

VISION-2025



IASRI Perspective Plan

INDIAN AGRICULTURAL STATISTICS RESEARCH INSTITUTE
LIBRARY AVENUE, PUSA, NEW DELHI- 110 012

Phone : 011-25841479

Fax : 011-25841564

E-mail : director@iasri.res.in

Website : <http://www.iasri.res.in>



INDIAN COUNCIL OF AGRICULTURAL RESEARCH



Perspective Plan

IASRI

VISION-2025



INDIAN COUNCIL OF AGRICULTURAL RESEARCH

INDIAN AGRICULTURAL STATISTICS RESEARCH INSTITUTE

LIBRARY AVENUE, PUSA, NEW DELHI- 110 012



Published by
RESEARCH COORDINATION AND MANAGEMENT UNIT

on behalf of

DIRECTOR

INDIAN AGRICULTURAL STATISTICS RESEARCH INSTITUTE
LIBRARY AVENUE, PUSA, NEW DELHI- 110 012

Phone : 011-25841479

Fax : 011-25841564

E-mail : director@iasri.res.in

Website : <http://www.iasri.res.in>

Published in 2007

Contents

Foreword

Preface

Executive Summary

1. Preamble	1
2. Mandate	2
3. Growth	2
3.1 Infrastructure	2
3.2 Budget	5
3.3 Manpower	5
4. Research Achievements	6
5. Impact	29
6. Scenario and SWOT Analysis	31
7. Perspective	36
8. Issues and Strategies	37
9. Programmes, Projects and Fund Requirements	38
10. Linkages (Co-ordination and Executive Arrangements etc.)	52
11. Critical Inputs	53
12. Risk Analysis	55
13. Review	55
14. Resource Generation	56
15. Outputs	56
16. Outcome	57

Foreword



Indian agriculture must continuously evolve to remain ever responsive to manage the change and to meet the growing and diversified needs of different stakeholders in the entire production to consumption chain. In order to capitalize on the opportunities and to convert weaknesses into opportunities, we at the ICAR attempted to visualize an alternate agricultural scenario from present to twenty years hence. In this endeavour, an in-depth analysis of the Strengths, Weaknesses, Opportunities and Threats (SWOT) was undertaken to place our research and technology development efforts in perspective so that we succeed in our pursuit of doing better than the best. Accordingly, the researchable issues are identified, strategies drawn and programmes indicated to have commensurate projects and relevant activities coinciding with the launch of the 11th Five Year Plan.

In view of ever challenging issues of agricultural production, processing and domestic as well as export trade, there is far greater dependency now for acquisition of relevant information and its transformation into knowledge for effective planning and decision making related to profitable agriculture. Agricultural Statistics is a constituent of the foundation to support sustainable agricultural development. Indian Agricultural Statistics Research Institute, New Delhi will be visualizing agricultural scenarios through latest techniques including data mining, artificial neural network, fuzzy regression, bioinformatics, geo-informatics in relation to the programmes and policies governing agriculture leading to the formulation of appropriate strategies and action plans. The specific programmes include up-to-date statistical tools for agricultural research, forecasting, techniques for planning and execution of surveys, modeling of biological systems, agri-informatics and other relevant analytical methods. Efforts in the areas on non-linear modeling, risk and uncertainty analysis, and market intelligence research have become extremely important in dealing with the globalized trade in agriculture. Agricultural scientists and engineers are in constant need of computational algorithms for statistical computing and knowledge management. The Institute will endeavor to imbibe appropriate capacities and programmes of human resource development for building a school of excellence in Agricultural Statistics and Computer Applications.

It is expected that realization of the Vision embodied in the document would ensure that the IASRI, New Delhi continues to fulfill its mandate and make Indian agriculture locally, regionally and globally competitive. The efforts and valuable inputs provided by my colleagues at the ICAR Headquarters and by the Director and his team at the Institute level for over a year to develop Vision 2025 deserve appreciation. It is hoped that the implementation of the programmes mentioned in the document will go a long way to strengthen agriculture sector in the country.



(MANGALA RAI)

Secretary, Department of Agricultural Research & Education
and

Director General, Indian Council of Agricultural Research
Dr. Rajendra Prasad Road, Krishi Bhawan, New Delhi 110001, India

Preface

Over the years, the Indian Agricultural Statistics Research Institute (IASRI) under the aegis of the Indian Council of Agricultural Research has served a very useful purpose and has made some notable contributions to the research in Agricultural Statistics in the fields like Sample Surveys, Design of Experiments, Statistical Genetics, Forecasting Techniques etc. The Institute has also made useful contributions in Econometrics and Computer Applications in Agriculture and Software development. The contributions of the Institute towards the education and training in Agricultural Statistics and Computer Applications have been outstanding. The Institute has played a significant role in strengthening the National Agricultural Research System (NARS) and the National Agricultural Statistics System (NASS). Nevertheless, in the fast changing global context, managing the change on a time scale, by converting weaknesses into opportunities to become internationally competitive, is considered important. We need to be forward looking and visible with appropriate research policies in place supported by the cutting edge technologies in order to attain and sustain global advantages. It is in this background that the formulation of a perspective plan with a visionary approach for the next 20 years is quite necessary. The clearly spelt out options and likely changes would enable the system to capitalize on our strengths so that the threats, if any, are converted into opportunities.

Accordingly, the Institute has prepared its Perspective Plan up to 2025 for taking up the challenges of providing agricultural research workers with the required statistical methodologies for enriching the quality of the agricultural research in the country.

Work on drafting a Perspective Plan began with the scientists of the Institute discussing and suggesting the direction in which the Institute has to reorient itself. Based on this, the first draft of Perspective Plan was prepared and discussed with seven subject matter experts appointed by ICAR. It was redrafted in the light of their comments. The draft was presented on several occasions in Director's meet at SMD level and at that time a new format was also suggested for the Perspective Plan. Secretary, DARE and DG, ICAR has also given useful suggestions for the improvement of drafts.

It is hoped that the framework prepared would continue to be reviewed to accommodate changes in future so that the perceived vision continues to be close to the expected target. In the years to come, based on the long term perspective, it would be relevant to put implementable plan to action on five yearly basis to match with the on going planning system of the country.

I take this opportunity to put on record our appreciation to Dr. Nawab Ali, DDG (Engg.), Dr. Pitam Chandra, ADG (PE) and Directors of the various ICAR Institutes in the Engineering Division for their valued input in bringing out this document.

We are also thankful to other experts in Agricultural Statistics who helped us in improving this document. Thanks are also due to all the colleagues in the Institute particularly Research Coordination and Management Unit (RCMU) for their devoted work in preparing/improving this document.

I do hope that readers will find it quite informative and useful. However, valuable suggestions and comments for further improvements are most welcome.



Director

IASRI, New Delhi

Executive Summary

The Indian Agricultural Statistics Research Institute has made important contributions in the frontier areas of research in statistical applications in Agricultural Research which contributed significantly towards National Agricultural Research System (NARS). An important aspect has been towards taking up many new studies at national level covering various aspects of emerging information needs in agricultural scenario. The Institute has also made important contributions towards teaching and training programmes in the field of Agricultural Statistics and Computer Applications in Agriculture. Over the years, the Institute has developed infrastructure and human resources to meet the challenges in the emerging newer areas with some additional support. In the context of changing national and international scenario, the Institute has to further gear up its research activities to meet the challenges of research and education in Agricultural Statistics and related fields and Computer Applications so as to meet the global challenges of agricultural research in newer emerging areas. In order to prepare the Institute for the near and distant future, the Institute has to visualize the national and international directions of research and to identify the newer emerging areas of research and also to prepare road map for future research so that the Institute can continue to play its role of leadership for Agricultural Statistics and Computer Applications in the National Agricultural Research System and the National Agricultural Statistics System. In order to meet these challenges, the Institute has also to develop a work plan. The Institute has to grow on its strengths and overcome its weaknesses. It has to identify the opportunities that it should grab so as to maintain its role of leadership in research and education. It has also to remain alert from the threats that could come in its way of progress and development. For making a unique identity in the ICAR system, the Institute needs to play a very important role in terms of basic research in Agricultural Statistics and Computer Applications, applied research in partnership mode with other ICAR Institutes and statistical and computing support to National Agricultural Research System (NARS). IASRI would contribute to ICAR in the following broad areas of agricultural, animal and fisheries research:

- Development and analysis of experimental designs for agricultural system research
- Forecasting and remote sensing techniques and statistical applications of GIS in agricultural systems
- Development of techniques for planning and execution of surveys and analysis of data including economic problems of current interest
- Modeling and simulation techniques in biological systems
- Development of informatics in agricultural research
- Teaching and training in Agricultural Statistics and Computer Applications

Keeping in view the above broad areas of interest, the Institute has formulated the time schedule for carrying out research, teaching and training activities of basic and applied research in Agricultural Statistics and Computer Applications.

After gaining experience from the various basic and applied research studies, Institute needs to strengthen further in development and management of information system on agricultural intelligence involving more ICAR Institutes as partners.

Since inception the Institute is providing consultancy and computing services to researchers of various ICAR Institutes. The Institute will continue to provide services to the scientific community of NARS.

1. Preamble

Ever since its inception, IASRI has been mainly responsible for conducting research in Agricultural Statistics to bridge the gaps in the existing knowledge. It has also been providing education/training in Agricultural Statistics and Computer Applications to develop trained manpower in the country. This research and education is used in improving the quality of agricultural research and meeting the challenges of agricultural research in newer emerging areas. The functions and activities of the Institute have been re-defined from time to time in the past. In order to fulfil the mandate, the Institute has to develop a vision for the support it would require in terms of human resource, particularly in the newer emerging areas of research, the computing environment and the Information Communication Technology requirement, the requirements for training the scientists to improve their skills and their participation in the conferences both at national and international level, the Visitors Exchange Programme requirements, the Library requirements, the budgetary requirements etc. The Institute has to grow on its strengths and overcome its weaknesses. It has to identify the opportunities that it should grab so as to maintain its role of leadership in research and education. It has also to remain alert from the threats that could come in its way of progress and development.

The Council has recently decided that all the Institutes should revise their Perspective Plan Vision 2025. The revised Vision document should emphasize on the achievements made, identify the gaps in research that could not be undertaken because of some reason or the other and then clearly spell out the research programmes to be undertaken in the coming years till the year 2025. The programmes should be identified keeping in mind the newer developments taking place, particularly the technological and informatics developments, both at National and International level. Road map for the research programmes would be made on the specified time scale and the support required for meeting these challenges would be clearly spelt out. Accordingly, the Institute has done an exercise to prepare the Vision 2025 document.

This document provides the mandate to be followed in the coming years. A brief discussion on the research achievements made in Agricultural Statistics and Computer Applications have been incorporated. Based on the perspective of the Institute and certain issues and strategies, research programmes have been identified. The main emphasis has been on the problems of national interest and in the various emerging areas of biotechnology, bioinformatics, biodiversity, genomics, market intelligence, risk analysis, natural resources accounting, information communication technology etc. With a proper review, reporting and evaluation of these programmes, it is fervently hoped that the Institute would be able to meet its mandate, partly generate resources for its research programmes and remain a leader in research and education in Agricultural Statistics and Computer Applications and exhibit its indispensability in National Agricultural Research System and National Agricultural Statistics System.

1.1 Vision

Statistics and Information Communication Technology (ICT) for enriching the quality of Agricultural Research

1.2 Mission

Undertake research, education and training in Agricultural Statistics and Computer Applications for Agricultural Research

2. Mandate

The Institute has the following mandate:

1. To undertake basic, applied and adaptive research leading to new developments in Agricultural Statistics and related fields for bridging of gaps in the application of statistical techniques to the problems of agricultural research.
2. To assist in the development and strengthening of National Agricultural Statistics System.
3. To conduct post-graduate and in-service training courses in Agricultural Statistics and Computer Applications in agriculture.
4. To provide advisory/consultancy services to agricultural scientists, planners, policy makers and others on their statistical and computing requirements.
5. To act as a repository of information on Agricultural Statistics for research and dissemination of such information.
6. To develop the Institute as an Advanced Centre of Excellence for education and training in Agricultural Statistics and Computer Applications.
7. To liaise with ICAR Institutes, SAUs and State Agricultural/Animal Husbandry/Veterinary Sciences departments etc. and undertaking sponsored research and training for National and International organisations.

However, in view of the anticipated changes in the global agricultural scenario and increasing competitiveness, likely changes in the focus of the Institute in the coming years, and to realize the above stated vision of the Institute, the mandate would be the following:

1. To undertake basic, applied, adaptive, strategic and anticipatory research in Agricultural Statistics and related fields and use these researches in meeting challenges and improving quality of agricultural research.
2. To conduct post-graduate teaching and in-service, customized and sponsored training courses in Agricultural Statistics and Computer Applications at National and International level so as to be a leading centre of excellence in Human Resource Development.
3. To provide methodological support in strengthening National Agricultural Statistics System by establishing linkages with State Departments of Agriculture and allied fields, other research institutions, industry etc.
4. To lead in development of Agricultural Knowledge Management and Information System for National Agricultural Research System.
5. To provide advisory and consultancy services for strengthening the National Agricultural Research System and undertaking sponsored research and consultancy for National and International organizations.

3. Growth

3.1 Infrastructure

Physical

Indian Agricultural Statistics Research Institute (IASRI) is a premier Institute with glorious tradition for carrying out research, teaching and training in the area of Agricultural Statistics and Computer Applications in Agriculture. Recognising the importance of research and education in Agricultural Statistics, the then

Imperial Council of Agricultural Research established a small Statistical Section to assist the State Departments of Agriculture and Animal Husbandry in planning and designing their experiments, analysis of experimental data, interpretation of results and also rendering advice on the formulation of the technical programmes and examining the progress reports of the schemes funded by the Council. Research in sampling theory, developing objective method of crop yield and production estimation techniques and training of field and statistical staff of the state governments were the activities initiated in this period resulting in the re-organisation of the Statistical Section into a Statistical Branch in 1945 with associated expansion in its strength. The designation of Statistician was changed to Statistical Advisor. The Statistical Branch was renamed as Statistical Wing in 1949. The Statistical Wing soon acquired the international recognition as a Centre of Research and Training in the field of Agricultural Statistics. Subsequently, in recognition of the important role as a training and research institution and based on the recommendations of FAO experts Dr. Frank Yates and Dr. D.J. Finney, the Statistical Wing was re-designated as the Institute of Agricultural Research Statistics (IARS) on 02 July 1959. On 01 January 1978 the name of the Institute was changed to Indian Agricultural Statistics Research Institute (IASRI) emphasizing the role of Agricultural Statistics as a full fledged discipline by itself.

Computer Facilities and Computing Laboratories

In the initial stages of the development of the Institute, there were no Statistical Computing Labs available for scientists and students but for some hand-operated FACIT machines and calculators for the students for conducting practical and the scientific staff for doing the analysis of their data. These were replaced to some extent from time to time by electric and electronic calculators. In 1957 Mechanical Tabulation Unit was established with 40 column card processing equipment for statistical analysis of data generated in the projects of the Institute. An important landmark in the development of the computing facilities of the Institute was the installation of an IBM 1620 Model II Electronic Computer in 1964. This system was replaced in 1977 by a third generation computer Burroughs B-4700 system. Gradually the Personal Computer (PC) culture started gathering momentum and PCs were introduced in the Institute. In 1991 the Burroughs B-4700 system was replaced by a Super Mini COSMOS-486 LAN Server with more than 100 nodes consisting of PC/ATs, PC/XTs and dumb terminals all in a LAN environment. Later, COSMOS-486 LAN Server was replaced by a Pentium-90 LAN Server having state-of-art technology with UNIX operating system. Computer Labs equipped with PCs, terminals and printers etc. were set up in each of the six Scientific Divisions as well as in the Administrative Wings of the Institute. The LAN at IASRI has steadily been strengthened and the three buildings of IASRI have been connected using fibre optics cable as backbone and connectivity has been established for 265 nodes, out of which 208 are active nodes, the LAN being switch manageable. E-mail and Internet facilities are being provided to the scientists/technical/administrative staff of the Institute and NCAP, another ICAR Institute located in the campus. The Intranet services consisting of E-mail, notice board, details of account holders, search facility etc. is also available over the LAN to all the users. The notice board facility is being used for information dissemination among the users of the Institute.

With the increase in the research activities in the newer emerging areas, more and more Computing Labs with additional computing facilities are being added to the system. Remote sensing and GIS Labs with peripherals like GPS, Data Warehouse Lab, Labs for National Information Systems on Animal Experiments and Long Term Fertilizer Experiments, Library Information Services, Farm Mechanization etc. are being created from time to time, when required.

Keeping pace with the state-of-art technologies, the Institute has been constantly upgrading the existing platforms with the newer platforms.

The following is the list of important computing Labs:

- Divisional computing Labs and Labs for conducting teaching and training programmes
- Post-Graduate students Lab with Internet facility in campus and in hostel
- Remote sensing and GIS Lab
- NATP Lab for handling computer intensive NATP projects
- INARIS Lab for Data Warehouse
- Agricultural Research Information System Lab
- Multimedia Lab for conducting training programmes in Information Technology
- Labs with servers facilities for National Information Systems on Animal Experiments and Long Term Fertilizer Experiments, Farm Mechanization, Library Information Service etc.

Library

The Library of the Institute was originally established in a small room. Over the years, the Library has grown in size along with the growth of the Institute and presently it is located on the second floor of the Computer Centre Building. In fact, the second floor houses exclusively the Library.

The library collection in terms of scientific books and journals has been periodically strengthened. The library has about 24,500 books and 6500 bound periodicals. There are 53 on-line journals. There are about 800 theses of M.Sc., Diploma and Ph.D. in Agricultural Statistics and M.Sc. in Computer Applications. There are about 8000 technical/scientific reports. Besides, there are six on-line databases, two digitized databases, one current content, 200 CD ROMs and 13 CD ROM databases.

The library of the Institute has been identified as a regional library. It has the capacity to support research, teaching, and training programmes in Agricultural Statistics and Computer Applications. The facilities available in the library can be utilized by the NARS on-line. The library is now an E-Library and the borrowing and lending of numbers is done on computer using barcodes. The search for any number can be made on-line and any number can also be reserved on-line. The Computer Lab in the library is equipped with Pentium Server, Intel Pentium IV Computers, Barcode Reader, Barcode Printer, UPS, All-in-one Printer Scanner and Copier, Laser Printer, Reprographic Services and Scanners.

Services available for its users in library are:

- Computerized Borrowing and Lending of Numbers
- Archives of Theses and Journals
- On-line Search and Reservation of Numbers
- Journals Custom Content
- New Arrivals in the Library
- Portals like MathSciNet, Ingenta etc.
- Bibliographical Services
- On-line Journals
- Databases - Indiastat.com
- CD-ROM Databases/Access
- Science Direct

To support the research programmes, the reprographic facilities have also been strengthened over time. A Reprographic Lab, equipped with state-of-art photocopiers has been created for meeting the photocopy

requirements of the personnel of the Institute. Photocopiers are also available in the Scientific Divisions, Training Administration Cell, Bio-informatics Lab, NARP-training Lab, Director’s Office, Library, Administrative and Accounts units etc.

3.2 Budget

Actual utilization Plan wise (Rs. in Lakhs)

Plan Period	Plan	Non-Plan	Total
IX Plan	558.45	4,495.02	5,053.47
X Plan	825.00	5,700.00	6,525.00

Budget for the XI Plan

	2007–08	2008–09	2009–10	2010–11	2011–12	Total
Plan	309.00	404.00	259.00	282.00	346.00	1,600.00
Non-Plan	1,200.00	1,250.00	1,300.00	1,350.00	1,400.00	6,500.00
Total	1,509.00	1,654.00	1,559.00	1,632.00	1,746.00	8,100.00

3.3 Manpower

Growth of sanctioned manpower over the years in different Plan Periods

Plan Period	Scientific	Technical	Administrative including Financial and Supporting
IV Plan	41	200	68
V Plan	138	305	182
VI Plan	157	304	235
VII Plan	153	323	255
1991	154	304	238
1992	154	304	238
VIII Plan	154	304	238
IX Plan	132	260	218

Personnel position as on 31 March 2006

Category	Sanctioned	In Position
Director	1	1
Joint Director	1	1
Scientists	130	90
Technical	234	129
Administrative	109	104
Auxiliary	14	10
Supporting	85	81

4. Research Achievements

To describe the salient research achievements, a list of research projects completed during 1996 to 2005 is appended below.

4.1 Research and Development

Programme 1: Development and Analysis of Experimental Designs for Agricultural Systems Research

Targets Set

1. Theoretical studies/Basic research
2. Review of planning and analysis of experiments conducted in the past
3. Planning, designing and analysis of on-going experiments under AICRP
4. Development of databases for experiments conducted under different AICRP
5. Development of software packages for generation of design and analysis of experimental data

Projects Undertaken

(a) Institute Funded Projects

1. A cataloguing and construction of variance balanced block designs: Computer algorithms for construction
2. A statistical investigation on the long term effect of fertilizers on productivity of cereal crop sequences
3. Construction of efficient designs for asymmetrical factorial experiments
4. A diagnostic study of designs and analysis of field experiments
5. Statistical investigation on the fertilizer use efficiency in relation to cultural practices

6. Three-associate class partially balanced incomplete block designs and their applications to partial diallel crosses
7. Statistical evaluation of agricultural field experiments

(b) Collaborative Projects

1. Planning, designing and analysis of experiments planned ‘On-Stations’ under the Project Directorate for Cropping System Research
2. Planning, designing and analysis of ‘On-Farm’ research experiments planned under Project Directorate for Cropping Systems Research
3. Planning, designing and statistical analysis of data relating to experiments conducted under AICRP on Long-Term Fertilizer Experiments
4. Planning, designing and analysis of experiments relating to Soil Test – Crop Response Correlations
5. Design and analysis of agro forestry experiments

(c) AP Cess Funded Projects

1. Study of designs for two or more sets of treatments applied at different periods of experimentation
2. Design of fitting response surfaces in agricultural experiments
3. Design and analysis of ‘On-Station’ and ‘On- Farm’ agricultural research experiments: A revisit
4. Statistical study on competition effects among neighboring units in field experiments
5. Studies on block designs for biological assays

(d) Other Funded Projects

1. Fertilizer response ratios for different crops in India

Achievements

Optimal/Efficient Experimental Designs

- An exhaustive catalogue of binary balanced designs was prepared. These designs allow unequal replication of treatments and unequal block sizes. These designs are known to be the most efficient designs in a competing class of designs.
- Nested block designs (balanced and partially balanced) were obtained and catalogued.
- Optimality aspects of non-proper block designs with nested rows and columns were studied. Optimal structurally incomplete row-column designs were also obtained. A correspondence between structurally incomplete row-column designs, block designs with nested rows and columns and designs for two stage experiments were established. A catalogue of efficient designs for two stage experiments viz. block designs for two non-interacting sets of treatments applied in succession was prepared.
- Equivalence between extended group divisible designs and designs for crop sequence experiments was established. This equivalence has encouraged the agricultural experimenters in the use of extended group divisible designs for their experimentation. This equivalence is also useful for the experimental situations where the blocking criteria are implemented in succession and there is likelihood of the interaction effect between the direct effects and residual effects of the treatments applied at two successive stages.

- Optimal proper and non-proper incomplete block designs for diallel and double cross experiments for the estimation of contrasts among the general combining ability effects were also obtained and catalogued.
- Weighted A-optimality of designs for the experimental settings (i) where the test vs test comparisons are made with less precision but test vs control comparisons are made with high precision and (ii) when there are several controls and test vs controls have different importance, were investigated.
- An expression for optimum number of replications of the control treatments in an augmented randomized complete block design that maximizes the efficiency per observation was obtained.
- Some modified and/or rotatable response surface designs useful for response optimization and slope estimation for symmetric as well as asymmetric factorials with equi-spaced doses were obtained.
- Efficient and cost effective block designs for studying competition effects among treatments were developed. A catalogue of optimal block designs for estimation of competition effects was prepared.
- A-optimal/efficient block designs for parallel line/multiple parallel line assays for estimating relative potency of pesticides and drugs were obtained and catalogued.
- Optimality aspects of change over designs balanced for first and second order residual effects were studied. Minimal balanced repeated measurement designs for odd number of treatments were obtained.
- Some new association schemes along with method of construction of some PBIB(3) designs based on these schemes were obtained. A catalogue of existing and new PBIB(3) designs was prepared.
- In some experimental situations, the adjacent experimental units may be correlated. To take care of the correlation among the spatially correlated units, efficient neighbour balanced block designs were catalogued.
- Binary balanced block designs that are robust against (1) missing observations, (2) exchange of a treatment, (3) interchange of a pair of treatments and (4) presence of systematic trend in blocks were identified.
- Binary balanced block designs for diallel crosses that are robust against (1) missing observations, (2) missing block and (3) exchange or interchange of crosses and presence of a single outlier were identified.
- Robustness of partially balanced incomplete block designs, Latin square designs and Youden square designs were studied against missing observations.
- Robustness of designs for making test treatments vs control comparisons against a missing observation, or presence of outliers were investigated.
- Generalized property for A-designs for multi-factor experiments were obtained that were structure resistant against the loss of all observations pertaining to the treatment combinations containing one level of a particular factor. Robustness aspects of designs for such situations were studied.
- Change over designs obtainable from Williams Squares was shown to be robust against missing observations.

Analytical Techniques Developed on the Demand of User Agencies

- A linear programming approach was developed for estimating/projecting the energy requirement in agricultural sector. The approach used the maximization of yield subject to the constraints on the availability of energy from different sources. This technique was used by the All India Co-ordinated Research Project on Energy Requirement in Agricultural Sector, Central Institute of Agricultural Engineering, Bhopal at all its 12 centres in the country.

- A fatigue score card based on qualitative and quantitative physiological characteristics of camel was developed in collaboration with Krishi Vigyan Kendra, Rewari under the aegis of All India Co-ordinated Research Project on Utilization of Animal Energy. Suitable work cycles were also obtained for various drafts.

Review of Planning, Designing and Analysis of Experiments Conducted in the Past

- The experimental data available in the AFEIS and PDCSR was critically analyzed after carefully looking into the assumptions. It was observed that in more than 10% of the experiments the assumptions of normality and homogeneity of errors were not satisfied in more than 70% cases the replication effect was found to be non-significant.
- A procedure of estimation of genetic parameters like genotypic and phenotypic variance and correlation from unbalanced data generated through the use of incomplete block designs was developed using the analysis of variance of a dual design under a mixed model. The expressions for the estimates of the variances of the estimated genotypic and phenotypic variances were also obtained. This technique was successfully used in the research work on garden pea by the Division of Vegetable Crops, IARI, New Delhi.
- A method of analysis of data from the experiments conducted to assess the related performance of the crop rotations of different periods in terms of crop productivity, yield stability and soil health was obtained.
- Several techniques like nearest neighbour methodology, multivariate analysis of variance, multivariate contrast analysis, combined analysis of experimental data etc. were identified for the analysis of data from field experiments.
- Analysis of several uniformity trials data sets revealed that the nested block designs with smaller block sizes are beneficial in comparison to usual block designs where blocks generally had rectangular of square strips.
- It was shown that the resolvable blocks were quite helpful in on-farm research to take care of the (a) plot to plot variation and (b) variation in farmer's/trainer's managerial skills. An application of augmented designs was shown in the trials designed and managed by farmers, with some intervention of the researcher. Reinforced block and nested block designs were shown to be useful for the on-farm research experiments where the farmers can be grouped on the basis of farmer's practice.
- The linear, nested mixed effect model was used for analysis of on-farm trial data currently being generated by PDCSR, Modipuram.
- Variograms and principal component analysis were used to assess spatial and temporal variation of soil microbial diversity in rice-wheat cropping system.
- An analogy between experiments with mixtures and replacement series intercropping experiments was established.
- Long term trends in yield over the years for the rice-rice, rice-wheat and sorghum-wheat crop sequences and economics of different fertilizer treatments were studied.
- Improvement in fertilizer use efficiency in presence of cultural practices was investigated.
- Indices for evaluation of agricultural field experiments using the data from Maharashtra State were developed.

Planning Designing and Analysis of On-going Experiments under AICRP on (a) CSR, (b) ECF, (c) LTFE and (d) Agro-forestry

The work on following collaborative projects was continued:

- (a) Planning, designing and analysis of experiments planned on stations under the Project Directorate of Cropping Systems Research
- (b) Planning, designing and analysis of 'on-farm' research experiments planned under Project Directorate of Cropping Systems Research
- (c) Planning, designing and analysis of data related to experiments conducted under AICRP on Long Term Fertilizer Experiments

Following New Initiatives were taken

- (a) Planning, designing and analysis of experiments related to AICRP on Soil Test Crop Response Correlations' (STCR)
- (b) Design and analysis of Agroforestry Experiments

Following were the Specific Achievements

- BIB designs and partially confounded designs were recommended and adopted
- Sampling plans and designs for 3 types of on-farm trials conducted with objectives as (1) Response of nutrients on farmers' field, (2) Crop intensification and diversification and (3) Agronomic management practices for sustainable production system were recommended.
- A design with 3 factors in 21 design points was suggested for experiments conducted under AICRP on STCR. This design is capable of including organic manures as one of the factors.
- Developed methodology for obtaining site specific doses of N, P and K for given soil test value using the technique of exploration of response surface in the vicinity of stationary point.
- Mid-course bifurcations were suggested for the situations where build up or depletion of nutrients has taken place in the experiments conducted under AICRP on LTFE.
- Multivariate analytical procedures were developed for the analysis of data from long term experiments.
- Fertilizer response ratios for 14 major crops in the country were estimated using the data of on-farm trials.
- Path analysis, principal component analysis were used in the analysis of data from the experiment on evaluation of fodder trees with and without crops under rainfed arable farming for semi-arid conditions conducted at IGFRI, Jhansi. Impact of trees on the under storey crops was also investigated.
- Analytical techniques based on transformation of data and fuzzy regression methodology was developed for the analysis of data from sampling in field experiments.

Programme 2: Forecasting and Remote Sensing Techniques and Statistical Applications of GIS in Agricultural Systems

Targets Set

1. Application of remotely sensed data for improvement of area and production statistics and development of yield models
2. Application of Geographic Information System for study of land use statistics and identification of potential agro-forestry area

3. Development of models for forecasting crop (including brood-lac) yield based on weather data, remotely sensed data and farmers appraisal data using various techniques
4. Development of models for forecasting fish production
5. Development of forewarning systems for pests and diseases
6. Estimation/forecasting of losses due to weeds, pests, diseases, droughts and floods
7. Development of models for forecasting livestock and poultry products

Projects Undertaken

(a) Institute Funded Projects

1. Use of remote sensing technology in crop yield estimation surveys
2. Use of remote sensing satellite data in crop surveys
3. Use of discriminate function of weather parameters for developing forecast model of rice crop
4. Pilot study for developing Bayesian probability forecast model based on farmer's appraisal data on wheat crop
5. Study to develop model for assessing the effect of flood on yield of crops
6. Yield forecast based on weather variables and agricultural inputs on agro-climatic zone basis
7. Integrated yield forecast model using biometrical characters, agricultural inputs, weather and remotely sensed data
8. Non linear statistical models for pre-harvest forecasting of inland fish production from ponds
9. Forecasting sugarcane yields using multiple Markov chains
10. Development of GIS based technique for identification of potential agro-forestry area

(b) Collaborative Projects

1. Forecasting the loss in yield due to weeds
2. Forecasting fish production from ponds
3. Development of early warning and yield assessment models for rainfed based on agrometeorological indices
4. Development of weather based forewarning system for crop pest and diseases

(c) AP Cess Funded Projects

1. Use of remote sensing satellite data in crop survey
2. Study on land use statistics through integrated modeling using Geographic Information System
3. Pilot study on forecasting of brood-lac yield from *Buteamonosperma* (Palas)
4. Modeling for forecasting crop yields using weather and agricultural inputs

Achievements

Development of Forecast Models for Agricultural Systems

- Methodology for forecasting crop yield at agro-climatic zone was developed for wheat (Vindhyachal Plateau zone) and rice (Chattisgarh Plain and Bastar Plateau zone considered together) in Madhya Pradesh. Reliable forecasts could be obtained two and a half months before harvest with one percent deviation from observed yield for wheat and about six percent deviation for rice. Further, forecast

model worked well even when data on some districts were not available either at the stage of model development or at forecasting stage. The data requirement reduced to 10–15 years as against 25–30 years for district level studies.

- At district level, use of discriminant function analysis of weather parameters was explored for developing forecast model for rice crop in Raipur district. Reliable forecast could be obtained about two months before harvest with about one percent deviation from observed yield.
- In a collaborative project with Directorate of Cropping Systems Research, Modipuram models for rainfed crops using weighted stress indices were developed for rice – Raipur, sorghum – Delhi and Parbhani, and maize – Delhi, based on water balance technique. These models provided forecast six weeks before harvest for sorghum, four weeks before harvest for maize and five weeks before harvest for rice.
- Forecast models for sugarcane were developed based on higher order (multiple) Markov chains. When the order of Markov chain increases and/or the definition of states became finer, the mean yield forecasts approached the actual yield. Also, appreciable advancement in the time of forecast, for the same precision, could be obtained when multiple Markov chain models are used in preference to the existing models viz. first order Markov chain models and regression model.
- A study in collaboration with ILRI, Ranchi (Jharkhand) for developing models for forecasting the yield of brood-lac from Palas tree revealed that forecast of brood-lac yield is possible 10–11 weeks before harvesting.
- A study based on farmers' appraisal data was carried out using Bayesian approach for wheat in Muzaffarnagar district. Expert opinion data were collected in a number of rounds by interviewing the selected farmers regarding their assessment about the likely crop production and chance of occurrences in various yield classes. Forecast of yield could be obtained about two months before harvest. The per cent deviation of yield forecasts from observed ones ranged between 2 to 18%.
- An attempt to obtain an integrated wheat yield forecast models using biometrical characters, agricultural inputs, weather and remotely sensed data was made in collaboration with IARI, New Delhi using experimental data. The result indicated the possibility of replacing leaf area index, dry matter and soil moisture by thermal and spectral indices. However, satisfactory forecast model could not be developed. It seems that the experimental data could not mimic the field conditions appropriately.
- With the objective of incorporating data on various types of variables, a study was undertaken to combine the forecasts from various models. Different strategies for combining forecasts were proposed and discussed in the light of variances of errors of individual forecasts and their correlation patterns. The strategies were compared theoretically as well as empirically through a case study on sugarcane.
- A study was carried out to develop model for assessing effect of flood on crop yields. Flood indices were computed and used to develop the model through regression approach. The losses obtained through the model were quite close to the losses estimated directly.
- In an attempt to model losses due to weeds in soyabean and wheat crops (in collaboration with IARI, New Delhi), growth behaviour of weed parameters were examined and relationship of yield with various weed parameters was studied.
- A study on utility of non-linear modeling in agriculture has been conducted wherein ARCH model (i.e. Autoregressive Conditional Heteroskedostic model) was used to model onion price data. Also using marine product export data, bilinear time-series model was developed to obtain forecasts of marine exports.

- Besides developing forecasting methodology for crop yields, non-linear models were developed for forecasting production of inland fish from ponds. A study conducted for three species, viz. Rohu, Mrigal and Common Carp revealed that logistic model can be used to forecast fish weight three months before harvest for indigenous species i.e. Rohu and Mrigal species. For exotic species i.e. Common Carp, the forecast can be provided three months before the harvest by using Gompertz model. Models were also modified under the assumption of heterocedasticity with auto correlation of error variance. The forecasts obtained were better than those obtained from the earlier models.
- A Cess fund project has been completed with the objective of developing forecast models for important crops of UP at state level, by extending/modifying existing district level models/methodology. Using these models reliable forecast of rice and wheat can be obtained about two and a half months before harvest whereas for sugarcane reliable forecast can be provided in the middle of September.

Development of Forewarning Systems for Crop Pests and Diseases

- A study in collaboration with NCIPM, New Delhi was conducted to develop models for forewarning aphid population in different weeks during the crop season in potato for Pantnagar (U.P.), Kalyani (West Bengal) and Deesa (Gujarat). Regression models using cosine, log and exponential functional forms of weekly weather parameters and complex polynomials using GMDH technique were developed. The reliable forewarning could be issued using these approaches with 1–2 weeks lag.
- A project has been undertaken in collaboration with CISH, Lucknow with an objective to develop forewarning of outbreak of mango fruit fly population. The data were not adequate for development of week wise models separately. Therefore, combined model was developed in two steps (i) fitting appropriate non-linear models to natural cycle of fruit fly population and (ii) relating the residuals in different weeks to appropriate weather parameters. This model provided forewarning two weeks in advance.
- Under a study in collaboration with NDUAT, Faizabad, stepwise regression models and weather indices based models were developed for forewarning paddy pests 1–2 weeks in advance of peak incidence.
- Study on epidemiology and forecasting of powdery mildew in mango was taken up in collaboration with CISH, Lucknow. The forewarning system developed using logistic regression models gave satisfactory forewarning probabilities which compared well with the observed year-wise responses.
- The scientists of the Forecasting Techniques Division were collaborating with CRIDA, Hyderabad in a NATP project entitled, ‘Development of weather based forewarning systems for crop pests and diseases’. Various models for forewarning important pests and diseases in rice, cotton, mustard, sugarcane, pigeon pea, groundnut at several locations were developed. The forewarnings obtained through these models were in close agreement with the observed status.

Remote Sensing and GIS application in Agricultural System

- A study entitled ‘Use of remote sensing technology in crop yield estimation surveys’ showed that use of satellite data along with the survey data might led to considerable gain in efficiency of crop yield estimator and hence corresponding reduction in cost of the general crop yield estimation surveys.
- A sampling methodology for estimation of crop acreage and crop yield based on the combined use of satellite data and ground survey data on crop yield based on crop cutting experiments and small area estimators of crop yield at tehsil/block level was developed in a study undertaken on ‘Use of remote sensing satellite data in crop surveys’. Crop yield forecasting models were also developed under this study.

- A study was undertaken to examine the use of remote sensing and GIS technologies in improving the agricultural statistics based on a sample of villages. From the study, it was observed that quality of revenue records was quite reliable. The results of the study showed that (i) the data quality of the records enumerated by patwaris were found satisfactory, (ii) the prediction of area under different land use categories based on satellite data using spatial models was also found to be satisfactory and (iii) the spatial models were found quite satisfactory at a village level and hence the land use statistics at small area levels like village panchayat/blocks/tehsils could be easily developed using only sample of villages as recommended by the National Statistical Commission.
- A GIS based technique for identification of potential agroforestry areas was developed. In this study the important factors responsible for growth of agroforestry were identified and suitability index using Objective Spatial-Analytic Hierarchy Process was constructed. A composite development index with respect to agroforestry at village level was also developed. The village development index was compared with the suitability index of the village.
- A project to develop a remote sensing based methodology for collecting agricultural statistics in Meghalaya initiated. The main aim of this project is to develop a survey methodology for estimation of area and production of principal crops in hilly region in general and Meghalaya in particular.

Programme 3: Development of Techniques for Planning and Analysis of Survey Data Including Economic Problems of Current Interest

Targets Set

1. Development of model based small area techniques for estimation of parameters from agricultural and allied surveys
2. Studies on enquiry based farmers estimate with a view to improve the present method of crop estimation surveys
3. Re-appraisal of the sampling methodologies for estimation of crops, livestock products, fisheries, horticultural crops and cotton
4. Studies for estimation and marketing of crops, livestock and fisheries and other data gaps in agricultural sector needed for speeding up the planning process
5. Studies relating to theoretical aspects on analysis from surveys data and its applications to agricultural surveys such as regression analysis of survey data, categorical data analysis, variance estimation of non-linear statistics from complex surveys and multi variate analysis
6. Studies on assessment and control of various non-sampling errors such as coverage errors, response and non-response errors as well as errors due to sensitive questions
7. Studies on estimation of floriculture crops
8. Studies relating to farm mechanization
9. Cost of cultivation studies
10. Assessment of harvest and post-harvest losses
11. Modeling of technical change and agricultural production
12. Econometric models for technological dualism in poultry production
13. Estimation of demand for perishable farm products
14. Study on farm production and rural forestry
15. Study on technical efficiency in agriculture

16. Food and nutritional security
17. Studies relating to agricultural marketing, risk and uncertainty, agricultural credit and natural resources

Projects Undertaken

(a) Institute Funded Projects

1. A study for estimation of area and production of important vegetable crops on the basis of partial harvest
2. Estimation of flow and change in dynamic populations
3. To study the effect of various input components on the yield
4. Studies on feed intake by bovines through stall feeding and grazing
5. Estimation of regression co-efficient from sample survey data
6. Sample survey to evolve methodology for estimation of fish catch from rivers or streams especially in hilly areas
7. A study of variance estimation in complex survey
8. An analysis of yield gap for buffaloes milk
9. Pilot sample survey to develop a sampling methodology for estimation of poultry meat production
10. Development of database relating to basic and current agricultural and allied statistics over time and space
11. Small area estimation of milk production
12. Pilot sample survey for estimating the area and yield rates of ginger and potato in hilly areas
13. A study of production efficiency and resource use in poultry production
14. Economic study of micro-irrigation system on farmer's fields
15. Study of demand for agricultural products and its implication for food security in India
16. Estimation of farm level technical efficiency and its related parameters under error decomposition methodology of Stochastic Frontier model in the production of wheat
17. Dietary pattern and nutritional status of rural household – state wise analysis

(b) AP Cess Funded Projects

1. Sampling procedure for selection of representative samples of fertilizer from ships
2. Study of lac marketing in India

(c) Other Funded Projects

1. Crop yield estimation at small area level using farmer's estimate (Funded by Ministry of Statistics and Programme Implementation, CSO)
2. A pilot study on cost of production of coconut in Kerela (Funded from Coconut Development Board, Kochi, Kerala)
3. Assessment of harvest and post harvest losses (A mission mode project)

Achievements

- A methodology based on small area estimation technique was developed for milk production to obtain reliable estimates at the district level.
- A study for estimation of wheat yield at block level using crop-cut and farmers' estimate was undertaken

in Karnal district of Haryana. Further a detailed study on 'Crop yield estimation at small area level using farmers' estimate was carried out in Sirsa and Bhiwani district of Haryana involving all the major crops of kharif and rabi seasons of these two districts. The closeness of the estimates of yield obtained through the crop-cut approach vis-à-vis the corresponding estimates obtained from the farmer by inquiry was examined. There did not emerge any clear-cut trend between these approaches of yield estimates. To develop block level estimates of average yield of crops under study, two different estimators were considered i.e. one based on simple average values of crop-cutting experiments conducted in a block while the other was the double sampling regression estimator utilizing the eye-estimated yields of the field as auxiliary information besides the crop-cutting experiments data. Reduction in the percentage standard error of the estimator to the tune of 96% was observed in some cases in the double sampling regression estimator over an estimator based on simple mean values. The reduction in cost to the extent of 95% was obtained in cases where there was high correlation between the farmers' estimate and the estimates obtained through crop cutting approach by adopting the double sampling regression estimator. However, the reduction in cost strictly did not depend on the magnitude of correlation coefficient. Also, cheaper the cost of obtaining the farmers' estimate compared to the crop cutting estimates, greater was the percentage reduction in cost obtained by adopting the double sampling regression estimator over an estimator based on simple mean values of crop-cutting experiments data.

- A sampling methodology for estimation of area and yield of cultivated fodder crops other than Jowar and Berseem was developed.
- A study for estimation of area and production of important vegetable crops on the basis of partial harvest was undertaken. In this study, an alternate procedure was investigated in which yield is estimated on the basis of partial harvest. An approach for a variety of sampling designs associated with sampling over time was also developed using the varying probability sampling methods.
- A methodology for estimation of fish catch from rivers and streams of the hilly areas was developed.
- A study for sampling procedure for selection of representative sample of fertilizer from ship was undertaken. Using data on physical parameters for testing the quality of fertilizers, namely, moisture content and particle size, the required number of samples, necessary for quality check for the fertilizers Diammonium Phosphate and Mutate of Potash imposed at the Kandla and Kakinada port respectively, were determined.
- A project on 'Pilot sample survey for estimating the area and yield rates of ginger and potato in hilly areas' was undertaken to develop sampling methodology for estimating the area and yield rates of ginger and potato. The potato and ginger crops are main and most important crops grown in Meghalaya. The study for estimating the area and yield rates were also undertaken in East Khasi hills for potato and East Garo hills for ginger during 1997–98.
- A study was undertaken to develop a sampling methodology for estimation of poultry meat production. The results obtained in this study provide satisfactory estimates of poultry meat production through organised poultry farm. In the study attempt were also made to estimate the other aspects of poultry husbandry like dynamics of poultry population at farms and sale and purchase of poultry birds monthly, seasonally and annually.
- A Pilot study on cost of production of coconut in Kerala was undertaken. Reliable and efficient estimates of cost of cultivation of coconut were built and the agricultural practice in coconut was studied. The information collected for the study of the agricultural practice in coconut on input details to formulate more remunerative cultivation practice was also utilized.

- A project was undertaken on estimation of flow and changes in dynamic population. In this project estimators were developed for estimating the flow of units in various classes in a dynamic population in order to assess the social and economic development of population engaged in agricultural sector, industry sector etc. due to general developmental phenomena.
- A mission mode NATP project entitled ‘Assessment of harvest and post-harvest losses’ was undertaken that helped to assess the harvest and post harvest losses of major oilseeds, wool, milk, meat, eggs & poultry meat, marine and inland fisheries at different levels i.e. producer, consumer and market.
- Under the project entitled ‘To study the effect of various input components on the yield of important vegetable crops’, the functional relationship relating to the response of changing levels of different inputs on the yield of vegetable crops were studied.
- A study on feed intake by bovines through stall feeding and grazing had shown the feasibility of estimating the intake through grazing with reliable precision.
- A project entitled ‘An analysis of yield gap for buffaloes milk’ was undertaken to identify the factors responsible for the gap and to estimate the contribution of each factor to the gap.
- A project entitled ‘Development of data base relating to basic and current agricultural and allied statistics over time and space’ was undertaken to develop the database containing the information at country level for (i) data on area, production and yield of food grains, fruits, vegetables, spices, oilseeds etc., (ii) data on production and consumption of fertilizers, (iii) data on irrigated area and cropping intensity, (iv) data on live-stock numbers and production of milk, eggs, wool and meat and (v) data on land use statistics. The necessary software for storage and retrieval of data from the database was developed using Fox Pro.
- A study for estimation of regression coefficients from sample survey data was undertaken to study the performance of alternative estimates of regression coefficients for survey data, to examine the problem of multi-colinearity in the context of survey data and to estimate the regression coefficients when the variables are in errors.
- A project entitled ‘A study of variance estimation in complex surveys’ was undertaken to examine the effect of sampling designs on variance estimators of complex surveys, the relative performance of different variance estimators in complex surveys for non-linear statistics and an attempt to modify these estimators for reducing higher order biases in complex surveys.
- The status paper entitled ‘Information support for management of agriculture’ pertaining to the study entitled ‘State of the Indian farmer – A millennium study’ was prepared.
- The methodology pertaining to National Agriculture Insurance Scheme was provided by the Institute and was taken up on pilot basis in one district each of six states by the Ministry of Agriculture, Govt. of India.
- A project on ‘Estimation of wool production – emerging data needs and a methodological reappraisal’ was carried out to modify the existing sampling methodology for estimation of wool production, to estimate the breed-wise sheep number, average wool yield, total wool production and seasonal variation at district level with a reasonable precision and to study various sheep rearing practices prevailing in different regions and the socio-economic status of farmers engaged in sheep rearing.
- A project on ‘Sample survey to develop sampling methodology for estimation of area, production and productivity of important flowers on the basis of market arrivals’ was undertaken to estimate the parameters of interest for important flowers in Delhi on the basis of market arrivals as well as by survey approach.

- A project on 'Study relating to formulating long term mechanisation strategy for each agro climatic zone/state' was undertaken. The main objective of the study was to formulate farm mechanization strategies for different agro climatic regions/states.
- A project on 'A study on editing and imputation using Neural Networks' was initiated to study the performance of artificial neural network technology for editing of statistical records, to investigate the accuracy of imputing missing values using neural network and hot deck imputation procedure and to develop software for the imputation of missing data.
- Agricultural Research Data Books (1997, 1998, 1999, 2001, 2002, 2003 and 2004) were also prepared and published.
- In a project, 'An econometric approach for measurement of indemnity and premium rates under crop revenue insurance', an alternative approach (crop revenue insurance) to the existing yield and area approach for calculating the premium rates in crop insurance was developed on the basis of farm gross returns.
- In a study, 'On farmers behaviour towards risk and its impact on cropping pattern, level of resource use and farm income', the risk-aversion coefficient indicated the extent of risk-aversion for a particular farmer in a particular crop on the purchased input i.e higher the value of coefficient, higher was the risk aversion.
- In a study 'Jai vigyan national science and technology mission project on household food and nutritional security for tribal, backward and hill areas', there was an increase in wool yield and income in 2004 over the base year 2001 in Ajmer district of Rajasthan and Kangra district of Himachal Pradesh. The percent change in food security, compared to the base year (2001), indicated that consumption of surplus food items, viz. cereals and milk had decreased marginally in Ajmer district and increased marginally in Kangra district.
- Under the study 'Estimation of economic gains from technological advance in rice cultivation', the producers were the major beneficiaries of technological advance in rice cultivation in all the states. The consumer gains were found to be less prominent.
- In a study on 'Technical efficiency analysis of rice-wheat system in Punjab', there exist 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. Input utilization of the factors of production under farmer's control was assessed which had direct bearing for determining rational minimum support price policy with the help of heuristically deduced results of actual and frontier figures relating to levels of output, gross revenue and net returns.
- In a project entitled 'Study of technological change in poultry production', there was substantial saving in input resources such as in employment labour (about 33%), electricity cost (40%), feed (about 38%) and in medicine cost (about 11%) by shifting from Deep Litter system of poultry keeping (traditional technology) to Cage system of Technology (modern technology).
- Under a study 'Economic study of micro-irrigation systems', the fruit crops grown under drip and crops grown under sprinkler irrigation had high benefit cost ratios as compared to other methods of irrigation and a considerable savings of resources.
- In a study 'Estimation of demand for agricultural credit and its effect on farm income and employment', the farmers who availed the credit facilities were economically better off than the non-borrowers. The net returns could be increased considerably on marginal, small, medium and large farms in the relaxed capital situation as compared to restricted capital situation at the existing level of technology. The

- demand for credit in both adopted as well as recommended level of technologies was interest inelastic.
- Under a project entitled ‘Study of lac marketing in India’, the important lac markets spread over within the same state (except for Chhattisgarh state) and among different states were not properly integrated. The price movement in different markets was not synchronized to each other and there existed a significant price difference. However, the speed of adjustment to equilibrium price in many markets was found to be faster.
 - In a study ‘Dietary pattern and nutritional status of rural households: State wise analysis’, there was a general trend of reduction in consumption of cereal in favour of non-cereal foods. However the shift from cereal based to non-cereal based diet was not visible uniformly in all categories of socio-economic groups. In most of the states, the proportion of deficient rural households was higher in landless, sub-marginal and marginal class and decreased with the size of holdings.

Programme 4: Modeling and Simulation Techniques in Biological Phenomena

Targets Set

1. Computer simulation studies and applications of re-sampling techniques like Bootstrap, Jackknife, Balanced Repeated Replications in Agricultural Statistics
2. Non-linear statistical modeling of biological, ecological and economic phenomena
3. Studies on gene action, estimation of genetic parameters and genetic merit, genetic progress and other related statistical methods

Projects Undertaken

(a) Institute Funded Projects

1. Study of contagious distributions and dynamical models for aphid population growth
2. A study to compare the performance of different methods of estimating repeatability and to assess their stability by Bootstrap technique
3. Application of bootstrap techniques for studying statistical properties of genetic parameters
4. Studies on growth pattern and heritability of fitness traits in Indian breeds of goats
5. Investigation on the properties of projection matrices in population biology
6. On some robust estimation of heritability
7. Empirical investigations on the influence of fixed effects on the estimates of heritability

(b) Collaborative Projects

1. Development of statistical procedures for selecting genotypes simultaneously for yield and stability

(c) Other Funded Projects

1. Study on data processing techniques for statistical analysis of large field variability in hilly and salt affected soil regions

Achievements

- Under a study, ‘Empirical investigations on the influence of fixed effects on the estimates of heritability’, influence of non-genetic fixed effects on the estimates of heritability was studied under half-sib and

full-sib models for different numbers of fixed effects, sample sizes and family sizes. Using Harvey's technique vis-à-vis mixed model technique, the performance of different ways of correcting the data for non-genetic fixed effects prior to the estimation of heritability was assessed.

- Simulation and Bootstrap techniques were used for the estimation of variance components, heritability and its confidence intervals. Further, it was used for estimation of standard error of genetic correlation. Another study was also conducted to compare the performance of different methods of estimating repeatability and to assess their stability by Bootstrap technique.
- The success of crop improvement activities was largely depend on the identification of superior varieties for mass propagation. A variety could be considered superior if it had potential for high yield under favorable environment, and at the same time a great deal of phenotypic stability. Few parametric as well as non-parametric stability measures were proposed for the measurement of yield stability in the presence of genotype by environment interaction. Also, interrelationships among common stability measures were developed.
- Integration of stability with performance through suitable measures had to go a long way in selecting high yielding, stable cultivars simultaneous selection measures. Three new indices for selection of genotypes simultaneously for yield and stability were developed and it was shown empirically that these indices were superior to Kang's rank-sum method, which has an inherent weakness that it is weighing heavily towards better yield performers, apart from the arbitrariness in the scoring procedure. Few more superior simultaneous selection measures based on AMMI models were also developed.
- Proposed a MANOVA procedure suitable for carrying out stability analysis for several traits simultaneously and illustrated it on sugarcane data. The results indicated that the technique would be quite useful whenever the GE interaction was largely linear.
- Using the path analysis, formulae for heritability of herd-life in dairy cattle was derived from the correlation between half-sib for the traits. The reliability of the formulae was demonstrated through simulation.
- For studying the crop yield stability, a bootstrap procedure was proposed for obtaining robust estimates of the variance components and illustrated it by computing heritability for different combinations of variety and location numbers. In an empirical investigation on non-linear genotype \times environment interactions, the procedures of two-phase regression, refined two-phase regression and non-linear regression were tried on live data on vegetable crops and the strength and weakness of the procedures were brought out. A new procedure to overcome the defects in the two-phase regression approach was developed.
- Comparing the performance of different genetic groups of dairy animals based on multiple traits yielded better information on the economic value of these animals as well as on the optimum level of exotic inheritance at which the crossbred were stabilized. Some studies on growth performance of crossbred goats were undertaken by plotting the second dominant root (λ_2) against the first root (λ_1) of the determinantal equation namely $|\mathbf{B} - \lambda\mathbf{W}| = 0$, where B and W are between and within sires covariance matrices.
- Admissible estimates of heritability and genetic correlations utilizing breeding data of Sindhi cows on three dairy traits were obtained and the workability of the Amemya's procedure was demonstrated.
- Stayability is a threshold trait in dairy cattle, which needs a special kind of statistical treatment. Herd-life, a measure of stayability depends on number of traits including milk production. A realistic measure of heritability of stayability can be obtained only if the herd-life is adjusted for production and other

auxiliary traits. Using Beta-binomial distribution heritability of stayability was estimated. The work was later extended to cover unbalanced data situations. The important message from the studies was that in situations where assigned values of stayability were unavailable, the beta-binomial method was preferable to all other procedures.

- In field experiments the newer concept of spatial relationship among adjacent observations was also brought to the notice of researchers by using geo-statistical techniques such as variography and kriging. Using the notion of co-kriging, the influence of soil characteristics on performance of plant growth traits was illustrated under spatial patterns. Recently, a CGP (NATP) project entitled, ‘Studies on data processing technique for statistical analysis of large field variability in hilly and salt affected soil regions’ was initiated. Under this project a software package Spatial Variability and Interpolation, which visualize the spatial variability in graphical form was developed. Programs for kriging in regular grids, with four inbuilt fitting models viz. Spherical, Gaussian, Exponential and Logarithmic were also developed.
- Using clustering techniques and bootstrap methodology, Indian commercial wheat varieties were classified based on molecular markers and DNA finger printing data.
- A number of interesting investigations were conducted in the area of modeling biological phenomena.
- Aphids are recognized as serious pests in cereals, pulses and vegetable crops. To investigate optimal control measures for this pest, a description of spatial and temporal spread of aphid population is of vital importance. The conventionally used, negative binomial distribution frequently fails to describe the aggregation or clustering pattern of the pest over a particular area. Accordingly, a non-linear statistical model for describing the dynamics of aphid population growth was proposed for modeling for spread of insects, pests and pathogens. Later on, a number of advanced contagious distributions like Neyman Type A and Thomas distributions were considered and finally advocated the use of Lagrangian-Poisson distribution for the purpose.
- For developing models for fishery growth and harvesting, single and multi-species stochastic fish population growth models were investigated and optimal fishing effort as well as the optimal expected yield was worked out for the Fox and Schaefer models with time delay in random environment. Further investigations for modeling fish production, which includes a comparative study of non-equilibrium and equilibrium Schaefer models, were conducted. A number of studies involving length-weight relationships in different fish species were conducted. Allometric model was generalized for describing length-weight relationships. Further, Von-Bertalanffy model was discussed with an auto-correlated error term and a similar model for random environment was proposed. A non-linear procedure for obtaining length-weight relationship was also described.
- Modeling and forecasting of country’s total food grain production was carried out using ‘Bayesian analysis of time-series’ and ‘Structural time-series (STS)’ approaches. The STS methodology with prominent trend and intervention was employed for modeling India’s oilseed production data while lac production data was modeled through STS with cyclical fluctuations. In order to forecast crop yield based on remotely sensed data, use of ‘Fuzzy regression methodology’ was demonstrated. Appropriate nonlinear statistical models were developed for describing path of wheat production, productivity and area under HYV at State level. Auto Regressive Conditional Heteroscedastic type of nonlinear time-series model was thoroughly studied to model volatile onion price data.

Programme 5: Development of Information Technology in Agricultural Research

Targets Set

1. Development of stand alone and web enabled databases and information systems
2. Development of data warehousing including data mining for agriculture resources
3. Strengthening of LAN and Internet connectivity
4. Expert systems in agricultural research
5. Computer software for agriculture research data analysis
6. Computer network of agricultural statisticians

Projects Undertaken

(a) Institute Funded Projects

1. Development of software for On-line Information System on Personnel Management in ICAR
2. Agricultural Experiments Information System
3. Development of Statistical Package for Agricultural Research (Windows Version) – SPAR 2.0
4. Agricultural Field Experiments Information System

(b) Other Funded Projects

1. Short-term training programmes in Information Technology
2. National Information System on Agricultural Education on Internet (NISAGENET)

Achievements

- Under the project ‘Development of information technology to support the applied biotechnology research’, a ‘Bio-Informatics Centre’ was set up for Livestock Biotechnology Research. Selective Dissemination of Information Services (SDI) started by implementing CD-ROM based bibliographic databases consisting of Biotechnology Abstracts, VETCD, BEASTCD and AGRICOLA. Selected information on requests received from various ICAR institutes was retrieved and the output was sent to the users. Under this project computing, reprographic, e-mail, video-projection facilities were created for the Institute. Statistical software like SAS, GENSTAT and GLIM were also procured.
- National Information System on Agricultural Education on Internet (NISAGENET) laid emphasis on providing a unified information base for collection, compilation and analysis of information about the activities of the agricultural education system in India. The information on academic, infrastructural facilities, budget provision, manpower employed, research and development activities of all the SAU’s, and Deemed Universities of ICAR was made available. Finally, it was an effective solution for the class of users varying from common man to academicians, planners, policy makers, scientists, technologists, and students for undergoing higher education in agriculture.
- The main objective of the project entitled, ‘Development of Website for National Seed Project’ (Project in collaboration with National Seed Project (Crops) was to provide all the information (both static and dynamic) regarding the AICRP, National Seed Project (Crops) on World Wide Web. At the back end a database was designed and developed for information storage. Forms Module is meant for centre wise data entry/updation for Breeder Seed Production and Seed Technology Research centres. Reports Module was meant for generating dynamic reports based on the information filled in the database.

Seed Stock Module provided the daily availability of seed (variety wise) at different centres along with the quantity available. Static help was also provided.

- For Online Information System on Personnel Management in ICAR, a software PERMISnet was developed on client-server three tier distributed architecture for the management of human resources consisting of scientific, technical and administrative, and finance and accounts services of the Indian Council of Agricultural Research. It deals with the personal and the professional attributes of the Council's employees. The PERMISnet has a user-friendly environment for entering the data on personal records, updating whenever essential at the institutional level, viewing or printing the management reports for all levels of management requirements. The other important segment of the system is the user-customized reports. User can interact with the system to generate the queries and get information immediately on personnel management. The implementation part of the system is in progress.
- The aim of the project, short term training programmes in Information Technology under Revolving Fund Scheme was to train manpower in the field of Information Technology and to expose the scientists of NARS to latest developments in Information Technology. 908 participants were trained during the period of the project (April 1998 to December 2003). A multimedia lab with 21 computers was established along with the procurement of other equipment like a photocopier, scanner, printers etc. as an asset of the Institute. An amount of more than Rs. 2 lakhs was saved after meeting the expenditure on the training, salary of faculty and repayment of loan from ICAR.
- SPAR 2.0 is a Windows Version of in house built DOS based package SPAR 1.0 (Statistical Package for Agricultural Research) with some additional modules. The package has modules for Data Management, Descriptive Statistics, Estimation of Breeding Values, Correlation and Regression Analysis, Variance and Covariance Components Estimation, Stability Analysis, Multivariate Analysis and Mating Design Analysis. This package has been developed in Microsoft Visual C++ 6.0 language. This package is user-friendly, interactive, Password protected, completely Menu-Driven. Context-Sensitive Help with Index, Contents and Search facility has been provided.
- Under the NATP-Mission Mode Project 'Integrated National Agricultural Resources Information System' (INARIS), a state of art Central Data Warehouse (CDW) of agricultural resources of the country is under the process of development at IASRI, New Delhi. This is probably the first attempt of data warehousing of agricultural resources in the world. This will provide systematic and periodic information to research scientists, planners, decision makers and developmental agencies in the form of On-line Analytical Processing (OLAP) decision support system. The above project is being in progress with active collaboration and support from 13 other ICAR institutions. In all 59 databases on agricultural technologies generated by Council, research projects in operation and the related agricultural statistics from published sources at least from the year 1990 onwards at the district level are being integrated into this information system. The system is currently under development phase with subject-wise data marts being created, multi-dimensional data cubes being developed for publishing on Internet/ Intranet and the validation checks being implemented. The above system has been developed keeping in view the three groups of users i.e. (1) research managers and planners, (2) research scientists and (3) general users. The information of this data warehouse will be available to the user in the form of decision support system in which all the flexibility of the presentation of the information, it's on line analysis including graphic is inbuilt into the system. The system also provides the facility of spatial analysis of the data through web using functionalities of Geographic Information System (GIS). Apart from this the subject wise information system has been developed for the general users. The user of

this system has the access of subject wise dynamic reports through web. The facilities of data mining and generation of ad-hoc querying will also be extended to limited users. The website of the project is already launched (<http://www.inaris.gen.in>) and the multidimensional cubes, dynamic reports, GIS maps and some of the information systems are already available to the users.

- Under NATP sub-project ‘Institutionalization of Research Priority Setting, Monitoring and Evaluation and Networking of Social Scientists’ under O & M component, a software PIMSNET has been designed and developed to meet the organizational requirements of research projects concurrent monitoring and evaluation under NATP. Information on 845 Research Projects running under PSR (Arid, Coastal, Irrigated, Rainfed, Hill & Mountain) Agro-echo System and other research modes like Mission Mode, Competitive Grant Program, Team of Excellence of NATP in the country is available in the system (<http://www.pimsnet.gen.in>). It has been planned and designed to capture the projects working details in 4 components namely Data Management, Projects Progress Monitoring, Reports & Queries and System Administration. Finally, it is an on-line tool for research planners, policy makers and scientists for monitoring and concurrent evaluation of the on going research projects and a latest information base of the agricultural research and development being conducted in the last four years in the country under NATP. A Network of Agricultural Statisticians (<http://www.iasri.res.in/asn/>) has also been developed for providing dynamic working linkages among the statisticians with emphasis on research information exchange, resource sharing and optimizing response time for addressing methodology related problems and foster fellow feelings among the group.
- NATP sub-project ‘Expert System of Extension’ under CGP component, was undertaken with the aim to taking latest technologies developed in labs to the fields of the farmer by using Internet technology. A web enabled expert system of extension has been developed under the project that act as a helping tool for the farmers and extension workers to take appropriate decision regarding the variety selection, insect and disease identification, nematode and physiological disorder identification and their control. The system also helps the user to calculate cost of cultivation and cost benefit analysis for a particular variety at the district level for the selected crops. The system is actually a pilot system for a country level expert system for all the crops and for all the districts of the country. The system has been built with a user-friendly utility to create the online decision trees. Experts from different subject matter can use this utility to create decision trees for solving different agriculture problems.
- Development of Statistical Package for Animal Breeding 2 (SPAB2) is a window-based version using a platform independent programming language. Twenty-four modules have been developed so far out of 40 modules planned. These modules have been thoroughly tested and they work in the window editor developed for the project.
- The system Development of Expert System on Wheat Crop Management has been designed to cover the agriculture operations, variety selection, fertilizer application, identification of disease and insect/pest and insecticide/pesticide application on one hand and economic benefits on the other hand. It will help in extending research to farmers. It will be an effective means of extension. Data management module provides the facility to enter a new variety and its characteristics. In variety selection module, a farmer/user can select a variety on the basis of state, zone, sowing condition, sowing period, sowing time, yield, maturity, year of release, different grain characteristics and with the combination of above mentioned criteria. Database designing for the disease identification part of the plant protection module has been completed. Home page of the site has been designed.

(c) Inter-Institutional Completed Projects

- Development of website for ‘Network of Social Scientists’ in collaboration with National Centre for Agricultural Economics and Policy Research (NCAP), New Delhi
- Development of pesticide residue free IPM package for some major vegetables in collaboration with Indian Institute of Horticulture, Bangalore

Software Development

● **Statistical Package for Animal Breeding Data (SPAB)**

The package is menu driven and works in a user-friendly manner. This package can handle least square analysis using Harvey’s algorithms, single trait or multi-trait restricted and unrestricted mixed models using Henderson’s BLUP procedure, computes genetic parameters for one-way and two-way classified data, D^2 analysis, regression analysis and calculation of selection index.

● **Statistical Package for Balanced Incomplete Block Designs (SPBD- Rel. 1.0)**

This package enables an experimenter to select, generate and gives randomized layout of a Balanced Incomplete (BIB) design. It also gives the analysis of variance with both treatments adjusted and block adjusted sum of squares, adjusted treatment means, variance of estimated contrasts, critical differences at 5% and 1% level of significance etc. The package generates BIB designs up to 601 treatments with replication number and block size up to a maximum of 20 for asymmetric BIB designs and up to 30 for symmetric BIB designs.

Softwares Developed and Released

- Statistical Package for Balanced Incomplete Block Designs (SBD Release 1.0)
- Statistical Package for Factorial Experiments (SPFE 1.0)

Softwares Under Development

- Statistical Package for Augmented Designs (SPAD)
- Statistical Package for Two-associate Partially Balanced Incomplete Block Designs
- Agri-designer: PBIB(3) Designs and PDC
- Design and Analysis Systems: Generation of efficient block designs for making all possible pair wise treatment comparisons, test treatment - control treatment(s) comparisons

4.2 Technologies and Patents

The Institute has developed various statistical methodologies useful for enhancing the quality of agricultural research. These methodologies are in public domain. The developed methodologies have been applied in experimentation and in carrying out in depth analysis of data relating to various agricultural sectors including livestock and fisheries. Besides development of efficient statistical methodologies, information systems and statistical software packages have also been developed as under:

Information Systems

(a) Integrated National Agricultural Resources Information System (INARIS)

A Central Data Warehouse (CDW) of agricultural resources of the country has been designed, developed and implemented at IASRI, New Delhi (lead center) and databases on different subjects by 13 ICAR Institutions (co-operating centres), namely 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 resource), NBPGR, New Delhi (for plant genetic resources), NCAP, New Delhi (for socio-economic resources), CIAE, Bhopal (for agricultural implements and machinery), CPCRI, Kasargod (for plantation crops), IISR, Calicut (for spices crops), ICAR Research Complex for Eastern Region, Patna (for water resources), NRCAF, Jhansi (for agro forestry) and IIHR, Bangalore (for horticultural crops) under NATP, Mission mode project. The target users of information systems and decision support system developed under this project are (i) Research Managers (ii) Research Scientists and (iii) General Users. In this project a state of art Central Data Warehouse (CDW) of agricultural resources of the country has been developed at IASRI, New Delhi. This is probably the first attempt of data warehousing of agricultural resources in the world. This provides systematic and periodic information to research scientists, planners, decision makers and developmental agencies in the form of On-line Analytical Processing (OLAP) decision support system.

It contains 59 data bases on agricultural technologies generated by council, research projects in operation and related agricultural statistics from published official sources from the year 1990 onwards at the district level. Subject-wise data marts, multi-dimensional data cubes have been developed and published on Internet/ Intranet.

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, it's on line analysis including graphic is inbuilt into the system. The system also provides facility of spatial analysis of the data through web using functionalities of Geographic Information System (GIS). Apart from this, subject wise information system has been developed for the general users. The user of this system has the access of subject wise dynamic reports through web. The web site of the project is already launched (<http://www.inaris.gen.in>) and the multidimensional cubes, dynamic reports, GIS maps and information systems are already available to the users.

(b) Personnel Management Information System Network (PERMISnet)

Personnel Management Information System Network (PERMISnet) for ICAR setup has been developed for providing information for systematic planning and development of human resources in ICAR. System maintains up to date information on ICAR personnel under various services on personal and professional attributes. This system provides information on Scientific, Technical, Administrative and Supporting Staff on personal, professional and referential parameters besides information on cadre strength and institutional structure to help the management in taking appropriate timely decision.

The system is maintained by the Database Administrator (DBA) at Indian Agricultural Statistics Research Institute (IASRI), New Delhi. Information on personal and professional attributes of each employee and institute parameters are being continuously updated by the Nodal Officers of all the institutes. System has been launched from IASRI server and is available at <http://www.iasri.res.in/permisnet/>

(c) Agricultural Statistician Network (ASN)

Agricultural Statistician's Network (ASN) website was developed at IASRI under a sub-project 'Institutionalization of Research Priority Setting, Monitoring & Evaluation and Networking of Social Scientists' of the National Agricultural Technology Project (NATP). This ASN system provides information on professional aspects of statisticians. It has online interaction facilities that facilitates the sharing of information among fellow colleagues and enhances the scope of statisticians for global collaboration. It

also aids the statisticians by providing information in terms of statistical journals published, statistical software, dictionary of statistical terms and information on agricultural statistician's conference, meeting etc. Site has been enriched with features like chat, discussion group, notice board, search, online registration and online data management facility. The site is hosted from IASRI and is available at the address <http://iasri.res.in/ASN>.

(d) National Information System on Long Term Fertilizer Experiments (NISLTFE)

This information system covers online data management and reporting for long term fertilizer experiments. The key source of information under the project is the data generated under long term fertilizer experiments conducted/in progress at various organisations under Horticulture, Crop Sciences and NRM Divisions of ICAR. For this linkages with various organisations engaged in LTFE were established to acquire the experimental information available on various aspects of agro technologies since their initiation. This system contains detail information related to those experiments. The site is hosted from IASRI and is available at the address <http://www.iasri.res.in:8081/nislftfe/>

(e) Agricultural Field Experiments Information System (AFEIS)

The information system aims at systematic maintenance of data of field experiments conducted on various aspects of agricultural technology at a central place and retrieval of information on selective basis as per requirements. It was evolved over years as an outcome of National Index of Agricultural Field Experiments Scheme. The Purely Varietal trials have been excluded from this database system. The site is hosted from IASRI and is available at the address http://www.nisaeserver.iasri.res.in:8080/opk_afeis/index.html

(f) National Information System on Animal Experiments (NISAE)

The experiments in various disciplines of animal sciences are being undertaken at various ICAR institutes dealing with Animal Sciences and Agricultural/Veterinary Universities. Information relating to the results of these experiments is not available in compatible form at one place to the scientific community. Keeping in view, National Information system on Animal Experiments (NISAE) has been developed wherein the information relating to the experiments conducted in the country in various fields of Animal Sciences can be store at a central place in a compatible form. This is web based system developed using Java technology. The site is hosted from IASRI and is available at the address <http://www.nisaeserver.iasri.res.in:8080/nisae/index.html>.

(g) National Information System on Agricultural Education (NISAGE)

It contains information on education in agriculture sciences. It is a stand alone version and network system is under development.

(h) Design Resources Server

To disseminate the developments in the field of designed experiments to the experimenters and practicing statisticians, IASRI has taken a lead in generating Design Resources Server (<http://www.iasri.res.in/design>). The main objective of this design resources server is to develop a WEB DESIGN in NARS and to start E-advisory services in NARS. At present material on binary balanced block designs and designs for making test treatments.

Control treatment comparisons along with an electronic book on Design and Analysis of Agricultural

Experiments are available on this site. One can also generate the layout of a block design for making all possible pair-wise treatment comparisons for $v < 35$, $b < 50$, $k < 34$ such that average replication number of treatments is not more than 20 and $k < v$. A discussion forum has also been created so as to introduce E-advisory services. This design resources server has become very popular with the experimenters statisticians.

Softwares Developed

1. SPAR 2.0: Statistical Package for Agricultural Research data analysis is useful for the analysis of experimental research data in Plant Breeding and Genetics. The package consists of eight modules (i) Data Management, (ii) Descriptive Statistics, (iii) Estimation of Breeding Values, (iv) Correlation and Regression Analysis, (v) Path Analysis, (vi) Variance and Covariance Components Estimation, (vii) Stability Analysis, (viii) Multivariate Analysis and (ix) Mating Design Analysis.

2. SPAD: Statistical Package for Augmented Designs is useful for designing agricultural experiments conducted for comparing existing practices/check varieties with new practices/varieties/germplasm collections, where the experimental material for the tests is limited and it is not possible to replicate them in the design. The package generates a randomized layout of an augmented randomized complete block (RCB) design and augmented complete block design with equal or unequal block sizes. The optimal replication number of the control treatments in every block is obtained by maximizing the efficiency per observation for making tests vs controls comparisons. User has a flexibility to choose the replication number of the control(s) in each of the blocks. The package generates randomized layout of the design as per the procedure of Federer (1956), which is generally overlooked while conducting such experiments. The package also performs the analysis of data generated from augmented block designs (complete or incomplete). The different treatment comparison components of interest *viz.* (i) among test treatments, (ii) among control treatments and (iii) among test treatments and control treatments can be done. Multiple comparison procedures for making all possible pairwise treatment comparisons can also be employed through this package. A null hypothesis on any other contrast of interest can also be tested.

3. SPFE 1.0: Statistical Package for Factorial Experiments generates the designs for symmetrical and asymmetrical factorial experiments with and without confounding. It also generates the randomized layout of the designs for factorial experiments. The design is generated on listing the independent interactions to be confounded. It also generates fractional factorial plans for symmetrical factorial experiments. The data generated through these designs are analyzed as per usual procedure of designs for single factor experiments. Contrast analysis is carried out to obtain the sum of squares of main effects and interactions. A null hypothesis on any other contrast of interest can also be tested. This package, besides being useful for the experimenters in the NARS, will be quite useful for teaching of Design and Analysis of Factorial Experiments in the classroom.

4. SPBD Release 1.0: Statistical Package for Balanced Incomplete Block Designs enables a user to select and generate a randomized layout of Balanced Incomplete Block (BIB) Design. The package generates BIB designs with replication numbers up to a maximum of 20 for asymmetric BIB designs and 30 for symmetric BIB designs. The package also provides the analysis of variance with both treatments adjusted

and blocks adjusted sum of squares, adjusted treatment means, variance of the estimated treatment contrasts and the contrast sum of squares, etc. The definitions of the terminology used are available on-line. The package is useful for the experimenters, classroom teaching as well as for the researchers in Statistics with special interest in Design of Experiments.

5. SPAB2: Statistical Package for Animal Breeding 2 is useful for analyzing animal breeding data with respect to estimation of breeding value of a sire, construction of selection indices including partial and restricted indices. The package is useful for estimation of genetic parameters, prediction of genetic merit (Best Linear Unbiased Prediction (BLUP)) and for carrying out analysis of multivariate data through principal components, fitting of discriminant functions etc.

5. Impact

5.1 Impact Assessment

- Work done on the analytical techniques for estimating/projecting the energy requirements in agricultural sector using linear programming approach is quite significant and is being exploited by the All India Coordinated Research Project on Energy Requirement in Agricultural Sector, Central Institute of Agricultural Engineering, Bhopal at all its 12 centres around the country.
- A design for fitting response surface for the AICRP on Soil Test Crop Response Correlations that incorporates the effect of both the inorganic and organic fertilizers into the models has been developed. The experiment is a symmetrical factorial of the type $3 \times 3 \times 3$ in 21 runs. AICRP on STCR has approved the design and all the centres have adopted this design.
- Response Surface Designs and Experiments with Mixtures Methodology for Food Processing, Ready-to-Serve fruit beverages, intercropping experiments, farm power and equipments etc. have been widely used in NARS.
- Analytical Techniques developed for artificially created environments are useful for the analysis of data from post harvest storage, water management and seed technology experiments and have widely been adopted.
- The procedure developed for the estimation of genetic parameters like genotypic and phenotypic variance and correlation from unbalanced data generated through the use of incomplete block designs has encouraged the experimenters in the use of incomplete block designs and has been used successfully in the research work on garden pea of the Division of Vegetable Crops, IARI, New Delhi; sunflower in Panjabrao Krishi Vidyapeeth, Akola and field pea at CCS Haryana Agricultural University, Hissar.
- The equivalence established between the designs for crop sequence experiments and extended group divisible designs have encouraged the experimenters in the use of extended group divisible designs in place of split plot designs currently being used, which have inherent problems. Several experiments have been laid out in extended group divisible designs at Division of Agronomy, IARI, New Delhi and Research Centres of Project Directorate of Cropping Systems, Modipuram.
- The sample survey methodology for quality assessment of imported fertilizer consignments, riverine fish resources estimation, flower estimation, horticultural crops estimations etc. have been developed and passed on to the user agencies.

- Statistical software packages developed for cataloguing and generating the randomized layout of the designs and analysis of experimental data are quite useful for scientists in the NARS. The packages have been widely appreciated by both the statisticians and agricultural experimenters. As a consequence of their wide appreciation, balanced incomplete block designs have been adopted at several centres under Project Directorate of Cropping Systems Research, Modipuram.
- The methodology developed for General Crop Estimation Surveys (GCES), cost of cultivation studies, Integrated Sample Surveys (ISS) for livestock product estimation, fruits and vegetable survey etc. are being adopted throughout the country.
- Methodology based on small area estimation technique for National Agricultural Insurance Scheme suggested by IASRI has been pilot tested in 5 states in the country.
- Methodology for estimation of cost of cultivation of coconut is being used by Coconut Development Board.
- Non-linear modeling has very useful applications in long term projections of foodgrain production, aphid population, marine fish production etc.
- Personnel Information Management Information System network has been implemented for Indian Council of Agricultural Research for manpower planning, administrative decision making and monitoring.
- PIMSNET, a concurrent monitoring and evaluation system developed has helped in monitoring the research programmes under National Agricultural Technology Project.
- By activating the advisory services and through various ad-hoc and tailor made training programmes organized for the scientists under NARS, the Institute has been able to disseminate the recent advances in Agricultural Statistics and informatics to agricultural research workers in the NARS and the basic research conducted has been effectively used by the users.
- The analytical techniques for the analysis of data from the experiments conducted to study the post harvest storage behaviour of the perishable commodities like fruits and vegetables are being widely used in NARS.
- The Institute has achieved international recognition for its high quality research and teaching work in the field of Agricultural Statistics and Computer Application. The Institute has been functioning as a Centre of Advanced Studies in Agricultural Statistics and Computer Applications. Several distinguished statisticians and computer experts from abroad visited the Institute with a view to interacting with the scientists of the Institute, giving seminars/lectures and suggesting improvements in the research programmes of the Institute. Several faculty members of the Institute have received wide recognition and have been bestowed with several honours and awards.

5.2 Lessons Learnt

In spite of several advanced designs, sophisticated analytical procedures and the software packages for carrying out statistical analysis of data that are available in the literature, the designs adopted for experimentation in NARS are still preliminary in nature and statistical analytical tools that are employed are also of elementary level. Therefore, more concerted and proactive approach is required to apprise the researchers in the advanced statistical methodologies. Rigorous persuasion for adoption of efficient experimental designs and sophisticated analytical techniques in their research programme through teaching/advisory services would be a step in this direction. Greater collaboration with the organizations in the NARS is required.

The Institute has also made very significant contributions in developing the analytical techniques for the estimation of genetic parameters, models for pre-harvest forecasting of crop yields, models for fore-warning of incidence of pests and diseases and econometrics. But wide scale adoption of these models could not be advocated due to lack of up-scaling of these methodologies.

The technologies in the development of information systems are changing at a very rapid pace. The information systems need to be developed in a dynamic mode. The success of any information system developed is based on the database at the back-end. Often the data flow from the concerned organisations is irregular and hinders the timely updation of the information. Therefore, the sensitization of the researchers, managers and planners is a must for the timely availability of quality data. To ensure the continuous data flow, it should be made mandatory for the concerned organisations to populate the information system with the current data. Further, the validation checks must also be performed. For ensuring regular updation, needed resources where required, be made available.

The mobility of scientists is essential to generate new ideas and also to expose them to newer areas of research at international level. The lack of international exposure to the researchers in Agricultural Statistics and Computer Applications was also strongly felt. Agricultural Research Statisticians from NARS should move out to advanced laboratories and the scientists from other places in India and abroad be invited for academic interactions. It is also required to initiate action on providing e-advisory services on statistical techniques in the NARS. One can visualize situations wherein a complete statistical consultation/solution is provided over the Internet. The Institute has already taken a lead in this direction by initiating a Design Resources Server on its website.

6. Scenario and SWOT Analysis

6.1 Scenario: Current and Future

The Institute has made some notable contributions to the research in Agricultural Statistics in the fields like Sample Surveys, Design of Experiments, Statistical Genetics, Forecasting Techniques etc. The Institute has also made useful contributions in Econometrics and Computer Applications in Agriculture and Software development. The contributions of the Institute towards the education and training in Agricultural Statistics and Computer Applications have been outstanding. The Institute has been playing the role of a leader in research and education in Agricultural Statistics in the country. Over the years the Institute has developed infrastructure and human resources to meet the challenges in the emerging newer areas with some additional support. In the context of changing national and international scenario, the Institute has to further gear up its research activities to meet the challenges of research and education in Agricultural Statistics and related fields, and Computer Applications so as to meet the global challenges of agricultural research in newer emerging areas. In order to prepare the Institute for the near and distant future, the Institute has to visualize the national and international directions of research and to identify the newer emerging areas of research and also to prepare road map for future research so that the Institute can continue to play its role of leadership for Agricultural Statistics and Computer Applications in the National Agricultural Research System and the National Agricultural Statistics System. For making a unique identity in the ICAR system, the Institute needs to play a very important role in terms of basic research in Agricultural Statistics and Computer Applications, applied research in partnership mode with other ICAR institutes and statistical and computing support to National Agricultural Research System (NARS).

6.2 SWOT Analysis

The SWOT analysis of the Institute is given in the sequel. This analysis would help to identify the strengths of the Institute on which the Institute can further develop and strengthen its research and education programmes. The weaknesses identified would be very helpful in plugging the gaps that come in the way of the progress of the Institute. There are many opportunities that are arising because of the changing scenario and need to be grabbed by the Institute to undertake the role of leadership in research and education in Agricultural Statistics and Computer Applications and to meet the challenges of agricultural research in newer emerging areas. The identification of the threats would allow the Institute to make concerted efforts to counter the threats lest these threats start affecting the progress and development of the Institute.

Strengths

The efforts made by the Institute in conducting basic, applied and adaptive research in Agricultural Statistics to bridge the gaps in the existing knowledge and also undertaking research in newer emerging areas has put the Institute on the global map. The Institute has conducted basic research in various fields of Agricultural Statistics like Sampling Techniques, Design of Experiments, Statistical Genetics and Bio-Statistics, Crop Forecasting Techniques, Statistical Economics etc. that has received loud appreciation and brought fame and recognition to the Institute at International level. The research findings have appeared in important statistical journals of international repute. Some of the research work conducted at this Institute has generated a lot of interest among the scientists world over and a large number of research papers have appeared subsequently on these topics. The Institute has initiated research in several newer areas like efficiency balanced and partially efficiency balanced designs, designs for fitting response surfaces, designs for experiments with mixtures, optimality aspects of designs with unequal block sizes under fixed and mixed models, designs for making test treatments vs control(s) comparisons with unequal precision according to the importance of the comparisons, sampling on successive occasions, unequal probability sampling, categorical data analysis, use of combinatorics in sampling techniques like varying probability sampling, variance estimation from large scale complex survey data, small area estimation etc. and as a result has become an Institute of international importance. Some of these researches have now appeared in seven text books and three handbooks brought out by the Institute. The research carried out in the Institute has contributed towards a strong growth of the discipline of Agricultural Statistics in the country and through this research the Institute has developed the capacity and capability to support and meet the challenges of agricultural research. The Institute has also the expertise to provide research support in the development and strengthening of National Agricultural Statistics System in particular and agricultural development in general.

On the applied front also the research of the Institute is praise worthy. Several methodologies have been developed for the estimation of the parameters of importance in the agricultural system. These methodologies are being used by State Departments of Agriculture, Animal Husbandry, Horticulture and others. The Institute has also suggested a small area estimation methodology for the implementation of the crop insurance scheme to the farmers. The Institute has of late taken a big leap towards developing data warehouse for agricultural research. The Institute has also taken a lead in the Information Technology for planning and monitoring the agricultural research and also planning the human resource in the Council.

Teaching and training in Agricultural Statistics and Computer Applications have helped in human resource development which is a crucial input to research and development at the national level. The Institute has also organized in-service, customized and sponsored training programmes. The Institute has also been

offering training programmes for International Organisations from Afro-Asian, Asia-Pacific countries, Sri Lanka, Gambia etc. The Institute has very good infrastructure for providing training at various levels like M.Sc., Ph.D., in-service and short-term. The Institute has been identified as a Centre of Advanced Studies in Agricultural Statistics and Computer Applications.

One of the important strengths of IASRI has been the efforts made in getting projects funded by outside agencies like AP Cess Fund of ICAR, Department of Science and Technology, Directorate of Economics and Statistics, Ministry of Agriculture, Planning Commission, CSO, Coconut Board etc. Through quality research and maintaining time target, the Institute has proved its indispensability in the National Statistical System.

The Institute has also developed advisory and consultancy services for taking the research in Agricultural Statistics and related fields to the users and stakeholders. Through its advisory services the Institute has made its presence felt in the NARS and NASS, and has enabled to improve the quality of agricultural research.

The Statistical Computing facilities and Information Technology tools at IASRI have been second to none. The Institute has acquired almost all the latest and important statistical softwares for research. The Library of the Institute has also been identified as a regional Library and is in fact heading towards an E-Library.

The strengths of the Institute are summarized below:

- Basic, applied and adaptive research in Agricultural Statistics
- Human Resource Development activity in terms of conducting Post-Graduate teaching in Agricultural Statistics and Computer Applications and organizing in-service, customized and sponsored training programmes
- Supporting National Agricultural Research System in improving quality of agricultural research
- Providing research support for strengthening of National Agricultural Statistics System
- Sponsored research and training programmes for National and International Organizations
- Software development and Information Technology support
- Adequate capacity for building Web-enabled Information system and Data Warehouse technology
- Indispensability in the NARS
- Timely completion of outside funded programmes to the satisfaction of the funding agency
- Library Information Service

Weaknesses

There has been a depletion of human resource, both scientific and technical, because of superannuation. There has also been a lack of skilled human resource in newer emerging areas of research. For some reason or the other, several positions of scientists have remained vacant for long, resulting in lack of availability of qualified personnel in adequate number for undertaking research and teaching/training activities of the Institute. The average age of the scientists is very high and there is a strong need to appoint young scientists in the Institute through ARS and also some senior level scientists in newer emerging areas of specialization through lateral entry. The depletion of technical personnel by way of superannuation has led to inadequate support to research programmes and information technology programmes.

To undertake research in newer emerging areas, it is essential that the scientists get enough opportunities to update their knowledge and skills by way of attending training programmes and participation in conferences in India and abroad. There should be a provision of Visitors Exchange Programme for both research and education. Such activities should have adequate financial support from the Council.

Another weakness that has been witnessed for some years now is the inability of the Institute to undertake research for methodological developments that involve primary data collection. The primary data is required for undertaking certain validation studies, impact assessment studies, and conducting pilot surveys for evolving sampling techniques. The survey data, as required for the proposed studies, is generally not available/obtainable from surveys conducted by other agencies. Realizing the importance of primary data collection, there should be a provision in the budget to support such methodological studies.

In NARS several research programmes are undertaken that involve conducting sample surveys in the fields of crops, animal husbandry, horticulture and fisheries etc. These Institutes do not have adequate expertise to design the sample surveys for data collection and then to analyze the survey data to draw meaningful interpretations. Consequently, it happens that the survey is not properly designed and the estimates obtained from the survey data are not reliable. The useful information contained in the survey data is also not extracted through sophisticated analysis. The institute should make serious efforts to develop linkages with the NARS to provide expertise in the survey techniques for improving the quality of agricultural research.

There has been a feeling developed over the years that the Institute has failed to make its presence felt in the NARS. Perhaps the advisory services at the Institute have not been so strong as to make its research useful to the agricultural research in NARS. As a matter of fact, the advisory and consultancy service should have been the strength of the Institute. Over the last few years, this trend has reversed though. An area which is a weakness of the Agricultural Statistics research is lack of its interaction with the other ICAR Institutes and SAUs.

The introduction of Agricultural Research Services and induction into it of the existing staff has created certain aberrations. This has been compounded further with the adoption of UGC scales. The Institute is still struggling to correct the imbalances.

The weaknesses of the Institute are summarized below:

- Depleting scientific manpower (superannuation and no recruitment)
- Lack of skilled personnel in newer emerging areas
- Inadequate HRD avenues for addressing emerging issues in research adequately
- Inadequate opportunities for the scientists to participate in the International Conferences
- Lack of Exchange Visitor Programmes
- Depletion of technical personnel has led to inadequate support to research programmes and information technology programmes
- Unable to undertake research programmes involving primary data collection for development of methodologies

Opportunities

Although the Institute has established itself as a leading Institute for research and education in Agricultural Statistics and Computer Applications, there are still many opportunities that need to be availed for further development of the Institute. All important issues of environment, rural development, food and nutritional security, disaster management, quality assessment and marketing channels of imported food stuff, processed food etc., market intelligence, competitive intelligence, risk analysis etc. need to be addressed.

The Information Communication Technology needs to be fully exploited for planning and monitoring of agricultural research and human resources in the NARS. Fusion of technologies would be the key word. Data warehouse on agricultural research data needs to be strengthened and data mining research needs to be undertaken. Data parking is another important area for creating a data bank for supporting agricultural

research in NARS. On-line training, advisory and consultancy is another important opportunity that needs to be grabbed for establishing indispensability of the Institute in NARS and NAAS. Web Designing i.e. making all the experimental designs along with layout available on the web for use of experimenters will enable the experimenters to use latest designs that have relevance to their experimental setting.

Research in newer emerging areas in Agri-informatics like bio-informatics, micro array experiments, bio-diversity, molecular biology, genomics of plants, livestock, horticulture, fisheries, flora and fauna etc. offer big opportunities to exhibit its leadership role in the NARS. Statistical modelling, forecasting and forewarning of agricultural system using state-of-art technologies, are other opportunities that the Institute would like to grab.

A closer interaction with the subject matter specialists to identify newer research areas and to effectively disseminate research to the stakeholders would provide an opportunity to undertake research programmes aimed at strengthening the agricultural statistical system. These interactions would also enable the Institute to meet its demand for collection of primary data through the user organizations by providing them the methodologies and analytical support. Research issues emerging from the recommendations of the National Statistical Commission and need to concentrate on developing statistical methodologies for database generation suiting local governance also provides an opportunity for the Institute to establish its leadership role in NAAS.

Sponsored research and training for national and international organizations is a good opportunity for the Institute to augment its financial resources. Online training and online advisory services for NARS is another important opportunity for making the role of the Institute visibly felt and becoming indispensable in NARS and NAAS.

The opportunities of the Institute are summarized below:

- To address emerging methodological gaps in view of rapidly changing scenario, both nationally and internationally, on technology front, environmental concerns and global economic competition
- To address the statistical and economic issues on important national problems of hunger, poverty, environment, employment in agriculture, rural development, disaster management etc.
- Statistical research in newer areas such as genomics, bioinformatics, bio-diversity, geoinformatics, natural resources accounting, competitive intelligence, risk analysis, forecasting and forewarning etc.
- Research issues emerging from the recommendations of the National Statistical Commission and need to concentrate on developing statistical methodologies for database generation required for local governance
- To increase interaction with private sector to undertake research programmes aimed at strengthening agricultural statistics system
- To create data warehouse for agricultural research data and consequently develop methodology for use in simulation and model based research including data mining techniques
- Integrating databases from Central Data Warehouse to provide multi-dimensional analysis of national and regional scenarios
- Sponsored research and training for national and international organizations
- On-line training and on-line advisory services

Threats

The Institute has grown to its present stature through sheer perseverance. There are several opportunities just described that need to be grabbed if the Institute has to keep pace with state-of-art and continue as a

leader in research and training in Agricultural Statistics and Computer Applications and become indispensable in the NARS and NASS. If the Institute is not geared up to accept these challenges coming in way of opportunities, then it is likely to lose its place as a Centre of Advanced Studies in Research and Education in Agricultural Statistics and Computer Applications. The Institute also foresees threat from peer organizations and private sector. The present trend of the NARS in converting the posts of Statisticians to the Computer Application posts is a serious threat to the discipline. In fact, statisticians with good knowledge of computer application should be the demand of the day. A proper blend of statistician with computer application is desirable for maintaining harmony and meeting challenges of the emerging needs of agricultural research and improving the quality of agricultural research. By way of publications in good refereed international journals would make the Institute known globally.

A summary of threats to the Institute is given below:

- Failing to adequately address the statistical, economic and other related issues in newer emerging areas of agricultural research
- Global competition with peer organizations and private sector
- Growing demand for personnel in the discipline of Computer Applications without a strong base in Agricultural Statistics rather than for personnel in the discipline of Agricultural Statistics with good knowledge of Computer Application
- Indiscriminate use of friendly software for analysis of data by experimenters without consulting statisticians
- Failing to update the research skills of scientists leading to not publishing the research output in refereed journals of repute
- Non-availability of human skilled resource
- Inadequate financial support for updating the skills of scientists
- Non judicious replacement of Agricultural Statistician by Computer Scientists affecting the quality of agriculture research

7. Perspective

Visualizing the changes in global scenarios viz. increasing population pressure, rapid urbanization, decreasing arable land, diversification of agriculture, depleting quality natural resources, growing need for agricultural produce processing and global competition under IPR regime controls, the Institute needs to re-orient itself for addressing related statistical and informatics issues by developing and/or refining newer statistical methodologies for better planning of agricultural research, enhancing the research quality through efficient experimental designing, statistical modeling and evolving efficient sampling strategies etc.

The Institute needs to play a role for futuristic vision visualizing agricultural scenarios using advanced techniques such as data mining, artificial neural network, fuzzy regression etc. For effectively playing a role of such kind, the Institute needs to build the appropriate capacities in the system through human resource development in the relevant areas including bio-informatics, artificial intelligence, data mining etc., adequate international academic exposure, infrastructural development etc. for building a school of excellence in Agricultural Statistics and Computer Applications. Accordingly, following issues have been identified:

- Improving the quality of agricultural research through addressing statistical and economic issues in newer emerging areas

- Addressing planning and policy issues of national importance through statistical research
- Creating information warehouse and model building to synergize Agricultural Research and knowledge society
- Agricultural knowledge management through Information Communication Technology (ICT)
- Development of trained manpower in statistics and ICT through various modes of learning
- Capacity building

8. Issues and Strategies

The issues requiring concerted efforts in research, teaching and training are (a) to improve and widen the base of availability of Agricultural Statistics, (b) efficient planning and designing of experiments on crops, animals and fisheries, (c) to study the intricacies of various biological phenomena related to crops, livestock and fisheries through statistical modeling and simulation studies, and (d) human resource development in Agricultural Statistics, Computer Applications and Computing Science for the ICAR system. The specific issues and strategies are as under:

Issues

- To conduct basic research in Agricultural Statistics for meeting the challenges of agricultural research in newer emerging areas
- To conduct innovative applied research in Agricultural Statistics and Informatics in collaborative mode with Subject Matter Divisions and State Agricultural Universities so that the output can get converted into outcome and knowledge
- To provide service to the Subject Matter Divisions in terms of developing data warehouses and information systems
- To provide support to NARS by developing Knowledge Management Systems
- To develop methodologies for strengthening the National Agricultural Statistical System
- To develop trained manpower in the country through education and training so as to meet the challenges of agricultural research and to make the agricultural research globally competitive

Strategies

To create a school of basic research in Institute to carry research

- To develop efficient designs for agricultural systems research
- To develop efficient designs for food processing experiments, storage experiments, micro-array experiments, computer experiments etc.
- To develop sampling methodologies for small area statistic (Gram Panchayat level) for crop production of principal crops, commercial crops, crop insurance etc.
- To develop statistical models for forecasting crop yield, forewarning outbreak of pests and diseases etc.
- To develop statistical models for forecasting technologies
- To develop models for demand projections of commodities, development and governance for economic prosperity, food security, livelihood security and nutritional security incorporating the unemployment, gender dynamics and ever increasing population pressures

To create a school of applied research to work in collaboration with Subject Matter Divisions and State Agricultural Universities

- To develop indicators of development
- To study statistical, economic and marketing issues related to food chains, import and export of food items etc.

To create a school of Statistical and Informatics Service for meeting the requirements of the Subject Matter Divisions and State Agricultural Universities

- To develop data warehouses on various parameters of agricultural systems, economic parameters, marketing, volumes of import and export, market prices–national and international etc.
- To develop decision support systems for agricultural systems research

To create a school of Teaching and Training for developing trained manpower

- To implement in spirit the concept of visiting faculty at the Institute
- To start e-learning and e-advisory services
- To introduce M.S. and Ph.D. programmes in bio-informatics

These schools will form a super structure over the existing divisional structure of the Institute.

9. Programmes, Projects and Fund Requirements

The main purpose of the Perspective Plan – Vision 2025 manual is to prepare a road map on time scale on the research programmes that the Institute intends to undertake in the coming 5 years, coming 10 years, coming 15 years etc. Research on some problems is already in progress and for other problems, the action would be initiated. The problems have been identified keeping in view the present and the emerging scenario, the recommendations of the QRT, RAC, IRC etc., the suggestions made by the expert group appointed for the preparation of the perspective plan and by discussions with the scientists of the Institute. Broadly, the research problems identified are given below:

- To undertake methodological studies on urgent national problems in Agricultural Statistics like environment studies, natural resources accounting, quality improvement, water bodies etc.
- Application of Remote Sensing, Geographical Information System and Geographical Positioning System, Artificial Neural Network Techniques etc. in modeling for forecasting, early warning, generating quick estimates, preparing atlas, modeling agricultural system etc.
- To undertake research on statistical and related issues in newer emerging areas in agricultural research like molecular biology, biotechnology, bio-diversity, genomics of plant, livestock, fishery, flora and fauna etc.
- To undertake methodological studies for reappraisal and refinement of existing methodologies and development of new methodologies for agricultural system and for impact assessment of various intervention programmes
- Development of Agri-informatics and Agricultural Knowledge Management and Information System for National Agricultural Research System
- Undertaking research in design of experiments, sampling techniques, statistical genetics, forecasting techniques, econometrics, linear and non-linear modeling etc.

- Human Resources Development by training the scientists in newer areas, allowing the scientists to participate in conferences, strengthening exchange visitor programmes at both national and international level
- Establish closer interactions with the subject matter specialists to identify newer research areas and to effectively disseminate research to the stakeholders
- To make the presence of the Institute visibly felt in NARS and NASS and to establish indispensability in these systems for research support
- To provide enabling environment to the scientists

The research on the problems just identified would be carried out through the six programmes that would cut across the boundaries of the Divisions at the Institute. Interdisciplinary research would be encouraged. In all the research programmes timeliness would be the key word. The six research programmes are as follows:

Broad Six Research Programmes

1. Development and analysis of experimental designs for agricultural system research
2. Forecasting and remote sensing techniques and statistical applications of GIS in agricultural systems
3. Development of techniques for planning and execution of surveys and analysis of data including economic problems of current interest
4. Modeling and simulation techniques in biological systems
5. Development of informatics in agricultural research
6. Teaching and training in Agricultural Statistics and Computer Applications

Programme 1: Development and Analysis of Experimental Designs for Agricultural System Research

Thrust Areas

- Development of efficient and robust designs and analytical techniques for farming systems, agro-forestry, horticulture, animal experiments, post harvest processing and biological assays
- Designs and analytical techniques for micro-array experiments, experiments for precision agriculture and sustainable agriculture

Sub Programmes

Basic Research

- Designs and analytical techniques for multi-response experiments useful in food-processing experiments, intercropping and agro-forestry experiments
- Designs for animal experiments, bio-equivalence trials, bioassays and test–treatments – control(s) comparisons
- Fractional factorial designs useful for large number of factors with scarce resources
- Designs and analytical techniques for studying treatment effect in presence of neighbour effects and spatially correlated observations
- Efficient and robust designs for horticultural experiments
- Designs and analytical techniques for micro-array experiments
- Computer aided search of efficient and robust designs for different experimental settings

Applied Research

- Review of designing and analysis of experiments conducted in the past
- Planning, designing and analysis of on-going experiments under various AICRP's and ICAR institutes
- Development of information systems with value addition for agricultural experiments conducted in the NARS

Service

- To provide on-line and off-line advisory services on designing and analysis of agricultural experiments to enhance the quality of agricultural research

Programme 2: Forecasting and Remote Sensing Techniques and Statistical Applications of GIS in Agricultural Systems

Thrust Areas

- Methodologies for spatial surveys, spatial modeling of agricultural system, small area estimation and natural resource management using remote sensing techniques and Geographic Information System
- Models for forecasting and forewarning in agricultural systems

Sub Programmes

Basic Research

- Development of spatial sampling techniques in agriculture and allied areas
- Study of effects of sampling designs, measurement errors, missing observations on forecast estimation/ methodology

Applied Research

- Development of forecast models (macro and micro level) for agricultural systems using linear, non-linear time series procedures
 - Markov chain approach
 - Wavelet analysis
 - Simulation techniques
 - Bayesian techniques
 - Multivariate techniques
 - Growth curve modeling
 - Climatic modeling relevant to agricultural systems
- Application of remotely sensed data and Geographic Information System for improvement of area and production statistics and development of yield models for agricultural systems including fisheries and agroforestry in different agro-climatic regions, particularly in hilly regions
- Use of machine learning techniques such as neural networks, fuzzy logic, neuro-fuzzy systems, rough set theory etc. for forecasting agricultural system
- Development of small area techniques for estimation of parameters from agricultural and allied surveys using remotely sensed data and Geographic Information System

- Development of forewarning systems for outbreak of crop pests and diseases
- Development of appropriate models for forecasting crop (including perennial crops) yield based on weather data, remotely sensed data and farmers appraisal data
- Development of models for forecasting in fisheries, livestock and poultry products
- Comparison and validation of various forecast models

Service

- Dissemination of survey methodologies and forecast models to the stakeholders

Programme 3: Development of Techniques for Planning and Execution of Surveys and Analysis of Data Including Economic Problems of Current Interest

Thrust Areas

- Research for analysis of complex survey data
- Methodologies for estimation of parameters related to agriculture including high value commodities
- Re-appraisal and fine-tuning of existing survey methodologies
- Methodologies for impact assessment of technological interventions
- Models for estimation and projections of economic parameters
- Studies on food and nutritional security and gender specific socio-economic issues

Sub Programmes

Basic Research

- Studies relating to theoretical aspects on analysis of survey data and its applications to agricultural surveys such as regression analysis in survey data, categorical data analysis, variance estimation in complex surveys, multivariate analysis, Bayesian analysis of survey data, model based inference

Applied Research

- Studies on editing and imputation using Artificial Neural Network, non parametric regression etc.
- Studies on enquiry based farmers estimate with a view to improve the present method of crop estimation surveys
- Assessment studies relating to harvest and post-harvest losses, food and nutritional security etc.
- Studies on technical efficiencies in agriculture and impact assessment of technological interventions
- Assessment of feasibility and performance of micro-finance in rural areas
- Marketing costs and margins studies in agricultural/livestock/fisheries sector
- Study on efficiency, equity and sustainability issues of irrigation water
- Estimation and projection of demand and supply of food commodities
- Studies relating to gender dynamics and women employment
- Studies on divergence of estimates of cotton
- Studies for filling data gaps in crops, livestock products, fisheries, horticulture, floriculture and cotton
- Development of suitable methodologies for the measurement of risk and uncertainties in agriculture

- Development of model based small area techniques for estimation of important parameters including crop insurance from agricultural and allied surveys
- Re-appraisal/refinement of sampling methodologies to improve the current methods of crop estimation surveys
- Evaluation studies for measuring the impact of development programmes

Service

- Dissemination of methodologies to the stakeholders

Programme 4: Modeling and Simulation Techniques in Biological Systems

Thrust Areas

- Statistical techniques for plant and animal breeding research including genomics
- Modeling for biological phenomena

Sub Programmes

Basic Research

- Stochastic process modeling through discrete nonlinear time-series approach

Applied Research

- Cluster analysis methodology in plant and animal breeding
- Nonparametric stability measures for simultaneous selection for yield and stability
- Effect of selection of incomplete model specifications on heritability estimates
- Study of rainfall distribution and rainfall insurance

Service

- Dissemination of methodologies to the stakeholders

Programme 5: Development of Informatics in Agricultural Research

Thrust Areas

- Information warehouse and model building for knowledge society
- Informatics for supporting agricultural research
- Knowledge management for technology dissemination
- Statistical software for agricultural research

Sub Programmes

Basic Research

- Development computational methods and algorithms for agricultural research

Applied Research

- Strengthening of INARIS Central Data Warehouse to include databases from other ICAR Institutes
- Developing Competitive Intelligence/Market Intelligence/GIS based decision support systems utilizing data warehouse and data mining facilities created under INARIS, NATP
- Software development for generation of designs for various experimental settings along with randomized layout of the generated design and analysis of the data generated, analysis of sample survey data, animal breeding, plant breeding data analysis; bioinformatics etc.
- Development of web enabled Management Information Systems (PIMSnet for ICAR, NISAGEnet for Agricultural Education, PERMISnet etc.), Expert Systems (extension, wheat etc.) in agricultural research
- Development of Management Information System Network for ICAR for Integrated GIS databases on research, human resources, financial resources and physical resources
- Software development for agricultural research
- Strengthening of AFEIS by extending its coverage and including experimental data relating to perennial crops, fodder crops, post harvest experiments, varietal trials, NILTFE and NISAE
- Software development for generation of designs for various experimental settings along with randomized layout of the generated design and analysis of the data generated, analysis of sample survey data, analysis of animal breeding and plant breeding data and bioinformatics
- Refinement/upgradation/maintenance of information systems, decision support systems, expert systems, internet solutions, web services, network infrastructure, software for data analysis keeping in view the emerging technologies and user needs

Service

- Consultancy for data analysis and related IT services

Programme 6: Teaching and Training in Agricultural Statistics and Computer Applications

Thrust Areas

- Post-Graduate degree programmes in Agricultural Statistics and Computer Applications
- Customized and ad-hoc national and international training programmes
- In-service certificate courses
- On-line training and e-learning programmes

Sub Programmes

- Introducing on-line training and e-learning programmes
- Introducing Ph.D. programme in Agri-Informatics
- Strengthening the Post-Graduate teaching programmes in Agricultural Statistics and Computer Applications
- P.G. syllabi would be revised incorporating the research conducted at the Institute and elsewhere and new courses would be introduced from time to time to meet the research requirements
- Organizing in-service, customized and sponsored training programmes/courses in Agricultural Statistics and Computer Applications for national and international organizations
- Preparing text books and teaching material both in printed as well as in electronic media form

Time Frame

The perspective plan, programme wise, giving thrust areas and action plan on time scale is given in the sequel.

Programme 1: Development and Analysis of Experimental Designs for Agricultural Systems Research

Thrust Areas

- Development of efficient and robust designs and analytical techniques for cropping and farming systems, agro-forestry, horticulture, food processing, animal experiments, biological assays and experiments on post harvest storage behaviour of perishable commodities like fruits and vegetables
- Computer aided search of efficient and robust designs for different experimental settings
- Designs and analytical techniques for micro-array experiments, computer experiments, experiments for precision agriculture and sustainable agriculture

Sub Programmes	Phases (Duration in Years)			
	I (5)	II (10)	III (15)	IV (20)
● Designs and analytical techniques for multi-response experiments useful in food-processing experiments, intercropping and agro-forestry experiments				
● Designs for animal experiments, bio-equivalence trials, bioassays and test for treatments – control(s) comparisons				
● Fractional factorial designs useful for large number of factors with scarce resources				
● Designs and analytical techniques for studying treatment effect in presence of neighbour effects				
● Designs and analytical techniques for studying spatially correlated observations				
● Studies relating to designing aspects of quality improvement programmes, cropping and farming systems research, precision farming and sustainable agriculture		//////		
● Bayesian approach to the analysis of experimental data		//////		
● To prepare a handbook on designs relating to agricultural experiments		//////		
● Design and analysis of mixture experiments useful in food processing, split application of fertilizers etc.		//////		
● Designs and analytical techniques for micro-array experiments		//////		
● Computer aided search of efficient and robust designs for different experimental settings		//////		
● Development of expert system on design of experiments for the benefit of agricultural research personnel		//////	//////	

(contd...)

Sub Programmes	Phases (Duration in Years)			
	I (5)	II (10)	III (15)	IV (20)
● To provide on-line and off-line advisory services on designing and analysis of agricultural experiments				
● Efficient and robust designs for horticultural experiments				
● Review of designing and analysis of experiments conducted in the past				
● Planning, designing and analysis of on-going experiments under various AICRP's and ICAR institutes				
● Development of information systems with value-addition for agricultural experiments conducted in the NARS				
● To strengthen the advisory services in design of experiments to enhance the quality of agricultural research				

Programme 2: Forecasting and Remote Sensing Techniques and Statistical Application of GIS in Agricultural Systems

Thrust Areas

- Application of remote sensing techniques and Geographic Information System in spatial surveys, spatial modeling of agricultural system including natural resource management etc.
- Development of forecast models for agricultural systems viz. agricultural and horticultural crops, livestock population, dairy and poultry products, fish production, prices, exports etc.
- Development of forewarning systems for crop pests and diseases
- Statistical procedures for quick assessment of disaster

Sub Programmes	Phases (Duration in Years)			
	I (5)	II (10)	III (15)	IV (20)
● Development of spatial sampling techniques in agriculture and allied areas				
● Application of remotely sensed data and Geographic Information System for improvement of area and production statistics and development of yield models for agricultural systems including fisheries and agroforestry in different agro-climatic regions, particularly in hilly regions				
● Development of forecast models (macro and micro level) for agricultural systems using linear and non-linear time series procedures				
● Development of forecast models (macro and micro level) using Markov chain approach				
● Development of forecast models (macro and micro level) using Wavelet analysis of time series data				

(contd...)

Sub Programmes	Phases (Duration in Years)			
	I (5)	II (10)	III (15)	IV (20)
● Development of forecast models (macro and micro level) using simulation techniques, Bayesian techniques, multivariate techniques, growth curve modeling etc.		//////		
● Climatic modeling relevant to agricultural systems		//////		
● Use of machine learning techniques such as neural networks, fuzzy logic, neuro-fuzzy systems, rough set theory etc. for forecasting agricultural system		//////		
● Study of effects of sampling designs, measurement errors, missing observations on forecast estimation/methodology		//////		
● Development of small area techniques for estimation of parameters from agricultural and allied surveys using remotely sensed data and Geographic Information System		//////		
● To prepare a manual describing various methodologies developed for forecasting and forewarning		//////	//////	
● To study statistical and economic issues in disaster management			//////	
● Development of methodologies for area and production estimation of horticultural and minor crops				
● Development of RS & GIS based methodology for generation of agricultural intelligence				
● Development of forecast models for agricultural systems using newer techniques like non-parametric regression, re-sampling techniques, multivariate adaptive regression splines (MARS), statistical learning theory		//////	//////	
● Assessment of crop losses due to floods, droughts, weeds, pests, diseases etc.		//////	//////	
● Development of GIS databases at small area level		//////	//////	
● Application of remotely sensed data and Geographic Information System in Environmental Statistics		//////	//////	
● Studies on the use of Spatial Statistics and Geo-Statistics to improve the method of crop estimation surveys		//////	//////	
● Studies relating to natural resource accounting and management using remote sensing and Geographic Information System		//////	//////	
● Development of forewarning systems for outbreak of crop pests and diseases		//////	//////	
● Development of appropriate models for forecasting crop (including perennial crops) yield based on weather data, remotely sensed data and farmers appraisal data		//////	//////	
● Development of models for forecasting in fisheries, livestock and poultry products		//////	//////	
● Comparison and validation of various forecast models		//////	//////	

Programme 3: Development of Techniques for Planning and Analysis of Survey Data Including Economic Problems of Current Interest

Thrust Areas

- To undertake methodological studies on urgent national problems in Agricultural Statistics like environment studies, natural resources accounting, quality improvement, water bodies etc.
- To undertake research for development of methodologies for estimation of parameters related to agriculture and allied fields, in general, and minor and high value crops and commodities, in particular
- To undertake research for analysis of complex survey data using recently developed sampling techniques
- To provide methodological support to strengthen National Agricultural Statistical System
- To develop methodologies for impact assessment of technological interventions and economic policies
- To develop econometric models for studying technical, allocative and economic efficiencies, technological dualism etc.
- To develop models for estimation and projections of production, demand, supply, market integration, structure and channels, marketing risk and risk aversion strategies of agricultural, horticultural, livestock commodities and processed products
- To undertake studies on food and nutritional security and gender specific socio-economic issues

Sub Programmes	Phases (Duration in Years)			
	I (5)	II (10)	III (15)	IV (20)
● To undertake studies on enquiry based farmers estimate with a view to improve the present method of crop estimation surveys				
● To undertake studies relating to farm mechanization and cost of cultivation etc.				
● Studies relating to theoretical aspects on analysis of survey data and its applications to agricultural surveys such as regression analysis in survey data, categorical data analysis, variance estimation in complex surveys, multivariate analysis, Bayesian analysis of survey data				
● To undertake assessment studies relating to harvest and post-harvest losses, food and nutritional security etc.				
● To undertake studies on editing and imputation using Artificial Neural Network, non parametric regression etc.				
● To undertake studies on technological dualism, technical efficiencies in agriculture and impact assessment of technological interventions				
● Assessment of feasibility and performance of micro-finance in rural areas				
● Marketing costs and margins studies in agricultural/livestock/ fisheries sector				
● Study on efficiency, equity and sustainability issues of irrigation water				
(contd...)				

Indian Agricultural Statistics Research Institute

Sub Programmes	Phases (Duration in Years)			
	I (5)	II (10)	III (15)	IV (20)
● Estimation and projection of demand and supply of food commodities				
● Studies relating to gender dynamics and women employment				
● Studies relating to Non-linear modeling				
● Studies on divergence of estimates of cotton		////		
● To undertake methodological studies as per National Statistical Commission 2001 recommendations for filling data gaps in crops, livestock products, fisheries, horticulture, floriculture and cotton		////		
● Studies relating to cost of cultivation		////		
● Efficiency, equity, sustainability and policy issues related to irrigation water		////		
● Modeling risk management strategies related to agriculture		////		
● Farm and non-farm employment in rural areas		////		
● Issues related to farm finance, micro-finance with farm subsidies, farm efficiencies and related issues		////		
● Gender related socio-economic issues		////		
● Studies on assessment and control of various non-sampling errors such as coverage errors, response and non-response errors as well as errors due to sensitive questions		////		
● Studies on new methods of editing and imputation		////		
● Econometric models to solve problems related to marketing of agricultural commodities, market intelligence etc.		////	////	
● Estimation of demand and supply of food commodities in India		////	////	
● Status, problems and prospects of agricultural finance in India		////	////	
● Development of suitable methodologies for the measurement of risk and uncertainties in agriculture		////	////	
● Studies relating to demand for feed and fodder requirements			////	
● Impact of trade liberalization and other economic policies on Indian agriculture			////	
● Studies relating to efficiency in agricultural production			////	
● Studies on estimation of high value minor crops			////	
● Studies relating to estimation of sensitive parameters pertaining to farm sector, public-private interfaces in agriculture			////	
● Studies relating to Natural Resource Management			////	
● Studies relating to efficiency in agricultural production and impact assessment of technologies			////	

(contd...)

Sub Programmes	Phases (Duration in Years)			
	I (5)	II (10)	III (15)	IV (20)
● Marketing issues of agricultural commodities locally and globally				
● To undertake basic research in new emerging areas like survivor analysis, environment etc. in sample surveys				
● Reappraisal of sampling methodologies				
● Studies relating to marketable surplus or post harvest losses of various commodities				
● Model based estimation of various parameters of interests in agricultural surveys				
● Development of model based small area techniques for estimation of important parameters including crop insurance from agricultural and allied surveys				
● Re-appraisal/refinement of sampling methodologies to improve the current methods of crop estimation surveys				
● Evaluation studies for measuring the impact of development programmes				

Programme 4: Statistical Investigations in Genetics, Biotechnology and Related Areas

Thrust Areas

- To develop advanced statistical techniques applied to plant and animal breeding research
- To undertake studies on statistical issues in genomics for plants, livestock and fisheries
- Statistical modeling for biological phenomena

Sub Programmes	Phases (Duration in Years)			
	I (5)	II (10)	III (15)	IV (20)
● Cluster analysis methodology in plant and animal breeding				
● Nonparametric stability measures for simultaneous selection for yield and stability				
● Effect of selection of incomplete model specifications on heritability estimates				
● Study of rainfall distribution and rainfall insurance				
● Stochastic process modeling through discrete nonlinear time-series approach				
● Stochastic difference and differential equations modeling				
● Development of techniques for improved estimation of genetic parameters				
● G×E interaction and varietal selection for both high yield and stability in multi-environmental data				
				(contd...)

Sub Programmes	Phases (Duration in Years)			
	I (5)	II (10)	III (15)	IV (20)
● Development of expert system for animal sciences				
● Investigations on statistical issues in bioinformatics				
● Multivariate statistical techniques in agricultural biotechnology				
● Statistical modeling through structural risk minimization and support vector machines etc.				
● Statistical techniques for genetic diversity in crop and animal germplasm				
● Studies on QTL by environment interaction in plant and animal breeding				
● Studies on statistical issues in molecular embryo transfer technology in animals				
● Developing network among plant/animal biotechnologists engaged in conducting research under NARS				
● Development of models based on functional data analysis				

Programme 5: Development of Informatics in Agricultural Research

Thrust Areas

- To strengthen the activities of informatics for supporting research in Agricultural Statistics and allied fields in general and the research programmes of the Institute in particular
- To strengthen the activities of Informatics and Data Warehouse for agricultural research in National Agricultural Research System and to meet information needs for becoming eyes and ears of the ICAR

Sub Programmes	Phases (Duration in Years)			
	I (5)	II (10)	III (15)	IV (20)
● Strengthening of INARIS Central Data Warehouse to include databases from other ICAR Institutes				
● Developing Competitive Intelligence/Market Intelligence/GIS based decision support systems utilizing data warehouse and data mining facilities created under INARIS, NATP				
● Software development for generation of designs for various experimental settings along with randomized layout of the generated design and analysis of the data generated, analysis of sample survey data, animal breeding, plant breeding data analysis; bioinformatics etc.				
● Development of web enabled Management Information Systems (PIMSnet for ICAR, NISAGEnet for Agricultural Education, PERMISnet etc.), Expert Systems (extension, wheat etc.), in agricultural research				

(contd...)

Sub Programmes	Phases (Duration in Years)			
	I (5)	II (10)	III (15)	IV (20)
● Development of Management Information System Network for ICAR for Integrated GIS databases on research, human resources, financial resources and physical resources				
● Development of Integrated System for Knowledge Management in agricultural research		////		
● Setting up of a centre of e-learning that would encompass research and education in Agricultural Statistics and allied subjects, advisory services for agricultural research and education		////		
● Strengthening of Integrated System for Knowledge Management in agricultural research for dissemination of knowledge to stakeholders		////	////	
● Fusion of technologies for sustainable agricultural system			////	
● Software development for agricultural research		////	////	
● Strengthening of AFEIS by extending its coverage and including experimental data relating to perennial crops, fodder crops, post harvest experiments, varietal trials; NILTFE and NISAE		////	////	
● Software development for generation of designs for various experimental settings along with randomized layout of the generated design and analysis of the data generated, analysis of sample survey data, analysis of animal breeding and plant breeding data, bioinformatics		////	////	
● Refinement/upgradation/maintenance of information systems, decision support systems, expert systems, internet solutions, web services, network infrastructure, software for data analysis keeping in view the emerging technologies and user needs		////	////	

Programme 6: Teaching and Training in Agricultural Statistics and Computer Applications

Sub Programmes	Phases (Duration in Years)			
	I (5)	II (10)	III (15)	IV (20)
● To introduce M.Sc. programme in emerging Information Communication Technology and Bioinformatics		////	////	
● To introduce On-line training and e-learning programmes		////	////	
● To introduce Ph.D. programme in Computer Science/Computer Applications		////	////	
● To strengthen the Post-Graduate teaching programmes in Agricultural Statistics and Computer Applications		////	////	
● The P.G. syllabi would be revised incorporating the research conducted at the Institute and elsewhere and new courses would be introduced from time to time to meet the research requirements		////	////	
				(contd...)

Sub Programmes	Phases (Duration in Years)			
	I (5)	II (10)	III (15)	IV (20)
<ul style="list-style-type: none"> To organize in-service, customized and sponsored training programmes/courses in Agricultural Statistics and Computer Applications for national and international organizations 				
<ul style="list-style-type: none"> To prepare text books and teaching material both in printed as well as in electronic media form 				

10. Linkages (Co-ordination and Executive Arrangements etc.)

The Institute has to play the role of a leader in the National Agricultural Research System (NARS) and the National Agricultural Statistics System (NASS) in the country and has to make its presence visibly felt and establish its indispensability. This could be possible by establishing closer interactions with the subject matter specialists to identify newer research areas and to effectively disseminate research to the stakeholders. Interdisciplinary research would be encouraged. Advisory services would be strengthened. The Institute would also lead in Agri-informatics.

To meet the ends just described, the Institute would make concerted efforts to establish linkages with ICAR Institutes, Project Directors, National Research Centres, All India Coordinated Research Projects, Project Director of Cropping Systems Research, State Agricultural Universities etc. The Institute would also develop linkages with Consultative Groups on Indian Agricultural Research Centres, other research organizations and peer institutions like Indian Statistical Institute. It would also develop linkages with Department of Statistics, Department of Computer Sciences, Informatics in Universities, particularly Agricultural Universities, outside the country. For human resource capacity building, Visitors Exchange Programme would be prepared. A calendar of training programme for the scientists of the Institute would be prepared on time scale. The calendar would indicate clearly the topics along with the campus where the training would be received and the duration of the training. These training programmes would be arranged in India and abroad.

The Institute would also make concerted efforts in establishing linkages with state departments of agriculture, animal husbandry, fisheries, horticulture etc. One way of establishing these linkages would be through the in-service and customized training programmes that are conducted by the Institute. The National Agricultural Statisticians Conference organized by the Institute in different states is another serious attempt in establishing linkages with states and understanding their problems that need attention.

In order to fulfil the mandate, the Institute would also establish linkages with Central Statistical Organization, National Sample Survey Organization, Department of Economics and Statistics, Ministry of Agriculture etc. For the research programmes related to forecasting and early warning systems, the Institute would develop linkages and co-ordination with Space Application Centres, Remote Sensing Application Centres, Meteorology Department, FASAL etc. in India and abroad.

The Institute would also establish linkages and Co-ordination with Agriculture Departments outside the country, particularly the Afro-Asian and Asia-Pacific countries, for conducting sponsored research and organizing training programmes. This would also help in generating resources for the Institute.

The Institute would also build linkages with the following institutes and research organizations:

Institutes and Organizations with whom collaboration would be made

- | | |
|---|--|
| <ul style="list-style-type: none"> ● National Agricultural Research System ● National Sample Survey Organization ● Central Statistical Organization ● Directorate of Economics and Statistics ● Ministry of Agriculture ● State Governments ● Coconut Development Board ● Universities and Organizations outside country dealing with Space Application, Remote Sensing, Geographical Information System, Artificial Neural Networks etc. ● Departments of Agricultural Statistics, Computer Science, Informatics etc. outside the country | <ul style="list-style-type: none"> ● National Remote Sensing Agency ● Space Application Centres ● Indian Space Research Organization ● Indian Meteorology Department ● National Informatics Centre ● Non-Government Organizations ● FASAL ● Departments of Agriculture in Afro-Asian and Asia-Pacific countries ● Any other user or sponsoring organization |
|---|--|

11. Critical Inputs

11.1 Funds

Critical inputs are needed for addressing issues in emerging areas such as bio-informatics, geo-informatics, artificial intelligence, data mining etc. Growth of funds for this purpose is estimated to be around 25% per annum in the first decade and 15% per annum thereafter.

11.2 Personnel

To address emerging issues, the vacant positions need to be filled up in the first instance and subsequently annual growth rate of specialized personnel be maintained at 5%.

11.3 Human Resource Development

In order to meet the challenges of research in newer emerging areas as identified, it is essential that the research skills of the scientists be updated in these areas from time to time. Accordingly, some areas of training are identified programme wise and are listed below. The participation in such training programmes may be at both National and International level. Accordingly, the provision would have to be made in the budget to implement this activity.

Programme 1: Development and Analysis of Experimental Designs for Agricultural Systems Research

- Design of experiments and analysis of data for sustainable agriculture

- Design and analysis of micro-array experiments
- Design and analysis of multi-response experiments
- Design and analysis of data for precision agriculture
- Design and analysis of agroforestry experiments
- Computer aided designs
- Bayesian design of experiments
- Development of expert systems for designed experiments
- Graph theory vis-à-vis design of experiments
- Design and analysis of mixture experiments
- Statistical techniques in the biotechnology
- Design for computer experiments

Programme 2: Forecasting and Remote Sensing Techniques and Statistical Application of GIS in Agricultural Systems

- Forecasting crop production using remote sensing and GIS application
- Forecasting system for pests and diseases using fuzzy regression, non-parametric regression, rough set theory, ANN, Artificial Intelligence (AI)
- Non-linear time series modeling and forecasting for agricultural products
- Non-linear stochastic modeling
- Application of remote sensing techniques and geographic information system in spatial surveys
- Application of remote sensing techniques and geographic information system in spatial modeling of agricultural system
- Application of remote sensing techniques and geographic information system in small area estimation
- Application of remote sensing techniques and geographic information system in natural resource management
- Application of remote sensing techniques and geographic information system in agroforestry
- Use of spatial statistics in crop estimation surveys
- Geo-informatics in agricultural surveys

Programme 3: Development of Techniques for Planning and Analysis of Survey Data Including Economic Problems of Current Interest

- Large scale sample surveys and analysis of complex surveys
- Assessment of harvest/production and post harvest/post production surveys
- Computer intensive techniques in sample surveys
- Small area estimation
- Recent advances in data editing and imputation
- Sampling techniques in natural resource management
- Methodological issues related to valuation of natural resources, its degradation, depletion etc. in view of sustainability concept
- Advanced analytical techniques relevant to the study of domestic and international trade under WTO regime with reference to Indian agriculture

- Application of econometric tools for measurements of risk and uncertainties pertaining to agricultural production, insurance and investments in modern agriculture
- Advanced econometric tools for measurement of technical efficiencies, equilibrium and policy analysis

Programme 4: Statistical Investigations in Genetics, Biotechnology and Related Areas

- Statistical techniques in biotechnology
- Nonlinear time series modeling
- Bioinformatics
- Applications of newer statistical modeling techniques like fuzzy and nonparametric regression
- Recent advances in statistical genetics
- Modeling for valuation of degradation of environment
- Modeling in agriculture through stochastic difference and differential equations

Programme 5: Development of Informatics in Agricultural Research

- Knowledge management
- Emerging web and mobile technologies
- Emerging network technologies
- Information communication technology in precision farming
- Artificial intelligence
- Development of expert systems in agriculture
- Data warehousing and data mining
- Multimedia applications in research and education
- Bioinformatics

12. Risk Analysis

In the realization of visualized perspective, the availability of the inputs such as trained manpower, infrastructure and funds play a vital role. In the situations when all the resources are made available, the success rate of the visualized perspective may be around 90% because of inherent uncertainties. However, if there are constraints on the resources, then the success rate may decline substantially i.e. if x% amount of resources are not available, then success rate may decrease by some multiple of x% or more. Further, the future of all the programmes may depend upon the policy of the government and the dictates of ICAR. The flexibility in the programmes and corrective actions from time to time will ensure minimal risk and maximum productive output.

13. Review

The progress of the research projects of the Institute are monitored continuously at various forums such as Divisional Research Committees (DRC), Institute Research Committee (IRC), Senior Officers Meetings (SOM) etc. The findings of these projects are published in the form of the project reports and the research papers in the journals of repute. The dissemination of the achievements of these projects is also done through regular seminars, institute's newsletters, annual reports and pamphlets etc. The comprehensive

review of the projects in terms of financial, physical and academic aspects is also done through a well designed monitoring proforma on a half yearly basis and through RPFs.

Before the initiation, the research projects are put to various screening and evaluation procedures. Firstly, the presentation is made by the Principal Investigator at the Divisional Research Committee level. At this stage, it is thoroughly reviewed for further improvement. After incorporation of all the suggestions, the same is again presented at Institute's level in the form of open seminar. After these presentations, the project proposal is sent to three external referees for their inputs and valuable suggestions. Finally, Chairman of the IRC takes final decision about the start of the project.

14. Resource Generation

- The Institute will generate resources through training programmes in Agricultural Statistics and Computer Applications, at national and international level, for which the Institute will charge a fee.
- Consultancy and advisory work from government, non-government, private agencies within the country and agencies like FAO, International Bank for Rural Development (IBRD), IFPRI and UNDP for which suitable revenue will be charged.
- Sponsored research for which sponsoring authorities will bear the expenses.
- Scientists will be allowed to take up research at behest of Institutions like CSIR, DST, DOE on payment basis.
- Publications of technical reports, bulletins, manuals, handbooks etc. incorporating the results of research carried out at the Institute which will be priced and will provide some revenue to the Institute.
- On request of sponsor agencies, the Institute may undertake to write manuals on specialized topics of current interest. This may generate resources to the extent of Institute.

15. Outputs

- Efficient designs and analytical techniques for various experimental situations can be available for agricultural research.
- Indigenous softwares and information system on experiments may be available for the use of research workers and planners.
- Appropriate methodologies for estimation of different parameters of interest in agriculture and allied fields may be available for use.
- Methodologies for forecasting various aspects of agricultural systems such as output of various crops, fisheries, livestock and poultry, forewarning systems for pests and diseases and assessment of losses due to pests, diseases, droughts and floods, climate in relation to agriculture.
- Knowledge management system for dissemination through web from a common platform.
- Decision support system for agricultural research and management.
- Expert systems in agriculture.
- ICT based system for dissemination of agricultural technologies to the stakeholders.
- MIS for enterprise resource management.

16. Outcome

- The designs and analytical techniques developed can help agricultural scientists in drawing valid and precise conclusions out of their experiments for recommendations.
- Indigenously developed softwares can help in designing and analysis of experiments and information system may help in planning the future research programmes.
- Newer methodology may help in precise assessing the breeding worth of individuals for genetic improvement in plant and animal breeding programmes.
- Sample survey methodologies developed may help in obtaining the precise estimates of parameters of interest needed for policy planning.
- The forecasting methodologies developed can help planners, administrators, traders, farmers in taking various policy decisions well in advance.
- Subject wise scientific and technical documentation of information available in public domains including web, news articles, reports etc. and reduction of scientific knowledge gap of the researchers in NARS.
- Monitoring agricultural status of the country and issuing suitable advisory note to the managers to increase agricultural production in a region.
- Dissemination of expert knowledge to extension workers and farmers to cope up with uncertainties in agriculture and better decision-making.
- Web base system for dissemination of agricultural technologies to extension workers/farmers for reduction of technological yield gaps.

Concluding Remarks

As statistics plays a key role in planning for agricultural development so in nutshell, the research carried out at this Institute will help in enhancing total farm production, productivity, resource-use efficiency and capital formation in agriculture.

