the production front due to low productivity. China occupied the top position in production of rice, which produced 181.5 million tonnes (rough rice) in 28.6 million hectares of area. The productivity of rice compares unfavourably in India as compared to other rice growing countries. As compared to the average rice yield in China, Japan, Korea and Egypt of 6.35 tonnes/ha, 5.80 tonnes/ha, 6.00 tonnes/ha and 5.60 tonnes/ha respectively, it is only 2.09 tonnes/ha in India (TE 2000-02). The story of long term growth of productivity has been worrisome globally in the recent years. The changing pattern of growth by country groups shows that productivity growth rate during 1970-90 was 2.8 per cent in east Asia, 2.5 per cent in South east Asia. 2.2 per cent in south Asia and 0.8 per cent in rest of Asia, which declined across the regions to 0.5

per cent, 1.5 per cent, 1.3 per cent and 1.9 per cent respectively during 1990-2004[3]. Low productivity of rice in India, is a matter of concern, not only in international front, but also in domestic context. In case of international trade, while the countries such as Thailand and Vietnam outperformed in the rice export trade, Indian export has been fluctuating. Despite noticeable fluctuation, on the whole, there is however, some improvement in rice export in India past couple of years.

However, export stability requires yield improvement as well as quality rice acceptable to international consumers. Moreover, in view of the changing rice price scenario during past 3-4 years (in 2000, international price of rice was US$ 170 per tonnes, which increased to US$ 300 in 2005 in quick response to the dwindling stock of rice), an efficient and stable production system would be beneficial. This is important as there is significant production fluctuation from year to year and across other countries in the world (Table 2).

Table 2 : Area and production of rice in million plus countries

	Harvested Area (Million ha)	Production (million ton)			
		2001	2002	2003	Yield 2003
World	151.20	585.15	576.1	591.2	3.91
China	28.59	181.51	176.3	167.5	5.86
India	44.50	131.90	113.6	133.5	3.00
Indonesia	11.70	49.40	51.5	51.8	4.43
Bangladesh	10.90	34.28	38.2	39.9	3.66
Viet Nam	7.50	31.93	34.4	34.7	4.63
Thailand	9.80	25.20	25.6	26.8	2.73
Philippines	4.09	12.70	22.8	24.6	6.01
Myanmar	6.50	20.60	13.0	13.5	2.08
Brazil	3.15	10.21	10.6	10.4	3.30
USA	1.33	9.44	9.6	9.0	6.77
Pakistan	2.25	6.75	6.7	6.9	3.07

Source : FAO 2004, Agricultural Statistics, Rome

3. Mahbub Hossain, 2005, Recent trends in global rice economy: Implications for rice research strategy in India, paper presented at ICAR-IRRI workplan 2003-05 meeting, June 22, New Delhi.

b. Relative importance of rice

Rice has been an important food crop in India for ages. It is grown in all the four zones in the country, which is the livelihood of a very high proportion of the farmers and the poor. Among the four zones, the east zone occupies more than 40 per cent of total area in the country, next is the north zone with 19 per cent area and the south and west zones having 17 per cent area each. While the productivity is the highest and stable in the north zone due to favourable irrigation and adoption of modern varieties and other methods, the same in the largest east zone (synonymous to eastern India) is highly vulnerable and productivity low. Agriculture in eastern India is characterized primarily as rainfed systems. The rice production in the rainfed areas, not only suffer from drought and floods simultaneously in the same year, but also the yield fluctuates widely. Table 3 shows a simple relationship between share of area, production and yield across the states and the zones during1995-2000. It depicts a clear inverse relationship between area and production, when superimposing the hydrological factor. A clear divide in production is discernible as the irrigated area having lesser proportion of area contributed more than proportionally in production, while the rainfed areas showed exactly opposite picture of higher area share and lowest production share. Table 3, which is self-explanatory, shows that individual states within the zones also behave alike.

Table 3 : Inter-state variation in average share area and production and yield of rice in India 1995-2000

Zones	State	Area share (%)	Production share (%)	Yield (t/ha) Rice
East Zone	Assam	5.7	4.1	1.37
	Bihar	11.5	8.4	1.39
	Orissa	10.3	6.6	1.21
	West Bengal	13.6	15.6	2.19
	Uttar Pradesh	13.1	14.1	2.05
East Zone Total		**54.2**	**48.8**	**1.61**
North Zone	Haryana	2.2	2.9	2.51
	Himachal Pradesh	0.2	0.1	1.34
	Jammu & Kashmir	0.6	0.6	1.83
	Punjab	5.3	9.3	3.30

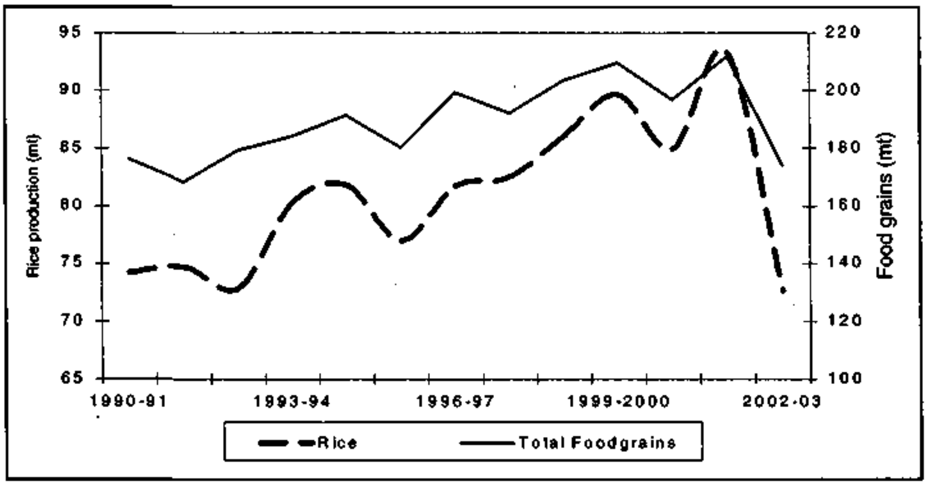
Zones	State	Area share (%)	Production share (%)	Yield (t/ha) Rice
North Zone Total		**8.3**	**12.9**	**2.39**
South Zone	Andhra Pradesh	8.7	11.8	2.57
	Karnataka	3.1	4.0	2.45
	Kerala	0.9	0.9	1.94
	Tamil Nadu	5.1	8.1	3.03
South Zone Total		**17.9**	**24.9**	**2.65**
West Zone	Gujarat	1.4	1.2	1.52
	Madhya Pradesh	12.2	6.8	1.06
	Maharashtra	3.4	3.0	1.68
	Rajasthan	0.3	0.2	1.02
West Zone Total		17.4	11.1	1.22
India Total		100.0	100.0	1.90

It appears that that the rainfed areas failed to break productivity barrier and seems to entrap in the stability at low productivity syndrome.

3. Rice Production System in a Critical Cross Road

Overwhelmingly a large proportion of India's population (accounting for nearly 726 million rural populations in 2001) lives in rural areas. Agriculture provides direct employment to about 67 percent of the working people in the country. It is also the backbone of India's economy, and the primary means of livelihood. Nearly 29 percent of the total domestic income (GDP) comes from agriculture and contributes to over one-fourths of India's exports. It enjoys the double distinctions of being the single major crop and a staple food of nearly 65 percent of the total population in India. Rice contributes a lion's share of more than half of the total food grain and 55 percent of total cereal production. Total production of rough rice increased to 135 million tonnes (89 million tonnes of milled rice) in 2000-2002 from 112 million tonnes (74 million tonnes milled rice) in the beginning of 1990s. But it started decreasing significantly in the recent years (Fig 2).

Fig 2 : Trends in rice and foodgrains in India



Among the factors responsible for violent fluctuation in rice production include heavily dependent vagaries of nature and sensitive to biotic and abiotic stresses. This mass-based food crop being highly vulnerable to natural calamities and other adversities, aggravate the instability of production. This affected the flip-flop picture of overall production and productivity growth rate (Table 4). While favourable conditions increase production and productivity, unfavourale production condition decrease it drastically. At the same time, there is hardly any safety net against multiple risks to which the poor farmers confront regularly, particularly in the vulnerable rainfed areas. Despite development of modern variety and other related technologies, it is a matter of concern that a single severe drought or a flood wipes out the rice production significantly. This shows the deficiency of resistant rice varieties to protect against various stresses. Another source of instability is the lack of irrigation facility. At present, a very high proportion of rice is grown under rainfed situation and the worst is that this ecosystem is highly monsoonal dependent. About two-thirds of the total area under rice is under rainfed system, whose productivity has been below the national average. It thus raises question on the sustainability of production necessary to cater to the basic need of the vast population.

Table 4 : Decadal compound growth of Area, Production and yield on rice in India

	1970s	1980s	1990s
Area	0.87	0.42	0.35
Yield	1.05	3.62	1.32
Production	1.92	4.04	1.68

As discussed earlier, the historical analysis shows that the phenomenal pace in increase of rice production has been uneven and the regional disparity is highly pervasive among the states and across diverse ecosystems. Clearly, the gain due to modern rice technology has been discriminatory against the resource poor areas, which is also dominated by small and marginal farmers. The variability of production as well as the process of deceleration of growth is more apparent at disaggregate regional level as compared to the national level.. In order to understand the spatio-temporal dimension of the variability, ten yearly moving average and growth series of rice production is estimated, which track the changing pattern across the states along the growth path (Figures appended). It shows a clear deceleration in production growth during the period 1970-2000 in the well-endowed areas (eg. Punjab), though the same in resource poor rainfed areas is modest. Relatively not-so-bad growth performance in rainfed areas indicates that adequate policy incentives are required to stabilize the growth and evolve strategies of "reaching out" to the poor. Therefore, enhancing adaptability and stability of productivity and providing more entitlement to livelihood to the rice growing population is a major challenge to the agricultural research and development system.

4. Regional Differences in Production and Productivity of rice

As mentioned earlier, on account of stern ecological and socio economic diversity, the issue on regional dimension of rice production systems is of crucial interest to agricultural researchers. Four zones of the rice growing areas in the country has distinct behavioural pattern and production conditions, which has implication on overall production. Therefore, a proper understanding of inter-zone and intra-zone dynamics is essential for effective regional planning.

Table 5 : Share of Area, Production and Yield of Rice in Major Rice Producing States

Zones	1999-2000			2000-01			
	Area %	Production %	Yield (t/ha)	Area %	Production %	Yield (t/ha)	Irrigation % area
East Zone	66	55	1.61	65	52	1.36	36.0
North Zone	8	13	2.87	8	14	3.03	94.8
South Zone	18	25	2.72	18	27	2.73	79.0
West Zone	5	4	1.58	5	4	1.42	49.7
All India	100	100	1.99	100	100	1.91	52.3

Source : Govt. of India, 2003, Agriculture Statistics at a glance, Ministry of Agriculture, New Delhi

Table 5 gives the share of rice area and production in the year 1999-2000 and 2000-01 across the zones, which is also indicative of their typology of characterisation. It shows that the northern zone with about 8 per cent of total rice area produces 13 per cent of total production, a ratio of production share to area share at 1.55. That is, the unit area contributes more than one and half times the total production. Whereas the eastern zone with 66 per cent area produces approximately 50 per cent (29.83 million tonnes of rice in 1999-2000) of total output of rice, the ratio being 0.90. Although rice is the major crop in eastern India (in many cases it is the only crop in the kharif season), its productivity performance has been dismal. The corresponding figure in the southern zone is 25 per cent of the total production in 18 per cent area. Thus, it may be inferred that the resource endowment directly influences the production performance. The production condition is generally homogeneous under irrigated situation (as in northern and southern zone) whereas rainfed rice in eastern India is grown to highly diverse ecosystems and almost in natural conditions. The heterogeneity in the production environments is the primary source of disparity in production among the zones. It has been observed that, not only the production, the disparity in productivity performance is also significant across the regions. The high performing states of Punjab and Tamil Nadu have reached the level of rice yield at 5.85 tonnes/ ha and 5.15 tonnes/ha in 2000-03 respectively. On the contrary, the picture is highly disappointing and dismal in the vast areas of rainfed states such as Bihar, Orissa, Madhya Pradesh, Chattisgarh and Jharkhand.

4a. Patterns of changes in agricultural productivity (State-level)

According to a recent study, the growth rate in the value of agricultural output in eastern India has changed drastically over time (Bhalla and Singh 2001). Using the triennium 1970-72 as the baseline, the growth rate in the value of agricultural output during the triennium 1980-82 was low and below the rate of growth in population in most of the eastern Indian states (Table 6). Bihar even registered a negative rate of growth in the value of agricultural output. However, relative to the triennium 1980-82, the perfor-mance improved substantially in several states of eastern India during 1992-94.

Table 6 : Growth rate (%) in value of agricultural output in eastern India.

	1980-1982[a]	1992-1994[b]
Assam	2.80	2.15
Bihar	-0.41	2.08
Orissa	2.65	1.15
West Bengal	0.68	5.39
Madhya Pradesh	1.28	4.71
Uttar Pradesh	2.77	2.83

[a]Base year is 1970-1972, [b]Base year is 1980-1982,
Source : Bhalla and Singh (1997).

West Bengal experienced a dramatic growth in agricultural output of 5.39 percent per year during the intervening periods. Even in Bihar, the performance improved substantially. While the improvement in the performance of Madhya Pradesh was driven mainly by the growth in output of oilseeds and pulses, rapid growth in the output of rice was the major source of growth in West Bengal and Uttar Pradesh. Despite this impressive performance, the growth rate actually decelerated in Assam and Orissa. On the whole, the overall improvement in the growth performance of eastern India has been an important development that has positively affected the overall performance of the Indian agriculture during the late 1980s and early 1990s. A part of this growth in the value of agricultural output can be accounted for by the increase in cropping intensity. The cropping intensity thus, increased in all states although West Bengal again led other states of eastern India on this account. The growth in cropping intensity is low in Bihar where both the gross and net sown area declined over time. Bihar is the only state in eastern India where even the gross sown area declined as the area under fallow and waste land increased. In West Bengal, the rapid growth in the area of Boro rice was the main factor for an increase in the cropping intensity. The emergence of Boro rice is important as it changed the cropping season from a risky kharif to relatively safer rabi season. Moreover, the productivity of Boro rice is at least double the kharif rice yield. Similarly, the introduction of short duration modern rice varieties facilitated an increase in cropping intensity in other states too. This made a positive change on cropping pattern. Rice dominated the cropping pattern in most of the states. Table 7 shows that on the whole rice occupies more than two-thirds of the cropped areas in the eastern India, with an exception of Uttar Pradesh. In Uttar Pradesh, rice is dominant in the eastern Uttar Pradesh.

4b. Inter-district disparity in rice productivity:

It is amazing that despite the dominance of rice in the cropping pattern, the disparity in productivity is highly conspicuous. Historically, the average rice yield was in the range 1-2tonnes/ha in 90 percent of the rice area of eastern India during 1970-79. But during 1990-97, this has changed substantially, whereby only 47 percent of the rice area was in this yield range, and 51 percent of the area increased yield levels higher than 2tonnes/ha. Despite this achievement at the aggregate level, the growth has been non-uniform across regions. Because, during 1990-97, more than 60 percent of the areas in Bihar and eastern Madhya Pradesh had rice yield in the range of 1-2 tonnes/ha. On the other hand, eastern Uttar Pradesh had no districts in this yield range and West Bengal had only three hilly districts; Coochbehar, Darjeeling and Jalpaiguri in the northern

Table 7 : Changing pattern of cropping pattern in eastern India (% triennium averages)[a]. (Contd.)

	1970-1972	1980-1982	1990-1992	1996-1998	1970-1972	1980-1982	1990-1992	1996-1998	1970-1972	1980-1982	1990-1992	1996-1998
	Assam				**Bihar**				**Orissa**			
Food grain	78	76	75	75	93	92	92	92	91	85	83	89
Rice	72	69	69	68	48	51	51	52	70	53	54	63
Wheat	2	3	2	3	16	17	21	22	0	1	0	0
Coarse Cereals	1	1	1	1	14	12	9	9	7	9	5	3
Pulses	3	3	3	3	15	13	11	9	14	22	24	23
Non-Food grain	22	24	25	25	7	8	8	8	9	15	17	11
9 Oilseeds	6	8	9	8	2	2	2	2	5	10	11	6
Fibre	0	0	0	0	1	1	0	0	1	1	1	1
Jute	5	3	3	2	1	2	2	2	1	1	1	0
Cotton	0	0	0	0	0	0	0	0	0	0	0	0
Sugarcane	1	2	1	2	1	1	2	1	0	0	0	0
Remaining crops	10	11	12	13	2	2	2	3	2	3	4	4
	West Bengal				**Madhya Pradesh[b]**				**Uttar Pradesh[b]**			
Food grain	89	83	81	79	86	86	77	72	78	78	83	83
Rice	72	72	73	71	23	23	23	22	18	20	22	23
Wheat	6	3	3	4	17	17	16	18	24	31	36	37
Coarse Cereals	2	2	1	1	24	23	17	11	21	15	13	11
Pulses	9	6	4	3	22	23	21	21	15	12	12	12
Non-Food grain	11	17	19	21	14	14	23	28	22	22	17	17
9 Oilseeds	2	5	7	6	10	10	19	25	15	14	7	7
Fibre	1	1	0	0	0	0	0	0	0	0	0	0

Table 7 : Changing pattern of cropping pattern in eastern India (% triennium averages)[a].

	1970-1972	1980-1982	1990-1992	1996-1998	1970-1972	1980-1982	1990-1992	1996-1998	1970-1972	1980-1982	1990-1992	1996-1998
Jute	6	7	7	8	0	0	0	0	0	0	0	0
Cotton	0	0	0	0	3	3	3	2	0	0	0	0
Sugarcane	1	0	0	0	0	0	0	0	6	6	8	8
Remaining crops	1	4	5	7	1	1	1	1	1	2	2	2
Assam, Bihar, Orissa, West Bengal												
Food grain	90	86	85	86								
Rice	62	59	60	63								
Wheat	8	8	8	9								
Coarse Cereals	8	8	5	4								
Pulses	12	12	12	10								
Non-Food grain	10	14	15	14								
9 Oilseeds	3	6	7	5								
Fibre	1	0	0	0								
Jute	3	3	2	3								
Cotton	0	0	0	0								
Sugarcane	1	1	1	1								
Remaining crops	2	4	5	5								

[a] : Total cropped area is the sum of area under 43 major crops. [b] : For the whole state, not for its eastern region only.

part of the state, in this yield range, accounting for only 10 percent of rice area of the state. In most area of these latter two states the rice yield has exceeded 2 tonnes/ha. Therefore, as Bihar, eastern Madhya Pradesh and Orissa accounting for over 50 percent of the total rice area in eastern India, productivity improvement in these states will have positive impact on overall productivity performance of eastern India.

A critical examination of the performance of the districts over time suggests that the yield growth accelerator has been widespread in eastern Uttar Pradesh and West Bengal. In Assam, yield has continued to stagnate within the 1-2 tonnes/ha range in the four districts of Darrang, Goalpara, Kamrup and Lakhimpur. These districts represent North Bank Plains zone and the Lower Brahmaputra Valley zone. Chronic incidence of flood may be a major cause of low productivity in these zones. In Bihar, only three districts Gaya, Patna and Shahabad belonging to South Bihar Plains zone moved from 1-2 tonnes/ha yield bracket during 1970-79 to 2-3t/ha yield interval during 1990-97. Rice productivity growth in other districts of Bihar remained too low. The coastal districts of Ganjam and Puri and the inland districts of Sambalpur and Bolangir are the only four districts that have made some change in yield in Orissa. In the case of eastern Madhya Pradesh (now Chattisgarh), Raipur is the only district that has made this transition

On the whole, the overall picture indicates that a fairly broad-based yield growth occurred in West Bengal and eastern Uttar Pradesh. In other states of eastern India, growth is limited to selected pockets only (see appendix map). While favorable conditions have led to growth in some districts, productivity growth in other districts has been modest. This differential performance might have resulted from the variations in biophysical conditions (e.g., soil type, rainfall patterns), investments in irrigation and other infrastructures, and institutional set up across districts and states.

Further analysis reveals that, at the All India level, also the picture of rice productivity is identical to that of eastern India emerged in the recent years. Table 8 presents a clear picture that emerged, which categories the number of districts in five productivity classes viz., high productivity, medium productivity, medium low productivity, low productivity, and very low productivity[4]. Ironically,

4. High productivity: more than 2.5 t/ha of rice, Medium productivity: at 2-2.5 t/ha., Medium Low productivity: 1.5-2.0 t/ha, Low productivity: 1-1.5 t/ha and Very low productivity: less than 1 t/ha.

Table 8: Inter-district variation in Rice Productivity in 1999

State	Number of districts in various category of productivity 1999					
	# districts	High >2.5 ton/ha	Medium 2-2.5 ton/ha	Medium low 1.5-2.0 ton/ha	Low 1-1.5 ton/ha	Very Low <1 ton/ha
Andhra Pradesh	22	14	5	2	1	
Arunachal Pradesh	13			1	5	7
Assam	23			11	9	3
Bihar	55		5	7	25	18
Gujarat	11	1	2	3	4	1
Haryana	18	3	11	4		
Himachal Pradesh	10		1	1	8	
J&K	12	5	1	4	2	
Karnataka	27	13	7	5		2
Kerala	14	2	4	7	1	
Maharastra	27	5	1	1	11	9
Manipur	9	3	1		3	2
Meghalaya	7			2	5	
Mizoram	5			2	3	
MP	42		2	2	10	28
Nagaland	7			2	5	
Orissa	30			9	11	10
Punjab	17	16	1			
Rajsthan	18			1	14	3
Sikkim	4			1	2	1
Tamilnadu	28	28				
Tripura	4		1	3		
Uttar Pradesh	83	6	29	32	13	3
West Bengal	18	6	5	3	4	
A&N Island	2	1			1	
Other	5	4	1			
Total	**511**	**107**	**77**	**103**	**137**	**87**

Source : Directorate of Rice development, 2004, Rice yield performance by districts, Patna even after the four decades of green revolution, the productivity level of rice in 224 out of 511 districts is less than 1.5 t/ha, which is below the national average. It is to be noted that more than half (numbering 134) of these districts belong to eastern India. Eastern India has a total 251 out of 511districts in the country. Among the high performing districts, 24 out of 57 districts belong to northern zone and 57 out of 91 districts in southern zone and the lowest number of 12 out of 251 districts in the eastern zone. It thus speaks of the urgent need for policy to focusing on productivity improvement in the poor performing eastern India. The problem of rice cultivation in the rainfed areas is accentuated due to lack of the alternative options (technology and/or other policy incentives) to the farmers to choose the better one from.

The inter-district variation in productivity sharpen the contradiction that the high productivity areas subjected to severe externality of intensive agriculture and the low and risky productivity in the vast rainfed rice areas in eastern India suffered due to lack of appropriate rice technology and policy alternatives. The suspected externality due to cereal intensification (such as soil degradation, depletion of ground water and water tables), led to a strategy of diverting some prime rice growing areas in favour of crop diversification. At the same time, low and uncertain production condition has been perpetuating the rural poverty. Under the circumstances, unless, adequate alternative options are made available in promoting and developing modern rice production technology in the rainfed areas, the country is likely to face severe set back in rice production in future.

4c. Explaining inter-district variations in rice yield

Inter-district variations in yield may result either from the differences in agroclimatic factors or from differences in crop management practices. Agroclimatic factors such as rainfall and soil types define natural conditions of agricultural production, which are normally not subjected to management controls[5]. Crop management practices reflect human adaptations to these natural conditions as well as the socio-economic conditions of the farmers. Therefore, models to explain spatial variations in yield should contain these factors. A host of variables simultaneously influence inter-district variations in yield. The explanatory variables are grouped into five major categories, viz., economic and institutional factors (population

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density, farm size), environmental factors (rainfall, incidence of flood, incidence of drought, soil properties), technological factors (chemical fertilizers, HYV, mechanical inputs), management factors (cropping intensity), and infrastructures (road, credit, markets) (Rao et al 1985). However, there are some inherent problems of obtaining the relevant disaggregate data for all districts, apart from the problem of multicollinearity among the most explanatory variables. For example, the use of HYV and fertilizers tend to be highly correlated as farmers apply more fertilizers to HYV than to the local varieties. Similarly, the use of fertilizers tends to be correlated with infrastructural variables. Hence, a careful selection of proxy variables is needed to specify the model. Fertilizer use was considered to be a good proxy variable to represent several factors: the adoption of HYV, the area under irrigation and the infrastructural variables.

Apparently, the districts having low level of fertilizer use represent a combination of unfavorable agroclimatic conditions and unwillingness or inability of farmers to apply the chemical fertilizer, a critical component of improved rice technology. While reverse is true in the better off districts.

To separate out the effect of agroclimatic conditions, dummy variables can be used in the regression equation in explaining variations in yield. Table 9 shows that a single critical factor the quantity of fertilizers alone explains nearly 40 percent of the variations in rice yield across the districts pertaining to a wide range of socio-economic and environmental conditions. The explanatory power of the model increases as dummy variables representing the state or the agroclimatic zones are added. Significant coefficient of fertilizer indicates that it explained the inter-district variations in rice yield as well as the differential adoption of improved technologies.

Table 9 : Factors determining inter-district variations in rice yield

	Model 1	Model 2	Model 3
Intercept	1.6904***	2.1122***	3.0386***
Fertilizer consumption, 1995 (kg/ha)	0 0100***	0.0044**	0.0034**
Bihar		-0.4258*	
Orissa		-0.3680*	
West Bengal		0.4726*	
E. Madhya Pradesh		-0.9122***	

	Model 1	Model 2	Model 3
E. Uttar Pradesh		0.4537*	
Zone 1			-0.6371**
Zone 2			-1.1079***
Zone 3			-1.4066***
Zone 4			-1.3334***
Zone 5			-0.9262***
Zone 6			-1.1785***
Zone 7			-1.3371***
Zone 8			-1.4347***
Zone 9			-0.2642
Zone 10			-0.5284**
Zone 11			-1.5090***
F-value	48.85	22.87	14.62
R^2	0.38	0.65	0.72
Adj R^2	0.37	0.62	0.67
Sample size	81	81	81

Dependent variable: Average yield for 1995-1997.
Agroecological zones:

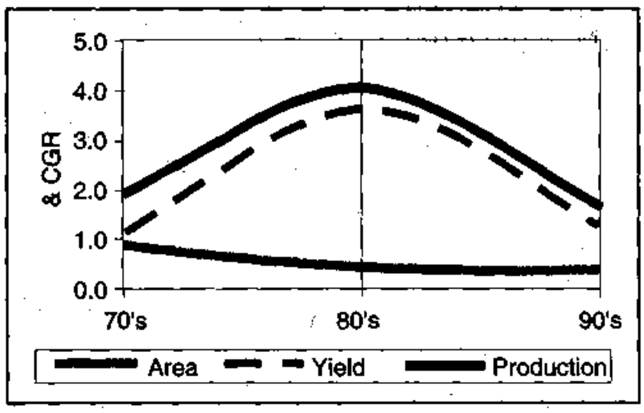
Zone 1 - BVZ+CBVZ+HILL, Assam
Zone 2 - LBVZ+NBPZ+UBVZ, Assam
Zone 3 - NEAP, Bihar
Zone 4 - NWAP, Bihar
Zone 5 - S. Bihar AP, Bihar
Zone 6 - East & South Eastern Coastal, Orissa
Zone 7 - Ghat (N.E., E., S.E.), Orissa
Zone 8 - Chattisgarh Plains, E. Madhya Pradesh
Zone 9 - E. Plain, E. Uttar Pradesh
Zone 10 - North Eastern Plain, E. Uttar Pradesh
Zone 11 - Plateau, Bihar, E. Madhya Pradesh, Orissa, West Bengal
Zone 12 - Lower Gangetic Plain, West Bengal

The coefficients of dummy variables indicating the location effect also explain to some extent the differential adoption of technologies across the agroclimatic zones.

5. Growth of Area, Production and Productivity of Rice

During the past four decades, rice production grew in a phenomenal pace. At the beginning of the 1950s, the total rice production was barely 32 million tonnes and the harvested area was 31 million hectares. The productivity per hectares was as low as around a ton per hectare. The production accelerated in the mid-1960s on account of the green revolution. It increased more than double at 75 million tonnes with a marginal increase in area in the triennium ending 1970. This increase in production was mainly credited to be a productivity-led. The production growth rate increased to 3.62 percent per year in the 1980s, from 1.95 percent in 1970s, which has fallen again to below 2.00 per cent mark in 1990s. (An inverted bowl shape, see figure 3).

Fig 3 : Decadal Growth of Rice in India



The sluggish production in the rice growing states during the 1990s affected the growth performance adversely. On the whole, in the recent years, the productivity of rice increased marginally from 2.64 t/ha (rough rice) in 1991-93 to 3.02 t/ha in 2000-02, an annual growth of 1.33 percent (compound growth rate). This growth rate is, however, lower than that of the population growth. The question arises, whether the deceleration in growth is the outcome of usual production cycle, or the on-set of long term deceleration process?

The weirdest aspect is that the disaggregated zonal analysis shows more sharper inter-regional picture, barring a few exceptions (see appendix table of compound growth rates). The growth rates were statistically significant. The production and productivity showing identically improved growth pattern, while rice area stagnating. In order to examine the inter-year dynamics, a series of 10-year moving growth rates were calculated for rice areas as well as production. The trend in 10 yearly moving average and growth of rice and production show that growth is sensitive to external factors such as annual weather conditions. The effect of inter-year variation which signifies annual weather condition that influences the growth rate (In Figs 4 and 5).

Fig 4 : Trends in moving average and growth of rice area in India

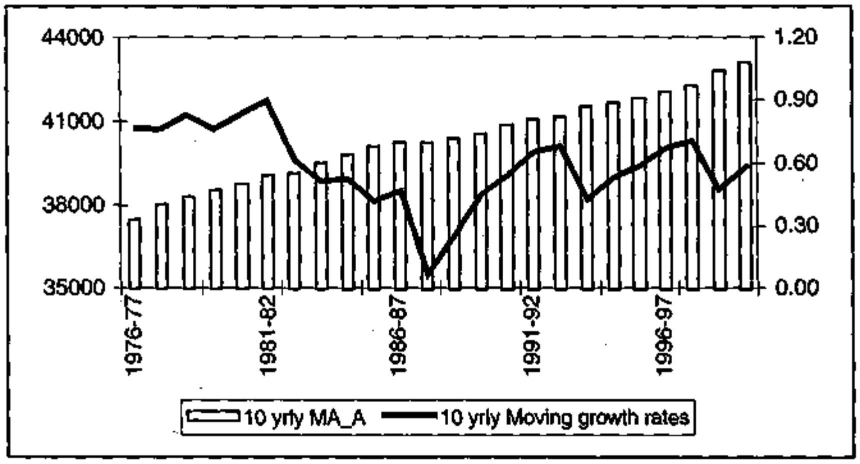
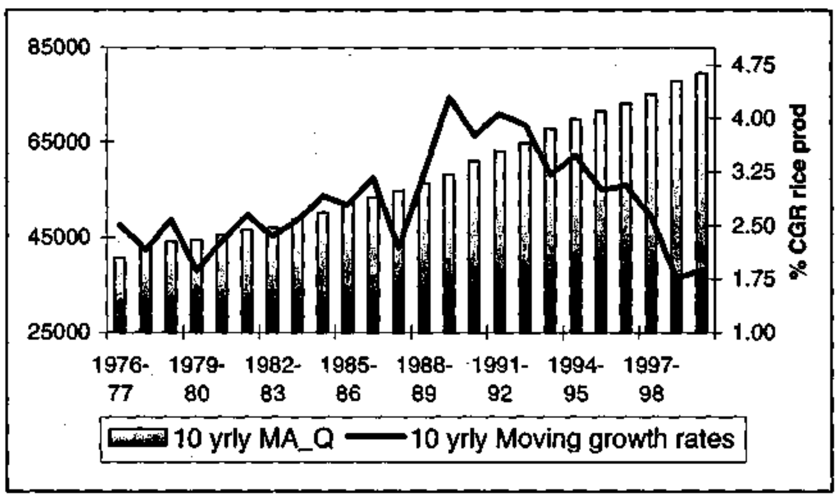


Fig 5 : Trends in moving average and growth of rice production in India



Therefore, in order to achieve stable future growth, a strong R&D input is required to boost the productivity and break the yield barrier, which provide safety net against the aberrations in climatic conditions. This is essential as the productivity enhancement is primarily technology and management dependent.

6. Shifting production base from irrigated to rainfed condition

It has been observed that the regional dimension of rice production systems depicts an interesting picture of inter-regional disparity in production and productivity performance. In brief, the irrigated tracts demonstrate a highly progressive scenario as against diametrically opposite and unequal picture in the rainfed areas. As mentioned in Table 5, the share of area and production indicates the relative importance and contribution of the major production zones in the country.

It shows that while the northern zone and southern zone avail high proportion of area under irrigation, the eastern zone has the least[6]. The introduction of modern high-yielding rice varieties and efficient support systems contributed to the impressive productivity of rice in the northern zone. The favourable irrigation infrastructure, institutional reforms in marketing, pricing support and procurement policy enabled rapid expansion in area under rice. This resulted in increasing rice production from 0.67 million tonnes (rough rice) to 13.3 million tonnes in Punjab and from 3.9 to 13.9 million tonnes in Uttar Pradesh during the period of 1968-69 to 2001-02. However, this level of production started declining and raised doubts on its sustainability in recent years. The negative externalities of intensive agriculture in irrigated tracts resulted in severe soil degradation and water and soil pollution, which prompted the governments to resort to alternative policy intervention. The strategy designed to divert area under cereals to other crops in favour of crop diversification, is expected to break the dominance of rice-wheat system. Adopting the strategy, Punjab has already diverted about 1.75 lakh acres of area under crop diversification in 2003-04 from barely 12234 acres in rabi 2002. The area under crop diversification is likely to increase upto 22 lakh acres in the next 4-5 years. In the process, total food grain production has decreased from 249 thousand tonnes in 2001-02 to 235 thousand tonnes in 2002-03 showing a decline of 5.66 percent in Punjab. The gross area under food grains has also decreased from 6155 thousand hectares in 2001-02 to 6132 thousand hectares in 2002-03 at the rate of 0.37 percent and the

6. Northern Zone consists of Punjab and Haryana, Himachal Pradeh, Jammu & Kashmir
Southern Zone : Andhra Pradesh, Tamilnadu, Karnataka and Kerala
Eastern Zone : Chattisgarh, Madhya Pradesh, Orissa, Bihar, Uttar Pradesh, Assam, West Bengal and other northern eastern States.
Western Zone : Maharastra, Gujarat, and Rajastan.

wheat production recorded a negative growth rate of 8.60 percent in 2002-03 over the previous year. The trend is almost similar in Tamilnadu and Andhra Pradesh, where crop diversification and precision farming in commercial crops, is followed in recent years. This change in production in the resource-rich areas raises an alarming signal for the food security. On the contrary, not only the technology factors, market imperfection and unrealized pricing policy also frustrates the producers in the backward areas. In a sharp contrast, the eastern zone, which is characterised by rainfed production environment, has barely 36 percent of the area under irrigation. But it occupied as high as two-thirds of total area and produced only a slightly more than half of total production. The low input traditional mode of production resulted in lower productivity of rice in this zone. The farmers are susceptible to the exploitative market mechanism and the input-output delivery systems remained in the hands of the informal players at large. The productivity of rice is low and variable despite the enormous production potential. Perhaps the existing incentive structures (technology as well as support policy) is not adequate for the farmers to go for intensive cultivation. Therefore, there is need for a policy shift from the core green revolution areas to the green revolution bypassed and the less developed rice production system in eastern India.

Moreover, it is also to be noted that while combined areas under wheat and rice is stagnating around 69 million hectares (accounting 57 per cent of total foodgrain area), the rice yield in over the two-thirds area is hovering around 2 tonnes per hectare. This consistent low productivity has severe implication on the household food security of the millions of small and poor farmers, a phenomenon, likely to reach an un-manageable situation in future. The low productivity and vulnerability to natural calamities push a large number of the population towards abject poverty (Appendix figure 1). It shows that poverty (particularly the rural poverty) is more acute in eastern India as compared to other parts of the country. Hence, if Punjab chooses to divert rice-wheat area in pursuant to newer developmental path and Tamilnadu and Andhra Pradesh follow the suit, it may create an unexpected vacuum in the food production frontier. At the same time, the production situation is frightening in eastern India as the growth rate in the major states of Bihar and Orissa is not only declining but also turned negative in some cases. Rice is traditionally a crop of kharif season, which is usually vulnerable to natural calamities. It resulted in production loses and the farmers have to contend with low productivity, as there was no alternative to kharif rice in the past. But concerted strategy of the governments over the years ensure some scope for production possibility in rabi season too. A carefully designed production strategy in rabi season such as Boro rice cultivation practice is relatively safer and higher yielding too. This innovative practice has shown promising results as in case of Boro rice in West Bengal and parts of Assam. It thus paves the path for policy shift in rice production, not only spatially from irrigated areas to rainfed area, but also a temporal shift in growing season from kharif to rabi season. Therefore, the strategy for productivity enhancement and stability supplemented by supportive interventions in providing more entitlement to livelihood to the rice growing population is indeed urgent. This necessarily requires effective policy support for a paradigm shift in production-base from irrigated to rainfed areas in developing appropriate technology and assured supportive services strategies.

7. Looking east-ward : Eastern India a potential source of future growth

In the changing scenario, rice in eastern India emerges as important and strategic crop. The region has the largest area suitable for rice cultivation and follows a unique practice of cultivation in three times a year. There is a huge rice-wise agricultural labour force and rich biodiversity. The region has abundant water and dependable rainfall in parts of the region. Therefore, changing scenario and technology, has thrown open the opportunity to utilize the ample potential for rice production in the region and enhance their role in the food security. This section reiterates some of the salient features of eastern India and appraises the performances of rice in the context.

Box
Salient features of Rainfed rice production systems 2000

Area	**Production**
Total Rice Area : 43.43 million hectares	Total Production : 82.30 million tons
Rainfed Areas : 28.73* mha (67% of total rice area)	Rainfed Production : 46.25 mt (56%)
Total Population : Nearly half of total population	Average Yield : 1577 kg/ha
% Area without Irrigation : upto 73%	National Yield: 1882 kg/ha
* including the rice area of Uttar Pradesh	

Proportion of small and marginal farmers: 81%

Poverty in eastern India: As many as 142 million of total 260 million (55%) poor belongs to eastern India.

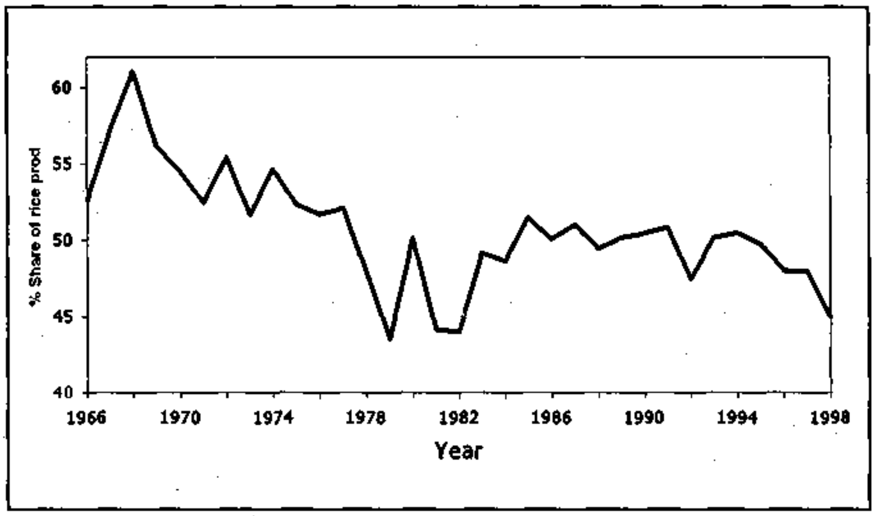
Rural poverty in the individual states: Assam 40%, Bihar 44%, Orissa 48%, Uttar Pradesh 31% and West Bengal 32%

A brief account of the changes that occurred in eastern India is provided below :

a. **Production changes and incremental output of rice :** The percentage share of rice output in eastern India to All India total output declined at the advent of green revolution but picked up after 1981 as rice production growth accelerated. The share declined again during the 1990s with a fall in growth rate in rice production in eastern India (Fig 6).

The share of incremental output of rice increased initially accounting for almost 50 percent in the mid-80s. The share subsequently decreased, which revived recently, but remain below the 1970s level

Fig 6 : Changes in share of production of rice in eastern India to total production



b. **Incremental yield :** Per year incremental yield varies from as little as 9 kg/ha in Madhya Pradesh to 72 kg in west Bengal having aggregate eastern India average of 34 kg/ha.

c. **Nature of growth process :** Stagnant yield up until 1981 and yield growth picked up afterward, fairly widespread and rapid growth in Eastern Uttar Pradesh and West Bengal. Yield and production growth slowed down after 1994. Growth in other states barely able to keep up with the population growth rate. Virtually no growth in almost 50 percent of the area.

d. **Cropping pattern change :** Share of rice area almost stagnant, wheat & oilseed replace most coarse cereals. In general, food grain production remains the main land use. Crop Diversification has taken place in west Bengal in faster pace.

e. **Pattern of Technology Adoption :** HYV has spread in all states, while in irrigated area it is more discernible. Compared to percent area under irrigation, HYV adoption rate is higher implying that HYVs have spread into rainfed areas as well, despite sparse modern varieties. The issue is not just of HYV spread but that of the productivity. There is increase in fertiliser use during last three decade albeit slower pace. Cropping intensity improved of varying order with highest increase in west Bengal and least in Madhya Pradesh and next is Orissa and Bihar.

f. **Development of Modern Rice Technology** : Under investment in varietal development in particular and agricultural R&D in general led to sparse technology situation. Currently, less than 0.5 percent of the value of rice and less than 0.1 percent of the value of agricultural output invested in R&D. The analysis of modern varieties has shown that number of modern variety per million hectare is 21 in irrigated systems, while it is only 13 in rainfed upland and 9 in rainfed lowland. Unfortunately even the adoption of the existing varieties has been slower in pace. It thus pointed out the inadequacy of the targeted varieties in the diverse ecosystems in the region.

The analysis has shown that after achieving four-fold increase in rice production during past four decades, irrigated rice production systems show sign of technology fatigue and surfaces many adverse externalities. These adverse impacts on food production have raised demands for alternative strategy to exploit and convert the untapped potential of rainfed ecosystems. Among others, one of the advantages of rainfed rice in eastern India is that rice is grown widely in vast and diverse rainfed areas and in three seasons a year. Unfortunately, these advantages are not translated into productivity enhancement. Ironically, the region suffers from low and risky productivity. The situation thus, warrants appropriate technological and policy intervention to manage risk of production, which may enable reversing the inverted dome shaped growth process, or else its continuation will endanger food security at large. A clear insight into the changing pattern is essential for designing appropriate policy intervention.

Understanding rainfed agriculture system is necessary to look at a promoter of food security. The following typology and unique features of rice in rainfed areas in eastern India emerged, whose implications are enormous in future R&D and policy options.

- Rich natural resource endowment and poor utilisation
- Home for mega biodiversity
- Abundant water and dependable rainfall in most parts of the region
- Large rural poverty intensity and skewed income distribution
- While Punjab, Haryana, UP, AP and TN are early adopters of green revolution, Assam, Orissa, MP, Chattisgarh and Bihar need a rice revolution
- Rice is the dominant production system, but its past performance was dismal.
- Inequitable distribution of modern rice varieties
- Predominance of rainfed agriculture
- Heterogeneity and diversity of production systems
- Multiplicity of agricultural systems
- Lack of functioning markets, intuitional and infrastructure supports
- Chronic Vulnerability to floods and submergence, droughts and cyclones
- Poor crop management care and modernisation
- Lack of economic incentives and political enabling environments
- Under investment as well as falling investment on agricultural R&D
- Lack of economic incentives and political enabling environment
- Preponderance of small and marginal farmers
- Lack of employment opportunities and low labour productivity
- Changing scenario emerging in restricted pockets but lacks uniformity

8. Ecological diversity and rice production system

Rice growing environments

Rice production environment in India is characterised by extreme diversity and disparity in multiple ways. It has been estimated that out of the total of 45 million hectares of harvested area under rice in India, only 46 percent of these are irrigated, about 38 percent are rainfed lowland, 13 percent rainfed upland, and 14 percent flood-prone (Singh 2002). While, the irrigated production system is homogeneous, the diversity is more conspicuous in the rainfed areas. Table 10 shows that ecosystem wise productivity of rice is showing that it is less than the national average of 1.9 t/ha in over 47 per cent of the total rice area.

Table 10 : Area, Production and Productivity under DIVERSE RICE ECOLOGIES

	Area (mh)	Area (%)	Production (mt)	Prod. %	Productivity t/ha
Irrigated rice	20.5	46	60	70	2.9
Wet season	16.5	36	46	50	2.8
Dry season	4.0	9	14	20	3.5
Upland (mh)	6	14	5.5	6	0.9
Favourable	2	5	3	4	1.5
Drought prone	4	9	2.5	2	0.6
Rainfed lowland	13	29	16	19	1.2
Drought prone	4	9	6	7	1.5
Favourable	3	7	6	7	2.0
Medium deep/ waterlogged	3	7	2.5	3	0.8
Submergence/ flood prone	3	7	1.5	2	0.5
Deep water	4	9	3	4	0.8
Deep water	3	6	2.5	3	.8
Floating rice	1	2	0.5	1	.5
Coastal Wetland	1	2	1	1	1
Total	44.5	100	85.5	100	1.9

Source : B N Singh 2002, High yielding rice varieties in India, Rice India, (March), pp 5-6

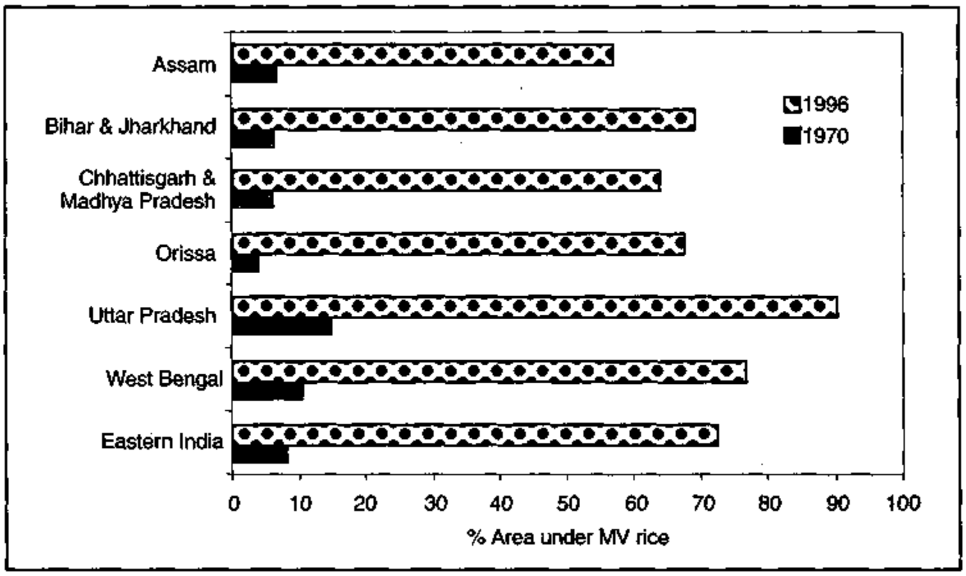
The low productivity in rainfed areas and ecological diversity created enormous demand for targeted technologies, particularly for ecosystem based rice research. But the existing technology is far from adequate in rainfed areas. From Fig 9, it is clear that the distribution of existing modern variety is inequitable disfavouring rainfed area. More than 55 per cent of the total number of modern varieties is targeted for irrigated areas, while the same is 27 per cent in rainfed lowland and 19 per cent for rainfed upland. That is, there are 25 modern varieties per million hectares of irrigated rice area, only 10 in rainfed lowland and deep water ecosystem, and 13 in rainfed upland rice ecosystem. The total area under irrigation in wet season is 16.5 million hectares, while the same is 17 million hectares in rainfed lowland and deep water and in rainfed upland about 6 million hectares. Obviously due to the scarcity of ecosystem-specific improved varieties, the rate of adoption of modern varieties has been moderately low, and thereby low productivity. Therefore, even if the adoption of the available modern varieties enhanced, rice production in rainfed areas could increase significantly.This scarcity of appropriate varieties and the diversity of production condition demand even larger number of modern variety in rainfed areas. A simple calculation shows that by enhancing the yield to the level of national average, the rice production could be increased by at least 24 million tonnes in the 47 per cent in the poor-performing rainfed areas. What inhibits the adoption of the existing technology is a question.

In this context, it is to be noted that apart from the diversity-led intervention, the escalating gaps in gain due to rice research achievement and growing nutritional insecurity has also created demand for appropriate and location specific research.

9. Adoption of modern varieties and input uses

Studies have shown that most increase in production and productivity has occurred due to the two major components of the improved rice technology, viz., HYVs and fertilizers. Expansion of irrigation facilitated the adoption of modern variety and fertiliser use increased the productivity of inputs. Rapid adoption of modern variety took place in irrigated areas, which suits the production conditions. Obviously by default, the rainfed areas lagged behind in adoption and thereby perpetuated the low productivity (Fig 7).

Fig 7 : Percentage area under MV rice in Eastern India



Between 1970 and 1996, the adoption rate in eastern India reached 70 per cent mark in area coverage with some regional variation. The rate of adoption of modern rice variety in Assam was the least and Uttar Pradesh the highest level. Bihar, Orissa and Madhya Pradesh (including Chhatisgarh) achieved adoption level of more than two-thirds of the rice area by 1996, although it did not reflect in proportional increase in productivity. It has proved that the adoption of varieties alone is not sufficient to impact productivity enhancement, other basic inputs also need to be accompanied at desired level and quantity. In view of the argument presented above, the analysis focuses basically on input use pattern in the rainfed areas around these three inputs, viz., seed, irrigation and agro-chemicals including plant protection measures.

- In the backdrop of the green revolution in the 1970s, the area under modern varieties was below 10 percent in Assam, Bihar, Orissa and Madhya Pradesh. Only Uttar Pradesh and West Bengal had a slightly higher ratio at 15 percent and 11 percent, respectively. The adoption of the improved varieties steadily increased in eastern India over time, and during the triennium ending 1996, it reached a level of 69 percent. In Uttar Pradesh, over 85 percent of the rice area was planted to MV during the triennium 1994-96. The adoption crossed the three-fourths mark in West Bengal, but it remained at low level in Bihar, Madhya Pradesh and Orissa. The rate of adoption was the lowest in Assam, which was estimated at around 50 percent. On the whole, compared to other inputs, the adoption of modern varieties have picked up in most parts of eastern India, although opportunities for further expansion remain mainly in Assam, Bihar, Orissa and Chattisgarh.

- An interesting picture emerging from the analysis is that the proportion of area under modern varieties was found to be larger than that of area irrigated. This implies that modern varieties spread to non-targeted rainfed ecosystems also, as farmers willing to encash the opportunities for increasing rice production through modern varieties even if they are unable to irrigate the fields. It is likely, however, that farmers would not invest much in fertilizers to avoid risk even if they grow modern varieties under rainfed conditions. The production gain from the expansion of the modern varieties has, hence, been modest in such situations. Hence, the adoption of modern varieties alone appears to be a poor indicator of greater impact of modern technology.

- Expansion of irrigation, especially that of the private tubewell irrigation, has been a strategic phenomenon, which played an important role in the rapid growth in rice production in eastern Uttar Pradesh and West Bengal. During the early 1980s, central and state governments initiated programs for subsidizing the expansion of groundwater irrigation in the Indo-Gangetic plains. While the percentage of rice area irrigated in Assam, Bihar, Madhya Pradesh and Orissa have not changed much over time, Uttar Pradesh experienced a rapid growth in the coverage of irrigation for rice. This was possible due to enhanced access to irrigation in Uttar Pradesh. On the whole, tubewell irrigation emerged as an important source of irrigation in eastern India. Existence of an active groundwater market has been an important characteristic of groundwater utilization in Uttar

Pradesh and West Bengal. This has facilitated the farmers who lack adequate capital for investing in pumps. Those having small irrigable area can purchase water from neighbors who have installed pumps. Notwithstanding the problems associated with irregular power supply and the high cost of diesel-operated pumps, irrigation has now become widely accessible in these two states and to a limited extent, in other states of eastern India. The relative reduction in risk due to ability to provide supplemental water as and when needed, has then encouraged rapid adoption of modern varieties and the increased use of fertilizers in eastern India. In the case of West Bengal (and of late in Assam), ground water irrigation was also instrumental in the expansion of summer rice (boro) cultivation.

- Compared to ground water irrigation, based on available data, the nutrients (N, P_2O_5, and K_2O) used per ha of gross cropped area was found to be low across all states in eastern India in 1975 (Table 11).

Table 11 : Fertilizer use
(kg of nutrients/ha of gross cropped area)

	1975	1980	1990	1995	1999
Assam	2	3	11	12	28
Bihar	13	18	57	72	97
Orissa	7	10	21	25	44
West Bengal	17	36	90	94	136
Madhya Pradesh	5	9	35	33	47
Uttar Pradesh	21	49	90	101	125
All India	17	32	72	74	95

Source : CMIE (1995) and CMIE (2000).

But, it picked up rapidly after 1990 in Uttar Pradesh and West Bengal at a rate higher than the national average. The application rate also increased in Bihar, Assam, Orissa and Madhya Pradesh, though at lower level of use. In general, average NPK use varies from 50 kg/ha in Assam, Orissa, and Madhya Pradesh (mostly rainfed areas) to more than 150 kg/ha in Punjab, Andhra Pradesh, and Haryana (irrigated land). Data on fertilizer sales show a large regional variation in the use of nutrients. Even in 1999, the lowest fertilizer use was in Assam, but West Bengal surpassed other states in fertiliser use.

- The use of pesticides in rice cultivation is usually higher in Punjab and Andhra Pradesh as compared to other states. Similar is the story of mechanization of agricultural operations (highly prevalent in Punjab, Haryana, Andhra Pradesh, western Uttar Pradesh, and West Bengal, but is almost absent in other states).

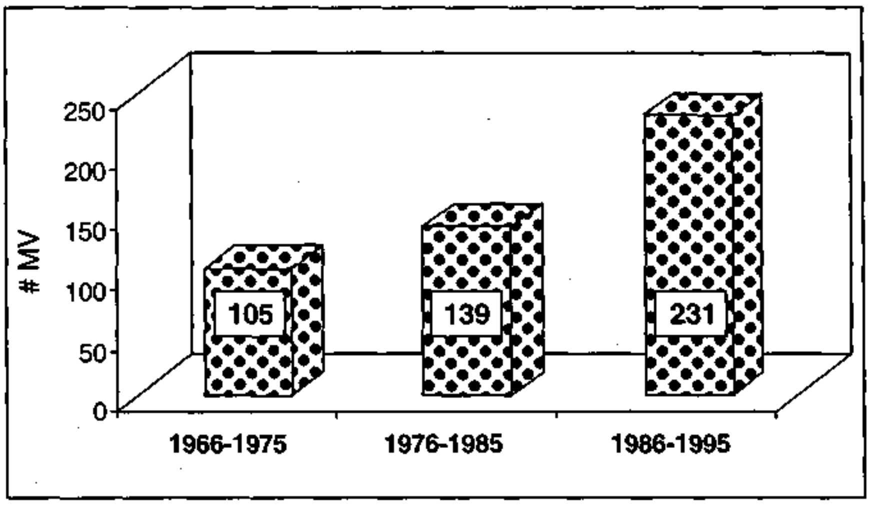
- Notwithstanding the past progress, rice research faces a number of challenges. Among these, low productivity and the regional differences in production are more prominent. The worrying aspect is that compared to other countries, the average yield of rice in India is 2.09 tonnes/ha (in 2000-02), and even this level of yield started declining from the later half of the 1990s. Lack of required genetic improvement in productivity breakthrough, low rate of adoption of modern variety, lack of varieties resilient to biotic and abiotic stresses such as droughts, pest and disease etc. and imbalance use of fertilizer are some of the probable reasons for low productivity. The adoption of new rice type such as hybrid rice is also limited. In 2000, the hybrid rice was planted only one lakh hectare as against a target of 1 million hectare.

10. Agricultural R&D system network and modern rice technology

India has a strong and competent rice research and development system in the world. In this system-wide initiative, the Indian Council of Agricultural Research (ICAR) developed a harmonious network partnership with the SAUs (State Agricultural Universities) and the International Rice Research Institute (IRRI). A number of private firms also participated in the rice research programmes. The Directorate of Rice Research (ICAR), Directorate of Rice Development (Govt. of India), Indian Agricultural Research Institute and the IRRI have rendered requisite training to rice researchers both in conventional breeding and Hybrid programme. The process helped achieving great success and has developed more than 700 modern rice varieties and hybrid in a period of past 35 years till 2004.

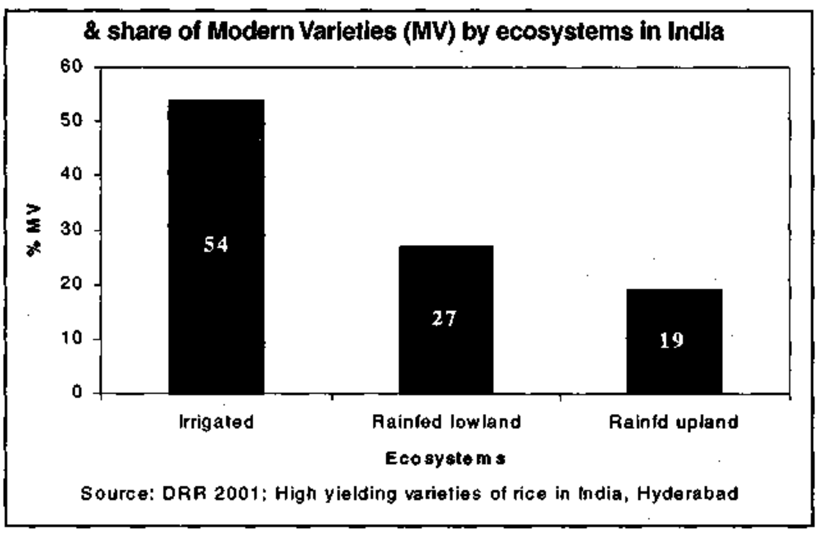
Figure 8 depicts a historical perspective of the development of rice varieties in the rice research system in India. During 1965-75 period, there 105 varieties were developed and released by the central variety release committee, which increased to 139 in the next ten years and further increased to 231 in 1986-1995.

Fig 8 : Trends in Released of Modern Rice Varieties in India



This is the largest stock of modern rice variety ever a single country possesses. But, it is ironical that this phenomenal achievement unable to meet the requirements of the stakeholders across the country. Since rice is grown and adapted in diverse agro-ecological situations and socio economic conditions, the need for demand-driven modern technology continue to loom large. During the green revolution period, the irrigated tracts benefited immensely from rice research with the development of short duration dwarf and high yielding varieties of rice. Most importantly, this was supported by favourable policy of infrastructure and institutional supports too. By implication, it means that rainfed areas were neglected and deprived of adequate research attention as it deserves. The ostracized green revolution actually totally bypassed the vast areas of rainfed areas, in particular the eastern India, which resulted in a clear disconnect between irrigated rice and rainfed rice production system. As mentioned earlier, the unequal distribution of modern variety also reflected a sharp bipolarity in the performance. It has been observed that the distribution of modern varieties across the ecosystems was uneven, wherein 54 percent of the modern varieties were targeted for the irrigated areas, 27 percent for the rainfed lowland, and 19 percent for upland areas (Fig 9). The unequal distribution severely affected productivity and accentuated the disparity. The productivity in the irrigated tracts exceeded 4 t/ha, while it remained at the level of less than 2 t/ha in the rainfed areas. The modern rice technology, although a pre-requisite for the sustainability of food security, its success depends on the back up support infrastructure, pricing policy and other policy interventions, which were neglected in the rainfed areas.

Fig 9 : % share of modern varieties across ecosystems in India



It is also observed that even though the varieties are targeted for a particular ecosystem, only a few stayed consistently at the actual fields. For example, Swarna (MTU 7029), a derivative of Mahsuri, is the most popular improved rice variety that is grown widely in number of states. Incidentally, Swarna was released two and half decades ago. In 1999, it was grown on about 12 percent of India's rice land (Rice Almanac 2000). The other popular varieties are Jaya, Vijeta (MTU 1001), Samba Mahsuri (BPT 5204), Mahsuri, Lalat, IR64, and IR36.

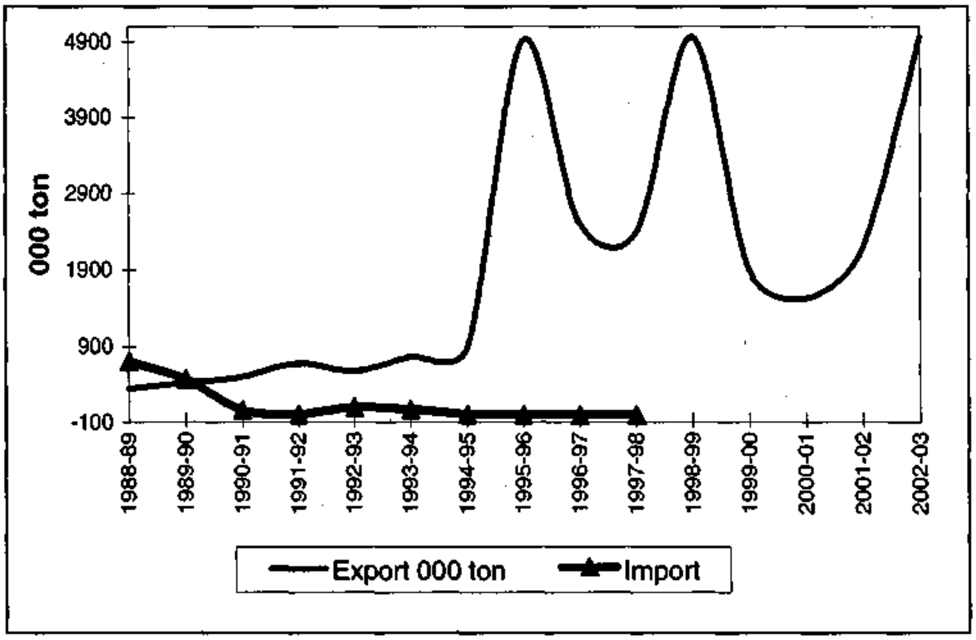
The national agricultural research system (NARS) recognized the importance of the rainfed areas in sustaining the food security in the country. The rice research priorities have gradually shifted from the irrigated ecosystem to the predominantly rainfed ecosystem in eastern and northeastern India. Rice research institutions such as Central Rice Research Institute, Cuttack and Directorate of Rice Research Hyderabad, along with the SAUs geared up to face the challenge and engaged in strategic research to increase the productivity of rice. The international research organizations such as the International Fund for Agricultural Development (IFAD), Ford Foundation, Rockfeller Foundation and the International Rice Research Institute (IRRI) collaborated in consortium mode and contributed significantly in this effort of variety improvement in rice. The Rice-Wheat Consortium (CIMMYT) for the Indo-Gangetic Plains studied the problem of sustainability of high yields in rice and wheat by examining system level issues. However, this unified effort yet to translate into tangible achievement antl express into wider productivity impact in the areas neglected in the past.

11. Other constraints

11a. Rice Quality, buffer stock and trade

Rice is an important export commodity in India. It gained even more importance as the economy opened up in the 1990s. It has also thrown open many opportunities as well as challenges in the rice sector. Quality, quantity and mode of production have become more important in the global scenario. In recent years, the export of Indian rice has experienced a seesaw movement in the international market. Exports jumped from 0.9 million tonnes in 1994 to 4.9 million tonnes in 1995, in response to the large increase in demand in the world market (Fig 10).

Fig 10 : Trends in International trade in rice in India



It reduced drastically in subsequent years and picked up again in 2002. This brings out a number of issues, eg. (i) India has potential to participate in the International rice trade, (ii) There is favourable market access to Indian rice, (iii) but then, why the export is highly fluctuating and unsustainable. The un-sustained exports of rice may be due to low quality rice and trade inefficiency. It is obvious from the fact that while the quality basmati rice trade in India has been more or less stable, the same for non-basmati rice is a variable. As a result, the fluctuation is more in case of the export of non basmati rice than the basmati rice. The export of basmati rice is almost constant at around 500 thousand tones, while the non basmati rice is fluctuating from year to year (Table 12). In such a situation of fluctuating export, the country could hardly benefit from the advantages of rice trade thrown open in the liberalization of the economy. Adequate preparations are required to meet the strict compliances of the WTO conditionality in term of quality, pricing and tariff regime etc.

Table 12 : Export of Rice in India

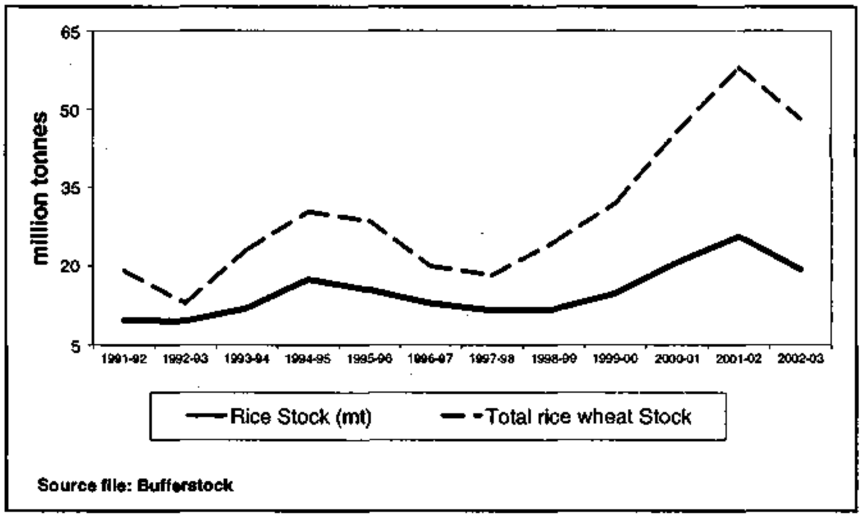
Year	Rice Production	Export of Rice			Per capita
	Total mt	Total mt	Basmati 000t	Non-Basmati 000t	Availability kg/yr
1988-89	70.5	0.350	314	36	69
1989-90	73.6	0.422	384	38	78
1990-91	74.3	0.505	232	273	77
1991-92	74.7	0.678	267	411	81
1992-93	72.9	0.580	325	255	79
1993-94	80.3	0.767	527	240	73
1994-95	81.8	0.891	442	449	75
1995-96	77.0	4.914	373	4541	80
1996-97	81.3	2.512	523	1989	75
1997-98	82.3	2.389	593	1796	78
1998-99	85.9	4.964	600	4350	73
1999-00	89.7	1.896	640	1260	74
2000-01	84.5	1.534	850	680	74
2001-02	93.3	2.208	670	1540	70
2002-03	72.6	4.967	590	4080	83

Source : GOI 2004 Economic survey 2004

The sharp fluctuation in rice export in the recent years also conveys the message that there is scope for absorbing higher volume of rice from India in the international market. Since the Indian rice claims to have comparative advantages in the World, therefore further in-depth analysis is needed to understand the changing scenario. Sustaining a comfortable level of export however, requires more research on food safety and other SPS measure, and effective public policy interventions.

In the domestic front, the public distribution system faced the problem of management of the accumulated stock of rice. It resulted in large unmet demand for staple food grains in most poverty-stricken States. In the beginning of the 2000s, total stock of rice and wheat reached the high of 58 million tonnes of which rice was 26 million tonnes (Fig 11). The paradox is that although rice stock is mounting, export has been modest and food distribution remained unfulfilled.

Fig 11 : Buffer stock operation of rice & wheat in India

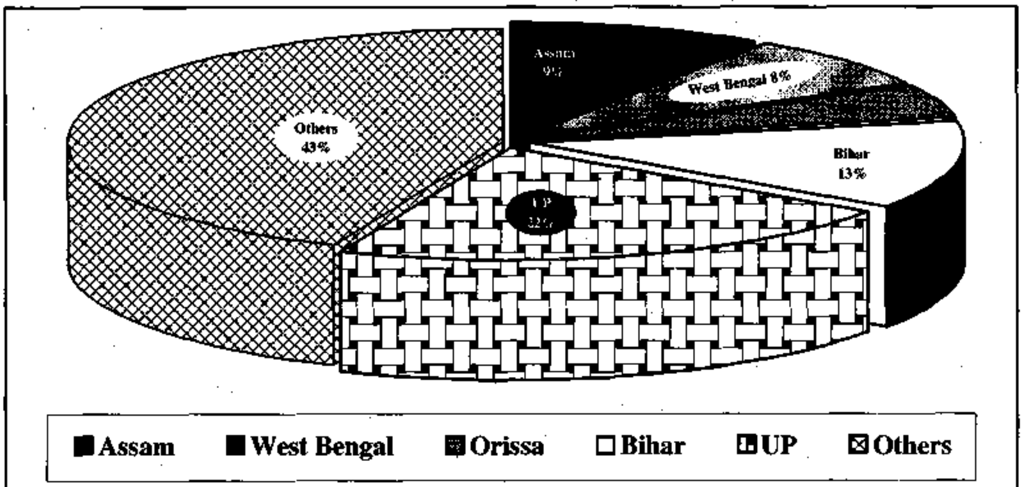


11b. Vulnerability to production risk

i. Water related factors:

The studies show that the rice production is subjected to multiple risks due to biotic and abiotic factors, apart from the market imperfection (Pandey S et. al. 2000). Since the major portion of the area under rice in India is rainfed, production is strongly tied to the favourable rainfall distribution. Moreover, very often, the simultaneous occurrence of drought and floods in the same location deteriorate the situation. Rainfall deficiency causing early drought situation affects vegetative development of crop, while submergence and floods due to high rainfall, damage the crop in the later period. In the eastern states, damage from flash floods is also increasing leap and bound. The occurrence of high intensity such as super cyclone as in Orissa in 1999-2000 and super floods in Assam in July 2004, have also become more frequent. Figure 12 depicts the geographical distribution of flood-affected areas of the country. It shows that at least 10 to 20 per cent areas, have been subjected to severe crop loss on regular basis. The chronic natural calamity of these types has reduced the overall productivity in the rainfed areas. Fortunately, the government's policy and research initiatives has helped developing relatively safer mechanism in management of production loss due to floods in kharif season, which has provided this relatively safer rice production system in rabi season. It is thus felt necessary to examine why the practice of cultivation rice in rabi season has not spread so far to a desired level. While the ground water development has become softer option for the safe irrigation facility, the problems of environmental externalities such as arsenicals in west Bengal and iron toxicity in Assam and other areas required serious policy attention.

Fig 12 : Distribution (%) of 40 million hectare Flood Prone Area in the Country



Source: Centre for Science and Environment 2001, Down to Earth Oct 31, New Delhi

ii. Soil related factors:

Other factors affecting vulnerability relate to the land and soil. Soil acidity is serious problem in southern and eastern India, whereas, in northern India, soil salinity and alkalinity is problematic. Low soil fertility, P and Zn deficiency are widespread. Most often excessive use of nitrogenous fertilizers also cause nutrient imbalance in the soil. Addressing these problems requires concerted efforts to educate farmers to adopt the practices of balanced use of fertilizers and other agro-chemicals. But, in reality, while educating the farmers for balance use of fertilizer, it should be kept in mind that the input supply chain, notably the informal marketing agencies perpetuate the inefficiency in fertilizer use. Inefficiency of input supply chain thus, is another notable constraint hindering full exploitation of the yield potential. The investment on proper drainage at field level and restoration of sodic soil on regular basis is also necessary. The use of organic manures as an alternative method to compensate the loss of nutrients in the cultivation of modern varieties has been limited. On the contrary, rather than recycling the crop residue and animal dung in cultivation fields, these sources of organic manure are put to multiple other uses such as livestock feed, thatching of roofs and fuel. In case of other biotic constraints, stem borers, brown plant hopper, green leafhopper, and gall midge are major insect pests causing large yield losses. Bacterial blight, blast, sheath blight, and brown spot are important diseases, which cause substantial loss of production.

iii. Vulnerability impact

As the intensity and frequency of the natural calamities such as droughts, cyclone, floods etc. are increasing over time, its impact on agriculture has become almost irreparable, particularly in the marginalized land. Severe floods cause soil erosion and destroy the crop land irreversibly. Experience shows that a severe drought could wipe out the production drastically as observed in the drought year 2002-03, when rice production reduced from 93 million tonnes in 2001-2002 to 72 million tonnes (approximately a decline in fourth of total production), indicating that there is urgent need to develop more resilient varieties to withstand such unfavourable production conditions. The drought was so severe that, according to the Indian Meteorological Department, 21 divisions out of 36 meteorological divisions in the country had scanty or deficient rainfall during June-September in the year 2002[7]. Down the line, its impact on reduction in production was much higher at individual state and district level. Under the circumstances, drought leaves its impact not only on the drought prone areas but the irrigated agriculture also gets affected. The impact is worst in the absence of rice varieties resistant to drought, floods and other biotic stresses.

7. Govt. of India 2005, Economic survey 2004-2005, Ministry of Finance, New Delhi, pp168.

Therefore in the changing production scenario in the rice production systems, a shift in emphasis in favour of rainfed rice areas is inevitable. Given the necessary policy strategies and assured technology support, the rice production in the rainfed areas could be potentially revolutionized, which will enable to exploit the enormous untapped opportunity in the eastern India.

12. Concluding remarks and emerging Issues

Beginning at the advent of introduction of dwarf and new dwarf high yielding variety of rice and wheat, the food production in India has increased manifold. The innovation alleviated the status from food deficit to a net food surplus country. However, the changing of pattern growth as well as the declining the production in recent years has sent caution signal against the complacency in future food security.

- Rice is the most important crop in India, which plays a critical role in food security. More importantly, it is a choice crop of the millions of poor and small farmers not only for income but also for household food security.

- The paper used the spatio-temporal rice related data from secondary sources pertaining to rice growing areas to study the trends and growth pattern over the decades (1950-51 to 2001-2002). It covered the relevant information pertaining to country, state and district level, which helped deriving a desired macro perspective, and the analysis of state and district level data also provide regional dimensions. The regional dimension of rice production systems assumes greater significance in developing regionally differentiated plans. This is also important in view of the phenomenal pace of increase in rice production, which has been uneven. The regional disparity is highly pervasive among the states and across the diverse ecosystems. Clearly, the gain due to modern rice technology has been discriminatory against the resource poor area, which is also dominated by small and marginal farmers. The analysis also brings out a distinct production divide between irrigated rice and rainfed rice production system. The paradox is that the un-sustainability of intensive system of agriculture (eg. Rice-wheat system in North-Western India), gradually pushing the ostracised green revolution out of stream and at the same time, the performance of the rainfed areas continue to be dismal. Moreover, core green revolution- states resorting to pro-diversification policy, may create an unexpected vacuum in the food production frontier. Apparently in order to compensate the loss of total production and depleting central pool of foodgrain in such an event, the onus automatically falls on the lesser performing rainfed areas. Should such event occur, rained areas would require at least three times additional area under rice, at the given level of productivity or to increase its productivity itself by 2 to 3 times. How to break the productivity barrier in the rainfed areas? Can the green revolution bypassed region and the less developed rice production system in eastern India play more innovative role in future.

- Notwithstanding poor performances, agricultural sector in eastern India showed considerable degree of dynamism in the recent years. However, these changes in the pattern of growth and the productivity performance have been almost isolated across space and time. An understanding of the changing situation is necessary. While some areas shows dynamism in outperforming in growth as well as productivity (say in west Bengal and eastern Uttar Pradesh), there are many laggard regions, where both deceleration of growth and productivity decline have been occurring simultaneously. This later group of regions being in majority and resource-poor, is a matter of concern. It has been observed that the pace of growth in production as well as productivity has been variable in dual spatio-temporal dimensions. The pattern of growth was impressive during the 1980s, but slackened considerably particularly during the 1990s. The only way to accelerate productivity growth will require a concerted effort in several research areas. A new wave of technology and investments in increasing rice productivity is indeed necessary to keep the rate of output growth above the rate of population growth. This requires a paradigm shift in research and development strategies particularly in eastern India, which must be cognizant of the evolving characteristics and new challenges that have arisen during the 1990s.

- Given that more than half of the poor people of India now live in eastern India, a further reduction in the national poverty level is dependent largely on the success in eastern India. This is specifically true in view of small and marginal farmers domination in agriculture, which is an important typology of characterising the rainfed rice production systems. Interestingly, the proportion of small and marginal farmers is bulging out over the years. Therefore, research and development efforts on productivity enhancement is required to consider the issues on growing preponderance of this group of farmers in eastern India. Such an effort will unleash the technological solution to poverty. The implication for agricultural research is that the development of future technology should consider the pro-small farmers merits. This approach is necessary as the capital requirement for investment in agricultural inputs is lumpy for developing water resource and soil, mechanisation and seed technology, therefore, the resource-starving farmers are unlikely to be able to make such investments in farm inputs and machinery.

- A small farm size also means that rice production constitutes a small proportion of the gross household income. Hence, there is need to moving away from "rice only" policy towards the "rice-plus" policy, keeping rice production in the centre stage. A carefully christened diversification systems including crop-livestock- agro-forestry systems would go a long way in providing more entitlement to the poor. Reforms such as input-output delivery institution (say development of rental markets, market for water pump, power tiller, etc.) are necessary to make significant impact on farm production. The mechanical technologies that are purely labour-displacing, may also be less appropriate in areas with abundant surplus labour as in eastern India.

- Apart from income inequality, which is conspicuous in the rural areas, the access to modern technology is also discriminatory across the ecosystems, which favours irrigated environment. The inequitable distribution in modern varieties, is even more severe in the rainfed areas, which affected the low productivity. Within the rainfed lowland, the number of varieties released for less favorable sub-ecosystems such as the semi-deep and deep water conditions is even lower. Despite scarcity, in the course of time, some varieties transgressed from irrigated ecology to rainfed areas. Therefore while adoption has occurred as farmers saw an opportunity to obtain a modest increase in yield compared to their own traditional varieties, the improved varieties adapted specifically to rainfed environments require to fully exploit the potential that exists.

- Eastern India is also characterized by a low rate of seed replacement in rice. As compared with the all India average of 14 percent seed replacement rate, Bihar, Madhya Pradesh and West Bengal have a much lower rate of seed replacement. Farmers basically keep their own seeds and use in the subsequent crop seasons, which might have hampered the adoption of new technology and affected productivity.

- Yield gap is another vexed issue in rice production. Using a simple method, the yield gap analysis classified the rice growing areas into low yield low gap, the medium yield low gap, and the high yield low gap category and derives the policy implications for each category. The table below briefly summarises the implications.

YIELD GAP-PRODUCTIVITY LEVEL BASIS FOR POLICY INTERVENTIONS

	Yield gap	
Average Yield	**Low**	**High**
Low	Parts of Assam, Chattisgarh, Coastal Orissa • *Yield-increasing technology*	Most Plateau regions • *Appropriate technology* • *Adaptive research* • *"Reaching out to farmers"*
High	Uttar Pradesh, West Bengal • *Higher input efficiency* • *Agricultural Diversification*	???

a. A targeted approach to agricultural research and development

- Based on the patterns of productivity growth and the current average yield of rice, the states of eastern India can be divided into two distinct groups. The first group includes eastern Uttar Pradesh and West Bengal. The second group includes the other states. The agricultural research and development strategy for the first group have to be somewhat different from the other group where rice yields are much lower. Without an efficient marketing system, farmers in this area will not be able to benefit from improved technology and the gains that have been made so far may be lost. Rice technologies that facilitate crop diversification are needed so that food production is not compromised as agriculture becomes diversified.

- For the second group of states, the average yields are still low and the growth in productivity has been modest. Drought is a major constraint that reduces productivity. Research to increase the productivity of the drought-prone areas is strongly needed to generate the required impact. Drought management in these areas will also require interventions that go beyond a single crop and include the whole of the watershed.

- The practices of leaving vast agricultural area fallow also add to the overall low productivity. The low land use intensity is due mainly to lack of irrigation. Watershed based approach complemented by traditional tanks and dugwells may provide some opportunities for intensification of land use. A number of institutional constraints such as low level of infrastructure, limited credit availability and poor extension of technologies prevent farmers from having access to modern inputs. Growth in these areas will remain sluggish without active involvement of the public sector in the provision of these public goods.

- The major challenge, thus is to enhance the productivity of rice and rice-based systems by focusing and prioritising the rice research in eastern India. This is likely to reduce the existing yield gap. It however, requires a well articulated design of system research in the following theme areas as lauded by the International Year of Rice 2004 declaration: Genetic improvement in rice variety for higher yield and stability, better crop management and crop care techniques, effective post harvest technology, and to strengthen the capacity building of the stakeholders. Not only developing modern and new technology but also imbibing the traditional knowledge base on the rice production systems is essential.

b. Some Prognosis in Rice Production Systems:

- **Next generation green revolution:** In view of widespread agricultural growth in eastern Uttar Pradesh and West Bengal and improved performance of rice productivity in Assam, there is huge untapped potential in eastern India for the next green revolution targeted in rainfed areas.

- **Public expenditure in infrastructure and agricultural R&D investment.** Following economic reforms, the fiscal compression forced further reduction in public expenditure in infrastructure. The agricultural R&D grew, but at a slower pace. The spill over effect of agricultural technology supported by ground water irrigation seems to have exhausted in some areas and other areas require new technology.

- **Innovative variety, seed multiplication & delivery system:** Innovative mechanisms are required for variety release as well as seed multiplication and delivery system. Inadequate supply and scarcity of seed of modern variety is crucial constraint to adoption.

- **Pro-active policy interventions** : The multiplicity and diverse production conditions in eastern India demand more critical policy interventions in regard to yield barrier, cutting edge technology, support infrastructure, access to information and delivery system.

As rice is the crop of the millions, eroding its genetic base could have serious consequences for their sustainable livelihood. Maintaining rice biodiversity and utilizing it for increasing productivity should go hand in hand in future. Rice is life, as it not only provides subsistence but also a source of income to meet the other household requirements in India. Rice is actually life sustaining.

In conclusion it may be inferred that following should be the arms of the future research and policy strategy for rice production systems:

- **Prioritization** : Prioritize the bypassed region for intensive promotion drive by involving people participation (A model is required)

- **Peoples' organization** : Strong peoples' organization is required to maximize benefits from time to time.

- **Bottlenecks** : Remove production, input/output delivery bottlenecks.

- **Infrastructure support**: Provide adequate enabling environment, but should owe accountability by all.

- **Free riders:** Reduce their role in development promotion activities.

- **Research and Development support** : Need strong and continuous R&D intervention in agriculture and rice in particular.

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Appendix Tables

Appendix Table 1 : Quenqunnial average Area under rice in India

Area

Zones	State	1967-1969	1975-1980	1985-1990	1995-2000
East Zone	Assam	2141.0	2229.9	2364.4	2503.0
	Bihar	5341.6	5366.8	5279.4	5043.4
	Orissa	4317.5	4391.4	4304.5	4508.1
	West Bengal	4776.5	5145.2	5433.5	5946.8
East Zone Total		**16576.6**	**17133.2**	**17381.8**	**18001.2**
North Zone	Haryana	220.0	394.4	579.0	948.2
	Himachal Pradesh	96.7	92.4	90.1	82.2
	Jammu & Kashmir	233.0	260.2	266.7	269.7
	Punjab	326.0	858.2	1785.8	2344.2
	Uttar Pradesh	4459.5	4868.2	5343.0	5726.9
North Zone Total		**5115.2**	**6079.0**	**7485.6**	**8423.0**
South Zone	Andhra Pradesh	3226.4	3714.1	3708.4	3834.4
	Karnataka	1164.0	1105.0	1146.3	1368.4
	Kerala	866.5	834.2	620.2	400.5
	Tamil Nadu	2620.5	2658.4	2016.0	2233.8
South Zone Total		**7877.4**	**8311.7**	**7491.0**	**7837.1**
West Zone	Gujarat	501.6	465.3	497.2	632.4
	Madhya Pradesh	4280.5	4709.4	4996.6	5339.2
	Maharashtra	1369.5	1476.4	1500.3	1492.9
	Rajasthan	112.0	179.0	124.4	143.3
West Zone Total		**6263.6**	**6830.1**	**7118.5**	**7607.8**
India Total		**36702.0**	**39632.8**	**41002.6**	**43821.9**

Appendix Table 2 :
Quinqunniel average Production of rice in India

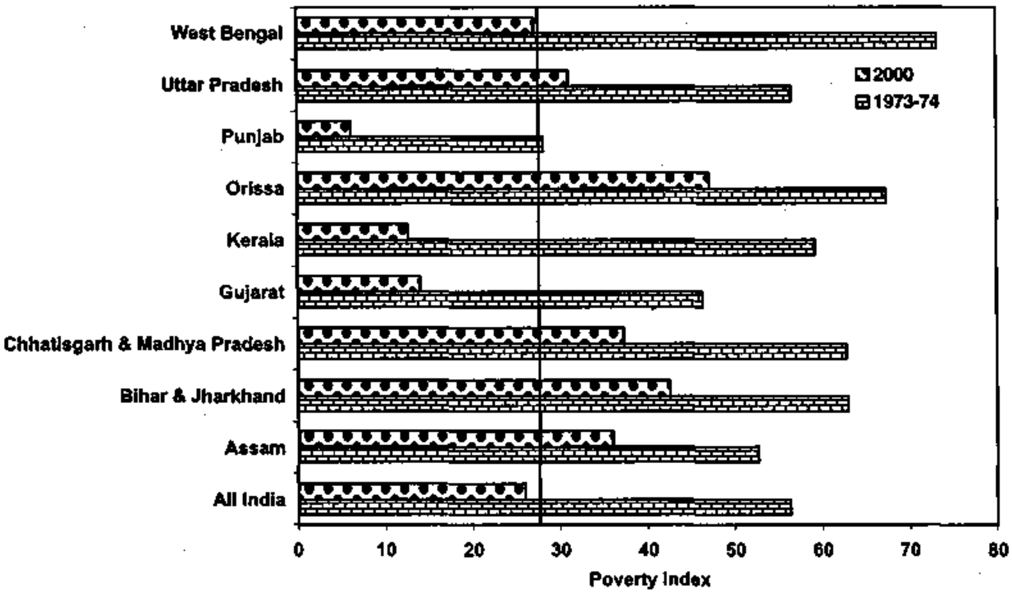
Production

Zones	State	1967-1969	1975-1980	1985-1990	1995-2000
East Zone	Assam	2115.3	2157.5	2636.3	3441.6
	Bihar	4964.5	4837.3	5887.0	7003.3
	Orissa	4227.0	3878.4	5022.4	5476.3
	West Bengal	5729.0	6574.8	9441.9	13006.8
East Zone Total		**17035.8**	**17448.0**	**22987.7**	**28928.0**
North Zone	Haryana	276.0	915.0	1477.4	2376.6
	Himachal Pradesh	104.4	107.9	97.9	109.9
	Jammu & Kashmir	383.5	464.8	545.6	494.0
	Punjab	437.5	2362.8	5707.0	7733.2
	Uttar Pradesh	3092.0	4461.0	8212.8	11767.2
North Zone Total		**4017.4**	**7396.5**	**14563.3**	**20104.3**
South Zone	Andhra Pradesh	4507.2	6145.0	8374.4	9868.9
	Karnataka	1899.0	2113.2	2207.4	3348.4
	Kerala	1262.0	1294.4	1084.9	776.2
	Tamil Nadu	4028.0	5296.4	5592.3	6770.2
South Zone Total		**11696.2**	**14849.0**	**17259.0**	**20763.6**
West Zone	Gujarat	346.8	556.1	572.5	962.5
	Madhya Pradesh	3099.0	3293.0	4604.3	5656.0
	Maharashtra	1403.0	2126.4	2113.6	2515.4
	Rajasthan	76.0	201.6	126.4	145.9
West Zone Total		**4924.8**	**6177.1**	**7416.8**	**9279.9**
India Total		**38686.5**	**47886.2**	**65061.1**	**83297.1**

Appendix Table 3 : Quinqunniel average Productivity of rice in India

Zones	State	Yield			
		1967-1969	1975-1980	1985-1990	1995-2000
East Zone	Assam	987.0	966.8	1113.8	1374.6
	Bihar	928.9	898.1	1113.6	1400.6
	Orissa	979.5	879.8	1162.3	1214.0
	West Bengal	1198.2	1278.3	1733.0	2187.4
East Zone Total		**1023.4**	**1005.8**	**1280.7**	**1544.2**
North Zone	Haryana	1255.5	2331.7	2541.9	2524.4
	Himachal Pradesh	1079.2	1166.1	1085.5	1340.0
	Jammu & Kashmir	1635.6	1782.7	2045.2	1832.2
	Punjab	1341.3	2736.1	3190.4	3298.6
	Uttar Pradesh	694.0	916.9	1534.2	2052.4
North Zone Total		**1201.1**	**1786.7**	**2079.4**	**2328.1**
South Zone	Andhra Pradesh	1398.2	1651.1	2241.4	2565.8
	Karnataka	1630.3	1902.1	1920.0	2438.0
	Kerala	1452.2	1553.2	1751.4	1937.4
	Tamil Nadu	1537.0	1987.7	2787.6	3017.6
South Zone Total		**1504.4**	**1773.5**	**2175.1**	**2489.7**
West Zone	Gujarat	686.0	1193.1	1115.6	1517.6
	Madhya Pradesh	725.0	700.0	921.2	1059.0
	Maharashtra	1024.5	1441.3	1404.9	1685.4
	Rajasthan	720.9	1143.9	995.1	1010.0
West Zone Total		**789.1**	**1119.6**	**1109.2**	**1372.3**
India Total		**1053.9**	**1206.6**	**1584.3**	**1898.6**

Appendix Figure 1 : Incidence of poverty in India.



Appendix Table 4 : Compound Growth Rates of Area, Production and productivity of rice in India (%)

State	Zone	Area			PRODUCTION			Yield		
		1970s	1980s	1990s	1970s	1980s	1990s	1970s	1980s	1990s
Assam	East	0.68	0.79	0.02	0.81	2.20	2.37	0.13	1.40	-1.03
Bihar	East	0.23	0.26	0.34	1.26	4.80	4.92	1.03	4.52	4.61
Orissa	East	0.07	0.46	0.16	-0.40	4.97	-1.32	-0.47	4.49	-1.47
West Bengal	East	0.85	0.75	1.19	3.14	1.59	6.52	2.27	0.83	5.27
East Zone Total		**0.17**	**0.59**	**0.32**	**0.11**	**4.77**	**2.01**	**-0.15**	**3.59**	**1.53**
Haryana	North	5.55	2.08	6.12	12.58	3.43	4.38	6.66	1.32	-1.64
Himachal Pradesh	North	-0.69	-1.05	-0.44	0.56	-0.39	0.82	1.26	0.66	1.30
Jammu & Kashmir	North	1.37	-0.02	-0.43	2.47	0.10	-1.76	1.08	0.13	-1.30
Punjab	North	10.28	5.41	2.48	19.00	7.24	2.50	7.91	1.74	0.02
Uttar Pradesh	North	0.89	0.26	0.85	4.98	9.18	3.14	4.05	8.89	2.27
North Zone Total		**2.23**	**1.21**	**1.57**	**6.53**	**5.41**	**2.85**	**3.52**	**0.94**	**-1.72**
Andhra Pradesh	South	1.77	0.71	0.12	3.58	2.94	1.31	1.78	2.21	1.17
Karnataka	South	-0.59	0.18	1.70	0.35	-0.10	3.52	0.94	-0.28	1.76
Kerala	South	-0.37	-3.72	-5.48	0.33	-2.64	-5.58	0.71	1.12	-0.12
Tamil Nadu	South	-0.33	-2.88	1.58	1.71	2.23	1.86	2.05	5.26	0.27
South Zone Total		**0.55**	**-0.59**	**0.44**	**2.22**	**2.22**	**1.51**	**1.46**	**2.46**	**0.78**
Gujarat	West	-0.98	0.70	1.91	3.77	1.18	3.71	4.79	0.48	1.74
Madhya Pradesh	West	1.05	0.44	0.55	1.00	5.51	0.19	-0.05	5.05	-0.36
Maharashtra	West	0.87	-0.01	-0.73	5.10	0.22	1.37	4.20	0.23	2.12
Rajasthan	West	5.56	-3.76	46.53	10.92	-0.16	54.36	5.08	3.74	5.33
West Zone Total		**0.95**	**0.22**	**0.16**	**1.16**	**1.01**	**0.67**	**2.18**	**0.32**	**-1.77**
All-India Total		0.76	0.41	0.62	1.95	3.62	2.00	1.17	3.19	1.35

Source; Estimated from disaggregate time series data

Appendix Box 1 : Global Rice Outlook 2004

The Food and Agricultural Organisation of the United Nations (FAO)'s first forecast of paddy production in 2004 shows a 4 percent increase from the previous season, to 613 million tonnes, which would be the highest level on record. However, initial results from on-going harvests in countries in the southern hemisphere already point to a 3 million tonne increase from the previous season, to 81 million tonnes. Along the south of the equator, prospects are positive so far in Indonesia as well as Malaysia where some 400 000 hectares of new land have been opened for rice cultivation.

- By contrast, drought at planting time has limited the production potential in Sri Lanka. In Africa, the season is well advanced in Madagascar, Mozambique and Tanzania. In Madagascar, production might fall this year, reflecting a poor start of the season and the impact of two cyclones that hit the country at a critical stage of crop development. A recovery from last year's shortfall is anticipated in Tanzania.

- High prices last year bolstered plantings in most of South America. Favourable growing conditions have further boosted the outlook for Argentina, Brazil and Uruguay. By contrast, drought conditions are expected to impair production in Ecuador and Peru.

- Low water allocations to producers in Australia constrained plantings again this year, but were sufficient to sustain a 54 percent increase in production from the dismal outcome of last season.

- The early forecasts of 2004 paddy production in northern hemisphere countries are mainly based on the prevailing government policies, expectations of favourable producer prices and "normal" growing conditions.

- In Asia, China and India are expected to account for much of the anticipated increase in world output. In the first country, rising domestic prices have raised concern of an imminent tightness, which has prompted the government to launch several initiatives to boost production.

- Sizeable production gains are anticipated in Bangladesh, Indonesia, Philippines and the Islamic Republic of Iran, consistent with the expansionary policies pursued by those countries.

- Production should recover in Japan and the Republic of Korea where adverse weather conditions hampered crops last season. Strong price incentives should also boost the sector in Thailand and Pakistan. By contrast, Viet Nam has set a smaller production target this season, reflecting a 10 percent loss of its winter-spring crop because of drought.

- In Myanmar, the disruption caused by sudden changes in policies and the resulting slump in domestic prices is also anticipated to depress output. Production in Africa is set to grow modestly, although government efforts to promote the sector could give rise to some increases in Ghana, Mali and Nigeria. High prices should also sustain growth in Egypt. High import prices should also boost output in Costa Rica, Nicaragua and Panama. In the rest of the world, the United States has forecast a record output in 2004, since producers are expected to respond to high prices by increasing plantings. Little change in production is currently foreseen for the EU, although the implementation of the new policy regime as of September, introduces some elements of uncertainty.

Contraction in international trade in rice 2004

- FAO's forecast of world trade in rice in 2004, which is largely determined by the outcome of production in 2003, has been reduced by some 0.8 million tonnes from the previous report to some 25.5 million tonnes, which is 2.5 million tonnes lower than the estimate for 2003. The lowering of the 2004 forecast mainly reflects a worsening of export prospects for China and India, which more than offset some upward revisions for Thailand, Cambodia, Egypt, the United States and Uruguay.

- According to the present outlook, China is anticipated to export 1.5 million tonnes during 2004, down from 2.6 million tonnes last year. In recent months the country has witnessed sharp increases in market prices that are likely to prompt the government, which holds a monopoly on rice exports, to restrict sales abroad. In India, steps have already been taken by the Food Corporation of India (FCI) to temporarily suspend sales for exports, pending an assessment of FCI buffer stocks, which were heavily depleted in the past two years.

- The ban coincided with the passing of new regulations, which will allow exporters to purchase rice directly from farmers rather than exclusively through the FCI. Sales from the country are currently prospected to hover around 2.5 million tonnes, down from 4.4 million tonnes in 2003. In January, Myanmar also prohibited exports for six months. As a result, the country's exports are forecast at 500 000 tonnes, little changed from last year but well below the country's potential.

- United States' shipments are expected to drop from 3.8 million tonnes to 3.2 million tonnes, constrained by high domestic prices and falling availabilities. Limited supply should also restrain sales from Australia to 200 000 tonnes, or about one-third of "normal" levels. Similarly, exports from Japan and the Republic of Korea, most of which are made in the form of food aid, are anticipated to be smaller following last season's production shortfalls and dwindling stocks.

- By contrast, shipments from Pakistan should remain of the order of 2 million tonnes, especially if the government maintains transportation subsidies, while sales by Thailand and Viet Nam, the two major rice exporters, are officially foreseen to increase to 8.5 million tonnes and 4.0 million tonnes, respectively. Viet Nam's export performance, however, will depend critically on the size of the winter/spring crop currently at the harvest stage.

- Scarcity of supplies already prompted the Government to advise exporters to refrain from signing new contracts requiring deliveries before the next harvest in June. In the rest of the world, favourable crops and higher international prices should boost shipments by Argentina, Uruguay and Egypt.

- The reduction in the 2004 global import forecast reflects a number of adjustments that take into account the prospects of higher prices and freight rates and the reduced availabilities in China and India.

- For instance, the forecast of aggregate imports by African countries, part of which were sourced in those two countries, has been cut. At the same time, the forecast of imports by China was raised, following news of an intensification of trans-border movements of rice into the country.

- Compared with 2003, imports by Asian countries are now anticipated to fall, mainly on account of weaker demand by Bangladesh and the Philippines following excellent harvests in 2003, and by Indonesia, where imports have been banned from 20 January to 30 June.

- Despite the recent announcement of the liberalization of rice imports by the Islamic Republic of Iran, the imposition of high tariffs (100 percent ad-valorem tariff plus a discretionary duty of some US$190 per tonne this year) and improved domestic availability should also result in reduced shipments to the country. Smaller flows of food aid are likely to cut overall rice deliveries to the Democratic Republic of Korea.

- By contrast, Iraq, where the control over food grain procurement passed from the World Food Programme to the country's Ministry of Trade in April, is anticipated to import 1 million tonnes, up from 700 000 tonnes last year. China (mainland) is foreseen to purchase about 1.2 million tonnes, the highest level since 1995. In Africa, overall rice imports are likely to fall again this year, especially if world prices and freight rates keep rising, with the Cote d'Ivoire, Nigeria and Senegal accounting for much of the contraction.

- However, deliveries to Ghana and Madagascar are forecast to increase, to compensate for the latest season production shortfalls. In Latin America and the Caribbean, Brazil cut the official import forecast to 550 000 tonnes, down from over 1 million tonnes in 2003, in anticipation of a good 2004 paddy harvest. However, deliveries to both the Dominican Republic and Peru are foreseen to increase substantially, to compensate for smaller domestic supplies.

- Among the other major rice markets, deliveries to the United States are anticipated to be larger, attracted by high domestic prices.

- The Russian Federation is also foreseen to step up its purchases, especially since, unless extended, the 10 percent tariff would no longer be subject to a minimum value of €30 per tonne as of 20 March. Imports to the EU are provisionally forecast to remain of the order of 700 000 tonnes, although the halving of intervention prices as of September 2004 might result in much lower variable import duties.

Stable overall rice consumption

- World rice utilization is forecast to reach some 415 million tonnes, in milled equivalent, little changed from the previous year. Most will be used for human consumption, with food utilization estimated to fluctuate around 368 million tonnes. On a per capita basis, rice food consumption is forecast at 58.6 kg in 2004, down slightly from 58.7 kg last year. Consumers are likely to face price rises this year, which will be compounded in the major importing countries by sharp increases in freight rates.

Global carry over stocks to fall for the fourth consecutive year

- Since global rice utilization is again anticipated to outstrip production, global rice stocks are forecast to fall to 102 million tonnes at the close of the marketing season ending in 2004, down from 120 million tonnes a season earlier. As in the previous years, China is likely to account for much of the contraction, as the country end-of-season inventories could shrink from 78 million tonnes to 62 million tonnes.

- Among major exporters, a decline is anticipated in Australia, Egypt, Thailand and the United States. Rice reserves should also diminish in some major importing countries, including the Islamic Republic of Iran and the Philippines, in part due to reduced imports prospects, as well as in Japan, the Republic of Korea, following last season production shortfalls.

- By contrast, carry-over stocks might increase somewhat in India, though remaining well below historical levels, and in Myanmar, but would change little in Viet Nam.

Rising International rice prices

- Rice prices recovered strongly over most of 2003, as reflected in the FAO all Rice Price Index (1998-2000=100), which averaged 82 for the whole year, up from 72 in 2002. The strength persisted in the first few months of 2004 as supplies tightened in major exporting countries. In March 2004, the index reached 109, the highest level since February 1999, and 20 points above the value in October.

- Although the past five months coincided with the harvesting of the main paddy crops in major exporting countries, prices of all the various types and qualities of rice have followed a rising trend since October.

- For instance, within the high quality Indica rice segment, the price of Thai 100%B rice rose from US$199 per tonne last October to US$253 per tonne in March, with an even stronger increase reported for rice from Pakistan. As for the lower quality Indica, the Thai A1 Super quotations passed from US$158 to US$213 over the period, sustained by the withdrawal of Myanmar and Indian exporters from the market.

- Particularly strong price increases also affected medium grain rice, with the Japonica rice price sub- index surging 21 points between October and March. The rise was less pronounced for aromatic rice prices, the index of which rose by 6 points in the same period.

- International rice prices are expected to increase further in the coming months, especially if China, which will not harvest its early rice crop before June, intensifies its purchases. However, the pressure would be mitigated, should Myanmar or India lift their restrictions on rice exports.

Source : Derived from the FAO reports on rice April, 2004

Appendix Box 2 :
Rice Science perspectives :
Views on cause and effect relationship in rice

A quote from a presentation by Ronald Cantrell, former Director-General, IRRI 2004.

- Asia's rice industry is in crisis due to inadequate support, driving farmers into penury and spurring mass migration with potential adverse implications on regional security.
- Not only is the rice industry in Asia facing a crisis in the supply of such essential resources as land, labor and water, but — most importantly of all — many nations are finding it difficult to develop sustainable ways to provide decent livelihoods for rice farmers and consumers.
- The stability in Asia including the troubled nations of Indonesia and the Philippines, is threatened by the continuing lack of development in its most important cereal crop.
- Rice farming remains a poverty trap in many Asian nations, mainly because of very small farm size and compounded by declining support for public rice research.
- Asia's rice producers enjoyed annual yield increases of 2.5 percent and production gains of more than three percent between the early years of the Green Revolution and up to the early 1980s. However, from the late 1980s until the late 1990s, the rate of annual yield increase was nearly halved, and the rate of production increase fell even further.
- As stagnating yields push them deeper into poverty, many rural rice communities in Asia are growing increasingly restless.
- Poverty and a lack of opportunity foster instability in socio economic and geo-politico sphere. A lack of opportunity in heavily agricultural Tenggulun has forced 20 percent of its working-age population to leave in search of employment — a story repeated time and again throughout rural Asia."
- At the same time the international support for public rice research has been collapsing, with mainly Western donor

nations taking aid money elsewhere, including to Africa after having achieved "visible success" in Asia.

- Moreover, new rice technologies have not reached ordinary farmers in many countries because the extension systems for delivering them are chronically underfunded.

- Assuming there are 200 million rice farmers in Asia, an investment of just 40 cents per farmer for each of the next 20 years would go a long way toward ensuring that they can earn a decent living sustainably supplying poor rice consumers with plentiful supplies of affordable, nutritious rice.

- Rice is so central to the lives of most Asians that any solution to global poverty and hunger must include research that helps poor Asian farmers reduce their risks and earn a decent profit while growing rice that is still affordable to poor consumers.

- It is thus essential to renew focus on the development of sustainable strategies to feed half of the world's population that depends on rice.

- Recognizing its importance, the United Nations declared the United Nations International Year of Rice 2004 for focusing on the food security of three billion rice eaters. Rice, covering about 150m hectares world-wide, has a profound impact on the environment and natural resources. It also threw a big challenge facing Asia, to meet national and household food security needs with an ever-declining natural resource base, especially water and land.

- Current annual rice production of 545m tonnes needs to be increased to 700m tonnes to feed an additional 650m rice consumers by 2025, using less water and less land, which is a big challenge. In addition, rice is seen as crucial in meeting a prominent UN Millennium Development Goal — the eradication of extreme poverty and hunger.

- Seven "key challenges" were mentioned to producing enough rice for the world and doing it sustainably. These are poverty and the environment, farm chemicals and residues, land use and degradation, water use and quality, biodiversity, climate change and the use of biotechnology. Each of these issues is crucial to rice production and efforts to ensure that the 800m rice consumers who have been trapped in poverty in Asia can get access to the rice they need to feed themselves and their families

- The fluctuating production and price of rice has been notable. As international rice prices jumped in the year 2004 by a surprising 40% because of shortages in some countries, we are reminded that we cannot take Asia's ability to feed itself for granted. If we do, millions will suffer because of our complacency.

- Since the start of the Green Revolution — which began in Asia with the IRRI's release in 1966 of IR8, the first modern, high-yielding semi dwarf rice variety — supporters of this technology-based drive say global rice harvest has more than doubled, racing slightly ahead of population growth.

- Farmers have also benefited as improved efficiency has lowered unit cost and increased profit, they say.

Source: Rice Reporter, November 2004

Appendix Box 3:
A lesson from PUNJAB model of Agriculture

Punjab agriculture as it stands today manifests a model of overall holistic approach to development. The growth has been induced by systematic planning and designing the development of the entire range of infrastructure affecting and supporting the sustainable agricultural production.

- Punjab scaled the vertex of developmental pyramid from almost an ordinary level in the 1950s to a proud stage of a "little-big" status in the present years. It claims little as Punjab occupies only 1.5 per cent geographical area in the country, and big because it contributes bulk to the central pool and nearly 95 per cent of interstate movement of foodgrain is from the stock procured at the state. Punjab leads the other States in terms of contribution of wheat and rice to Central Pool. It contributed 51.8 percent of wheat and 48.8 percent of rice to Central Pool in 2002-03. The total contribution of wheat and rice to the Central Pool has increased from 115.6 lakh tonnes in 1990-91 to 178.0 lakh tonnes during 2002-03 consisting of 98.6 lakh tonnes of wheat and 79.4 lakh tonnes of rice. Therefore the Punjab glory is basically a glory of agriculture.

- How does Punjab climbed such a glorious peak in a short period of history is a question worth emulating. A related question arises that why the Punjab model does not replicate in other states.

- An in-depth understanding of the agricultural development in Punjab requires a thorough both historical and contemporary account of the design and the process of growth and development.

- Agriculture is the most important sector and is the backbone of the State economy, which contributed 24.4 percent of Gross State Domestic product at constant prices (1993-94) during 2002-2003 and around 39.4 percent of the working population of the State is employed in this sector.

- The resource base of the state is almost fully utilized as 97.6 percent of cultivable land in the State is under plough. Thus, there is a little scope to bring more area under cultivation. The agriculture production can only be increased through enhanced cropping intensity, change in cropping pattern, improvement in seeds of high yielding varieties, cultivation practices and with the availability of better post harvest technology etc. State Govt. is trying to re-orient agriculture in this direction through various policy measures.

A historical perspective of agricultural scenario

- The developmental regime in Punjab agriculture can be divided into three distinct stages viz., a period of relatively dismal performance at the dawn of independence, post independent era of preparedness for structural change in agriculture, green revolution and quantum jump.

- Punjab was among the other states, and little known in the country at the dawn of Independence. It suffered due to the scar of a food grain deficit area. In 1951, total production of food-grains production was about 1.99 million tonne only, which was dominated by wheat at 1.10 million tonne and rice 0.11 million tonne. About 54 per cent of Gross Domestic Product of the state of Rs. 655 crores only (1970-71 prices) was originated from the agriculture sector. Although at that time, foodgrain crops occupied a major share in the cropping pattern at 68 percent of the cropped area, yet 32 percent of the area was cropped with pulses and coarse grains, mainly on un-irrigated lands. With net area of 3544 thousands hectare and gross cropped area of 4170 thousand hectare, intensity of cropping was 118 per cent only. Fertilizers and pesticides were rarely used, tubewells and tractors were unknown to the farmers in the state. Only 52 per cent of the area was irrigated and land holdings were quite fragmented.

- The state responded to this dismal performance and made adequate preparation for ushering a change. It resorted to policy implementation of mandatory consolidation of land holdings, which was considered a prerequisite for effective use of canal irrigation water that became available through the Bhakra Nangal Canal System. The availability of hydel power encouraged the installation of tubewells on consolidated holdings that provided assured irrigation supplementing the canal water supply. Although, the share of agricultural GDP remained at 54 per cent even in 1960-61, production of foodgrain improved to 3.16 million tonnes of which wheat was 1.74 million tonnes and rice 0.25 million tonnes. Irrigated area increased to 54 per cent of the net sown area and cropping intensity improved to 121 per cent.

- Yield of wheat in 1960-61 was still 1.24 tonne per ha. and of rice was 1.0 tonne. Similarly productivity of other crops; American cotton was 0.27 tonne and sugarcane 36.54 tonne only. Productivity of crops started improving but only marginally. Therefore, agricultural situation witnessed a marginal improvement up to the mid-60s.

The factor of change and Green Revolution

- The vigorous multi-pronged policy implementations during the late 1960s and 1970s provided adequate impetus for a changed the agricultural situation dramatically consequential upon the consolidation of holdings, availability of canal water, tubewell irrigation and establishment of Punjab Agricultural University with strong research and extension education components that developed close interactive relationship with the various stakeholder in the state in 1962. Introduction of dwarf wheat germplasm and cultivators from CIMMYT Mexico in 1964-65 and required assured irrigation, revolutionized agriculture in Punjab and set the stage for wheat-based green revolution in the state.

- With the indulgence of the state in creating conducive production environment, assured remunerative prices provided by the government through price support and procurement system as well as spread of rural and approach roads network, production and productivity as well as agricultural income induced the positive change quite fast. Tractors and tubewells started dotting the landscape everywhere, uses of fertilisers and pesticides expanded and irrigated area as well as intensity of cropping started increasing. Even net sown area also increased.

- Cropping pattern started witnessing significant change. The foundations of the green revolution were thus laid and enabling infrastructural, technological and economic environment was rendered conducive for the interaction of elements of growth and productivity in the state.

- Dwarf varieties for paddy crop were introduced and production increased manifold. New dwarf varieties of rice from IRRI were introduced and the area under rice production started expanding.

- Net sown area increased from 3.76 million hectare in 1960 - 61 to 4.05 million hectares in 1970 - 71. Gross sown area increased from 4.73 to 5.68 million hectare and cropping intensity improved from 121 to 140% over the same period. Share of area under wheat increased from 29% to 40% of the total cropped area.

- Production of food grains in 1970-71 more than doubled to 7.3 MT from 3.16 MT in 1960-66, with wheat production increasing to 5.15 MT. Wheat and rice played a major role in pushing up agricultural production. During the year 2002-03, 100 percent area of rice and wheat was under high yielding varieties. The production of rice of 65.06 lakh tonnes in 1990-91, increased to 88.80 lakh tonnes in 2002-2003 showing an increase of 36 percent. Similarly, the production of wheat, which was 121.59 lakh tonnes in 1990-91 rose to 141.75 lakh tonnes during 2002-2003 registering an increase of 17 percent.

- Input use revolution and green revolution matured in 1970s:

- It is a notable that within a decade, the state achieved marvelous success in agriculture. With the introduction of dwarf varieties for wheat and paddy, production increased manifold. By 1970-71 GDP of the state at constant prices increased to Rs1509crore, having the agricultural share of Rs 866 crore, which jumped about 86 per cent in one decade. Net sown area increased from 3.76 million hectare in 1960-61 to 4.05 million hectares in 1970-71. Gross sown area increased from 4.73 to 5.68 million hectare and intensity cropping improved from 121 to 140 per cent over the same period.

- Production of food grains in 1970-71, more than doubled to 7.3 million tonnes from 3.16 million tonnes in 1960-6, with wheat production increasing to 5.15 million tonnes. Rice did not as yet caught the imagination of the farmers although area under this crop and production had started increasing and the future looked bright.

Quantum jump

- From here on agricultural sector growth made a quantum jump. The growth in agriculture initiated by green revolution in wheat crop production in late sixties and further fuelled by rice revolution in mid-70s, continued un-abated under conducive commercial environment. By 1993-94, the GDP of the state had increased to Rs. 4565 crore at 1970-71 prices. Agriculture Sector GDP touched an all time high of Rs 2135 crore, whose share declining to 47 per cent from 54 per cent in 1970-71. Net sown area increased almost to its limit of over 4.2 million hectares. With cropping intensity of 181 per cent, the gross cropped area increased to over 62 million hectare. In the cropping pattern, wheat occupied 44 per cent of the gross cropped area and rice at 29 per cent, the foodgrain crops accounted for 76.9 per cent of the gross cropped area.

- During this period productivity improved dramatically with wheat yield increasing from 2.24 tonne to 4.01 tonnes per hectare and rice from 1.77 (2.68 tonnes in rough rice) to 3.51 tonne (5.32 tonnes rough rice) per hectare. Productivity of other crops also improved but not that significantly. The conducive policy impetus propelled the expansion of tubewell irrigation, tractor cultivation and intensive use of fertilizers. Fertilizer use increased from 54 kg per hectare of net area sown in 1970-71 to 266 kg per hectare in 1993-94. Pesticides use increased manifolds. The number of tractors increased from 10 to 80.3 per thousand hectare of net sown area and tubewells number increased from 192 thousand to 850 thousands in the state. Area irrigated increased from 71 to 93 per cent of the net sown area. This demonstrated a revolution in input use in the state. As a result, the cropping intensity increased to 181 per cent. Production of foodgrain increased to 21.58 million tonne, with wheat production at 13.34 million tonne and rice 7.65 million tonne.

Present Scenario

- At present over 84 per cent of the total geographical area of the state stands cultivated. Only about 28 thousand hectares land is classified as cultivable waste. This, however, limits the scope for expansion of crop cultivation horizontally. Moving ahead vertically, the cropping intensity has already touched over 186 per cent in the 2003-04. Moreover, with the restrictive policy followed on the present set of main economic crops grown in the state, Punjab seems to poise for another revolutionary change in the structure of agriculture. While trying to break the dominance of "prize-winning" rice-wheat system, state has already diverted about 1.75 lakh acres of area under crop diversification in 2003-04 up from 12234 acres in rabi 2002. It is proposed to cover an area of 22 lakh acres under the crop diversification based contract farming in the next 4-5 years. Newer crops such as Hyola, Barley, winter Maize, Guara, Moong, Castor etc. are put into cropping system. Corporate houses such as Rallis India, Mahindra Shubhlabh, Escort, DCM Hariyali and United Brewaries have participated in the innovative crop diversification programme. Can it pave the path for another success story?

- The last few years show a changing the scenario, which needs careful attention in the context of overall sustainability of food security of the country. Total food grain production has decreased from 249 lakh tonnes in 2001-02 to 235 lakh tonnes in 2002-03 showing a decline of 5.66 percent. The gross area under food grains has also decreased from 6155 thousand hectares in 2001-02 to 6132 thousand hectares in 2002-03 showing a decrease of 0.37 percent. Though, rice production shows a marginal increase of 0.63 percent, the wheat production has recorded a negative growth rate of 8.60 percent in 2002-03 over the previous year.

Source : www.punjabgov.nic.in, 2004

Abbreviations

AAU	:	Assam Agricultural University
AP	:	Andhra Pradesh
BPL	:	Below Poverty Line
BVZ	:	Barak Valley Zone
CBVZ	:	Central Brahmaputra Valley Zone
CGR	:	Compound Growth Rate
CIMMYT	:	International Maize and Wheat Improvement Center
DRR	:	Directorate of Rice Research
E	:	East
FAO	:	Food and Agriculture Organisation
GDP	:	Gross Domestic Product
GOI	:	Government of India
HYV	:	High Yielding Variety
ICAR	:	Indian Council for Agricultural Research
IFAD	:	International Funds for Agricultural Development
IRRI	:	International Rice Research Institute
IYR	:	International Year of Rice
Kg/ha	:	Kilogram per hectare
K_2O	:	Potashic fertilizer
MA	:	Moving Average
Mh	:	Million hectares
MP	:	Madhya Pradesh
mt	:	Million tons
MV	:	Modern Variety
N	:	Nitrogen fertilizer
NABARD	:	National Bank for Agriculture and Rural Development
NARS	:	National Agricultural Research Systems

NBPZ	:	North Bank Plain Zone
NCAP	:	National Centre for Agricultural Economics and Policy Research
NEC	:	North Eastern Council
NEPZ	:	North East Plain Zone
NPK	:	Nitrogen Phosphorous and Potash
NWP	:	North West Plain zone
P_2O_4	:	Phosphetic fertilizer
R&D	:	Research and Development
SAU	:	State Agricultural University
SE	:	South East
t/ha	:	ton per hectare
TN	:	Tamiladu
TV	:	Traditional Variety
UBVZ	:	Upper Brahmaputra Valley Zone
UP	:	Uttar Pradesh
WTO	:	World Trade Organisation