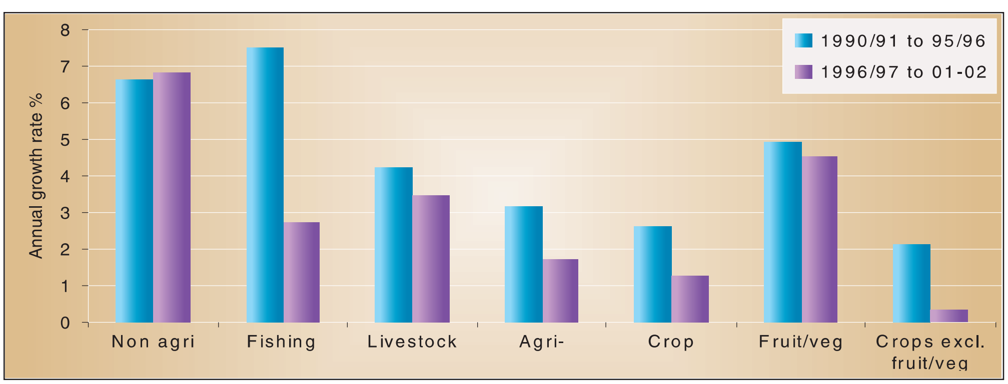
Social Sciences and Policies

- Present situation of agricultural markets in India and need of competition were studied.
- WTO agriculture negotiations vis-à-vis South Asian countries were studied
- Stagnation in public investment in agriculture is affecting agriculture growth
- GDP of agriculture is affected by both capital formation and subsidies, besides terms of trade
- An upward trend was observed in scientific productivity of ICAR-SAUs system
- The socio-economic impact of research and development efforts was studied
- Privatization of seed industry is increasing
- Productivity enhancement and substitution of low producers by high milk producers would improve milk production
- Productivity enhancement would give the rice production the required boost
- Information is becoming more and more critical input in overall rural and particularly agricultural development
- Flexible central data warehouse of agricultural resources developed
- Statistical package on agricultural research (SPAR 2.0) developed

Agricultural Marketing India—Implications for Competition: Markets for large number of commodities are competitive in the segment where agrocommercial firms are involved in transactions with other agrocommercial firms and are less competitive where business firms are dealing with consumers and producers. This is reflected in collusive behaviour of the buyers and imperfections at retail level. This calls for improving competition in agricultural markets particularly at farm and retail level. Alternative avenues for sale and purchase, through cooperative marketing agencies, dilute market power of private trade to some extent. Besides cooperative agencies, removing all kinds of restrictions on entry of private firms at various levels of agricultural marketing, particularly in purchase of farm produce, would intensify the competition.

The main reason for high charges and lack of competition in agricultural markets seems to be that small local players dominate the market. They are in large number but that does not improve market efficiency. They require large margins due to the large number and small operations and cannot take advantage of scale economies. There is a need to attract big business to invest and operate in agriculture market in bulk buying and selling. This would impart scale advantage that should help in better deal for consumers and producers.

WTO agriculture negotiations and South Asian countries: What was projected as a benefit for South Asian Countries (SACs) from Agreement on Agriculture (AOA) and expectations based on that are yet to come true. SACs should work together in the ongoing negotiations on AOA to address their concern adequately. A common agenda for SACs should suggest that *De minimus* support in developed country should be fixed at 5% of value of output as product plus non-product support and aggregate measure of support (AMS) commitment should apply at product level. Negative support should appear as such in computing AMS. Green box should include purely non-trade distorting measures like training, inspection, extension services, infrastructural services, and public stockholding for food security purpose. There should be a cap on green box assistance in developed countries. All export subsidies should be eliminated at the earliest. Measures like export credit guarantee and insurance should be allowed only to developing countries.



Growth rates during pre- and post WTO periods

Agricultural growth during the reforms: The growth rate analysis revealed that initial years of reforms were somewhat favourable for agricultural growth but post-WTO period witnessed sharp decline in growth rate of almost all commodity groups one by one. The current growth rates are too low to achieve the goal of 4% growth in output as envisaged in the National Agriculture Policy. Corrective measures are to be initiated soon to reverse the deceleration in agricultural growth otherwise even the growth targets of 10th Five Year Plan would be difficult to meet. Another disquieting aspect of recent growth process is that agriculture and non-agriculture sectors are on a disparate growth path. The probable causes for slowdown in agriculture growth are adverse impact of depressed international prices on domestic prices, neglect of price intervention for underdeveloped region having large growth potential, slowdown in adoption of improved technology and stagnation in public investments in agriculture for a long time.

Determinants of capital formation and agriculture growth: Rate of return to private investments, which in turn depends on terms of trade and technology, is the most important determinant of private capital formation. Institutional credit supplied to agriculture as short term loan or medium and long term loan was the other determinant of private capital formation. The impact of agriculture subsidies is also positive on private investments.

Agriculture GDP is affected by both capital formation and subsidies, beside terms of trade. Instant return to Re 1 spent in subsidy is much higher compared to the instant return to Re 1 spent for public sector capital formation. However, long term return from capital formation is more than double the return from subsidies. Diverting 1% resources from subsidies to public investment raises output by more than 2%. As there is a tradeoff in resources going into subsidies v/s resources available for public investment, diverting resources from subsidies to public sector capital formation is highly desirable to ensure growth in GDP agriculture.

Impact of subsidy and GFCF in agriculture on GDP agriculture at 1993-94 prices (value in Rs)

Particular	Impact
Gain/loss due to Re 1 going in subsidy rather than public capital formation	
At 10% discount rate	-2.83
At 8% discount rate	-4.23
Impact of shift of 1% subsidy amount to public sector capital formation on GDP agri (%)	
At 10% discount rate	1.82
At 8% discount rate	2.73

The public agricultural research system in India comprising institutes of the Indian Council of Agricultural Research (ICAR) and the state agricultural universities (SAUs) has been evaluated and reviewed several times. This coupled with slowdown in the rate of agricultural growth after mid-1990s has created an impression of slowing down of research impacts. It is at times, observed that the research system is not able to maintain up trend in the scientific productivity, and newly emerging stresses are threatening sustainability of our agricultural systems. How far this fear is true? This question is examined by using some empirical evidence. Scientific publications and technologies are the two main outputs of agricultural research which are applied in nature.

Trends in annual research publications of ICAR-SAU system

Particulars	ICAR institutes	SAUs	Total (ICAR and SAUs)	Articles per FTE[a] scientist
Number of articles indexed in SCI				
1980	696	758	1,454	0.14
1990	205	292	497	0.04
2002	299	231	530	0.05
Number of articles indexed in CABA				
1980	1,090	1,924	3,014	0.29
1990	1,645	4,413	6,058	0.48
1998	2,027	4,637	6,664	0.51
Number of articles indexed in ISA				
1990	1,170	4,308	5,478	0.43
2002	1,250	4,786	6,036	0.53

[a] Full-time equivalent (e.g., a scientist spending 50% of his time on research was considered as 0.5 FTE).

Scientific publications: Scientific productivity can be assessed by using research articles indexed by three abstracting sources for agricultural and allied sciences. These are the *Science Citation Index* (SCI), the *CAB Abstracts* (CABA), and the *Indian Science Abstracts* (ISA). Total number of research publications authored by the scientists working in ICAR institutes and SAUs are taken from these 3 sources. A drastic decline in the number of the SCI-indexed publications was observed in 1990 over that in 1980. This decline is deeper for SAUs and it continued even in 2002. ICAR institutes however showed a moderate recovery in 2002. What is more worrisome is that even the institutes and universities with the best publication record could not achieve the 1980 level in

Trends in rice variety development, 1971–2000

Particulars	1971–1980	19810û1990	1991–2000
Total number of varieties developed	127	223	257
Percentage of varieties with fine grain quality[a]	29.1	34.9	36.5
Percentage of varieties tolerant to diseases	50.4	67.2	51.0
Percentage of varieties tolerant to insect pests	10.2	25.1	20.2
Percentage of varieties developed for marginal areas[b]	41.7	50.6	46.0
Percentage of short to medium duration varieties[c]	74.8	53.8	52.5

a Long slender grain type, b Rainfed upland and lowland, deepwater, saline and alkaline ecosystems; c 50% flowering in less than 100 days, Source: Based on DRR (Hyderabad) data; 6 the marginal internal rate of return to investment in irrigation ranged from 4 to 6% during the corresponding period.

2002. This clearly shows depletion of upstream or strategic research in the ICAR and SAU system. A sharp decline in the SCI-indexed articles authored by the agricultural scientists echoes the broad trend observed for the Indian science. The total number of SCI-indexed research articles authored by Indian scientists in all fields of science decreased from 14,983 in 1980 to 10,103 in 1990, but rose back to 14,028 in 2002. However, part of the slow recovery of the articles of agricultural sciences during 1990s could be attributed to a shift towards publication in Indian journals which increased in number over time. Some of these journals were also rated high by the national professional academies and assessment boards. Trends in the total number of publications of agricultural science are quite encouraging. The number of CABA-indexed publications increased from 3,014 in 1980 to 6,058 in 1990, which further rose to 6,664 in 1998. A similar trend was also observed for the ISA-indexed publications. This increase in the number of publications during 1990s is important because it is believed that the number of agricultural scientists might have gone down during this period. The number of publications per scientist per year also increased from 0.48 in 1990 to 0.51 in 1998, registering an increase of about 6% (Table 1). This clearly shows an upward trend in scientific productivity of the ICAR-SAU system. However, there are some noteworthy patterns. Nearly 80% of the papers were published in the non-SCI journals with zero impact factor and only a small proportion of the papers was published in the journals with an impact factor greater than zero but less than two. About half of the SCI-indexed and more than 70% of the total publications were authored by the scientists working in SAUs, which is expected because of their scientific strength and dominance of student research. However, the tendency to publish in the low rating journals is a matter of concern. The average impact factor even for ICAR articles was 1.1 and 1.6 for CSIR in 2002, underscoring the need for improving the quality of publications in the country.

Technology development: The number of usable technologies developed is another indicator of scientific productivity, but it is very difficult to compile time-series data on them. Therefore, the trends in rice varieties developed, have been considered to indicate the broad pattern of technological contributions. Rice is one of the important crops receiving greater attention of the research system, and most other crop management technologies evolve around improved varieties. There is an upward trend in the number of varieties developed by Indian rice breeders. During the 1970s, 127 rice varieties were released, which rose to 223 in the 1980s—almost doubling the breeding productivity. The number of officially released varieties increased to 257 during the 1990s. Besides increase in the number of varieties bred, rice breeding also witnessed some qualitative changes over time. The proportion of varieties with fine quality (long slender) grain increased from 29% in 1970s to 36% in 1990s. Also, a significant increase was observed in the number of varieties developed for marginal production environments, as well as those tolerant to biotic stresses. This development led to a substantial reduction in yield variability even in the rainfed areas of eastern India. Development of hybrid rice in partnership with the International Rice Research Institute and private seed companies has established yield advantage of 15–20%. Thus, maintaining high and stable yields with improved grain quality is a major contribution of Indian plant breeding programmes. Focus was also on breeding short duration rice varieties, which constituted about half of the total varieties released during 1980s and 1990s, down from threequarters during the 1970s, owing to trade-off between yield enhancing and crop maturity reducing traits. Similar trends were also observed in breeding programmes for other crops, e.g. in maize, 50 varieties were developed during 1980–93 compared to only 45 during 1960–80. Breeding focus also shifted from varieties to hybrids during the 1980s. Now high protein maize hybrids are developed to meet the rising demand for food and feed. In wheat, till now more than 200 varieties have been released for cultivation in India, and yield potential has been increasing by 1% per year because of the persistence improvement in plant type. After the mid-nineties, an additional yield potential of above 0.7 tonne/ha has been established on farmers' fields, which is likely to be enhanced further through exploitation of hybrid vigour in wheat breeding. The success of crop breeding programmes, coupled with the policy of open access to public material, contributed to the growth of private seed industry in the country. In horticulture, forestry and medicinal and aromatic plants, rapid multiplication of disease-free planting material by tissue culture is contributing to rapid adoption of improved varieties and higher crop yields. The resource-conservation technologies are reducing groundwater use by 5 to 30% in the rice-wheat system. The packages for integrated management of pests and plant nutrients, along with pest tolerant varieties are expected to reduce the use of pesticides to the extent of 50%. Crossbreeding and nutrition and disease management research in livestock have increased milk and meat yields and reduced mortality rates. But, the success was confined to dairy, commercial poultry and fish sector only, and subsistence livestock sector suffered because of limited commercialization of technologies which are often capital intensive, causing a scale bias.

Socio-economic impact

Economic payoffs: Agricultural research and development (R&D) has been assessed quantitatively by several studies conducted by national and international organizations. Investment in agricultural R&D is a 'win-win' option as it is the largest contributor to agricultural total factor productivity (TFP), which in turn reduces rural poverty significantly. Although there are considerable variations, the average rate of return to investment in agricultural research was about 70% with a median value more than 50%. These rates are very much comparable to those obtained internationally, covering both developed and developing countries. Furthermore, the marginal internal rate of return to research investment in India ranged from 57 to 59% since the green revolution era. This is against 35% rate of return realized for private agricultural R&D, and 45% for public agricultural extension. The growth in agricultural TFP is estimated to be 1.4% during 1980–2000, which is equal to that observed for the crop sector during initial phase of the green revolution.

However, TFP decelerated growth for crops in the Indo-Gangetic Plains during the mid-1990s. This is certainly an undesirable trend, but it would be premature to entertain the deceleration hypothesis based on the data for few years. Moreover, there is no clear indication whether this deceleration is because of slow improvement in the technical efficiency—an important factor for growth in TFP—or technological regression. Thus, there is no clear evidence of decline in socio-economic impact of public agricultural research in the country. In fact, deceleration in the agricultural growth since the mid-nineties underscores the need for acceleration of technology flow to farmers, requiring higher investment in R&D.

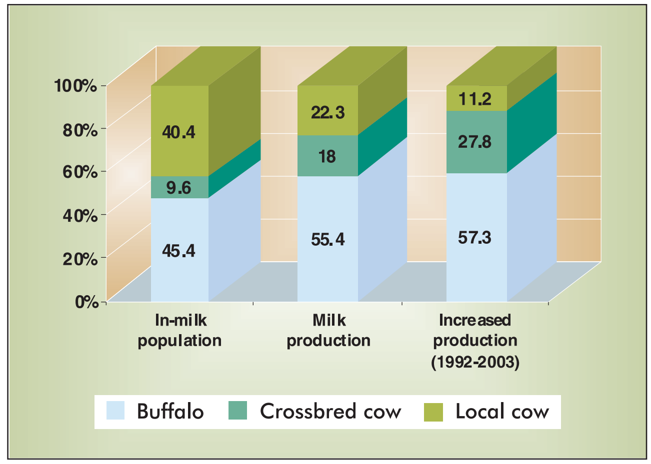
Internal rates of return (%) to agricultural research investment in India

Particulars	India (All studies)	Global estimates
Mean	71.8	79.6
Mode	50.0	26.0
Median	57.5	49.0
Minimum	6.0	-7.4
Maximum	218.2	910

Benefits to smallholders: Has agricultural research in India also benefitted smallholders and dryland areas? Since the green revolution technologies were neutral to scale, the growth benefits were also shared by small producers, and urban poor benefited through reduction in food prices. The high-yielding varieties also spread rapidly to dry and semi-arid regions of the central and peninsular India and covered more than 74% of area under sorghum and pearl millet, which is higher than that of paddy. Lately modern varieties rapidly spread in the eastern India, contributing to most of the increase in the national foodgrain production during the 1990s. A study, revealed that technological change has been pervasive even in the rainfed areas, and crops like coarse grains, pulses, oilseeds, fibres, and vegetables have also registered a positive growth in the total factor productivity. However, the impact has been rather limited in a few states, viz. Bihar, Madhya Pradesh, and Karnataka, partly because of incremental nature of technological advancements (unlike oneshot jump in irrigated areas), which are often eroded by erratic weather conditions. Barring these few limitations, the research system has been able to address the objective of sustainable agricultural development with social justice, and economic policy environment has helped in achieving this objective. International research community, mainly the CGIAR system, has been a useful ally in this endeavour, but, technology spillovers from the CGIAR system would not have been realized in the absence of the strong national system.

Significant changes were observed in the Indian seed system in the last decade or so, and the most significant development was the emergence of private seed sector. This has improved access of farmers to commercial seed. Study on cotton (Maharashtra), groundnut (AP), vegetables (HP), paddy (Haryana) and potato (HP and UP) indicate that a significant proportion of hybrid seed was purchased from the commercial sources (more than 90% of the cotton and tomato seed was procured from the commercial source by the farmers) but at the same time only 20 to 35% of the potato and groundnut seed was procured from the commercial sources indicating restricted participation of the private sector in the seed system of 'orphan' crops because of high investment, low profit margins and voluminous nature of seeds of such crops. A significant proportion of farmers, irrespective of their farm size, purchase seed from commercial sources for quality considerations. Majority of the farmers get to know about a new variety from the fellow farmers indicating the inefficiency in the public extension or seed system. For self-pollinated and vegetatively propagated crops, the public varieties still dominate. However, there are some instances of multiplication and supply of foreign variety seeds of potato, especially for the processing sector. Thus, there is an increasing trend towards privatization in the Indian seed industry. The public seed system is facing several resource and institutional constraints. In particular, there is a need for technological backstopping, developing partnerships with private and civil society organizations, and developing capacity at local level. There are significant changes in terms of seed regulations, management of genetically modified (GM) crops and protection of intellectual property. Since all these regulations are mutually enforcing, there is a need for developing institutional capacity for their enforcement, as well as flexibility to learn from the experience for future adaptations.

Considerable efforts have been made to improve the genetic potential of dairy cows and poultry over the last 3 decades. NCAP has attempted to quantify the contribution of crossbred cows and improved layers to their output growth for 1992–93 to 2003–04. In 2002/04 crossbred cows comprised 10% of the in-milk animals



Contribution of crossbreding technogy in dairying

and contributed 18% to the total milk production. Their share in in-milk bovines and in milk production almost doubled since early 1990s.

Between 1992/94 and 2002/04 total milk production in the country increased by 26 million tonnes, and 37% of this was because of increase in animal productivity. Crossbred cows contributed to 28% to the incremental milk production, and about 18% of this came from increase in productivity. On the other hand, indigenous cows contributed 11% to the incremental output, and most of it came from enhanced productivity. Buffaloes account for most the incremental production (61%) and yield improvements accounted for 37% of this.

These results imply that future growth in milk production should come largely from (i) a replacement of low-yielding indigenous cows with crossbreds and buffaloes, (ii) improvements in their yields as their potential is yet to be exploited—the potential yield of a crossbred cow is about 3,000 kg/annum and that of buffalo about 2,000 kg/annum, and (iii) better management of good milk yielding indigenous cows.

Losses in livestock production in India, 2002/03 (Rs billion)

Species	Losses due to					Output		
	Breeding problems	Diseases	Feed scarcity	Inefficient management	Total losses	Actual output	Attainable output	Attainable output lost (%)
Cattle	50.8	100.1	71.2	34.4	256.5	595.1	851.7	30.1
Buffalo	22.5	20.8	79.0	9.7	132.0	670.1	802.1	16.5
Sheep	6.6	4.5	4.7	0.3	16.1	24.5	40.6	39.7
Goat	3.4	3.4	3.4	1.7	11.9	62.7	74.6	16.0
Pig	0.0	4.3	1.4	0.0	5.7	13.3	19.1	30.1
Poultry	0.0	5.1	2.5	2.2	9.9	120.2	130.0	7.6
All	83.3	138.3	162.3	48.3	432.1	1485.9	1918.0	22.5
% of total	19.3	32.0	37.6	11.2	100.0			

Economic losses in livestock production in India

Livestock production faces a number of constraints related to health, breeding, nutrition and management. Livestock output worth Rs 432 billion (at 2002/03 prices) is annually lost due to inadequate feeding and nutrition, diseases, breeding problems and inappropriate management. This comprised 23% of the attainable output from the sector in 2002/03.

Feed and fodder scarcity is the main limiting factor to improving production and productivity. Output worth Rs 162 billion a year is lost due to inadequate supply of feed and fodders. Diseases cause an annual loss of Rs 132 billion, and breeding problems add another Rs 83 million to it. The magnitude of losses however varies across species. Nearly 30% of the attainable output of cattle and pig, 16–17% of buffalo and goat and 40% of sheep is lost due to different constrains.

Serious concern has been raised recently on the long run sustainability of the productivity effects of Green Revolution technologies in the light of decelerating trend in the yield growth of rice since the mid 1980s under irrigated ecosystem. However, the changes in physical yield are not true measures of productivity from efficiency perspective. Total factor productivity (TFP) is a true measure of economic efficiency of any technology impact. The study addresses this crucial issue empirically by analyzing TFP.

TFP grew at average rate of 1.2–1.3% per annum during Green Revolution (GR) period in the irrigated areas of Andhra Pradesh and Punjab. But, the TFP growth declined rapidly between early and late GR periods in Punjab and Karnataka. On the contrary, TFP growth picked up in the rainfed areas as modern variety (MV) adoption increased after 1980s.

Results suggest that various modern technologies (such as MVs) adopted by the farmers over the period have continuously affected rice productivity growth as reflected in the increasing trend of TFP growth. However, rate of increase in TFP growth decelerated under the irrigated ecosystem during the late GR period. This implies that 'level' of productivity impact of the successive generations of modern technologies (such as new MVs) has apparently been going down, which is not unusual to experience plateau or deceleration in TFP growth in the progressive areas (irrigated ecosystem) because TFP levels can not be increased at the same rate during the late GR period as it was during the early GR period.

Total factor productivity growth of rice in principal growing states

(% per year)

State	Period	Output growth	Input growth	TFP growth
Andhra Pradesh	Early GR	2.85***	2.16**	0.69**
	Late GR	1.97**	0.01	1.96**
	Overall GR	2.43***	1.13**	1.30**
Karnataka	Early GR	–0.46	–1.51*	1.04**
	Late GR	2.44**	2.84***	–0.40
	Overall GR	1.28**	1.10*	0.18
Punjab	Early GR	4.72***	1.10**	3.62***
	Late GR	–0.92**	–0.12	–0.79*
	Overall GR	1.67***	0.44*	1.23**
Uttar Pradesh	Early GR	2.52***	0.05	2.48**
	Late GR	0.72*	0.14	0.58*
	Overall GR	1.51**	0.10	1.41**
Assam	Early GR	1.30*	0.53*	0.76*
	Late GR	0.91*	0.24	0.68*
	Overall GR	1.11*	0.39	0.72*
Bihar	Early GR	0.14	1.13*	–1.00*
	Late GR	3.79***	–0.57*	4.36***
	Overall GR	1.15*	0.66*	0.49*
Madhya Pradesh	Early GR	2.25**	1.15*	1.10*
	Late GR	0.81*	1.35**	–0.55*
	Overall GR	1.53**	1.25**	0.28
Orissa	Early GR	1.18*	0.96*	0.22
	Late GR	2.79***	0.44*	2.36**
	Overall GR	1.89**	0.73*	1.16**
West Bengal	Early GR	2.88**	1.00*	1.89**
	Late GR	2.07**	1.13*	0.94*
	Overall GR	2.49**	1.06*	1.43**

***, **and *indicate 1%, 5% and 10% probability levels of significance respectively.

It is a matter of concern that despite four-fold increase in food production, the food security in the country has raised doubts on sustainability and raising anxiety in the food production front. Rice is a choice crop of the millions of poor and small farmers not only for income but also for household food security, therefore any deficiency in production will have serious implication on the whole.

Historical analysis shows that the phenomenal pace in increase in rice production has been uneven and 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 areas, which is also dominated by small and marginal farmers. The rice production growth rate has been depicting a picture in the shape of an inverted bowl, which is a matter of concern.

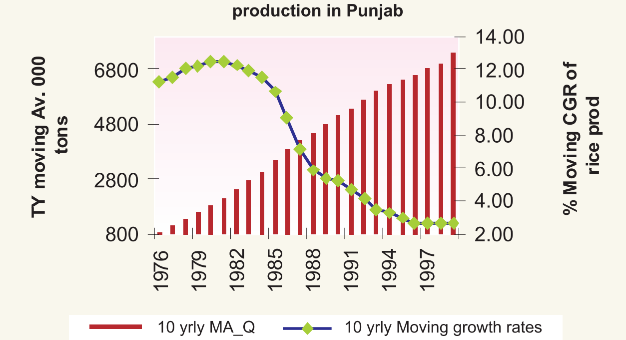
The trend analysis of 10-yearly moving average and growth in rice production brings out the changing pattern of rice production system across the state (eg. in Punjab on one hand and Orissa on the other hand).

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

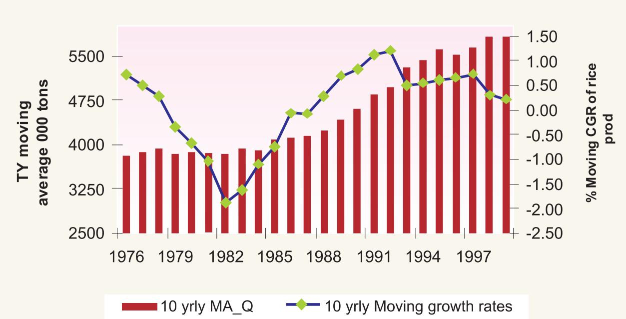
The regional dimension of rice production systems depicts an interesting contrasting picture. The irrigated rice in Punjab shows a highly progressive picture where the average production reached nearly 7.36 million tonnes of rice production in 1999–00, while the moving compound growth rate of production went down from more than 10% in early 1980s to a low of 2.58% in 1999–00. As against this, the same in rainfed rice in Orissa shows a diametrically opposite and unequal picture. The average production was 5.8 million tonnes in 1999–00 and the growth rate stagnating below the 1% per annum. The regional picture is also an identical picture between developed and less developed region.

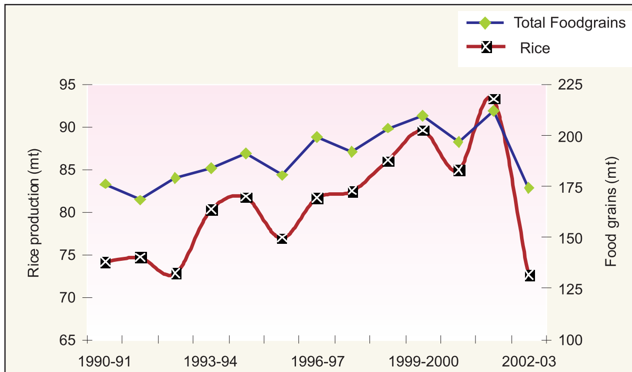
Hence the green revolution bypassed the less developed rice production system in eastern India and it is now required to play more innovative role in future.

Trends in moving average and growth of rice production in Punjab



Trends in moving average and growth of rice production in Orissa





Trends in rice and foodgrains in India

Rice seems to set trend in overall food production, where both rice production and food grain moves identically. The production of food grain decreased to 174 million tonnes in the dialectic is that while combined areas under wheat and rice is stagnating around 69 million ha (57% of area under foodgrains), at the same time, the productivity of rice in over two-third area has been hovering around 2 tonnes/ha, which affects 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. It, therefore,

Share of area, production and yield of rice during 1999–2000 and 2000–01 in major rice producing states

Zones	1999–2000 Area %	1999–2000 Production %	1999–2000 Yield (t/ha)	2000–01 Area %	2000–01 Production %	2000–01 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

Institutional innovations: a driver for rural prosperity

Rural institution is a crucial instrument to carry forward innovations and policy. Because, agriculture development being a public good, the individuals can rarely performs efficiently. Lack of efficient institution at rural areas thus hinders proper implementation of projects and hence failed in the"reach out" to the stakeholders. The mode of institution formation, functioning and role played by a mega institution in Assam was studied. The FMC (Field management Committee, locally known as called PPS- *pather parichalana samiti*) is a village level institution, which normally has about 50 voluntary members, possessing land holdings in the contiguous areas facilitating collective management. A little known institution in the country has been involved in many useful rural activities. Total FMCs are about 26, 000 covering almost every village in the state. A unique aspect is that the government recognised the FMC as village intermediary for schemes like million STW (shallow tubewell schemes), SKY (Samridhi Kisan Yojana of the Government of Assam), and for several NABARD schemes. Some of them are performing extremely successfully, although majority of them are not been able show any impact publicly. On the whole, as usual the *bads* are multiplying as free-rider and *goods* are not replicated in the required pace. To understand the impact of such a mega organisation, in-depth studies are required. Because, there is hardly any study undertaken to assess performance and evaluate the FMC for future improvisation. Actually, the FMCs helped the farmers

- in capacity building
- access to information, and
- forming cohesive groups for their well being.

This has increased the crop production and enhanced adoption of modern technology including crop diversification. A typical impact of the FMC, according to the villagers is that after formation of FMC, the villagers benefited to the extent of changing the desperate situation of enabling two-meals a week from their own food production to a most successful case of two-meals a day due to FMC-led innovations in agriculture. In another case, it was found that before the formation of FMC, the farmers were unaware of the existence of a agricultural research centres in the vicinity of their village, now they participate in several forums organised by the agricultural university and government departments to get benefits from the modern innovations. Comparison of few case studies revealed an interesting contrasting picture of success stories and the failures. The study brings out useful case studies depicting both the instances of organisational excellence and as well as laggardness. The findings provide excellent lessons in relation to pathways of rural organisational excellence.

implies the need for productivity enhancement and providing more entitlement to livelihood to the rice growing population, which is a major challenge to the agricultural research and development system. More particularly, the hub of green revolution state as Punjab, resorting to pro-agriculture diversification policy, which divert rice-wheat area in favour of other crops follow this new path and Tamil Nadu and Andhra Pradesh follow the suit, it may create an unexpected vacuum in the food production frontier. The situation is particularly frightening while reckoning the historical production performance in eastern India.

The study brings out certain critical factors affecting food production, which require more policy attention.

- The enhancement of the productivity of rice and rice-based systems with special emphasis on regional priority is essential. Not only the development of modern and new technology but also imbibing the traditional base on the rice production systems need to be considered carefully.
- Effective policy advocacy for more demand-driven technology and reaching out to the target groups along with developing more resilient varieties to biotic and abiotic constraints, require due emphasis.
- The quality improvement in rice is another area requiring more careful attention to ensure a niche in rice export.
- The need for regionally differentiated research and development is advocated, and intervention strategies identified.
- Immediate attention is required on the aspect that the overall annual growth of rice production is significantly lower than that of the population growth.

The contribution of Information and Communication Technology's (ICT) to national development has been steadily increasing since early 1990s. Special efforts are made to exploit the potentials of ICT for agricultural development.

The series of revolutions led to national food security but the agricultural sector is facing the challenges of diminishing land/ natural resources, increasing biotic and abiotic stresses, indications of factor productivity decline, economic inequality etc. Further Indian agriculture has come under significant adjustment pressure from market liberalization and globalization. New information intensive extension system has to be more diversified and demand-driven. To perform this broad based role, ICT can play complimentary role, because, it has the merits in terms of more subject matter coverage, decision support, direct access to information, minimize time and distance barriers, empower rural intermediary organizations. Thus, ICT has the potential to facilitate cost-effective production, vertical integration, improve value added marketing, minimize transaction costs, improve communication efficiency, encourage competitiveness and accelerate growth.

Realizing this, National Agriculture Policy of India has

Some innovative ICT-based initiatives in Indian agriculture

Project	Name of organization	Important features	Subject matter area
(a) Public Sector Cyber extension project	National Institute of Agricultural Extension Management (MANAGE), Hyderabad	Village information centers, institutional support to other ICT projects	Post harvest processing, women and child welfare
Help-line service	Chandra Shekhar Azad University of Agriculture and Technology (CSAUAT), Kanpur	Helpline service through telephone, researcher-farmers linkage	Cultivation practices, plant protection, new technologies
Gyandoot project	Grama Panchayat, Community, Dhar district, Madhya Pradesh	Soochanalayas, Portals, Partial recovery, Panchayat-community partnership	Agriculture produce, market intelligence, auction rates, land records
(b) Private Sector E-*Choupal*	Indian Tobacco Company, Madhya Pradesh	e-*choupal*, crop specific intranet	Market price, cultivation practice, weather
I-kisan portal	Nagarjuna group, Andhra Pradesh	Portal in regional languages	Agricultural practices, plant protection, animal husbandry, weather
(c) NGOs Village Knowledge Center	M S Swaminathan Research Foundation (MSSRF), Chennai	Knowledge center, pro-poor, pro-nature, pro-women, community ownership	Agronomic practices, cattle, feed, weather, schemes
Computer on wheels	Pingali Rajeswari-entrepreneur, Andhra Pradesh	Internet on motor bikes, portals, remote area, resource poor	Market, weather, plant protection, animal health

Differential features of selected ICT-based initiatives

Features	Public sector	Private sector	NGOs
Investment	Funds from central and state governments	Company expenditure	Funds from international organizations, state governments, etc.
Area of interest	Research, education, training and capacity building	Business goals with social orientation	Uplifting of remote area people
Salient services	Researcher-farmer linkage, call centers	Input-output marketing, technology dissemination	Agriculture and animal husbandry, social developmental work
Working areas	Based on the research and training needs, villages/districts	Commercial, strong marketing areas of the companies	Remote and socially under-developed areas
IT facilitator at the grass root level	Government officials, trained local personnel	Local trader, professional personnel	Volunteers from local areas and service-oriented personnel
Goals	To make a role model for agriculture and the allied development	To generate economic benefits for the people as well as company	To create awareness about socio-economic benefits of innovative technologies

emphasized to revitalize the 'Agricultural Extension Services' using ICT for communication between researchers, extension workers and farmers The Government's supportive policy has influenced the role of emerging pluralistic extension system in India in application of ICT in agriculture also. Public sector institutions (e.g. Department of Agriculture, research institutes, State agricultural universities), NGOs, cooperatives and various private firms (farm-related input marketing firms), are actively

Constraints experienced by the beneficiaries

Constraints	Organization/Percentage					
	E-C	IK	HL	COW	GD	MAN
Regional specific information-insufficient	25	55		40		50
Subject matter-inadequate	25	10	37.5	62.5		45
Not suitable to all information	20	-	30			
Support from facilitator-inadequate	10	35				37.5
Facilitator's knowledge is inadequate	52.5	30		25		35
Facilitator is required			50			
Lack of infrastructure facility		62.5			55	30
Internet/phone connectivity inadequate		50	50		50	47.5

E-C:E-*choupal*, IK: I-*kisan*. HL: Helpline service, COW: Computer on wheels, GD: Gyandoot, MAN: MANAGE

venturing into ICT-based initiatives for providing information on agricultural technology, production, processing, marketing and other farm-related aspects.

Constraints in ICT based initiatives

The utilization of ICT in agriculture and rural development in India is facing many field problems, while translating any ICT model into reality. For instance, among the various constraints reported by the beneficiaries in different initiatives, subject matter inadequacy and lack of content in local language were prominent constraints. Facilitator's cooperation and his subject matter knowledge skills were perceived as some of the significant constraints by more than one-third of the respondents. About half of the respondents expressed irregular internet connectivity as one of the major constraints, except case of initiatives like *e-choupal* and computer on wheels. These two initiatives had used solar cell and battery back up for the regular power supply and the e-choupal had VSAT connectivity whereas COW had GPRS connectivity. Farmers faced constraint to use helpline due to very low teledensity in the rural Uttar Pradesh (0.56 phones per 100 people by March 2003.

Strategies and policy options

Each initiative is a unique model in the application of ICTs to agriculture and has merits and constraints of its own. The study also helped in learning lessons from these initiatives for up scaling ICT-based initiatives. Accordingly, the following suggestions would be useful in framing appropriate strategies for greater use of ICT in agriculture sector.

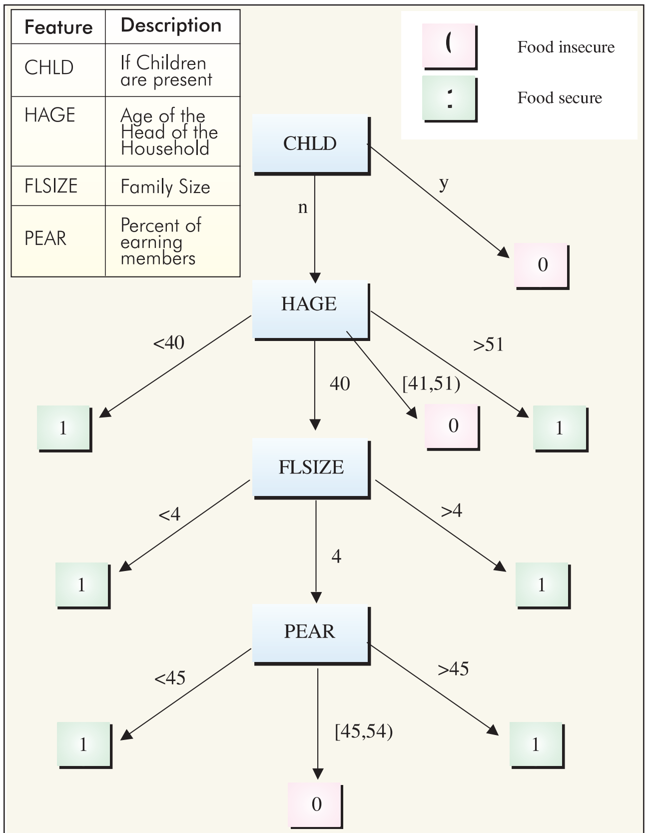
- Involve local people in content development as in village knowledge centre' to assess information needs and collection of indigenous knowledge, which can be synthesized, with information from experts/institutions
- Prepare user-friendly content in the regional languages also with visuals
- In kiosks, supplement the digital information with public address system, vernacular print media, and bulletin boards for wider dissemination
- Use alternative technologies to substitute electricity (batteries and solar panel) and telephone connectivity (wireless network), use space in rural institutions (*Panchayat* office, school, temple) to overcome infrastructure barriers (e.g. Soya-choupal, Village knowledge centre)
- Appoint facilitators exclusively for information service; they should be motivated and accountable, well qualified with adequate knowledge on subject matter and computer operation
- Support these initiatives by other quality services and rural infrastructure (extension expert's advice, market access, transport service, roads, development schemes etc.) to translate knowledge-based decisions into actions without bottlenecks
- Encourage networking of institutions and public-private partnership for improving rural teledensity, information generation and delivery, capacity building of the facilitators etc
- Public sector institutions have to play a greater role in synthesizing information while private sector institutions and NGOs disseminate it through information centres

Identifying vulnerable and food insecure households

Dynamic rough set based decision tree induction (Dynamic RDT) model was developed to extract rules and patterns which can identify vulnerable households. The produced ruleset is aimed to help in identification of the households which are vulnerable to food shortage. Nutrition dataset, a primary survey data of 180 rural households in Dharampuri district of the state of Tamil Nadu in India, is used for the demonstration. The dataset was collected for an independent study and was not manipulated for

Comparison of dynamic RDT with linear discriminant analysis

Algo	Accuracy	Number of rules	Number of features
Dynamic RDT	73.00	9	4.0
Linear discriminant analysis	71.1	–	8.0



A simplified decision tree induced using the entire data of Nutrition dataset using Dynamic RDT algorithm

experiments with the proposed model.

The estimated accuracy as obtained by using linear discriminant analysis (LDA) is used as a benchmark for comparing accuracy of the proposed model called dynamic RDT. LDA approach does not provide the rule based model hence number of rules are not possible in this approach. Also number of features that are required to predict the vulnerable and food insecure households using the developed model is 50% less as compare to the LDA along with comparable accuracy and improved understandability.

Several other data mining approaches were also experimented on the dataset. The estimated performance of the proposed model is better for the dataset.

Forecasting techniques in agricultural system

Models based on weather indices (simple/weighted total of values of weather variables and product off weather variables taken two at a time) were developed and validated for cotton (Whitefly, pink bollworm, American bollowrm for Lam) and rice (gall midge for Cuttack). Forecasts of subsequent years, not included in model development, were close to the observed values in all the cases.

Logistic regression models were developed for qualitivative data on alternaria blight and white rust in mustard crop. The forewarnings on the basis of models using two categories were satisfactory in al the cases artificial neural network (ANN) technique has been tried for powdery mildew in mustard (S.K. Nagar). The data of four years for forecasting maximum severity, crop age at first appearance and peak severity, were used. Technique worked very well for forewarning crop age at first appearance of disease whereas for other character further refinement is needed. A flexible Central Data warehouse (CDW) of agricultural resources of the country was developed at the IASRI, new Delhi, and was probably the first attempt of data warehousing of agricultural resources in the world. This provided systematic and periodic information to research scientists, planners, decision makers and developmental agencies in the form on On-line Analytical Processing (OLAP) decision support system. This project was implemented with active collaboration and support of NBSSLUP, Nagpur (for soil resources); CRIDA, Hyderabad (for agro-meteorology); PDCSR, Modipuram (for crops and cropping systems); NBAGR, Karnal (for livestock resources); NBFGR, Lucknow (for fish resources); NBPGR, New Delhi (for plant genetic resources); CIAE, Bhopal (for agricultural implements and machinery); CPCRI, Kasaragod (for plantation crops); IISR, Calicut (for spices crops); ICAR Research Complex for Eastern Region, Patna (for water resources); NRCAF, Jhansi (for aro-forestry) and IIHR, Banglore (for horticulural crops). Subject-wise data marts were created; multidimensional data cubes developed and published on Internet/Intranet. The web site and the project is already launched (www.inaris.gen.in) and the multidimensional cubes, dynamic reports, GIS maps, adhoc-queries and information systems are already available to the users. The information of this data warehouse are available to user in the form of decision support system in which all the flexibility of the presentation of the information, its on-line analysis including graphic is inbuilt into the system. The systems also provides facility of spatial analysis of the data throuh web using functionalities of geographic informations system (GIS). Apart from this, subject wise information systems have been developed for the general users.

Cropping systems research

Under AICRP on long-term fertilizer experiments conducted at Ludhiana, revealed that in the presence of residual P fertility of 82 kg/ha the reduction of P application by half under 100% NPK original treatment proved effective in sustaining the respective average yield levels of 31.85 and 48.71 q/ha of maize and wheat compared to the corresponding yields with optimal P application. With complete P omission under 100% NPK(-S) treatment the sustainable average maize and wheat yields were 28.8 and 45.10 q/ha. The depletion of available zinc from the initial level of 2.7 mg/kg to 0.62 mg/kg over the years at Pantnagar, became a yield limiting factor under the 150% NPK+S treatment. Its replenishment @ 25 kg $ZnS0_4$/ha significantly enhanced the average rice and wheat yields over the corresponding yields obtained without zinc application. The trend analysis of available phosphorus in soils under optimal and super optimal NPK treatments over the years indicated its huge build up of 169.7 kg/ha over its initial value at Palampur and at Barrackpore, indicating need of management intervention for rescheduling P application to enhance efficient fertilizer use and economic profitability of the fertilizer added to the cropping systems. On the basis of trials conducted on farmers' field adopting only the improved varieties and continuing with existing practices for rice and wheat crops, the increase in productivity was 10.89% and 10.30% respectively. In case when farmers had adopted improved varieties along with recommended dose of fertilizer, the increase in rice and wheat production was 25.71% and 28.85% respectively. The increase in productivity for rice crop owing to adoption of new varieties varied from 2.38% for Punjab to 16.61% in Maharashtra state under farmer's existing practices. In case of adoption of new varieties of rice along with recommended fertilizer doses, Punjab has shown decrease in production up to 1.07%, due to use of higher fertilizer dose 150 kg/ha of N + 40 kg/ha of P by farmers than the recommended dose of 120 kg/ha N. A database of Experiments on Long Range Effect of Continuous Cropping and Manuring on Soil Fertility and Yield Stability, for online storing and retrieving the data for different centres was prepared. Database for the project on Statistical and Algorithmic Approach for Improved Estimation of Treatments Effects in Repeated Measurements Designs, has been designed and parameters of 50 repeated measurements designs (RMDs) catalogued from literature were entered into it. Computer softwares have been developed in Visual Basic for the generation of various types of RMDs. Under design and analysis of experiments for spatially correlated observations in block design setup, the coefficient matrix of reduced normal equations for estimating treatments contrasts was obtained for a nearest neighbour correlation error structure and first order autocorrelation error structure. At Faizabad, normal method of wheat sowing provided maximum gross returns from rice-wheat sequence compared to late, transplanting and zero tillage methods.

Experimental designs for agricultural,animal and agroforestry research

A project entitled 'Studies on block designs for bioassays' was undertaken to obtain and catalogue optimal/efficient block designs for bioassays.

The following are some of the salient achievements.

(i) Optimality of block designs for multiple parallel line assays that allow estimation of three contrasts of major importance but do not necessarily allow the estimability of other treatment contrasts was also studied and a method to obtain such designs was developed. A catalogue of 35 A-optimal block designs for $3 \le m \le 8$, $8 \le k \le 16$, $k < 4m$, $bk \le 100$ was prepared for one standard and three test preparations.

(ii) A-optimal block designs for asymmetric slope ratio assays were obtained. A catalogue of 61 A-efficient block designs for asymmetric slope ratio assays was prepared. Wherever, A-optimal design is not obtainable a lower bound to A-efficiency is provided.

(iii) Besides cataloguing optimal/efficient block designs obtained in the studies on block designs for biological assays, a catalogue of the designs obtainable from the methods of construction available in literature is also prepared. A-optimality aspects of these designs for parallel line assays were investigated. None of the designs in the parametric range $3 \le m \le 6$, $4 \le k \le 10$, $bk \le 50$ were A-optimal for inferring on the contrasts of interest. Indeed it is possible that some designs with parameter combinations beyond these parameter combinations may turn out to be A-optimal.

The analysis of crop data on agro forestry experiment pertaining to various characters received from the collaborative center revealed that performance of the under storey crop was affected by the tree species and the distance of the crop from the tree base. The yield increased as the distance increased. The RBD analysis of tree data with 12 treatment combinations (4 tree species with 2 crops along with 4 sole trees, i.e. $4 \times 2 + 4$) in 2 replications indicated the treatment effects as significant. The crude protein yield was significantly different in group containing babul indicating the effect of crops on babul. Trend-free binary variance balanced block designs under homoscedastic model and heteroscedastic model (error variance proportional to some power of block size) were obtained when there is uniform trend within the blocks. Trend-free nested balanced incomplete block designs, when the trend effect is in nested blocks, were also obtained.

Assessment and evaluation studies

To finalise the farm mechanization strategies in the country a study was carried out. A large scale survey, adopting stratified multi-stage random sampling design, was planned and conducted in 120 randomly selected districts through 24 Centres (21 Centres of AICRP on FIM; GAU, Gujarat; SKUAST, Jammu; NDUAT, Faizabad) spread nation-wide. The analysis of data for all the states was carried out and the mechanization strategy draft for different agro climatic zones/states was submitted.

To develop a user friendly software for the imputation of missing data based on neural network based imputation concept along with other alternative methods of imputation, requirement analysis was done.

Production and area estimation

For studying the methodology of estimation of wool production a pilot study was taken up. The estimates of sheep number, average wool yield and total wool production for Kolar and Bikaner districts were prepared and finalised. The difference in estimates obtained by using different estimators was also tested.

From the study, "On efficient block level estimators of yield rates of important crops", the accuracy comparison of crop cut estimates and the farmers' estimates were made with actual production values. The crop cut estimates by and large were close to the actual production figures for crops harvested in multiple pickings, cotton, etc. The percentage standard errors of the estimates were obtained through crop cut approach.

Cost of production studies

Sampling methodology was developed for estimation of cost of production of coconut in Kerala. It revealed that technologies such as basin opening and application of organic manures were the most commonly adopted practices; plant protection, spacing for optimum plant density and cultivation of hybrid/high yielding varieties showed low level of adoption; applications of chemical fertilizers, irrigation, intercultural operations, inter/mixed cropping and mixed farming was having medium level of adoption.

Under the project 'On development of methodology for productivity of important flowers' estimated production of loose flowers on the basis of market arrival from Delhi as well as outside Delhi was studied. Percentage standard errors of the estimates of different kind of flowers traded in three flower *mandis* of Delhi clearly indicated the applicability of sampling methodology adopted.

Technological change, risk and uncertainty in agriculture

An econometric study of technological dualism in egg production was based on primary survey data of selected poultry farms in two districts Mansa and Ludhiana of Punjab state. Major factors influencing egg production are feed, labour, medicines and electricity costs. On cage system and deep litter types of farms most of the input variables except for feed cost were not properly utilized. If the poultry farms using deep litter system shifts over to cage system of technology there may be a substantial saving in the input resources. The existence of technological dualism in egg production revealed that inputs were not being efficiently used on deep litter farms. Factor share analysis in district Mansa revealed that the share of labour factor remained about 4 %, the share of poultry feed which is a proxy variable for capital, was maximum of about 62 % on both types of farms.

The study on 'Technical efficiency analysis of rice-wheat system in Punjab', revealed an ardent economic viewpoint that the majority of farmers in Punjab did not appear very far from frontier but there existed possibilities of increasing rice and wheat output with better use of technical skills at least in deployment of factors of production under farm control efficiently.

Modeling for agricultural marketing

The host wise details of brood lac in Jharkhand state were obtained. The annual average income of different host trees from lac cultivation were — in ber host income on small farms was Rs 545, on medium farms Rs 272, and on large farms Rs 224. Income from *palas* host on small farms was Rs 319, on medium farms Rs 405 and on large farms Rs 537. In *kusum* host income on small farms was Rs 641, on medium farms Rs 1,073 and on large farms Rs 868.

Food security and poverty alleviation

The study was based on primary data collected for base year, 2001 and the year 2004 on household food and nutritional security for tribal, backward and hilly areas under 'Jai-vigyan national science and technology mission project'. Technology intervention improved the benefits from sheep husbandry resulting in food security and poverty alleviation in the studied areas.

Under the study 'Determinants of performance of self-help groups (SHG) in rural micro-finance', the divergences between Andhra Pradesh and Uttar Pradesh states in terms of agro climatic and socio-economic parameters was examined. SHG progress was very fast in Andhra Pradesh compared to Uttar Pradesh. This scenario rejected the hypothesis that there should be a higher positive correlation between female population and number of SHGs.

Software development

Statistical package on Agricultural Research (SPAR 2.0) was developed. The package consists of the following eight modules, which have sub-modules for various type of data analysis:

- Data management—(i) Editing of data (ii) Transformatin of data
- Descriptive Statistics—(i) Measures of Central Tendency, (ii) Measures of Dispersion, (iii) Generation of Moments, (iv) measures and Coefficients of Skewness, (v) measures and Coefficents of Kurtosis (vi) Measures of Partition Values
- Estimatino of Breeding Values—Generations Means (Six Parameter Model, Five Parameter Model, Three Parameter Model) and scaling and Joint Scaling Tests
- Correlation and Regression Analysis—Estimates of the Regression Coefficients, Analysis of Variance of Regression, and Regression Equations (linear regression or multiple), Simple Correlation, Partial and multiple Correlations, Validity of Test of Significance and Path Analaysis.
- Variance and Covariance Components Estimation—Computation from ANOVA, Components of Variances such as Phenotypic Coefficient of Variation and heritability (borad sense), Standard Error and Critical Differences, Bivariate Analysis of Variance and Covariance Components such as Phenotypic Covariance, Genotypic Covariance
- Stability Analysis—(i) Eberhart and Russell's, (ii) Perkins and Jinks' (iii) Freeman and Perkins' Models
- Multivariate Analysis—(i) Cluster Analysis, (ii) Discriminent Analysis (iii) Principal component Analysis
- marting Design Analysis—(i) Complete Diallel, (ii) Partial Diallel, (iii) Line × Tester (with parents), (iv) Line × Tester (without parents), (v) Three Way Cros, (vi) Double Cross (vii) North Carolina Designs Analaysis.

Training programmes

Several training programmes were conducted at the IASRI, New Delhi.

1. Senior Certificate Course in Agricultural Statistics and Computing was organized for the benefit of research workers engaged in handling statistical data collection, processing, interpretation and employed in research Institutes of the Council, State Agriculural Universities and State Government Department, etc. and foreign countries including SAARC countries. The main objective of the course was to train the participants in the use of latest statistical techniques as well as use of computers and software packages.
2. Winter School on 'Sample Survey Techniques in Agricultural Research'.
3. Recent Advances in Biometrics under Centre of Advancd Studies in Agricultural Statistics and Computer Application.
4. Advances in Designing and Analysis of Agricultural Experiments.
5. Sampling Techniques, Sample Surveys and Methodological Aspects relating to Cost of Cultivation Studies.
6. Statistical tools for data analysis.
7. Working with INARIS data warehouse.
8. Exposure and usage of Personal Management Information System
9. Large Sample Survey.