भाकृअनुप
ICAR

Vision 2030

INDIAN AGRICULTURAL STATISTICS RESEARCH INSTITUTE
(INDIAN COUNCIL OF AGRICULTURAL RESEARCH)
LIBRARY AVENUE, PUSA, NEW DELHI – 110 012
www.iasri.res.in

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डा. एस. अय्यप्पन
सचिव एवं महानिदेशक
Dr. S. AYYAPPAN
SECRETARY & DIRECTOR GENERAL

भारत सरकार
कृषि अनुसंधान और शिक्षा विभाग एवं
भारतीय कृषि अनुसंधान परिषद
कृषि मंत्रालय, कृषि भवन, नई दिल्ली 110 114

GOVERNMENT OF INDIA
DEPARTMENT OF AGRICULTURAL RESEARCH & EDUCATION
AND
INDIAN COUNCIL OF AGRICULTURAL RESEARCH
MINISTRY OF AGRICULTURE, KRISHI BHAVAN, NEW DELHI 110 114
Tel.: 23382629; 23386711 Fax: 91-11-23384773
E-mail: dg.icar@nic.in

FOREWORD

The diverse challenges and constraints as growing populations, increasing food, feed and fodder needs, natural resource degradation, climate change, new parasites, slow growth in farm income and new global trade regulations demand a paradigm shift in formulating and implementing the agricultural research programmes. The emerging scenario necessitates the institutions of ICAR to have perspective vision which could be translated through proactive, novel and innovative research approach based on cutting edge science. In this endeavour, all of the institutions of ICAR, have revised and prepared respective Vision-2030 documents highlighting the issues and strategies relevant for the next twenty years.

Indian Agricultural Statistics Research Institute (IASRI), New Delhi is committed to undertake research, education and training in the discipline of Agricultural Statistics, Computer Applications and Bio-informatics to help provide the needed human resources to address emerging challenges in agricultural research.

It is expected that the analytical approach and forward looking concepts presented in the '*Vision 2030*' document will prove useful for the researchers, policymakers, and stakeholders to address the future challenges for growth and development of the agricultural sector and ensure food and income security with a human touch.

Dated the 8th July, 2011
New Delhi

(S. Ayyappan)

Preface

Indian Agricultural Statistics Research Institute (IASRI) is a pioneer Institute in research, teaching and training in Agricultural Statistics and Computer Applications. The Insitute has used the power of Statistics, as a science, blended judiciously with Information Communication Technology and has contributed significantly in improving the quality of Agricultural Research. 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 Information Technologies so as to meet the challenges of agricultural research in newer emerging areas.

Vision 2020 was the very first systematic effort to formulate its strategies followed by Perspective Plan 2025 after five years to address the changes that had taken place. IASRI Vision 2030 presents the strategies planned by the Institute to capitalise on the opportunities and to convert weaknesses into opportunities and revolves around the strategies to answer the question "How can research in Statistics and Informatics, including bioinformatics, help in improving the status of agricultural systems research so as to enable to draw statistically valid, appropriate and replicable inferences that help in making agricultural research globally competitive, visible and acceptable?"

I would like to express my gratitude to Hon'ble Secretary, Department of Agricultural Research & Education (DARE) and Director-General, Indian Council of Agricultural Research (ICAR) for his invaluable guidance in preparing *IASRI Vision 2030*. I am grateful to Deputy Director General (Engineering) for his keen interest and thankful for his valuable suggestions in finalising this Document.

I appreciate the efforts of all Heads of Divisions of the Institute for their whole-hearted support and cooperation in preparing this Document. I wish to express my sincere thanks to all my colleagues in Research Coordination and Management Unit and Prioritization Monitoring and Evaluation Cell of the Institute in bringing out this Document.

I am hopeful that the readers will find it quite informative and useful. I welcome useful suggestions and comments that would be helpful in undertaking need based research in Agricultural Statistics and Informatics.

VKBhatia

01 July 2011
New Delhi

(VK Bhatia)
Director
IASRI, New Delhi

Preamble

Agricultural research is a very complex phenomenon and the elements of uncertainty are most prevalent. Because of the large variability inherent in biological and agricultural data, knowledge of statistical sciences and computer application are necessary for their understanding, interpretation and drawing valid inferences.

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 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.

The Council has recently decided that all the Institutes should revise their Perspective Plan in the form of *Vision 2030*. The Vision document brings out the achievements made, the gaps in research that could not be undertaken and clearly spells out the research programmes to be undertaken in the coming years till the year 2030. The programmes have been identified keeping in mind the newer developments taking place, particularly the technological and informatics developments, both at National and International level. Road map for research programmes need to be carried out in the specified time scale and support required for meeting these challenges are clearly spelt out. Accordingly, the Institute has done an exercise to prepare the *Vision 2030* 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 outlined. Based on certain issues and strategies, research programmes of the Institute have been identified. The main emphasis has been on the statistical issues of national interest in various emerging areas of biotechnology, bioinformatics, biodiversity, genomics, market intelligence, risk analysis, natural resources accounting and information communication technology. With a proper review, reporting and evaluation of these programmes, it is fervently hoped that the Institute would be able to fulfil its mandate, partly generate resources for its research programmes and remain a leader in research and education in Agricultural Statistics and Informatics and exhibit its indispensability in National Agricultural Research System and National Agricultural Statistics System.

In an effort to continue the glorious traditions of the Institute, efforts to maintain a judicious balance of basic and innovative applied research and also to expand the horizon of the teaching and training programmes have been envisaged. The Institute would delve on developing roadmaps on combating the major concerns of depleting natural resources, climate change, uncertainties of economy and marketing by addressing the statistical issues involved in it. This would be beneficial in building a bridge between the statisticians, informatics experts and the farm scientists so as to bring prosperity to the farmers. The Institute would undertake research in newer emerging areas with fresh vigor and zeal.

Contents

Growth and Achievements

Growth

Indian Agricultural Statistics Research Institute (IASRI) is a premier Institute of the Indian Council of Agricultural Research (ICAR) with glorious tradition of carrying out research, teaching and training in the areas of *Agricultural Statistics* and *Informatics*. Recognizing the importance of research and education in Agricultural Statistics way back in 1930, 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. The activities of the Section increased rapidly with the appointment of Dr. PV Sukhatme as Statistician to the Council in 1940 and studies were initiated for developing objective and reliable methods for collecting yield statistics of principal food crops. The efficiency and practicability of these methods was demonstrated in different States for estimating crop yield. As a result, in the course of a few years, the method was extended practically to the entire country to cover all principal food and non-food crops. Research in sampling theory and training of field staff and statistical staff were the activities initiated in this period resulting in the re-organization of the Statistical Section into a *Statistical Branch* in 1945 with appropriate 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 International recognition as a centre for research and training in the field of Agricultural Statistics. During 1952 on the recommendations of two FAO experts, Dr. Frank Yates and Dr. DJ Finney, who visited the Council on the invitation of the Government of India, activities of the Statistical Wing were further expanded and diversified. Subsequently, in recognition of its important role as a training and research institution, the Statistical Wing was re-designated as the *Institute of Agricultural Research Statistics* (IARS) on 02 July 1959. In April 1970, the Institute was declared as a full-fledged Institute in the ICAR system and is since then headed by a Director. 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.

Basic purpose of creating a full-fledged Institute called Indian Agricultural Statistics Research Institute, was to conduct Basic Research in Agricultural Statistics

- to impart Education and Training in the disciplines of Agricultural Statistics and Computer Applications
- to develop Trained Manpower in the country in the disciplines of Agricultural Statistics and Computer Applications for meeting the challenges of Agricultural Research in the newer emerging areas

The research, teaching and training are conducted through six Divisions namely

1. Design of Experiments
2. Biometrics and Statistical Modelling
3. Forecasting and Econometrics Techniques
4. Sample Surveys
5. Computer Applications
6. Centre for Agricultural Bio-informatics [CABin]

Research Achievements and Impact

The Institute has made some outstanding and useful contributions to the research in Agricultural Statistics and Informatics in the fields like development of efficient design of experiments; development of new statistical techniques; sample surveys; forecasting techniques; statistical modelling; statistical genetics; econometrics; novel applications in agricultural sciences; computer applications in agriculture; development of information systems and statistical packages and trained human resource. IASRI has conducted basic and original research on many topics of interest and has published number of papers in national and international journals of repute. Research and education is used in improving the quality and meeting the challenges of agricultural research in newer emerging areas. The Institute has been providing and continues to provide support to the NARS by way of analyzing voluminous data using advanced and appropriate analytical techniques. IASRI has also been very actively pursuing advisory services on the designs to be adopted in the agricultural experiments; analysis of data generated and interpretation of results; evaluation of schemes sponsored by the ICAR for its statistical content and appropriateness; advocating newer, efficient and sophisticated analytical techniques for statistical data analysis to agricultural researchers in their research endeavours; involvement in many AICRPs that has enabled the Institute to enrich the quality of agricultural research in the NARS.

Design of Experiments

For generation of agricultural technologies (such as varieties, package of practices, type and dose of inputs such as fertilizers, pesticides, resource conservation technologies, animal breeds, animal feeds etc.) experimentation is an essential component. The data generated through proper designed experiments, the analysis of data and interpretation of results obtained create knowledge in agricultural sciences. Since its inception, the Institute has made many notable contributions in both basic research and innovative applications of the theory of statistical designs and analysis of experimental data.

Some of the areas that brought the Institute and the discipline on the world map are:

(i) Designs for single factor experiments which include variance balanced, efficiency balanced, and partially efficiency balanced designs; designs for tests versus control(s) comparisons; designs for multi-response experiments; crossover designs; designs with nested structures; neighbour balanced designs; optimality and robustness aspects of designs; (ii) Designs for multi-factor experiments which include confounded designs for symmetrical and asymmetrical factorials; block designs with factorial structure; response surface designs, mixture experiments for single and multi-factor experiments; Orthogonal main effect plans; orthogonal arrays; Supersaturated designs; (iii) Designs for bioassays; (iv) Designs for microarray experiments; (v) Diagnostics in designed field experiments; (vi) Computer aided construction of efficient designs for various experimental settings; etc.

The scientists of the Institute participate actively in planning and designing of experiments in the NARS and have also involved themselves in the analysis of experimental data. Basic research work carried out on balanced incomplete block designs, partially balanced incomplete block designs, group divisible designs, α-designs, reinforced α-designs, square and rectangular designs, nested designs, augmented designs, extended group divisible designs, response surface designs, experiments with mixtures etc. have been adopted widely by the experimenters in NARS. The application of α-designs has improved the precision of treatment comparisons in crop improvement programmes of rapeseed and mustard, sorghum, etc. Extended group divisible designs have been widely used in crop sequence experiments in NARS. Designs for factorial experiments such as response surface designs and experiments with mixtures have been used for food processing and value addition experiments; soil test crop response correlation experiments; experiments with fixed quantity of inputs and ready to serve fruit beverage experiments, etc. The analytical techniques based on mixed-

effects models and biplot developed for the analysis of data generated from Farmers Participatory Trials for resource conservation agriculture have been used by Rice-Wheat consortium for Indo-Gangetic plains for drawing statistically valid conclusions. Institute has developed linkages with the CGIAR organizations such as CIMMYT, IRRI and ICARDA.

The analytical techniques for estimating/projecting the energy requirement in the agricultural sector has been exploited for the analysis of countrywide data. 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 works in close collaboration with NARS organizations and many projects are being run in collaboration with All India Co-ordinated Research Projects and ICAR Institutes. The status of experimentation is now changing and with the support provided in terms of suggesting efficient designs and analyzing the data using modern complicated statistical tools, the research publications of the agricultural scientists are finding a place in high impact factor international journals.

Sample Surveys

For food security planning, we need to know the reliable estimates of food grain production, livestock products and fish production, etc. Similarly for proper planning, precise estimates of resources are required. The subject of sampling techniques helps in providing the methodology for obtaining precise estimates of parameters of interest. The Institute is involved in evolving suitable sample survey techniques for estimation of various parameters of interest relating to crops, livestock, fishery, forestry and allied fields. The Institute has made significant contributions in theoretical aspects of sample surveys like successive sampling, systematic sampling, cluster sampling, sampling with varying probabilities, controlled selection, non-sampling errors, analysis of complex surveys, various methods of estimation such as ratio and regression methods of estimation and use of combinatorics in sample surveys.

The methodology for General Crop Estimation Surveys (GCES), cost of cultivation studies for principal food crops, cash crops and horticultural crops, Integrated Sample Surveys (ISS) for livestock products estimation, fruits and vegetable survey, which are being adopted throughout the country are research efforts of IASRI. Methodology based on small area estimation technique for National Agricultural Insurance Scheme, also called Rashtriya Krishi Bima Yojana, suggested by IASRI has been pilot tested in the country. A status paper on chronological development and present status of information support system for management of agriculture was prepared as a part of State of Indian Farmer: A Millennium Study of Ministry of

Agriculture. The sample survey methodology for imported fertilizer quality assessment, estimation of fish catch from marine and inland resources, flower production estimation, area and production of horticultural crops estimation, etc. have been developed and passed on to the user agencies. Integrated methodology for estimation of multiple crop area of different crops in North Eastern Hilly Regions using Remote Sensing data has been developed. Sampling methodology for estimation of post harvest losses has been successfully adopted in AICRP on Post Harvest Technology for assessment of post harvest losses of crops/commodities.

Reappraisal of sampling methodologies, Evaluation and impact assessment studies like studies to make an assessment of Integrated Area Development programmes, High Yielding Varieties programmes, Dairy Improvement programmes, Evaluation of cotton production estimation methodology etc. have been undertaken. Most of the methodologies developed are being adopted for estimation of respective commodities by the concerned state departments. The Institute is regularly publishing the Agricultural Research Data Book since 1996. It contains information pertaining to agricultural research, education and other related aspects compiled from different sources.

Statistical Genetics and Genomics

The Institute has made very significant contributions in statistical genetics for improved and precise estimation of genetic parameters, classificatory analysis and genetic divergence, etc. The modification in the procedure of estimation of genetic parameters has been suggested for incorporating the effect of unbalancedness, presence of outliers, aberrant observations and non-normality of data sets. Procedures for studying genotype environment and QTL environments interactions have been developed and used for the analysis of data generated from crop improvement programmes. The research work on construction of selection indices, progeny testing and sire evaluation have been used for animal improvement programmes. The Institute has now initiated research in the newer emerging area of statistical genomics such as efficient designs for microarray experiments; rice genome functional elements information system; comparative genomics and whole genome association analysis. The establishment of a National Agricultural Bioinformatics Grid (NABG) is being initiated.

Statistical Modelling for Biological Phenomena

The Institute has made significant contributions in developing models for pre-harvest forecasting of crop yields using data on weather parameters; agricultural inputs; plant characters and farmers' appraisal. The models were developed for rice, wheat, sugarcane, potato, jute, cotton, jowar, groundnut,

sorghum, maize, tobacco and apple using weather and growth indices based regression models, discriminant function approach, markov chain approach, bayesian approach, within year growth models and artificial neural network approach, etc. Methodologies for forewarning important pests and diseases of different crops have been developed which can enable the farmers to use plant protection measures judiciously and save cost on unnecessary sprays. These models have been developed for rice, sugarcane, mustard, groundnut, cotton, pulses and mango. The methodology developed for forecasting based on weather variables and agricultural inputs was used by Space Application Centre, Ahmedabad, to obtain the forecast of wheat yield at national level with only 3% deviation from the observed one. Models developed for forewarning of aphids in mustard crop were used by Directorate of Rapeseed and Mustard Research, Bharatpur to provide forewarning to farmers which enabled them to optimize plant protection measures and save resources on unnecessary sprays consecutively for three years.

Statistical modeling of biological phenomena is carried out by using non-linear models, non-parametric regression, structural time series, fuzzy regression, neural network and machine learning approaches. Forecasting of volatile data has been attempted through non-linear time series models. Such models were developed for forecasting onion price, marine products export, lac export, etc. Non-linear statistical models were developed for aphid population growth and plant diseases. Modelling and forecasting of India's marine fish production was carried out using wavelet methodology. Artificial neural network methodology was used for modelling and forecasting of maize crop yield. A statistical study of rainfall distribution and rainfall-based crop insurance was carried out. The models developed have potential applications in long term projections of food grain production, aphid population, marine fish production, etc.

Econometrics

The Institute has made significant contributions in understanding the complex economic relationship of the factors like transportation, marketing, storage, processing facilities; constraint in the transfer of new farm technology to the farmers field under different agro-climatic conditions of the country. Some of the important contributions of the Institute are measurement of indemnity and premium rates under crop revenue insurance, production efficiency and resource use, a study on impact of micro-irrigation, technological dualism/technological change, a study on return to investment in fisheries research and technical efficiency of fishery farms, the impact of technological interventions, price spread and market integration, price volatility and a study on the dietary pattern of rural households.

Information Communication Technology

The Institute is a pioneer in introducing computer culture in agricultural research and human resource development in information technology in the ICAR. The Institute has the capability of development of Information Systems, Decision Support Systems and Expert Systems. Realizing the need of integration of databases to prepare a comprehensive knowledge warehouse that can provide desired information in time to the planners, decision-makers and developmental agencies, Integrated National Agricultural Resources Information System (INARIS) with the active support of 13 sister institutes as partners has been developed. The data warehouse comprises of 59 databases on agricultural technologies of different sectors of agriculture and related agricultural statistics at districts/state/national levels, population census including village level population data as well as tehsil level household assets and livestock census. Subject-wise data marts have been designed, multi-dimensional data cubes developed and published in the form of on-line decision support system. It is being developed as knowledge data warehouse through the development of Knowledge Management for Agricultural Research and Technologies (KMART). The system also provides facility of spatial analysis of the data through web using functionalities of Geographic Information System (GIS).

The Institute has also developed information systems for agricultural field experiments, animal experiments and long term fertilizer experiments conducted in NARS as research data repositories. Besides, a comprehensive Personnel Management Information System Network (PERMISnet) has been implemented for the ICAR for manpower planning, administrative decision making, and monitoring. For National Agricultural Technology Project, a Project Information and Management System Network (PIMSnet) was developed and implemented for concurrent monitoring and evaluation of 845 projects. This is being developed as a Project Information and Management System for all ICAR projects. A National Information System on Agricultural Education Network in India (NISAGENET) has been designed, developed and implemented so as to maintain and update the data regularly on parameters related to agricultural education in India. Online Management System for Post Graduate Education has been developed and implemented for PG School, IARI, New Delhi. Expert Systems are helpful in taking the technologies developed to the doorsteps of the farmers. The Institute has taken a lead in the development of Expert Systems on wheat crop, maize crop and seed spices. AgriDaksh has been developed for facilitating the development of expert systems for other crops.

A milestone in the research programmes of the Institute was created when it started developing indigenous statistical software packages mainly for analysis of agricultural and animal breeding research data. Statistical

packages for generation of experimental designs for various experimental situations, both unstructured and factorial structure of treatments, catalogues of designs, randomized layout of design and analysis of data were also developed. Statistical packages developed and widely being used in NARS are:

- Statistical Package for Agricultural Research (SPAR) 2.0
- Statistical Package for Block Designs (SPBD) 1.0
- Statistical Package for Factorial Experiments (SPFE) 1.0
- Statistical Package for Augmented Designs (SPAD) 1.0
- Software for Survey Data Analysis (SSDA) 1.0
- Statistical Package for Animal Breeding (SPAB) 2.1

The creation of Design Resources Server, an e-learning and e-advisory resource for the experimenters, has been another revolution in the growth of the Institute. The server provides a platform to popularize and disseminate research and also to further strengthen research in newer emerging areas in design of experiments among peers over the globe in general and among the agricultural scientists in particular so as to meet the emerging challenges of agricultural research.

Human Resource Development

The one of the thrust areas of the Institute is to develop trained manpower in the country in the disciplines of Agricultural Statistics and Computer Applications for meeting the challenges of Agricultural Research in the newer emerging areas. A humble beginning in the area of development of trained manpower was made in 1945 with the initiation of two regular certificate courses, Junior Certificate Course (JCC) of six months duration and Senior Certificate Course (SCC) of one year duration. Besides these, there was another course of one year duration known as Professional Statisticians' Certificate Course (PSCC) to train professional statisticians. Subsequently, a Diploma course involving a research project of one year duration, in addition to PSCC consisting of one year course work in advanced statistics, was also introduced. 261 personnel in Junior Certificate Course, 630 in Senior Certificate Course, 320 in Professional Statisticians' Certificate Course, 175 Diploma in Agricultural Statistics and 10 in Diploma in Advanced Computer Programming were trained through these courses. These certificate courses helped in strengthening the linkages of the Institute with the State Departments of Agriculture and Animal Husbandry. These certificate courses were discontinued by the Indian Council of Agricultural Research (ICAR) in 1985-86. However, during 1997, the Senior Certificate Course in Agricultural Statistics and Computing was revived. This course is now of six months duration and lays more

emphasis on statistical computing using statistical softwares. The course is divided into two modules viz. (i) Statistical Methods and Official Agricultural Statistics, and (ii) Use of Computers in Agricultural Research, of three months duration each. 80 participants have completed both modules, 31 have completed module-I and 21 have completed module-II since 1997.

The year 1964 witnessed tremendous changes in the activities of the Institute when an Memorandum of Understanding (MOU) was signed with Indian Agricultural Research Institute (IARI), New Delhi to start new degree courses leading to M.Sc. and Ph.D. in Agricultural Statistics. In 1981, a two years Diploma Course in Advanced Computer Programming was introduced. On the recommendations of UNDP, this course was soon discontinued and in 1985 another new course leading to an M.Sc. degree in Computer Applications in Agriculture was initiated in collaboration with IARI, New Delhi. This course was re-designated as M.Sc. degree in Computer Application during 1993-94. The Institute has so far produced 176 Ph.D. and 298 M.Sc. students in Agricultural Statistics and 93 M.Sc. students in Computer Application. A new degree course M.Sc. in Agricultural Bioinformatics would begin from academic year 2011-12 in collaboration with IARI, New Delhi; NRCPB, New Delhi and NBPGR, New Delhi.

The functioning of the Institute as a Centre of Advanced Studies in Agricultural Statistics and Computer Application during October 1983 to March 1992 under the aegis of United Nations Development Programme was another landmark in its history. The purpose of this programme was to develop the Institute as a Centre of Excellence with adequate infrastructure and facilities to undertake advanced training programmes and to carry out research in various emerging areas of Agricultural Statistics and Computer Application. Under this programme, a number of illustrious statisticians and computer scientists from abroad visited the Institute with a view to interact with the scientists, giving seminars/lectures and suggesting gaps in the research programmes of the Institute. Under the programme a few scientists received training for capacity building from abroad. Another singular development in the growth of the Institute was the Centre of Advanced Studies Programme in Agricultural Statistics and Computer Application established during the VIII Five Year Plan in 1995. Under this programme the Institute organizes training programmes on various topics of current interest for the benefit of scientists of NARS. These training programmes cover specialized topics of current interest in statistics and agricultural sciences. The Centre of Advanced Studies (CAS) is renamed as Centre of Advanced Faculty Training (CAFT). So far 45 training

programmes have been organised under the aegis of CAS/CAFT. In all a total of 805 participants have been benefited.

There is yet another form of training courses, which are tailor made courses and are demand driven. The coverage in these courses is need based and the courses are organized for specific organizations from where the demand is received. The Institute has conducted such programmes for Indian Council of Forestry Research, Indian Statistical Service probationers and senior officers of Central Statistical Organization and many other organizations. The Institute has also conducted several international training programmes on request from FAO, particularly for African, Asian and Latin American countries. The Institute has broadened the horizon of capacity building by opening its doors to the agro-based private sector. One such training programme was organized for research personnel of E.I. DuPont Pvt. Ltd. The Institute has also conducted training programmes for the scientists/research personnel of CGIAR organizations such as ICARDA and Rice-Wheat Consortium for Indo-Gangetic plains. A number of research workers from the Institute have served as consultants and advisors in Asian, African and Latin American countries. Also, a number of statisticians and students of the Institute are at present occupying high positions in universities and other academic and research institutions of USA, Canada and other countries. The faculty of Institute has published 8 text books, 3 handbooks, several research monographs, etc. Most recent monographs are Monograph on α-designs and Monograph on Hadamard Matrices.

Infrastructural Developments

As the activities of the Institute started expanding in all directions, the infrastructure facilities also started expanding. Two more buildings 'Computer Centre' and 'Training-cum-Administrative Block' were constructed in the campus of the Institute in the years 1976 and 1991, respectively. There are three well furnished hostels, viz. Panse Hostel-cum-Guest House, Sukhatme Hostel and International Training Hostel to cater the residential requirements of the trainees and students. An important landmark in the development of the Institute was the installation of an IBM 1620 Model-II Electronic Computer in 1964. A third generation computer Burroughs B 4700 system was installed in March 1977 and then replaced in 1991 by a Super Mini COSMOS-486 LAN Server with more than hundred nodes consisting of PC/AT's, PC/XT's 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 laboratories equipped with PCs, terminals and printers, etc. had been set up in each of the six Scientific Divisions as well as in the Administrative Wings of the Institute.

For undertaking research in the newer emerging areas, a laboratory on Remote Sensing (RS) and Geographic Information System (GIS) was created in the Institute. The laboratory was equipped with latest state-of-art technologies like computer hardware and peripherals, Global Positioning System (GPS), softwares like ERMapper, PCARC/INFO, Microstation 95, Geomedia Professional, ARC/INFO Workstation and ERDAS Imagine with the funds received through two AP Cess Fund projects. This computing facility has further been strengthened with the procurement of ARC-GIS software under NATP programme. An Agricultural Bioinformatics Lab (ABL) fully equipped with software and hardware has been created to study crop and animal biology with the latest statistical and computational tools. Business Intelligence Server has also been installed for statistical computing for NARS.

Keeping pace with the emerging technologies in the area of Information Technology (IT), from the year 1998 onwards the computing infrastructure have been constantly upgraded/replaced with newer platforms and versions. The computing environment in the Institute has latest computing and audio visual equipments i.e. High Performance Computing having 144 cores Intel HPC cluster, rack mount & redundant SMPS servers, workstations, desktops, laptops, netbooks, documents printing & scanning, DVD duplicator, visualiser and wireless multimedia projectors etc. The Institute is also well equipped with 12 mbps bandwidth fiber optics backbone wired and wireless networking campus.

The networking services at IASRI have steadily been strengthened. Currently the internet services are being provided to the scientists, technical & administrative staff and students through Firewall, Content filtering, E-mail filtering, Antivirus, Application control and Data Leak Prevention (DPL). The Institute domain service like Primary and Secondary DNS, Domain (iasri.res.in) Website (http://www.iasri.res.in), Live E-mail services, more than 462 network nodes and number of various Online Information Systems are being developed and maintained by the Institute's officials.

There are various labs at the Institute for dedicated services like ARIS lab for training, Statistical computing lab, Stat lab for Statistical analysis, Student lab and Centre for Advanced Study lab. Some of the important available softwares are SAS 9.2, JMP 8.0, JMP Genomics 4.0, SAS BI Server 4.2, SPSS, SYSTAT, GENSTAT, Data warehouse software – Cognos, SPSS clementine, MS Office 2007, MS Visual Studio.net, MS-SQL Server, Oracle, Macro-Media, E-views, STATISTICA Neural Networks, Gauss Software, Minitab 14, Maple 9.5, Matlab, Web Statistica, Lingo Super, ArcGIS among others.

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IASRI 2030

The subject of Agricultural Statistics forms the backbone of the agricultural research. In order to make our research globally competitive, it is important that sound statistical methodologies be developed and used in the collection of data (both under controlled and uncontrolled conditions), analysis of data and interpretation of results. Thus, there is need to devise strategies of data generation based on statistical principles. Data generation; Data analysis; Inferences drawn from the analysis and Knowledge generated from the analysis and interpretation are the integral component of discipline of Statistics and go hand in hand. There are many success stories of the Institute which are fairly spread across all the specialization of Agricultural Statistics and Computer Applications. The contributions towards research, teaching and training have been monumental. Since scenario of agriculture research is changing at a very fast rate, the Institute has set its future agenda to meet the statistical and informatics needs. The efforts would be to become a lead organization in the world in the field of agricultural statistics, statistical computing, information communication technology including bioinformatics, and be responsive, vibrant and sensitive to the needs of researchers, research managers and planners.

Goal

To conduct research, education and training in Agricultural Statistics and Information Communication Technology

Vision

Statistics and Information Communication Technology (ICT) for enriching the quality of agricultural research

Mission

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

Mandate

The functions and activities of the Institute have been re-defined from time to time. The mandate of the Institute is

- To undertake basic, applied, adaptive, strategic and anticipatory research in Agricultural Statistics

- To conduct Post-Graduate teaching and in-service, customized and sponsored training courses in Agricultural Statistics, Computer Applications and Bioinformatics at National and International level
- To lead in development of Agricultural Knowledge Management and Information System for National Agricultural Research System
- To provide advisory and consultancy services for strengthening the National Agricultural Research System
- To provide methodological support in strengthening National Agricultural Statistics System

To accomplish the vision and the mission, IASRI gives highest priority to researchers of NARS and entire stretegy is based on 'Agricultural Researcher first'. The research, teaching, training and dissemination would be carried through following broad programmes:

- Development and Analysis of Experimental Designs for Agricultural Systems Research
- Forecasting, Modelling and Simulation Techniques in Biological and Economic Phenomena
- Development of Techniques for Planning and Execution of Surveys and Statistical Applications of GIS in Agricultural Systems
- Development of Statistical Techniques for Genetics/Computational Biology and Applications of Bioinformatics in Agricultural Research
- Development of Informatics in Agricultural Research
- Teaching and Training in Agricultural Statistics and Informatics

Design of Experiments

Design of Experiments has been and continues to be the backbone of agricultural research. As-a-matter-of-fact, designing an experiment is an integral part of agricultural research. It is through proper designing of experiments, analyzing the data and drawing valid inferences that knowledge is generated. Agricultural systems is vibrant and experiments need to be conducted for functional genomics, assessment and mitigation of effects of climate change, resource conservation agriculture, post harvest storage behaviour of perishable commodities etc.

There are basically two major components of experimental designs, viz., (i) the design itself and (ii) analysis of data generated. These two aspects dictate data requirements in view of the objectives of the research. The data need is dictated by a simple fact that the valid inferences to be drawn have very high efficiency and the probability of making a wrong decision is as low as possible. This enables the researcher to attach a very high

confidence on the success and repeatability of the knowledge derived through research.

The objectives of the experiments dictate the hypotheses to be tested; this in turn decides the analysis to be performed and therefore, what the data requirements would be and then comes the choice of a proper design. Designing an experiment assumes importance to take care of the variability in the experimental material, which by and large, forms a very large component of the total variability. There can be no thumb rule to decide the choice of a design. With the agricultural research being dynamic in nature and newer vistas of agricultural research opening up from time to time, the data needs change, the analysis changes and consequently the design changes. Therefore, to keep pace with agricultural research, it is pertinent to continue research in design of experiments on a continuous scale, in tune with the requirements of the agricultural research.

IASRI is involved in the planning, designing and analysis of experiments of on-going experiments pertaining to AICRP on Integrated Farming Systems Research (both on station and on farm trials), Long Term Fertilizer Experiments, Soil Test Crop Response Correlations. Linkages have also been developed with AICRP on Rapeseed and Mustard, All Indian Crop Improvement Programme on Sorghum, etc. These linkages need to be further strengthened. The innovative applications need to be developed as per changing needs of research in agricultural sciences. Service oriented computing models need to be developed for efficient working of AICRPs and network projects.

Research data repository is the lifeline of any research system. Online Agricultural Field Experiments Information System has been developed and data of about 30000 agricultural field experiments is available in this information system. With the availability of online data uploading and retrieval facility, it would be possible to link all the researchers of NARS to upload their experimental data. Further, at present this information system takes care of only single characters. In most of agricultural experiments, data on more than one response variables are generally observed. Therefore, there is need to modify this information system to accommodate multiple character data and also for developing a facility of linking over years and over locations. The scope of the information system needs to widen to include data from different AICRPs. It is also required to develop information system for experimental pertaining to horticulture, agroforestry, laboratory, animal experiments etc. There is also a need to strengthen the provision of value addition in this information through development of indigenous algorithms, as well as linking them with Business Intelligence Server for service oriented computing.

With the dimension of agricultural scientists spread along the length and breadth of the country, it is not possible to reach every scientist of NARS for advisory on this very important subject. Therefore, the creation of strong and efficient web resource is of paramount importance so as to meet the needs of all the scientists in NARS. An effort in this direction has already been made and a Design Resources Server is already available and can be accessed at www.iasri.res.in/design. There is a need of upgrading and strengthening Web resources in this server with efficient designs for spatially correlated observations, designs for functional genomics, response surface designs, computer experiments, and design of experiments with limited resources and online analysis of experimental data.

The above efforts would result in availability of efficient and robust designs for different experimental situations for improved status of agricultural experimentation in the country for enhancing the visibility and acceptability of agricultural research, use of appropriate and efficient experimental designs, both in terms of cost and precision, and advanced analytical techniques in AICRP to help in drawing statistically valid conclusions, online research data repository of designed experiments, service oriented computing and e-learning and e-advisory services.

Statistical Modelling

It is well recognized that crucial variables in an agricultural system involve complex nonlinear relationships. In order to determine these, the usual practice is to employ nonlinear statistical models formed by adding an additive error term to the deterministic model. However, this type of modelling may not be able to describe the underlying fluctuations in a satisfactory manner. In reality, parameters of a model no longer remain constant but fluctuate randomly. Therefore, it is desirable to study stochastic models in which the parameters, like growth rates are described by appropriate stochastic processes. Another advantage of such models is that, unlike nonlinear statistical models, these are applicable for modelling and forecasting in those situations in which the data on response variable can be obtained only on equidistant time-epochs. However, estimation of parameters of these models on unequal time points requires lot of research efforts. Subsequently, relevant computer programs/software packages need to be developed before stochastic models are applied to real data. This would enable development of efficient forecasting techniques based on sound statistical basis.

It is not always possible to describe the functional form involving response and explanatory variables. To this end, nonparametric approach is called for. Generally, artificial neural network methodology is employed for estimating cause-effect relationships among variables. However, these models

suffer from the drawbacks of overfitting and convergence at local minima. Recently, a very promising technique of Support Vector Machine (SVM), based on the principles of Statistical learning theory, has been proposed. The nonlinear SVM can be employed for classification, density estimation, regression analysis and time-series prediction. There is a need to fine-tune this methodology by carrying out a lot of concerted research efforts. SVM models would also require a lot of data. It is hoped that, in due course of time, the forthcoming Data centre would be in a position to meet this requirement by providing raw data.

Development of systematic roadmaps of agricultural research pathways using Technology Forecasting methodologies is a promising area that employs normative approach which includes backcasting from vision to present status along the pathways to realize the vision. That is, major developments in gamut of agriculture can be foreseen and alternatives explored aiding us in creating/inventing the desirable future by circumventing any possible negative trends besetting the system. Such an exercise can more than complement the conventional quantitative forecasting approaches such as projections and models which are attempted based on retrospective from past to present to know the current trends. Thus, both these methods in turn can be extrapolated into the future to give us a prospective perspective. Thus, it can be particularly useful for priority settings, partnerships and networks of agricultural science, technology, economy, environment and society. This may lead us to identify the areas of strategic research and emerging generic technologies likely to yield the greatest economic and social benefits.

The domain of data mining is yet another niche area in this era of information explosion with no dearth for data on spatio-temporal information. Thus, data mining models for geographic knowledge discovery in agricultural and fish ecosystems will be quite useful in not only understanding the underlying phenomena but also to build data driven models with no stringent apriori assumptions. In other words, instead of complex statistical models, one is ultimately supplied with easily comprehensible set of decision rules to predict or classify the future. In contrast to the conventional statistical models, such models have an advantage of handling data sets having very large number of cases and also huge number of variables leading to a multidimensional solution.

Forecasting Techniques

Reliable and timely forecasts provide important and useful input for proper, foresighted and informed planning, more so, in agriculture which is full of uncertainties. Agriculture now-a-days has become highly input and cost intensive. Without judicious use of fertilizers and plant protection

measures, agriculture no longer remains as profitable as before. Uncertainties of weather, production, policies, prices, etc. are leading to mass suicides by farmers. New pests and diseases are emerging as an added threat to the production. Under the changed scenario today, forecasting of various aspects relating to agriculture is becoming increasingly essential.

With this in view, methodologies have been developed at IASRI for forecasting crop yield in advance of harvest using various statistical techniques based on different types of data for selected crops at selected locations. In the coming years, it is proposed to develop models for crops, pests and diseases not covered so far. Use of some newer techniques will also be explored for improving the models. Statistical softwares will be developed for obtaining forecasts using different methodologies for different situations. This will be helpful to Crop Science Division for obtaining reliable forecasts of different crops and forewarnings of pests and disease.

Models were developed for forecasting marine fish catch and fish production from ponds. These studies will be helpful for obtaining forecasts in fisheries. However, more studies are needed in this area before final methodology is recommended for operational use. Though lot of work has been done in crops and some work in fisheries, no work has been done in the fields of animal sciences, natural resource management, etc. Work will be taken up in these unexplored areas which will be useful for these Divisions.

Statistical Genetics

The large quantity of qualitative and quantitative high dimensional multivariate data is being generated by the agricultural/animal scientists for high-throughput genotyping and phenotyping in our national agricultural research system under various research projects. There is need to intensify research in identification and application of advance multivariate statistical techniques such as classificatory analysis, artificial neural network, cluster analysis, dimensionality reduction techniques and genetic diversity analysis in high dimensional plant and animal germplasm data with reference to comparative genomics, phenomics and microarray experiments data in various situations. Exploring the possible application of computational models for visualization of high dimensional data in biological systems and to apply random regression model in animal breeding data is the need for extracting useful knowledge. There is huge data generated in animal experiments, field crops and horticultural crops in NARS under AICRPs on different plant and animal species. It will be of great interest to breeders to develop and identify suitable methods to study the genotype environment interactions in field and perennial crops for varietal selection

for both high yield and stability in multi environmental data. Suitable methodology for estimation of important genetic parameters under correlated error structures is not available and need to be developed. The possible application of mixed nonlinear models for studying growth pattern of different animals need to be explored.

In view of the rise of energy and insecticide costs for insect control in agriculture combined with growing social and ecological concerns about the over usage of these insecticides, it will be prudent to study insect survival patterns and their hazard rates in order to decide the optimum dose of an insecticide for controlling insect pests. The generalized lifetime distributions of insects will be able to reveal unimodal and v-shaped hazard rates which are required in management of insect pests by deciding least effective dose of insecticide. Under censored observations, parametric and nonparametric estimation procedures available for estimating survival functions need modifications. Identification of prognostic factors in animal diseases is very useful in providing insight into the mechanism of disease and assisting in allocation of treatments of a disease. It is usually done by parametric regression model and proportional hazard model which has many limitations. In order to overcome these limitations and widen the application and efficacy of prognostic factors, sound statistical methods need to be developed using accelerated failure model and non-proportional hazard models for identification of prognostic factors related to survival time data in animal diseases.

Agricultural Bioinformatics

In order to keep pace with the research and developments in agricultural bioinformatics at global level, country needs expertise and exposure in the area of bioinformatics research in agriculture. In this direction council initiated a project in 2010 for establishment of National Agricultural Bioinformatics Grid (NABG). Under this, development of biological databases, data warehouse, software and tools, algorithms, genome browsers and high-end computational facilities through systematic and integrated approach in the field of agricultural bioinformatics have been initiated. NABG is also aimed for capacity building for research and development and providing platform for inter-disciplinary research in cross-species genomics in agricultural bioinformatics and in turn agricultural biotechnology in National Agricultural Research System (NARS). In order to sustain this activity council established the Centre for Agricultural Bioinformatics (CABin) with the status of a division in this institute. The main responsibility of the CABin is to integrate number of other institutions/organizations in order to provide computational framework and support to carry out biotechnological research to bridge the gap between

genomic information and knowledge, utilizing statistical and computational sciences.

NABG will be further expanded and Centre of Excellence for Computational Biology in the field of Agriculture will be created in the Institute. Strengthening of genomic data warehouse and integrating biological sequences, molecular interactions, homology information, functional annotations of genes, network modelling of gene and biological ontologies will be taken up on priority basis. Further, activities such as development of algorithms and software tools for on-line computational analysis of genomic/proteomics data and web services for dissemination of research in agricultural bioinformatics need to be further expanded. The research projects will be initiated in the field of sequence analysis, genome annotation, analysis of gene/protein expression, analysis of regulation, prediction of protein structure, comparative genomics, modelling biological systems, high-throughput image analysis, protein-protein docking and development of computational methods for high throughput biological data analysis. This will help in facilitating new vistas for downstream research in bioinformatics ranging from modelling of cellular function, genetic networks, metabolic pathways, validation of drug targets to understand gene function and culminating in the development of improved varieties and breeds for enhancing agricultural productivity. It is expected that, in due course of time, information and knowledge generated through research on bioinformatics from the genomic knowledge base will start flowing downward and experimentations in different sectors of agriculture will be able to evolve internationally superior competitive varieties/breeds and commodities in agriculture.

Statistical Computing for NARS

Statistical support to agricultural research workers in their data analysis is a prerequisite so that the research remains globally competitive. Statistical computing methods enable to answer quantitative biological questions from experimental data and help to plan new experiments in a way that the amount of information generated from each experiment is maximized. Proper and appropriate use of statistical methods for agricultural data analysis, in particular, is crucial and serves as a tool to maximize the benefits obtained from investments in agricultural research. A healthy and enabling statistical computing environment has been provided in NARS through NAIP Consortium "Strengthening Statistical Computing for NARS". To make use of this facility to the fullest possible extent, customized modules using macros, stored processes and service oriented computing for commonly used statistical procedures will be developed for AICRPs and other NARS organizations. Further, the benefit of a high-end statistical

package can only be realized by proper knowledge of statistical techniques to be used and the accuracy of the statistical software package selected, therefore, training programmes would be organized for the research personnel of NARS. This will benefit the scientists in NARS immensely to enable them draw meaningful and valid inferences from their research.

Statistical Softwares for Agricultural Research

The important activity of developing indigenous statistical software packages would be rejuvenated with more vigor and zeal. Need based statistical softwares will also be developed for new techniques and developed statistical packages would be strengthened with the addition of new modules for newer experimental settings, sample survey data as well as for analysis of data generated in micro-arrays, genome sequencing etc.

Sample Surveys

The Institute has developed various sampling methodologies for estimation of important parameters in agriculture. The sampling methodologies developed in the Institute are being used in the entire country as well as some of the developing countries. However, the agriculture sector has undergone major changes over a period of time. Various development programmes have been launched by the Government to improve the socio-economic conditions of people in the country especially the poor persons. Many survey/census related programmes have been initiated.

Reappraisal and fine tuning of existing methodologies which are, both, easily implementable as well as do not require large manpower are of immense importance. Impact assessment and evaluation studies need to be carried out for proper monitoring. Development of appropriate methodologies for area and production estimation in the horticulture sector will remain a priority area. Besides, activities related to development and validation of models in the farm mechanization sector and surveys for estimation of important farm mechanization related parameters will be vigorously pursued.

Future work in the field of small area estimation will be focussed towards application of model based small area estimation techniques for estimation of parameters in crop, livestock and fisheries sector. Statistical analysis and inference will be done by combining data obtained from multiple sample surveys and other auxiliary sources.

Appropriate methods will be developed for small sample inference from sample surveys using spatial information. The potential of bootstrap methods for clustered correlated survey data shall be examined. Further,

methods for outlier robust estimates for small domains as well as for robust prediction of distributions shall be developed. Research efforts will be directed towards analysis of survey data using M-quantile and Expectile models and design consistent estimates for small area. The thrust of future research in small area estimation will be on development of application oriented techniques suitable for Indian conditions. Simulation tools will be used extensively towards this end.

There is a lot of scope of further research in the area of Remote Sensing and GIS applications in agricultural surveys. There is a need to standardize the methodology for crop acreage estimation of multiple crops using remote sensing and GIS in hilly regions. Sampling methodologies will be developed to improve the current methods of crop estimation surveys using remote sensing and GIS techniques. Studies will be undertaken to develop methodology for acreage and production of horticultural crops using remote sensing and GIS. Methodology for estimation of crop area under cloud cover in satellite imagery will be developed. Research studies in remote sensing and GIS will help in precise estimation of various parameters in agricultural surveys including crops, livestock, fisheries, horticulture, agro-forestry etc. These studies will be of direct relevance to the various SMD's in the ICAR namely Natural Resource Management, Fisheries and Horticulture.

Econometrics

Applied work in economics often requires a solid understanding of econometric methods to support decision making. Econometrics is changing dynamically with developments in the economic theory, mathematics and statistics fields. Econometric research in agricultural sciences encompasses several frontier areas of research such as supply and demand, international trade, value addition, market integration, efficiencies in production and marketing, agricultural commodities futures, price discovery, determination and transmission, impact of technological intervention and climate change and equity issues related to gender and categories in farming systems. The outcomes of econometric research in agriculture will be helpful in framing policy prescriptions related to efficiency, equity and sustainability of farming systems. Research work pertaining to the following thrust areas (a) impact assessment of technologies/research, (b) study on food security and poverty alleviation, (c) modelling for agricultural marketing, (d) natural resource management, and technological change, risk and uncertainty in agriculture would be further strengthened.

Information Communication Technology

Information technology has empowered both people and machines with

information, which is transformed into knowledge and intelligence. Appropriate use of the knowledge by both people and machines contributes to sustainable development. The Internet, major source of IT exploration has gained immense popularity over the past decade and in this age of information explosion; no country, organization and individual can afford to be ignorant of this emerging technology. It is the easiest way to link the documents and their sections in a nonlinear manner, over the different network paths. A very useful application of the Internet is to design and establish an on-line information system, where anyone around the globe with authorized access permissions can do the data updating and retrieval of useful information. Agriculture has a very wide span of activities spread over crop variety development programs, recommended set of cultural practices, plant protection practices against insects, pest and diseases, water availability and management, soil characterizations, farm implements and tools, livestock species, horticultural crops, plantation crops, agro-forestry, socio-economic characteristics of farmers etc. To meet the requirements of various stake holders in relation to Agricultural Research, Development and Extension activities in the country, number of initiatives will be undertaken in ICT.

Software solutions for knowledge management systems

With the advances in Internet technologies and mobile computing, there is a need to develop information systems that are Web 3.0 enabled or latest with the features like RSS feed, XML data interchange among applications and web services. RDF/RDFS and OWL are latest knowledge representation languages. The development of knowledge base of crops and technologies using these languages will be undertaken that will help in better inference to solve problems through expert systems or multi agent systems. With these new features different crop based systems will be accessible to human users as well as to other applications on the Internet. Crop based information systems will also be made mobile enabled. Value addition to the existing information systems, DSS and expert systems and development of new web enabled DSS and expert systems for important cereals crops, pulses, oilseeds, vegetables and fruits will help in strengthening the extension services and research outputs would reach the stake holders through ICT. A set of web based expert systems for various crops which will act as knowledge banks for farmers, extension workers, students and other researchers.

Computational techniques for knowledge extraction and management

Intelligent analysis of data sets, usually large and non-spatial and spatial, for meaningful and previously unknown insights will be undertaken. This

will help the stake holders to transform data into business decisions and policy making. Ontologies are being used as a knowledge representation technique so as to help in better storage of knowledge in a form that can be used by people and other software applications. Development of knowledge base in the form of a set of ontologies will be taken up in important agriculture areas.

Computational techniques, algorithms and software applications will be developed for pattern recognition from large data sets. Focus will be on the use of Machine learning techniques e.g. ANN, Fuzzy, Rough Sets, SVM and hybridized techniques for data mining. Applications of text mining, web mining and spatial data mining will be taken up for agricultural data sets.

Strengthening ICAR data centre

Agricultural research and development requires massive data sets particularly related to agricultural genomics and proteomics, geo-informatics, climate change apart from other data bases related to agricultural statistics and technologies etc. The development of databases, data warehousing for knowledge management, therefore assumes a great importance for future endeavours in agricultural research. This would require a platform for data integration, data sharing and data management. IT Infrastructure is also required for implementation of the e-Governance and other knowledge base systems of ICAR and its Institutes/ Centers/ SAUs. An integrated storage and archiving strategy will contribute towards optimization of resources by facilitating intelligent data movement, access to current and historical information, space savings to servers and storage devices, optimize system performance and increase energy efficiency. Many management tasks will get simplified by unification of documents, information systems and MIS leading to paperless office. In order to support these activities, development of data center and its maintenance will be undertaken.

Human Resource Development

Creation of adequate and quality human resources is the basic need of any organization to keep its vibrancy. Therefore, it is of importance to develop quality trained manpower in Agricultural Statistics and Informatics to address emerging challenges of Agricultural research and extension. This would be achieved through

- Preparing text books and teaching material in electronic format for Post-Graduate degree programmes in Agricultural Statistics and Computer Applications
- Modernize education system in terms of infrastructure and faculty

- Including problem solving approach in curricula
- Post-Graduate degree programmes in Bioinformatics in collaboration with IARI, New Delhi
- Senior Certificate Course in Agricultural Statistics and Computing
- Conducting training programmes under Centre of Advanced Faculty Training
- Conducting summer and winter schools
- Conducting customized and ad-hoc National and International training programmes
- On-line training and e-Learning programmes
- Content generation, development, management and dissemination of all informatics and databases

The Institute is conducting Post Graduate degree in Agricultural Statistics, Computer Applications and Bioinformatics; Ph.D. in Agricultural Statistics and Senior Certificate Course in Statistics and Computing. This horizon would be further broadened by initaiting the Ph.D. programmes in Computer Applications and Bioinformatics. These activities would be strengthened by creating a Centre of Excellence in teaching and training as Deemed University.

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Strategy and Framework

Following strategy would be adopted to accomplish vision and goals of the Institute and to enhance efficiency and effectiveness of research and teaching resources (for details, see Annexure-I).

- Advancement in methodology and novel applications.
  - Formulate network mode, need based research programmes cutting across disciplines, institutions both within and outside NARS;
  - Basic research in newer emerging areas to meet the need of future challenges of agricultural research;
  - Develop novel applications of the statistical techniques/models in agricultural research;
  - Strengthen collaborations with mainstream statisticians for basic and innovative applied research.
- Identification of statistical issues for different subject matter divisions.
  - Close interactions with specialists of different ICAR subject matter divisions;
  - Participation in annual workshops of AICRPs/Network projects.
- Facilitate dissemination of improved statistical techniques, knowledge and information.
  - Develop online resources on advances in statistical techniques and informatics;
  - Create and strengthen e-training, e-seminars, e-debates and discussions for outreaching the researchers;
  - Organize travel workshops-cum-trainings to outreach scientists;
  - Organize customized training programmes;
  - Pursue advisory services, etc.
- Strengthen statistical computing for NARS.
  - Provide high-end statistical computing facilities;
  - Develop service oriented computing modules;
  - Prepare customized modules for online analysis.
- Strengthen National Agricultural Bioinformatics Grid and provide framework for genomics data analysis.

- Improving efficiency of human and financial resources and effective utilization of infrastructure.
  - Network of statisticians working in NARS for pursuing large research agenda of basic, applied and adaptive research in agricultural statistics and informatics;
  - Strengthen use of ICT in creation of research data repositories, information systems, decision support systems and expert systems.
- Capacity strengthening in agricultural statistics and informatics through a Centre of Excellence as Deemed University.
- Interaction with various constituents of National Agricultural Research System and developmental organizations to infuse efficiency in research and development, planning, monitoring and management through the use of statistics, ICT including agricultural bio-informatics.

Epilogue

IASRI has a glorious history of over 80 years and has a strong base in statistics with a goal of developing trained manpower in the country so as to meet the challenges in the new emerging areas and in turn help to improve the quality, visibility and acceptability of agricultural research. The Institute interacts with other NARS organizations in the use of efficient and sophisticated statistical analytical techniques and has collaborations with several NARS organizations.

The research managers of the ICAR have aired their views at many platforms that Statistics is the grammar of all sciences, more so of agricultural sciences. Together with ICT, statistics has made inroads in many newer areas like bioinformatics, computational biology, etc. It has been reiterated at times that the statistical base of the Institute may further be strengthened so as to meet the challenges of agricultural research.

The exercise of spelling out new research directions is important but has little relevance if no practical path emerges from the current status towards the new dimensions of research. A continuous stream of new methodological advancements and new areas of application are vital. The ultimate role of statistical techniques in future will depend on its use. Initiation of proactive steps may ensure intensive application by the researchers.

Statisticians have to be pro-active in dissemination of their findings to the stake holders through policy dialogues, regular interactions and publications such as monographs, internet technologies, pamphlets, popular articles, working papers, etc. Reasons for non-adoption of sound statistical methodologies and identification of improvements required, if any, need to be identified through close interactions with subject matter specialists. These statistical issues then need to be addressed on priority basis.

Agricultural statistics together with informatics must address important needs of agricultural systems research and must be competitive at International level. It should also address problems of farmers (directly or indirectly) and give solutions to improve living conditions of farmers.

This would help in establishing a demand or need based research paradigm and make presence of statisticians visibly felt in NARS.

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Annexure 1: Strategic framework

Goal	Approach	Performance measure
Improving the status of experimentation in NARS for enhancing the visibility and acceptability of agricultural research	• Develop efficient designs both in terms of cost and precision for agricultural systems research • Develop need based statistical analytical techniques for analysis of experimental data • Rigorous advisory and research support to plan, design and analyze experiments conducted in NARS with emphasis on AICRP/network projects	• Availability of efficient and robust designs both in terms of cost and precision, and appropriate analytical techniques for different experimental situations for drawing statistically valid conclusions
Research data repository on designed experiments	• Develop/strengthen information systems with value addition for experiments conducted in NARS • Linking information systems to service oriented computing environment	• Online research data repository of designed experiments with value addition
Web resources on design of experiments	• Strengthening web resources on design of experiments for dissemination of advances in design of experiments through e-advisory and e-learning services • Develop decision support system on design of experiments	• e-learning and e-advisory services on design of experiments
Create super computing framework for bioinformatics	• Establish and strengthen National Agricultural Bioinformatics Grid (NABG) • Integration and implementation of different ICAR institutions in the NABG • Implementation of bio-clustering and bio-simulation services • Develop biological databases and data warehouse • Develop web portal for providing access of computing services in genomics	• Biological computational facilities and framework
Create interdisciplinary groups in the field of computational biology	• Initiation of research programmes with different national organizations	• Number of inter-institutional and inter-disciplinary programmes undertaken
Forecasting and forewarning models for agricultural systems	• Develop forecasting and forewarning methodologies using linear & nonlinear models, simulation techniques, Bayesian approach, machine learning techniques and climatic modeling relevant to agricultural systems • Develop systematic roadmaps of agricultural research pathways using technology forecasting methodologies	• Improved models for reliable forecasts in agricultural systems
Statistical modeling for biological phenomena	• Develop methodology for efficient estimation of parameters of stochastic models • Develop relevant computer programs/ software packages for application of stochastic models to real data for efficient forecasting • Fine tuning of nonlinear SVM for classification, density estimation, regression analysis and time-series prediction • Exploiting data mining techniques on spatio-temporal information for geographic knowledge discovery	• Improved efficiency in forecasting biological phenomena • Software package in statistical modelling for use in agricultural research • Efficient prediction methodology by using nonlinear SVM

Goal	Approach	Performance measure
Statistical techniques applied to plant and animal breeding research, particularly, estimation of efficient and robust genetic parameters	• Develop and apply new improved statistical models for explaining different agricultural scenario by applying data mining and resampling techniques • Intensify research in application of multivariate statistical techniques for genetic diversity in plant and animal germplasms with reference to microarray experiments • Explore the possible application of computational models for visualization of high dimensional data in biological systems and to apply random regression model in animal breeding data • Study insect survival patterns and their hazard rates with more precision • Develop sound statistical methods using accelerated failure model and non-proportional hazard models for identification of prognostic factors • Study G x E interactions in perennial crops for varietal selection for both high yield and stability in multi-environmental data	• Online sharing of knowledge and information for improving research efficiency in plant and animal breeding • New methods for handling high dimensional data • Reveal actual hazard behaviour of mortality of important insect pests which in turn help in finding optimum dose of a pesticide • Suitable methods for studying G x E interaction in perennial crops
Estimation and projections of economic parameters	• Work out supply and demand of agricultural commodities, market efficiency and food security • Work out equity, efficiency and sustainability in natural resource management and gender empowerment in agriculture • Develop agricultural market intelligence	• Knowledge on extent of sustainability of resource use and women empowerment in agriculture • Methodology for estimation of domestic supply and demand of agricultural commodities
Improve sampling methodologies for estimation of important parameters	• Reappraisal and fine tuning of existing sampling methodologies in crops, livestock and fishery sectors • Develop appropriate methodologies for improving area and production estimation in the horticulture sector • Develop and validate database in the farm mechanization sector • Impact assessment and evaluation studies for proper monitoring and effectiveness of various schemes • Statistical analysis and inference by combining data obtained from multiple sample surveys and other auxiliary sources • Develop methodology for estimation of parameters in allied areas	• Sample survey techniques for reliable estimation of crops, livestock, horticulture, farm mechanization and fishery sectors, etc.
Standardization of small area estimation techniques	• Develop and apply small area estimation techniques for estimation of parameters relating to crops, livestock, fishery and socio-economic aspects	• Reliable micro level estimates in crop, livestock and fisheries sectors

Goal	Approach	Performance measure
Application of remote sensing and GIS in survey sampling	• Standardization of the methodology for crop acreage estimation of multiple crops using remote sensing and GIS in hilly regions • Develop integrated methodology for acreage estimation of horticultural crops using ground survey and remote sensing • Develop geostatistical models for estimation of cloud cover in satellite imagery • Develop spatial prediction models • Develop remote sensing and GIS based methodology for generation of agricultural intelligence • Studies relating to natural resource accounting and management using remote sensing and GIS	• Methodology for precise estimation of various parameters of interest in agricultural surveys by using remote sensing and GIS • Methodology for estimation of cloud cover in satellite imagery
Enhanced use of ICT and software solutions for knowledge management	• Develop DSS and expert systems for transfer of technology • Set up a Data Centre for data integration, data sharing and data management • Develop and implement MIS for efficient functioning	• DSS and expert systems for sharing knowledge • Sharing of data for research and web services • Unification of documents and efficient services
Improve statistical computing for appropriate research data analysis	• Develop service oriented computing modules for AICRP/Network projects • Develop need based statistical software for new statistical techniques • Customised training for research workers on statistical softwares	• Service oriented computing modules for data analysis • Customized statistical packages for data analysis
Create adequate and quality human resources in Agricultural Statistics and Informatics to address emerging challenges	• Modernize education system in terms of infrastructure and faculty by including problem solving approach in curricula • Capacity strengthening of the faculty through training at national and international level • Conduct post graduate and Ph.D. courses in Agricultural Statistics, Computer Application and Bio-informatics • Ad-hoc national and international training programmes • On-line trainings and e-learning programmes • Preparing text books and teaching material in electronic format • Content generation, development, management and dissemination of all informatics and databases	• Qualified manpower in Agricultural Statistics and Informatics

हर कदम, हर डगर
किसानों का हमसफर
भारतीय कृषि अनुसंधान परिषद

Agrisearch with a human touch