Social Sciences and Policies

- Study on groundnut and potato seed production, revealed that proper farm level seed management and supply chain could fulfill the quality seed requirement
- Fast growth high value agriculture provided a cushion to agricultural growth
- Diversification with high value crops has to planned in a manner that it maximizes farm income without much damage to natural resource
- Faster growth in livestock sector has considerable potential to reduce poverty
- ICT saves 90-95% farmers time as well their money spent on acquiring agricultural technology information
- Prices showed positive effects while price risks negative effects on oilseed production

AGRICULTURAL ECONOMICS

Seed system of 'low value and high volume' seed crop

The public sector has several keyroles in seed system development. The greater part of seed sold in India is based on public germplasm, hence it is important to understand how the public sector should interact with the private and local level seed production. Groundnut and potato provide a perfect example of 'orphan' crops with low seed multiplication rate and high seed requirements. Seed systems of these crops were studied in Andhra Pradesh and Uttar Pradesh, respectively.

Farm level seed management

There is a bit concentration of varieties grown – more than 80% of the area under both the crops is sown with their dominant two varieties. In groundnut, TMV 2 is the most popular variety, covering 54% of the area. This is a very old variety preferred by farmers because of its ability to perform well in drought conditions. JL 24, Polachi and TAG 24 are other dominant varieties. In potato, Kufri Bahar 3797 is the top variety with 75% crop area. Rajendra 1 is another popular variety in eastern part of Uttar Pradesh.

Variety adoption and source of commercial seed

Particulars	Potato (Uttar Pradesh)	Groundnut (Andhra Pradesh)
Proportion of net sown area under the crop	58	80
Proportion of area under top one variety	75	54
Proportion of seed acquired off-farm in 2003–04	40	58
Sources of seed (% of quantity)		
Commercial	21	35
Other farmer	19	23
Farm saved	60	42
Reasons for acquiring off-farm seed (% of cases)		
To get pure seed of same variety	58	67
To change variety	12	15
Consumed or sold all stock	30	18

Farmers acquired 35% fresh groundnut seed from commercial sources, and 65% of seed requirement was met from the traditional sources, viz. own farm-saved seed exchange. In potato, however, the share of farm-saved seed (60%) is much higher compared to the commercial seed. Farmers multiply fresh commercial seed on their farm and use it for a few cropping seasons. This is offered for sale in the next season after meeting his requirements, resulting in comparatively low (21%) proportion of area planted with commercial seed. The farmers buy fresh seed mostly to get pure seed of the popular varieties. The percentage of potato farmers acquiring seed because of exhaustion of all the stock is also quite high (30%). Only 12–15% farmers acquire seed to change the variety. These are the farmers who have got commercial interests as well as resources (mainly irrigation) for seed production and multiplication. Seed quality is the most important criterion for the farmer while going for fresh/new seed.

Extension agencies are expected to play an important role in the two-way flow of information between farmers and plant breeders but results indicate a very poor performance of these agencies. In the absence of effective extension mechanism, majority of the farmers (80% or more) get to know about a new variety from fellow farmers. As plant breeding is still in the public sector and both the crops do not attract commercial interests at present, there is a case to strengthen information flow though public extension machinery. Most of the farmers demand variety by name, suitable soil type, weather condition and market requirements. They also insist on physical examination of seed to ensure seed quality. Price is, however, an important criterion to buy groundnut seed.

Supply chain and private seed

Supply chains in potato are evolving rapidly. This increased the demand for improved varieties and quality seeds, and has also offered incentives to commercial seed sector to participate in the supply chain. There is increasing demand for potato varieties suitable for processing, and private seed producers have tied up with the processing industry to supply seed to their contract growers. This activity has attracted lot of private interest. Tissue-culture based private seed companies are selling source and commercial seeds. The tissue-culture based seed is not yet approved for certification, hence, these seed companies are not able to take advantage of benefits (of certification and tax incentives) provided to other commercial seed producers. Despite this problem, the share of this hi-tech potato seed is likely to increase substantially in future and potato could soon be out of the category of 'orphan' crops.

Options for seed system development

More than half of the seed is acquired off-farm, so formal seed system must meet this demand, which is quite high by any standard. Public seed corporations should take lead in the seed supply to farmers, and complete the seed chain. They should focus on seed multiplication in favourable conditions, so as to increase seed yield. Much of this could be realized by coordination of seed activities of different states. Private seed producers, with little extra investment and efforts to maintain seed quality, can play a significant role in augmenting the seed supply. The expanding markets for quality products are providing major opportunity for private sector's participation. This is visible noticed in potato. For groundnut, the markets are for table purpose kernels in domestic and export market, high oil content groundnut, and groundnut cake. These markets enjoy considerable price premium that provides incentive to maintain product quality, as quality of seed has an important role to play in this. The government should link marginal production regions with the national and global markets. This would help develop supply chain, especially for premium market, which may eventually attract corporate sector in the product, as well as seed market.

Demand for urea towards 2011

Demand for urea by the year 2011 was projected under different scenarios. The first scenario is Business-as-usual (BAU), in which it was assumed that area under irrigation and HYV, and real price of urea would change at the same rate as witnessed from 1992–93 to 2001–02. In addition to these factors, one more factor is added to account for increase in demand for urea due to change in total cropped area. Demand for urea under BAU scenario is projected to increase annually by 3.29%, but by adding residual effect of all other factors then demand for urea is projected to increase by 3.41%. Total demand for urea in year 2011 is projected to be 24.96 million tonnes as against 19.06 million tonnes during triennium ending 2002–03. This scenario includes decline in real price of urea by 1.28% per year as witnessed during the reform period, which in turn implies either increase in nominal and real subsidies on urea or much faster increase in crop price relative to price of urea.

Owing to serious resource constraint there is a strong likelihood that real subsidies on urea does not increase in the country. This can happen if urea prices are increased at the same rate as the increase in prices of crops. This scenario shows that demand for

Demand projections for urea under various scenarios

		Scenarios: growth rates (%)			
Variables	Elasticity	BAU	BAU and freeze on subsidy	Freeze on subsidy, exploit irrigation	Attain 4% growth
Area under irrigation	0.843	1.27	1.27	2.13	2.13
Area under HYV	0.797	2.05	2.05	2.05	2.05
Gross cropped area	1.000	0.15	0.15	0.55	0.55
Real price of urea	–0.344	–1.28	0	0	–2.00
		Increase in real term	Urea price increase at same rate as crop price increase		
Growth rate in demand for urea due to 1 to 4		3.29	2.85	3.97	4.53
Growth rate including residual		3.42	2.98	4.10	4.66
Projected demand for urea in 2010–11 ('000 tonnes)		24,959.00	24,122.00	26,303.00	27,452.00

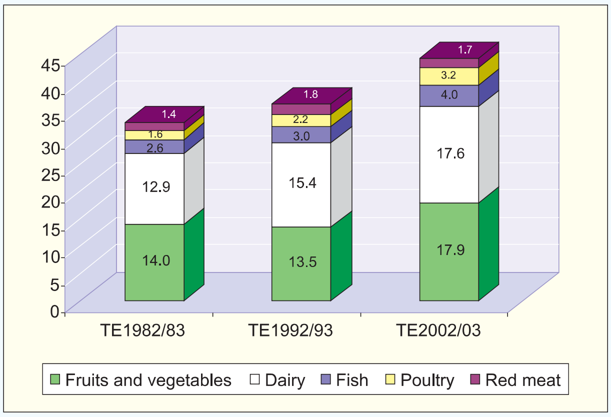
High-value Agriculture for a Faster and More Equitable Growth

The growth in agriculture and its allied activities, the main source of livelihood for a majority of the rural population in India, has started decelerating in recent years. This trend has to be arrested, otherwise it would have serious social and economic repercussions. High value agriculture may provide a cushion to agricultural growth.

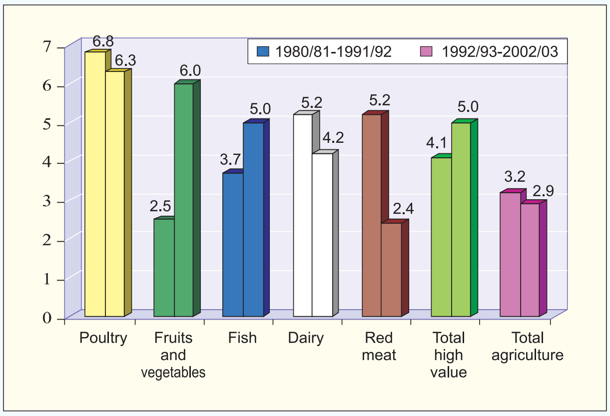
Share of high value food commodities (fruits, vegetables, milk, poultry products, meat and fish) in the value of agricultural output increased from 33% in 1982–83 to 45% in 2002–03. At a disaggregated level fruits and vegetables account for about 18% of the agricultural sector output, and is closely followed by dairy products. Fish share is 4% and poultry 3% in the agricultural sector output. The increasing share of high value food commodities in agricultural sector output is a clear indication of out of staple diversification of Indian agriculture.

Growth in high-value agriculture was more prominent since the initiation of economic reforms programme in 1991. Fruits and vegetable production increased at an annual rate of about 6% a year between 1992–93 and 2002–03, much faster than in 1980s. Dairy production increased consistently over 4% a year despite a marginal deceleration in the economic reforms period. Poultry production increased consistently over 6% a year throughout the last two decades.

Fish production accelerated from 3.7 to 5% during same period. High value segment of Indian agriculture grew faster, compared to rest of the agriculture over the last two decades. The deceleration in agricultural growth in the recent decades is largely because of significant fall in growth of rest of the agriculture from 2.7% during 1980s to 1.5% during 1992/93 – 2002/03. On the other hand, growth in high-value segment accelerated from 4.1% during 1980s to 5% during 1992/93 – 2002/03. Thus the fast growth high value segment provided a cushion to agricultural growth which otherwise would have decelerated at a faster rate.



Share of high value food commodities in agricultural sector output (1993-94 prices)



Annual compound growth rate in high value food production (%)

urea increases @ close to 3%, which would generate total demand of 24.12 million tonnes.

In third scenario it is assumed that the increase in urea price would match with increase in crop price, along with 2.13% annual growth in area under irrigation. This expansion of irrigation corresponds to full exploitation of India's irrigation potential by the year 2020. It is also assumed that expansion of irrigation would increase crop intensity. Empirical evidence on this indicated that 1% increase in irrigation results in 0.25% increase in gross cropped area. Under this scenario demand for urea grows to about 4% per annum which corresponds to 26.3 million tonnes of urea by the year 2011.

Under another scenario assumptions were 4% growth rate in output, full exploitation of irrigation potential, expansion of HYV by 2% per annum, and small increase in crop intensity because of increase in irrigation facility. Since growth rate in output is contributed by several factors, this scenario assumes 0.62% growth in output due to TFP and 0.51% growth in output due to diversification. On balance this scenario requires 4.6% annual growth in application of urea. This growth requires decline in real price of urea by 2% per year, which in turn requires growth in subsidies at a much higher rate than what was witnessed during the reforms period. Demand for urea under this scenario is projected to be 27.4 million tonnes toward by 2011.

Demand projections for urea based on positive approach are quite close to the projections based on normative approach. A synthesis of two approaches revealed that demand for urea towards 2011 would vary between 24 million tonnes at low output growth scenario to 27.6 million tonnes corresponding to relatively high growth scenario.

Promoting Growth in Livestock Sector for Poverty Alleviation

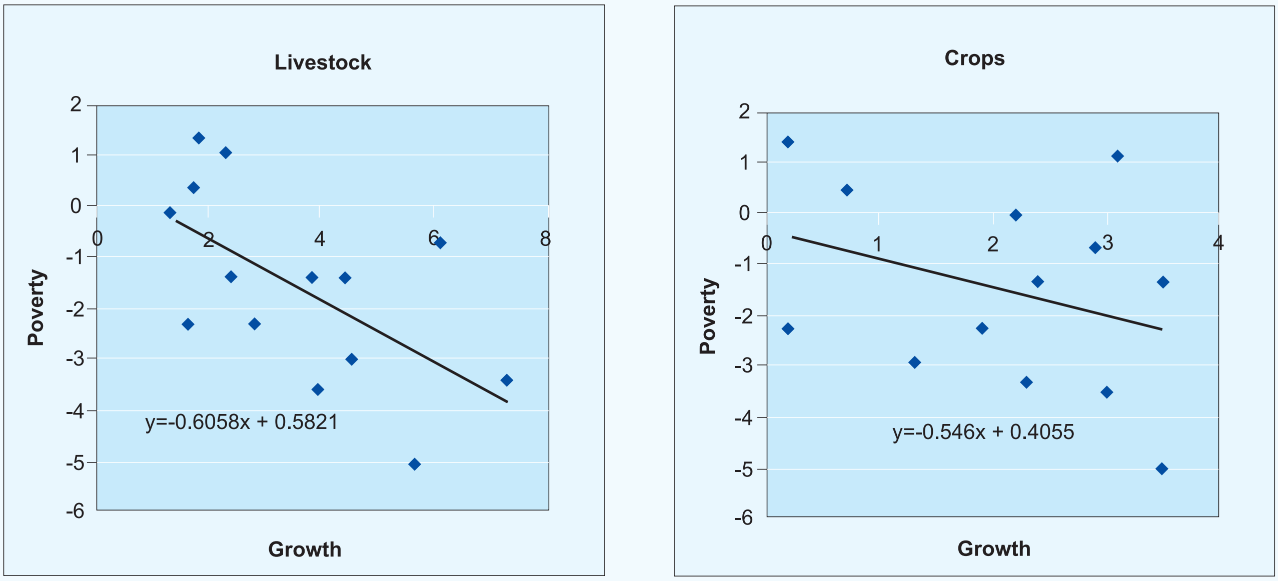
Growth in agriculture is more poverty reducing than the growth in other economic sectors in developing countries. Nearly 72% of India's population lives in rural areas, and 75% of it depends on agriculture and allied activities for livelihood. Further, of 261 million poor in the country, 75% are from rural areas. Accelerating agricultural growth is thus important to reduce rural poverty. The National Agricultural Policy targets a 4% growth in agricultural sector over the next two decades and envisages an important role for livestock sector in achieving this projected growth rate.

Livestock accounts for over a quarter of the agricultural gross domestic product and its growth was always faster than the agricultural sector as a whole. Besides, distribution of livestock resources is more egalitarian compared to land. In 2002–03 the small farm households (< 2 ha) that comprised 60% rural households controlled 76% cattle, 72% buffalo 80% small ruminants, 83% poultry and 90% pigs. Thus faster growth in livestock sector has considerable potential to contribute to agricultural growth and thereby poverty reduction.

Study on growth in head count rural poverty ratio vis-à-vis growth in livestock and crop sub sectors for major Indian states for the period 1983–84 to 1997–98 revealed a faster reduction in rural poverty where growth in livestock sector had been robust. Livestock production as well as poverty reduction performance in West Bengal, Tamil Nadu, Kerala, Karnataka, Haryana, Punjab and Maharashtra was better. Andhra Pradesh too witnessed high growth in livestock production but its impact on poverty reduction was not as high. This is because industrialization of poultry production that accounts for nearly half of the livestock income in the state. On the other hand, Assam, Madhya Pradesh, Rajasthan and Uttar Pradesh experienced low growth in livestock production as well as in poverty reduction.

Annual growth rate (%) in the value of output of various agricultural activities

Periods	Crops	Livestock	Fishery	Forestry
1970–71 to 1979–80	1.8	3.9	2.9	–0.6
1980–81 to 1989–90	2.5	5.0	5.7	–0.7
1990–91 to 2002–03	2.2	3.8	4.7	1.3



Relationship between growth and rural poverty in various states in India

Exploring possibilities of achieving four percent growth rate in Indian agriculture

Sources and growth prospects at state level were studied to find the possibilities to put agriculture on targeted growth trajectory. The study involved estimation of output elasticity with respect to fertilizer and irrigation, scope of irrigation expansion and increase in fertilizer use, scope of diversification through high value crops, improvement in TFP, and estimation of prospects of output growth through expansion of irrigation, increase in application of fertilizer, diversification and growth in TFP.

Feasible growth rate in Punjab was the lowest and less than 1%. Bihar has the scope to raise crop output annually by 6.64% in medium term, which is the highest among all states. Growth prospects seem to be low in Haryana and Rajasthan, which are projected to achieve 1.66 and 2.33% growth in crop output. Maharashtra, Himachal Pradesh and West Bengal possess potential

Sources of output growth (per cent) in 2011

States	Diversi-fication	Irriga-tion	Fertilizer	TFP	Total
Andhra Pradesh	0.25	1.71	1.14	0.40	3.50
Assam	0.27	1.42	1.33	0.88	3.89
Bihar	0.18	3.36	0.85	2.24	6.64
Gujarat	0.78	0.65	1.79	0.47	3.69
Haryana	0.33	0.00	0.68	0.65	1.66
Himachal Pradesh	0.69	3.02	0.70	1.08	5.49
Jammu & Kashmir	0.90	2.88	2.03	0.42	6.23
Karnataka	0.19	1.75	1.16	0.86	3.96
Kerala	0.00	1.54	1.46	0.60	3.60
Madhya Pradesh	0.75	1.62	0.81	0.26	3.44
Maharashtra	0.99	1.95	1.35	0.88	5.18
Orissa	1.05	2.33	0.92	0.14	4.44
Punjab	0.17	0.00	0.40	0.36	0.94
Rajasthan	0.46	0.00	1.61	0.25	2.33
Tamil Nadu	0.40	0.82	1.60	0.35	3.17
Uttar Pradesh	0.37	1.49	1.45	0.60	3.90
West Bengal	0.78	1.22	2.34	1.16	5.49
All India	0.49	1.43	1.32	0.72	3.96

for more than 5% growth rate. Growth prospects are also high for Orissa. Output growth rate in the remaining states is projected to be between 3 to 4%.

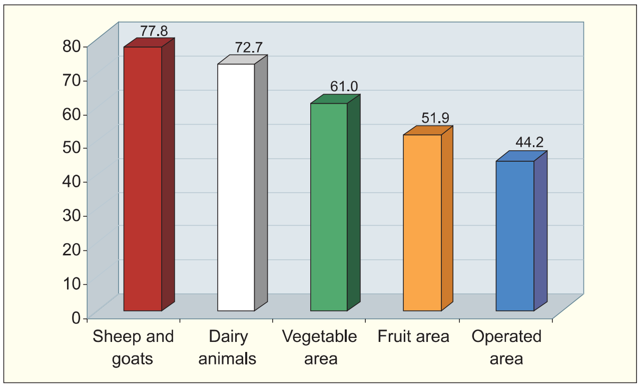
State-wise growth (per cent) in various factors needed to achieve 4% output growth at national level

State	Fertilizer	Irrigation	Area shift to other than foodgrain	TFP
Andhra Pradesh	3.15	2.39	0.555	0.40
Assam	6.94	3.00	0.166	0.88
Bihar	5.11	4.87	0.074	2.24
Gujarat	4.61	1.36	1.136	0.47
Haryana	2.42	0.00	0.500	0.65
Himachal Pradesh	1.75	3.13	0.146	1.08
Jammu & Kashmir	5.11	2.98	0.283	0.42
Karnataka	4.61	1.86	0.116	0.86
Kerala	4.61	1.98	0.000	0.60
Madhya Pradesh	4.40	3.88	0.854	0.26
Maharashtra	4.59	3.34	0.664	0.88
Orissa	6.89	4.93	0.884	0.14
Punjab	1.74	0.00	0.500	0.36
Rajasthan	4.44	0.00	0.640	0.25
Tamil Nadu	2.28	0.82	0.374	0.35
Uttar Pradesh	4.39	1.80	0.213	0.60
West Bengal	5.19	4.01	0.559	1.16
All India	4.35	1.95	0.497	0.72

India need to increase fertilizer consumption in agriculture by 4.35% and area under irrigation annually by 1.95% to achieve 4% output growth. There is also a need to shift about 0.5% area from foodgrains to non-foodgrains every year. Growth in TFP in India is projected to be 0.72% per year at all India level. TFP consists of contribution of several factors; most important being technology and its dissemination. Improvement in infrastructure and farmer's knowledge and skill applied to farming are other contributions to TFP.

High value agriculture and the poor

High value agriculture is more appealing from the perspective of poverty reduction. Most high value commodities require as much as 2–4 times more labour and generate 6–8 times more returns compared to cereals. The smallholders (< 2 ha) have sufficient labour of their own. Production of high value food commodities thus is a perfect opportunity for them to augment their income and utilize family labour more effectively.



Share of smallholders in high value agriculture (2002/03)

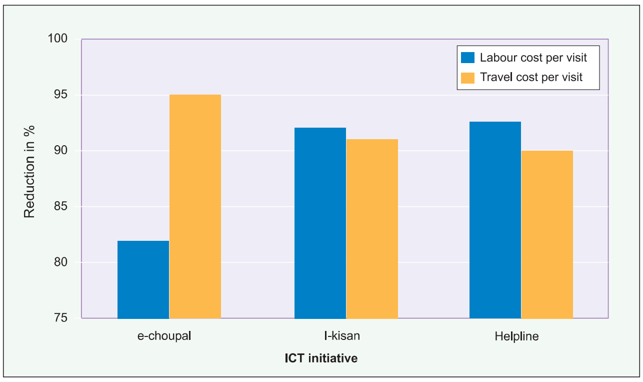
Smallholders' participation in the production of high value commodities was estimated by examining their share in area under horticultural crops, dairy animals and small ruminants. Smallholders account for 61% area under vegetables and 52% area under fruits, which is more than their share in total operated area. Their share in dairy animals and small ruminants is much higher, indicating that distribution of animals is more equitable as compared to land. On the assumption of identical productivity across farms, the share of smallholders in area under horticultural crops and animal population could be treated as their contribution to high value agricultural production. This, however, could be an underestimate of their contribution, because several studies showed that small farms are more efficient compared to large farms. Given that agricultural growth is pro-poor, and faster growth and higher participation of smallholders in the high value agricultural production it can be concluded that growth in high value agriculture would contribute more to poverty reduction than a similar growth in non-high value agricultural production.

However, it is often argued that because of their commercial orientation high value crops may endanger household food security especially of the smallholder households. Proportionately smallholders put large cropped area under foodgrains as do the large farmers who relatively participate less in production of fruits and vegetables because of their labour-intensive nature. As per ha income from high value crops is large, so smallholders may utilize this for purchase of foodgrains. It is also argued that many a high value food crops require more of chemical fertilizers, pesticides and irrigation and therefore may degrade land and water resources. It may be noted that excessive use of resources or inputs in any crop will deteriorate the quality of natural resources; high value crops are no exception to this. Nevertheless, leguminous vegetable crops peas and beans add to soil fertility. Water requirement of most high value crops, on per ha or per unit of output is much less as compared to rice, cotton and maize. The need is to plan diversification with high value crops in a manner that maximize farm income without much damage to natural resources.

Role of ICT-based institutional innovations in reducing transaction cost of farmers

The new economic forces, including globalization of agriculture, are leading to transition of subsistence farming to commercial one. Farm diversification, value addition, and recycling are the integrated farm approaches having the potential risk minimization capacity. The success of the approach depends on access to latest technical knowledge to the farmers. Acquiring relevant knowledge from the extension agents entails high cost and time, which influence the farmers' decision making. The information and communication technology (ICT) is one of the potential options available to access information by the farmers.

The ICT based initiatives in agriculture are in take-off stage in India. The study revealed that ICT made positive impact on reducing the transaction cost in accessing information. Segregating the exclusive impact of ICT is difficult but it broadly indicated that ICT is one of the significant sources for accessing information.



Reduction in transaction cost for accessing information

Traditionally for farmers go to nearby taluk headquarters and meet officials in department of agriculture getting information or any technical knowledge on crop cultivation, or get the suggestions while purchasing agro-inputs from private dealers. Usually private dealers do not spend enough time in offering technical advice to a farmer unless otherwise the latter purchase some agro-inputs, as well as decades also not have the required level of technical knowledge. In fact they give product-oriented advice rather than farmer/farm oriented advice. As a result, farmers in general are rarely benefited. The ICT initiatives change this scenario and save transaction costs of the farmers as they got technical advice by visiting kiosks located in the village or nearby village. The components of transaction cost incurred by the farmers covered 'distance traveled', cost equivalent of labour hours foregone, and traveling cost per visit. A farmer by using ICT services could save his traveling time and inturn transaction costs by more than 90–95%. ICT-based initiatives, viz. e-choupal by ITC, I-kisan by Nagarjuana group and Helpline by Chandra Sekhar Azad University of Agriculture and Technology, Kanpur were studied. e-choupal focuses on dissemination of price information while the rest 2 on dissemination of information on technologies.

Apart from information on technologies or farm inputs, farmers spend considerable time and money for marketing of the produce and price discovery. In this context, e-choupal (soy-choupal) sets a good model of ICT as a mechanism to overcome these difficulties of the farmers, i.e. add value to the time of the farmers. As per ITC estimates, by using soy-choupal, the farmers could save an average 68% of the transaction costs due to information led decision making and efficient marketing of farm produce (soybean). Therefore, it is appropriate to draw lessons from the ICT-based initiatives and derive means of minimizing transaction costs so as to enhance overall profitability.

Instability and supply response in oilseeds production in India

Oilseed is an important component of crop production in Indian agriculture. The continued production shortfall of oilseed after mid 1990s and yield fluctuations has critical macro-economic implications in the country. Presently, India meets its large parts of domestic demand (about 40%) of edible oils through import and this may go up.

Instability in oilseeds yield and prices

Average yield levels of edible oilseeds have increased in most of the states over the years, while its variability declined. In most cases average prices of oilseeds and its variability have declined. The imports of cheaper edible oilseeds and oils during 2001–02 might have helped in declining prices of oilseeds.

Instability in yield and prices of major oilseeds in selected states of India

Crop/State	Periods	Yield (kg/ha)		Price (Rs/q)	
		Mean	CV (%)	Mean	CV (%)
Groundnut					
Andhra Pradesh	I	938	9.00	883	8.5
	II	909	24.8	805	23.0
Gujarat	I	705	71.4	1030	84.5
	II	935	49.8	964	50.2
Rapeseed and Mustard					
Punjab	I	1010	7.6	1069	13.3
	II	1099	13.0	926	13.7
Rajasthan	I	832	10.4	948	16.5
	II	871	12.1	872	15.7
Sunflower					
Karnataka	I	473	24.8	856	48.3
	II	518	19.2	904	25.1
Maharashtra	I	373	15.0	973	19.1
	II	390	9.6	898	15.7
Soybean					
Madhya Pradesh	I	854	18.6	774	23.8
	II	977	12.8	660	25.4

*Indicates period I: 1986–87 to 1993–94, and period II: 1994–95 to 2001–02.

Effects of price and price risk on oilseed production

The economic environment and incentives are changing rapidly and farmers are responsive to these changes in oilseed sector. Mixed response was observed for instability in yield and prices, while covariate risks have increased. Expected price and price risk are important determinants of oilseeds production. The prices have positive effects while price risks have negative effects on oilseed production. The price elasticity of oilseed production varied between 0.26 and 0.88, while price risk elasticity was negligible. These results imply economic significance of prices and price risks, which may play important role in policy decisions to improve oilseeds production in the country.

AGRICULTURAL STATISTICS AND COMPUTER APPLICATIONS

Research achievements

Availability of reliable and timely agricultural statistics is of paramount importance to the planners, administrators, policy makers and research scholars as India is predominantly an agrarian economy.

- Method developed for estimating acreage under important crops in difficult terrains of Meghalaya
- Study was conducted on statistical algorithmic approach for improved estimation of treatment effects in repeated measurements designs
- Statistical method developed for analysis of long-term fertilizer experiments
- Role of balanced nutrition in long-term sustained productivity, studied
- Instability index studied for several crops
- 'Agricultural Rural Database 2006' released.

A study **'Developing Remote Sensing Based Methodology for Collection of Agricultural Statistics in Meghalaya'** was initiated by IASRI, New Delhi, in collaboration with Space Applications Center, Ahmedabad and NESAC, Shillong, Meghalaya. Meghalaya—mainly consists of hilly region with thick forest cover, has undulating topography and non-accessibility of vast area, the relative percentage area under the crops is very less, mostly terraced farming and jhum cultivation is practiced in these regions, is covered by clouds most of the time. Hence use of remote sensing satellite data also may not be able to provide reliable information. The major problem of optical remote sensing is availability of cloud free data which is very difficult for this region. Therefore, this project was developed. It has scientific methodology with strong

Assessment of survey capabilities of private sector

The primary objective of the study **"Assessment of survey capabilities of private sector"**, was to gather information on private organizations/agencies engaged in statistical surveys and studies, and to assess the survey capabilities of such agencies. Majority of the states and union territories of India are covered by way of headquarters and branches of the responding agencies. Some states like Tripura, Mizoram, Sikkim and Himachal Pradesh do not have either the headquarter or the branches of any of the agencies. Similarly, union territories like Andaman and Nicobar, Daman and Diu and Nagar Haveli, Pondicherry and Lakshadweep do not have representation by way of headquarters as well as branch office of any agency. Many of the agencies have wide range of experience having completed projects in socio-economic, agriculture, industry, infrastructure, service sector etc. Only 35 agencies satisfy the non-negotiable criteria. Only 10 agencies can be classified as potential agencies having the capability to conduct surveys at the national level. Only 9 agencies can be classified as potential agencies having the capability to conduct surveys at the regional level. There are 3 agencies which can be classified as operating up to state level having capability to take up complete survey.

Agricultural Research Data Book 2006

Information pertaining to agricultural research, education and related aspects available from different sources is scattered over various types of published and unpublished records. The Agricultural Research Data Book 2006, which is tenth in the series, is an attempt to put together main components/ indicators of such information. The Data Book comprising 260 tables, is organized, for the purpose of convenience of the users into 11 sections, viz. Natural Resources, Environment, Agricultural Inputs, Fisheries, Horticulture, Production and Productivity, Produce Management, Export and Import, India's Position in World Agriculture, Investment in Agricultural Research and Education and Human Resources under National Agricultural Research System (NARS). It also contains at the end, list of important National and International Agricultural Research Institutions associated with agricultural research and education along with their addresses, telephone numbers and e-mail addressses. The Data Book was compiled through the joint efforts of the Indian Agricultural Statistics Research Institute (IASRI) and Indian Council of Agricultural Research (ICAR).

statistical background, which is capable of providing reliable estimates of area under the crop. Under this project an integrated methodology based on remote sensing satellite data, GIS and sample survey data was proposed. In the absence of any satisfactory objective technique for this situation, this study was divided in 2 stages. In the first stage, field problems were studied by conducting pilot study in Ri-Bhoi district of Meghalaya, which is considered to be the rice bowl of the state. In the second phase, to validate the methodology developed during the pilot study, the study was repeated in the same district and also applied in Jantia Hills district. In the first approach ratio estimator is applied to find the paddy area under cloud based on the pixel value of current year image and previous year image. The paddy area is estimated as 8,075 ha. In the second case the paddy area was estimated using grid sampling based on previous year data. The total area under paddy came out to be 8,143 ha. Now this study needs to be further extended for estimating acreage under other important crops of the state. Potato, ginger, pineapple, banana, maize and paddy were identified for this purpose.

Under study on **"Some investigations on design and analysis of agro-forestry experiments",** the experiment consists of tree and crop combination in a plot, and the opinion is that the trees species grown in one plot may affect the performance of treatments applied on the neighbouring plots. For such situations, the concept of strongly neighbour balanced design was defined and some methods of constructing complete block designs for 2 factors (tree and crop) in a plot strongly neighbour balanced for 1 factor (tree) were obtained. These designs were variance balanced for estimating the direct effects of contrasts in the combinations of levels of both the factors (tree and crop). Some series of incomplete block designs balanced for adjacent tree effects were also obtained. These designs were partially variance balanced for direct effects.

In the study on **"Statistical and algorithmic approach for improved estimation of treatment effects in repeated measurements designs (RMDs)",** a class of reference balanced RMDs for estimating direct effects of formulations useful for bioequivalence trials has been obtained using Williams Square RMDs. Designs with each experimental unit receiving some or all of the treatments, one at a time, over a period of time are called repeated measurements designs (RMDs). The distinguishing feature of these designs is that the treatments applied in a particular period influence the responses of the experimental unit not only in that period but also leaves residual effects in the succeeding periods. In an RMD, a sequence of treatments is applied to an experimental unit and observations are recorded over the periods hence it is very much possible to observe interaction between treatments and experimental units. A non-additive model with interaction effects is used to deal with such situations as these effects also contribute significantly to the response measured. Considering a non-additive model, a balanced, uniform and non-circular class of RMDs with a pre-period was shown as universally optimal for the estimation of direct effects using calculus for factorial arrangements. Further, computer programs were developed in Visual Basic 6.0 for generation and randomization of different classes of RMDs catalogued from literature. Since it is very difficult to get real data for desired experimental situations, computer programmes were also written for simulating RMD data under different models of RMDs. Again, application potential of RMDs in bioequivalence trials was studied and some new classes of RMDs were obtained, which were reference balanced for residual effects. Database containing a catalogue of RMDs was developed and parameters {number of treatments (v), number of periods (p), number of experimental units (n), total number of observations (N), and source/type of the design} of RMDs catalogued from literature were entered into it. This catalogue contains total 206 RMDs falling under different classes for v £ 20, p £ 20 and n £100. User has the privilege to view the catalogue for particular number of input parameter(s) (for fixed number of treatment or period or units or total number of observations or combination of treatment, period and unit) besides viewing all designs option. Further, the database was linked to corresponding user interface to view the particular design as well as randomized layout of that design.

In **'Planning, designing and statistical analysis of data relating to experiments conducted under AICRP on long-term fertilizer experiments'**, the revised data after reanalyzing

the plant samples for Cu and Mn content for rice and wheat crop and available P in the soil were analyzed. In this data their contents were abnormally high. The results were provided to the centre incharge. The pooled analysis of super-imposed treatments data for Ludhiana centre, indicated that the reduction of P application by half over its optimal level continuously for 12 years under optimal and super optimal NPK treatments continued to sustain the maize yield levels under both the treatments at 34.3 q/ha and for wheat productivity levels at 47 q/ha and 50.4 q/ha, respectively, and were at par as obtained with the respective original treatments. The complete omission of P application under optimal NPK (-S) treatment resulted in a significant decline in the average yields of maize and wheat crops by 2 q/ha and 3 q/ha from their corresponding average yields of 33.1 q/ha and 46.2 q/ha under original treatment.

In the study on **'Combined analysis of experiments on long range effect of continuous cropping and manuring on soil fertility and yield stability'** the total factor productivity (TFP) index was calculated using Divisia-Tornqvist method which indicated that in most of the centres, treatments with N : P : K-80 : 80 : 40 and N : P : K-120 : 80 : 40, were the most sustainable. This showed the role of balanced nutrition in long-term sustained productivity.

The **instability index** using Cuddy Delta Valle approach as well as premium rates at different indemnity levels for different crops for Uttar Pradesh and Karnataka were estimated using yield approach methodologies, viz. MPD and normal curve technique and crop revenue insurance approach. Results showed that the premium rates by crop revenue insurance were low as compared to other techniques.

In a consultancy project following manuals, viz. the (*i*) Area and Crop Production Statistics, (*ii*) Animal Husbandry Statistics, (*iii*) Agricultural Prices and Marketing, (*iv*) Cost of Cultivation Surveys, and (*v*) Horticulture and Spices Statistics, were prepared and submitted to the funding agency.

Human resource development

Several training programmes and refreshing courses were organized at the IASRI for agricultural researchers, senior and middle level officers. Training programme on Design and Analysis of Experiments for Rapeseed-Mustard Varietal Trials.; several training programmes, refreshing courses were organized at the IASRI for agricultural researchers, senior and middle level officers; training course on Small Area Estimation Techniques; workshop on PERMISNET and Intelligent Reporting System (IRS); refreshing course on "On-line Library Information System; Workshop-cum-training programme on 'Design and Analysis of Farmers Participatory Research Trials'; Summer School on "Sample Survey Techniques in Agricultural Research"; and training programme on Statistical Methods for Agricultural Research.