

INDIAN
STATISTICAL
INSTITUTE

SIXTYTHIRD
ANNUAL REPORT

APRIL 1994—MARCH 1995



203 BARRACKPORE TRUNK ROAD
CALCUTTA - 700 035

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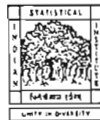
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24. Dr. Joseph Mathew, Dean of Studies.
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INDIAN STATISTICAL INSTITUTE

Annual Report
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INDIAN STATISTICAL INSTITUTE
SIXTYTHIRD ANNUAL REPORT
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BRIEF HISTORY OF THE INSTITUTE

Research in the theory and applications of Statistics as a new scientific discipline began in India in the early twenties through the pioneering initiative and efforts of Professor P.C. Mahalanobis. Soon after his return from England, Mahalanobis began to carry out statistical studies with the help of some part-time assistants. A chance meeting with Dr. Nelson Annandale (the then Director of the Zoological and Anthropological Survey of India) and subsequent interactions with him led to the first scientific paper by Mahalanobis on the statistical analysis of stature of Anglo-Indian males of Calcutta. This was followed by further research in anthropometry, in meteorology and in problems of flood control in North Bengal and Orissa. Gradually, a small group of young scientists were picked up by him in the Department of Physics, Presidency College, Calcutta, where he was a professor. This group formed the nucleus of a laboratory which later came to be known as the Statistical Laboratory.

In the early thirties, realising the necessity for a concerted effort for the advancement of theoretical and applied statistics in India, Professor Mahalanobis together with Professors P.N. Banerjee and N.R. Sen, both of Calcutta University, convened a meeting on 17 December, 1931, to consider various steps to be undertaken for the establishment of an association for the advancement of statistics in the country. It was unanimously resolved that the Indian Statistical Institute be established with Sir R.N. Mookerjee as President and Professor P.C. Mahalanobis as (Honorary) Secretary. The Indian Statistical Institute was registered as a non-Government and non-profit distributing learned society on 28 April, 1932, under the Societies' Registration Act No. XXI of 1860. The total expenditure in the first year was a meagre Rs.238 and the number of workers was only two or three. From such a modest beginning, the Institute grew, under the remarkable leadership of Professor Mahalanobis, into an all-India organisation which now has around 1600 workers, including about 500 scientific workers. The Institute has its headquarters in Calcutta and two other Centres at Delhi and Bangalore and a branch at Giridih. In addition it has a network of service units of Statistical Quality Control and Operations Research Division at Baroda, Bombay, Trivandrum, Pune, Coimbatore, Madras, Hyderabad, Calcutta, Delhi and Bangalore.

From the very beginning, Professor Mahalanobis and his associates who included Professors S.S. Bose, R.C. Bose, S.N. Roy, K.R. Nair, K. Kishen and H.C. Sinha worked with zeal and enthusiasm for the development of statistical theory and methods, and in promoting research and practical applications in different areas of natural and social sciences. *Sankhyā*, the Indian Journal of Statistics, was started in 1933 with P.C. Mahalanobis as its Editor, and received instant international recognition which continues till today. Pioneering research activities were carried out in many areas of statistical theory, especially in the core areas of multivariate analysis, sample surveys and design of experiments. Such activities were strengthened and new directions were opened up by Professor C.R. Rao and many others who joined the Institute in the forties and the tradition continues. The Institute pioneered the development of statistical methods in agricultural research and in the conduct of large scale agricultural enquiries. This led to a large number of research publications and to the introduction of training activities offering short term courses in statistics for officers in government departments and scientific institutions. The scientists of ISI, led by Professor Mahalanobis, helped in introducing the first post-graduate degree course in Statistics in India at the Calcutta University in 1941, and in securing a separate section for Statistics in the Indian Science Congress.

Activities of the Institute gained further momentum from 1938. Professor Mahalanobis started sample surveys to estimate the area under jute crop in Bengal in 1937 as an exploratory work, which later grew to a full-scale survey of the entire province in 1941. Gradually, sample surveys of agricultural crops and other socio-economic surveys became some of the most important activities of the Institute and earned the Institute and Professor Mahalanobis international reputation. After independence, Professor Mahalanobis was appointed Honorary Statistical Adviser to the Cabinet, Government of India, and in 1950, through his initiative, the National Sample Survey (NSS) was started for conducting socio-economic surveys of all-India coverage on a continuing basis. This was the first ever attempt in India to have a data base for various developmental programmes and the five year plans. The ISI group on sample surveys served as the Technical Wing of the NSS from 1950 till it was transferred to the Government of India in 1972.

The ISI was first again to play a pioneering role in starting the Statistical Quality Control (SQC) movement in India by organising a visit of Professor W.A. Shewhart, the father of SQC, to India in 1948 and later by inviting other experts like W.E. Deming for the same purpose. SQC promotional work was gradually spread all over the industrial centres in India under a comprehensive programme covering education and training, applied research and consultancy services.

Research in economics was greatly stimulated when in 1954 Prime Minister Jawaharlal Nehru entrusted the preparation of the draft Second Five-Year Plan of the country to Professor Mahalanobis and the Institute. The "Draft" submitted by Professor Mahalanobis and the planning models formulated by him in that connection have since been regarded as major contributions to economic planning in India. Since then many economists of the Institute have worked in different centres of the Institute on various aspects of national planning and until 1970, were directly helping the Planning Commission in the preparation of the long term perspective plans for the country. Research in other disciplines of Social Sciences was also started in the Institute in the late fifties. Professor Mahalanobis' participation in 1946 in the annual scientific conferences of the Milbank Foundation led to the initiation of systematic studies in India on the growth of population. Earlier, the well known Y-sample estimates for 1941 Census population were also derived by the ISI. Theoretical and empirical research in sociology using statistical techniques was started in the Institute for the first time in south-east Asia. Similarly, the development and introduction of psychometric tests for selection processes in different organisations was first made by the ISI in India besides carrying out basic research in Psychometry. The studies of the phonetic structure of some major Indian languages have been made on a continuing basis in the Institute under the guidance and collaboration of the famous linguist Djordje Kostic.

The Institute, since its inception recognised the need for development and use of accurate and fast computing equipment for the processing and analysis of data. Professor Mahalanobis strongly believed that to be a good theoretical statistician one must also compute and must therefore have the best computing aids. The Institute has lived up to this tradition from the very beginning. In 1953, a small analog computer was designed and built in the Institute. In 1956, the Institute acquired a HEC-2M machine from the U.K. which was the first digital computer in India. In 1958, a digital computer URAL was received as a gift from U.S.S.R. Since 1956 till mid sixties, the Institute had been serving as a de facto national computer centre for the country. In early sixties, the Institute, in collaboration with the Jadavpur University, undertook the design, development and fabrication of a fully transistorised digital computer, called ISIJU-1 which was commissioned in 1966 by Shri M. C. Chagla, the then Minister of Education, Government of India.

Quantitative analysis in Physical and Earth Sciences was one of the novel ideas of Professor Mahalanobis pursued in the true spirit of the Institute. In addition to evolving some interesting techniques and obtaining some very interesting results from the analysis of directional geological data, the Institute also made a significant contribution by discovering the bones of a 16m (+) long sauropod dinosaur named, *Baropasaurus togorei*, from the lower Jurassic Kota rocks near Sironcha, Gadchiroli district, Maharashtra, in the sixties. The discovery has helped in understanding the interesting problem about the origin and evolution of sauropod dinosaurs. It, in fact, represents the only intermediate form between the prosauropods and the sauropods, and is called a "missing link" in the evolution of the sauropod dinosaur.

The Institute expanded its research, teaching, training and project activities and earned national and international recognition over time. The substantial contributions of the Institute to the quality of theoretical and applied statistical work have culminated in the recognition of the Institute by the Government of India enacting "The Indian Statistical Institute Act, 1959" (No.37) which declared the Institute as an "Institution of National importance" and empowered it to award degrees and diplomas. None other than Pandit Jawaharlal Nehru, the then Prime Minister of India, piloted the bill in the Parliament. With this recognition, the already existing teaching and training programmes were consolidated and expanded and courses for the degrees of Bachelor of Statistics (B.Stat. (Honours)) and Master of Statistics (M.Stat.) were started from June 1960. The Institute was also empowered to award Ph.D./D.Sc. degrees from the same time. Later on, courses leading to Master of Technology degrees were started in Computer Science and in Quality, Reliability and Operations Research.

The role and importance of ISI in conducting and promoting teaching of statistics has been appreciated by international bodies as well. In 1950, the International Statistical Institute had initiated the International Statistical Education Centre (ISEC), Calcutta, jointly with ISI, to impart training in Theoretical

and Applied Statistics to participants selected from developing countries. The centre is run by ISI jointly under the auspices of UNESCO, International Statistical Institute and the Government of India.

Recognition of the Institute by the Act of Parliament provided greater encouragement to research activities not only in statistics and mathematics but also in various branches of the natural and social sciences, without whose live contact, it was believed, the methodology of statistics could not grow to its current level. It is also due to this fact that "Unity in Diversity" is adopted as the motto of the Institute.

In keeping with the changes over time, the Memorandum of Association of ISI has been updated in 1976.

The objectives of the Institute as laid down in the Memorandum of Association of 1976 are :

- i) to promote the study and dissemination of knowledge of statistics, to develop statistical theory and methods, and their use in research and practical applications generally, with special reference to problems of planning for national development and social welfare;
- ii) to undertake research in various fields of natural and social sciences with a view to the mutual development of statistics and these sciences; and
- iii) to provide for, and undertake, the collection of information, investigations, projects, and operational research for purposes of planning and the improvement of efficiency of management and production.

From the early days, the Institute has been in touch with many internationally famous scientists in different disciplines from the world over. Some of these scientists have worked in the Institute for several months or even longer. Sir Ronald A. Fisher, a pioneer of modern statistics, was a regular visitor to the Institute and lent it considerable support. Professor J.B.S. Haldane, a geneticist of international repute, was a member of the faculty for several years beginning 1957. At the inspiration of these stalwarts and other renowned scientists, the Institute began to expand and/or undertake research activities in several areas of natural and social sciences with the hope that collaboration under the same roof would foster the mutual development of statistics and other disciplines. In fact, the Institute stood up to Sir Ronald Fisher who called Statistics a "Key Technology" of the century, in view of its intimate relevance to all scientific endeavours which involve experimentation, measurement and inference from sample to aggregate.

Coming to more recent times, the Institute has continued to pursue its goal of attainment of excellence in the various fields of science. Fundamental research in statistics with its roots in applications has been the bottom line ever since the inception of the Institute. The contributions from the Institute in multivariate analysis, design and analysis of experiments, sample surveys, statistical methods of data analysis and statistical inference have found their places in text books and monographs, and the tradition continues. In addition, probability theory and stochastic processes have also been major areas of research in the Institute. The theoretical mathematicians of the Institute, in addition to collaborating with the statisticians, are also making fundamental contributions in several fields - Topology, Functional analysis, Harmonic analysis, Algebra, Combinatorics, Quantum Mechanics, Game Theory, to name some. The current trend of research in statistics not only carries forward the traditions set up in the Institute, but is also setting new directions, both in theory and applications, in different disciplines.

The Institute has been maintaining its tradition of high quality research and development in the field of computer science. In 1979, a microprogrammed signal processing system using Fast Fourier Transform (FFT) was designed and developed. Keeping pace with the global advances in computer technology, the activities of the Institute in the field of computer science gathered a tremendous momentum in the late seventies, resulting in diversification of research in different areas including Algorithms and Complexity, Parallel and Distributed Processing, Fault-Tolerant Computing, VLSI, Computational Geometry, Fuzzy Sets and Systems, Cybernetics, Pattern Recognition, Neural Nets, Artificial Intelligence, Image Processing, Computer Vision, Particle Physics, Fluid Dynamics, Plasma Physics etc. In recognition of its contributions in the field of computer science, the Government of India established, in collaboration with the United Nations Development Programme (UNDP), one of the five national Nodal Centres for Knowledge Based Computing Systems (NCKBCS) in ISI in the year 1988.

The different disciplines under the Social Sciences also continued to develop and flourish over time by carrying out basic research as well as inter and multi-disciplinary programmes. In economics, the Institute has come to be known as a specialized centre for its significant contributions in different branches of theory and also for studies on such areas as Demand Analysis, Poverty and Levels of Living, Measurement of Inequalities, Production and Prices, National Income and allied topics, Development and Planning etc. In Demography, Sociology, Psychometry and Linguistics also the Institute maintained its distinctive feature for the focus and emphasis on quantitative aspects. Mention may be made, in this context, about the pioneering theory for teaching and training for the hearing impaired children, developed by Prof. Kotic. Based on this theory the Electronics Unit of the Institute, in collaboration with the Linguistic Research Unit and the Government of Tripura, designed, developed and fabricated a set of instruments for the hard-of-hearing children of the Institute of Speech Rehabilitation, Government of Tripura, Agartala. This has come to be regarded as having significant impact on social welfare.

Plant and human biology have been the major areas of research in biological sciences. Both basic and applied research are conducted, with emphasis on quantification, statistical design and analysis, and modelling. In the area of plant biology, research has included quantification of natural variability and modelling, animal behaviour, effect of interaction of rice varieties on yield, use of protein extracted from leaves to supplement human food, mathematical modelling of ecological and embryological phenomena, etc. In the area of human biology, researches have included anthropometric, genetic and biochemical studies on population affinities, micro-evolution, studies on utilising data on anthropometric variability in designing car seats, human adaptation to differing environments, human ecology and growth and genetic epidemiology.

Depletion of technical personnel with collection and analysis of field data has adversely affected empirical research in the Institute. Moreover, the death of the faculty members in Certain Science Units has created the problem of optimum expansion of scientific activities of the Institute.

Over the years, the SQC & OR Division has grown to the size of having ten operating units all over the country and have uniquely served for promotion, education and training and technical guidance in Total Quality Management Methodology, Quality Assurance Systems for the benefit of the manufacturing and service industry over the decades. It has thus, as was intended, played a leading role in dissemination of new concepts, methods and techniques in the areas of Quality and Productivity.

The Central Library of the Institute is located at Calcutta with a network extending to other locations of the Institute. Over the years, the library of the Institute has attained the distinction of being one of the richest libraries in the country, particularly in the fields of statistics and related disciplines. The library has developed a well-equipped Reprography and Photography Unit. The library's gift collections include the personal libraries of Professor P.C. Mahalanobis and Professor Walter A. Shewhart. The library has been recognised as the Depository Library for World Bank publications. A separate collection of books and journals in Mathematics, Statistics etc., known as Eastern Regional Centre of NBHM has been developed out of the grants from the National Board of Higher Mathematics. Computerization of library facilities has been taken up which will certainly enhance the facilities for the users. Much more is on the anvil in this direction.

The Documentation Research and Training Centre (DRTC) established at Bangalore in 1962 by the late Professor S.R. Ranganathan, a doyen in the field of library and information science, is engaged in research, teaching and training in documentation and information science. The Institute awards post-graduate diplomas in documentation sciences.

An index of the contributions of the Institute is the publication of many books and monographs, in addition to a large number of scientific papers in national and international journals, in the recent past, receipt of national and international recognitions of very high order by scientists of the Institute by way of awards, titles, and fellowships, and holding of prestigious positions in various scientific organisations of higher learning as well as in governmental organisations not only in India but also in several international organisations. With a dynamic group pursuing and guiding research work in some of the most modern topics in statistics, mathematics and in various fields of natural and social sciences, there is close interaction with scientists from all over the world.

DIRECTOR'S REPORT

During the year, training in the core areas of Statistics, Mathematics, Economics, Computer Science, Electronics and Communication Sciences and other related fields was in full gear. The faculty kept a busy schedule with research activities both in theoretical and applied Statistics as well as in other interdisciplinary areas. Procedures for exploratory analysis of high dimensional data using tree-structured generalized regression and nonparametric quantile regression were developed. Such procedures are quite useful in analyzing data from biological and sociological studies. Several aspects of Pompeiu problem and "The Uncertainty Principle" were analyzed and L-analogue of the Wiener-Tauberian theorem was established. In a study on "The differential impact of modern rice technology across production environments" by the Computer Science Unit and Economic research Unit, marked advantages over the traditional methods were demonstrated. The development of a new neuro-fuzzy model by the Machine Intelligence Unit which handles imprecise, incomplete or linguistic input data has opened up a new avenue for development of connectionist expert system design for real life applications. A highly sensitive and specific antibody against folic acid has been obtained by the Biochemistry Unit by coupling folic acid with E-amino caproic acid. The Economic Research Unit, in one of their investigations on Macro-Economic Policy in India, analysed the relationship between technology, efficiency and industrial liberalization in LDC's with special reference to India.

In the light of the liberalization policy of the Government of India, the industrialists are facing competition and felt the need for improvement of product quality for export purposes especially to EEC Countries. The use of Statistical Quality Control and Operations Research and allied management techniques in controlling loss and cost and for improving and augmenting productivity in industries has generated impetus for the SQC and OR movement in the country. Through the drive of providing consultancy services in all areas of Quality Management and Quality System work related to ISO 9000 certification, the SQC and OR Division has successfully assisted twenty organizations in getting the International certificates for Quality Systems. Besides, the Division has trained Quality Mission Executives who in turn are deputed to various organisations for training and implementation of Total Quality Management and ISO 9000 techniques.

As all of you know, the interaction between Industry and Research Institutes and Universities is practically non-existent in our country and there is no in-house research and development in most of the industries. Planning Commission has appointed a Task Force to study how a bridge can be established to remove this gap. As support to this type of activity, Institute has established a Computer Vision and Pattern Recognition Unit, whose mandate is to develop application-oriented research in collaboration with Government and industries in the areas of Pattern Recognition and Image Processing. Another unit of the Institute which is involved in theoretical and applied aspects in these areas is Machine Intelligence Unit. It is participating in some projects which are defence-oriented and other projects under the DST and CSIR schemes. At the invitation of Government of West Bengal, the Institute is working on a project "Socio-Economic Survey of Quality of Life". A similar project in Andhra Pradesh is using the advice of colleagues in ISI, Hyderabad. Another project on "Foreign Tourists Survey" is expected to be taken up during the next financial year.

In appreciation and recognition of the high standard of research and scientific excellence maintained by the researchers of the Institute, several faculty members received laurels in the forms of Awards and Fellowships during the year. Professor T. Parthasarathy of the Theoretical Statistics and Mathematics Unit at Delhi has been elected a Fellow of the Indian National Science Academy and Professor B.B. Chaudhuri of Computer Vision and Pattern Recognition Unit has been elected a Fellow of the National Academy of Sciences, India. Professor Suresh Dasgupta was President of the Statistics Section of 82nd Indian Science Congress held in Calcutta. Professor Sankar Pal of Machine Intelligence Unit has been awarded Hari Om Prerit Vikram Sarabhai Research Award. Several other young faculty received Young Associate Awards, Young Scientist Awards, Career Awards and Fellowships from scientific bodies such as Indian National Science Academy, Indian Academy of Sciences, University Grants Commission, Indian Science Congress Association etc.

It has been a practice for the Institute to share its expertise and its facilities with colleagues and scientists from other Universities, Colleges, Institutes and Research Organisations. Following this view, various Summer/Winter Schools, Seminars and Workshops were held during the year to disseminate new results obtained, as well as to strengthen the research programmes in the Institute with fresh ideas. The Annual Conference on "Economic Theory and Policy" was organised by the Planning Unit at Delhi besides a two-day discussion series on "The Role of Planning in India". A Winter School on the "Application of Biometric Techniques on the Biology of Fish Growth and Reproduction" was organised by the Biometry Unit. A SERC School on "Stochastic Process Modelling" sponsored by Department of Science and Technology and a Winter School on "Discrete Mathematics" were held in the Theoretical Statistics and Mathematics Unit, Calcutta. A Winter School on "Non-commutative Harmonic Analysis" was held by the Theoretical Statistics and Mathematics Unit at the Delhi Centre as a follow up of a summer school conducted at the Bangalore Centre. A team of mathematicians at Bangalore Centre is participating in the Nurture Programme of NBHM. A UGC sponsored Refresher Course in Statistics for teachers who teach post-graduate courses, a workshop on "Reliability and Survival Analysis" and a workshop on "Analysis of Directional Data" were held in the Computer Science Unit. Institute invites a distinguished statistician every alternate year to deliver the Mahalanobis Memorial Lectures here and at our centres at Delhi and Bangalore. Lectures were delivered this year by Professor Alexander Philip Dawid of the University College, London. In his lectures he covered Bayesian Networks for the analysis of Drug Safety and Recent Advances in Probabilistic Expert Systems.

Regarding the teaching and training activities during the year, 7922 candidates applied for admission to various courses of the Institute including B.Stat.(Hons.), M.Stat. (M-stream and S-stream), M.Tech. (Computer Science) and M.Tech. (Quality, Reliability and Operations Research). A total of 4573 candidates appeared for the admission tests and a total of 401 candidates qualified for interview for selection. Based on the performance in the written tests and interviews, 193 candidates were offered admission to various courses leading to degrees and diplomas during the academic session under review. Twelve foreign students applied for admission to some of these courses and admission tests were conducted at various Indian Missions abroad for them.

It was felt that the Institute needs to develop the Bio-Statistics programme to meet some of the needs of the country in developing stochastic models for the study of AIDS and other such dreaded diseases. A specialization in M.Stat. programme has been started this year. Another area where the Institute should develop its expertise is "Time Series and Forecasting". Efforts are under way. Recruitment of faculty in different areas is in progress.

The International Statistical Education Centre (ISEC) is run by the Institute jointly with the International Statistical Institute under the sponsorship of the UNESCO and the Government of India since 1950. At present, the Centre is conducting its forty-eighth term with 8 foreign and 4 Indian trainees. Due to the discontinuation of the fellowships of the Government of India under SCAAP and ITEC programmes, representation from the African countries is conspicuously absent this year. The Institute has approached the Government to restore these scholarships as there are requests from UN Agencies and the African Governments for such a training.

As far as the financial position is concerned, for Plan and Non-Plan budgets for the year under consideration, Government approved only slight increases over the corresponding budgets for the previous year. While we have been able to spend what is provided for research projects, our performance on the construction side and to improve infrastructural facilities has not been satisfactory, especially at Calcutta. It is a matter of concern. Work culture needs improvement if we want to be ahead of others. Thanks to a dedicated Telephone Committee, we have been able to install better communication facilities on campus. Better quality drinking water facilities are provided to hostels and residents in one part of the campus. It is expected to have similar facilities in other parts of the campus. Additional floor space for academic and administrative activities at ISI, Bangalore, was constructed. Residential accommodation at ISI, Pune, was acquired. Similar efforts are under way for ISI, Bombay.

Embargo imposed by the Government on recruitment from outside still remains. Even though there are indications that Government is more receptive, tangible results are yet to come by. Over the years, a large number of middle level officers have retired. Institute has not been able to make new appointments due to embargo which has created a major problem for smooth functioning of the Institute here as well as at outlying centres and branches. Government has linked embargo with new pay-scale structure. Discussions are in progress. The Institute had to spend under the head "overtime" more than what was allotted. Some efforts were made to reduce overtime expenses following the directives from Government. It has been practically impossible to run the Institute with opposing requirements from the government, namely, no new recruitment and no excess overtime expenditure beyond what was allotted. The Institute was able to submit its Annual Report well in time. Following the Council's approval, a committee is appointed to look into computerisation of Accounts, Budget, Library, Stores and Inventory and other areas. I am glad to inform you that there is a positive response to this aspect from the workers' organization. It is hoped that the Institute will have better Library infrastructure and better administrative and accounting support.

Our Institute is nationally and internationally recognized as a centre of excellence both for its theoretical contributions to Statistics as well as applications of Statistics. We all pledge to uphold the standards and keep the banner of recognition high. "Work is Worship" should be our motto.

31 March 1995

(J.K. GHOSH)

Part I. Teaching and Training, Convocation, Research and Publication

I. TEACHING AND TRAINING

Degrees and Other Courses

A brief account of teaching and training activities during the period from April 1994 to March 1995 is given below.

During the academic session 1994-95, 7922 candidates applied for admission and were called for written selection tests on 8 May 1994 for the various courses offered by the Institute. The courses and fellowships for which admission was sought this year were - B.Stat. (Hons.), M.Stat. (M-stream and S-stream), M. Tech. in Computer Science, M.Tech. in Quality, Reliability and Operations Research, Two-year part-time post-graduate diploma in SQC and OR (Bombay and Madras), Research Fellowships in Statistics, Mathematics, Economics, Computer Science, Physics, Applied Mathematics and Fluid Mechanics, Electronic and Communication Sciences and Theoretical Computer Science, One-year part-time course in Statistical Methods and Applications and the course on Operation and Programming of Automatic Data Processing Equipment. Admission tests were conducted at 22 different Centres all over the country. A total of 4573 candidates finally appeared for admission tests and a total of 401 candidates who qualified in the written tests were called for interviews. Based on the performance in the written tests and the interview, 193 candidates were offered admission to various courses during the academic session under review.

There were twelve foreign students who applied for admission to these courses. Admission tests were conducted for them through the Indian High Commission/Embassy in Dhaka and Kathmandu.

The annual examination for all the regular courses were held in May/June 1994. The 1994-95 academic session commenced on 4th July, 1994.

Sixteen trainees in Engineering and Technology from various Universities (Jadavpur, IIT Kharagpur, Benaras Hindu University, College of Engineering, Burla etc.) received a four to six weeks practical training in the Electronics and Communication Sciences Unit, Machine Intelligence Unit, Computer and Statistical Services Centre, the Electronics Unit and in the Computer Vision and Pattern Recognition Unit.

One hundred and two candidates received their degrees and diplomas at the Twentieth Annual Convocation of the Indian Statistical Institute held on 1 February 1995. 89 candidates who passed the various regular courses of varying durations (one year or less) received the certificates during the year. Thirteen Research Fellows were awarded Ph.D. degrees of the Indian Statistical Institute and four Research Fellows were awarded Doctoral Degree by Calcutta University for work done in ISI during 1994-95.

The number of candidates admitted to the different degree, diploma and training courses in 1994-95 and the number of students passed in the annual examination in 1994 are given below.

NUMBER OF STUDENTS ADMITTED AND PASSED IN DIFFERENT COURSES

Course	Number of Students		
	Enrolled in 1993-94	Passed in the annual exam. in 1994	Enrolled in 1994-95
(1)	(2)	(3)	(4)
Degrees			
1.	Bachelor of Statistics with Honours [(B.Stat.)(Hons.)]		
	1st year	10	10
	2nd year	22	21
	3rd year	12	11
2.	Master of Statistics (M.Stat.)		
	1st year (M-stream)	12	12
	1st year (S-stream)	25	25
	2nd year	22	22
3.	M.Tech. in Computer Science		
	1st year	19	18
	2nd year	17	16
4.	M.Tech. in Quality, Reliability and Operations Research		
	1st year	19	14
	2nd year	12	11
Diploma/Certificate/ Associateships			
5.	Course on Operation and Programming of Automatic Data Processing Equipment		
	1st year	8	7
	2nd year	12	12
6.	Part-time Certificate/Diploma Course in Statistical Quality Control and Operations Research (Madras)		
	1st year	12	6
	2nd year	10	8

	(1)	(2)	(3)	(4)
7.	Associateship in Documentation and Information Science			
	1st year	9	9	12
	2nd year	7	7	9
8.	Part-time Course in Statistical Methods and Applications			
	Calcutta	16	9	19
	Delhi	16	*	-
	Hyderabad	59	*	18
9.	Six-month part-time Course in Statistical Quality Control			
	Bangalore - Jan. - June 1993	16	12	15*
	July - Dec. 1993	-	-	-
	Hyderabad - Jan. - June 1993	9	7	-
	July - Dec. 1993	-	-	-
10.	Intensive Course in Programming and Applications of Electronic Computers	10	10	16
11.	Indian Statistical Service Probationers (ISSP) Course	-	-	38
12.	Junior Diploma in Statistics	8	2	7
13.	Senior Diploma in Statistics	6	-	8
14.	Statistical Assistantship Certificate	16	1	14
Fellowships				
15.	Junior and Senior Research Fellows, Research Associates in different disciplines	140	13**	157
GRAND TOTAL		542	283	492

* Result not yet announced

** Awarded Ph.D. Degree

Ph.D. Degrees Awarded

(A) Ph.D. Degrees awarded by the Institute :

- i) Nachiketa Chattopadhyay : "On some measurement problems in economics".
Supervisor : Satya R. Chakravarty, ISI, Calcutta.
- ii) Krishnendu Mukhopadhyay : "Studies on design, routing and fault tolerance of inter-connection networks"
Supervisor : B.P. Sinha, ISI, Calcutta.
- iii) Ananthoth Koyitil Vijayarajan : "Hypergroups, graphs and sub-factors".
Supervisor : V.S. Sunder, ISI, Bangalore.
- iv) Debjyoti Dhar : "Survival function estimation under random censoring".
Supervisor : A.C. Mukhopadhyay, ISI, Calcutta.
- v) Malabika Roy : "Three aspects of industrial dualism in a developing economy".
Supervisor : Abhirup Sarkar, ISI, Calcutta.
- vi) Mocrakshi Rajeev : "Walrasian theory without an auctioneer : A study of monetary exchange through trading posts and a diagrammatic view of disequilibrium".
Supervisor : Dipankar Dasgupta, ISI, Delhi.
- vii) Uma Vishvanathan : "Optimal short run electricity supply in India : Rationing and pricing options".
Supervisor : Atul Sarma, ISI, Delhi.
- viii) Probal Sengupta : "On lexical and syntactic processing of Bangla language by computer".
Supervisor : B.B. Chaudhuri, ISI, Calcutta.
- ix) Saikat Dutta : "Essays in dynamic games".
Supervisor : Dilip Mookherjee, ISI, Delhi.
- x) Naresh Kumar Sharma : "Agricultural tenancy in Palampur".
Supervisor : V.K. Chetty, Medical College of Wisconsin, USA.
- xi) Sree Ramachandra Murthy Gudimella : "Some contributions to linear complementarity problem".
Supervisor : T. Parthasarathy, ISI, Delhi.
- xii) R. Kavita Rao : "Evaluating in a dual economy framework the Indian industrial performance during 1951-52 to 1989-90".
Supervisor : Pradip Maiti, ISI, Calcutta.
- xiii) Mahuya Datta : "Parametric homotopy principle of some partial differential relations".
Supervisor : Amiya Mukherjee, ISI, Calcutta.

(B) Ph.D. degrees awarded by other Universities to the Research Fellows of the Institute :

- i) Gautam Goswami : "Some aspects of quantum field theory and spin systems".
Supervisor : P. Bandyopadhyay, ISI, Calcutta.
- ii) Mausumi Poddar Sarkar : "Mammalian semiochemicals; chemical and behavioural aspects, with special reference to tiger".
Supervisors : R.L. Brahmachari, ISI, Calcutta, and Jyoti Dutta, Calcutta University.
- iii) Kasturi Sen (Dasgupta) : "New reptiles (Diapsida; Archosauromorpha) from the triassic yerrapalli formation, Deccan India; Their importance in geology and palaeontology".
Supervisor : Tapan Roychoudhuri, ISI, Calcutta.
- iv) Ketaki Das : "Genetic variability in sixteen tribes of Central India".
Supervisor : K.C. Malhotra, ISI, Calcutta.

International Statistical Education Centre (ISEC), Calcutta

The Centre was opened in 1950 and is operated jointly by the International Statistical Institute and the Indian Statistical Institute, under the auspices of the UNESCO and the Government of India. The Centre functions under a joint Board of Directors. The Directors represent International Statistical Institute, Indian Statistical Institute and the Government of India. Professor P.C. Mahalanobis was the Chairman of the Board of Directors since its inception in 1950 until his death in 1972. Since then National Professor C.R. Rao, P.R.S., has been the Chairman of the Board.

The Centre provides training in Theoretical and Applied Statistics at various levels to selected participants from the countries in the Middle-East, South and South-East Asia, the Far East and the Commonwealth countries in Africa, sponsored by respective Governments. Major training programme of the Centre is a 10-month regular course. In addition, special courses of varying duration are also organised. Since inception the Centre has trained 1224 trainees from 56 countries.

The 48th term of the Regular Course, the main training programme of this Centre, commenced on June 1, 1994 with 12 Government Statisticians of whom 5 are from Sri Lanka, 4 from India, and 1 each from Bangladesh, Myanmar and Maldives. All the foreign trainees are supported by various Government of India fellowships. However, participants from African countries could not join the course due to the discontinuation of fellowships by the Government of India under SCAAP and ITEC. The matter has already been taken up with the Government of India and it is hoped that some positive results will be achieved soon.

From June to September 1994 the trainees stayed in Calcutta and underwent intensive and other places training in Data Processing, Statistics, Economics and Mathematics. From October 3 to November 12, 1994 the trainees had to undergo a 6-week Official Statistics Programme of the Central Statistical Organisation at New Delhi. Since 14 November further training in statistics including specialisation courses depending on the background and needs of the trainees have been in progress. This term is scheduled to conclude on 31.03.95 when the Statistical Training Diplomas will be awarded to the successful trainees.

About 90 Teachers from the Indian Statistical Institute and from CSO participated in the ISEC Regular Course teaching. Two Government Statisticians, one from Myanmar and the other from Tanzania underwent on-the-job training programmes on Sample Survey Methodology and Applications, Economic Statistics and use of computers in Data Analysis under the sponsorship of UN Statistical Office and related divisions from July 1994 to December 1994.

Professional Examinations in Statistics

During the period January 1994 to December 1994, the Examination Committee of the Institute conducted professional examinations in Statistics for the award of

1. Statistical Assistantship Certificate
2. Junior Diploma in Statistics, and
3. Senior Diploma in Statistics

in July 1994 and December 1994 as usual at Bangalore, Bombay, Calcutta, Delhi, Hyderabad, Lucknow and Madras Centres.

Ninety-two candidates in all had registered for the examinations conducted in July 1994 of whom sixteen candidates had passed in one or more papers.

Eighty two candidates registered for the December 1994 examinations. Processing for the publication of results of the December 1994 examinations is under way.

2. TWENTYNINTH CONVOCATION

Indian Statistical Institute held its Twentyninth Convocation for awarding the Ph.D., M.Tech. (Computer Science), M.Tech. (Quality, Reliability and Operations Research), M.Stat., B.Stat. (Hons.) degrees and Diplomas, Associateship etc. on 1 February 1995.

Professor M.G.K. Menon, FRS, President of the Institute presided over the Convocation and awarded Degrees, Diplomas, Associateships and Awards to the students. Professor B.L.S. Prakasa Rao, FNA, Director of the Institute, presented annual review of teaching and training activities of the Institute. Professor U.R. Rao, Member, Space Commission, Bangalore, delivered the Convocation address. In his address, Professor Rao highlighted the role of statistics in space technology and statistical relationships involved in effectively dealing with the dynamics of sustainable integrated development.

The number of students who obtained Degrees, Diplomas, Associateships and Awards in the Convocation are given below :

Degree/Diploma/Associateship	Number of candidates
Doctor of Philosophy (Ph.D.)	13
Master of Technology (M.Tech.) in Computer Science	16
Master of Technology (M.Tech.) in Quality, Reliability and Operations Research	11
Master of Statistics (M.Stat.)	22
Bachelor of Statistics (Honours) [B.Stat.(Hons.)]	11
Part-time Diploma in Statistical Quality Control and Operations Research, Madras	8
Diploma on Operation and Programming of Automatic Data Processing Equipment	12
Associateship in Documentation and Information Science, Bangalore	7
Professional Examinations in Statistics : Junior Diploma in Statistics	2
Total	102

AWARDS 1994

1. Award of Mahalanobis International Symposium on Statistics prize to the most outstanding M.Stat. student of Statistics of the Institute :

Rajesh Ranjan Nandy

2. Award of ISI Alumni Association Prizes to the outstanding students of the Institute :

B.Stat. (Hons.)	:	Debashish Goswami
M.Stat.	:	Biman Chakraborty
M.Tech.(CS)	:	Sharmistha Chakraborty
M.Tech. (QROR)	:	J. Desmond Patel

3. RESEARCH AND OTHER SCIENTIFIC ACTIVITIES

The research activities of the Institute are grouped in the following Divisions :

Theoretical Statistics and Mathematics; Applied Statistics, Surveys and Computing ; Physical and Earth Sciences; Biological Sciences; Social Sciences; Statistical Quality Control and Operations Research; Library, Documentation and Information Sciences. There is also a well equipped Computer and Statistical Services Centre (CSSC) which provides computing and statistical services to researchers.

A brief account of the progress of research in different Divisions and Units of the Institute during the year is indicated below :

Theoretical Statistics and Mathematics Division

The Division with units at Calcutta, New Delhi, Bangalore and Hyderabad has a major role in teaching Probability, Statistics and Mathematics in the B.Stat.(Hons.), M.Stat., M.Tech. (CS), M.Tech. (QR&OR) and other courses of the Institute. The division also conducts courses for 3-4 semesters at an advanced level for research fellows enrolled for the Ph.D. degree of the Institute. The unit at Calcutta regularly conducts a Colloquium with speakers both from within the unit and outside. The Division regularly conducts workshops, summer/winter schools, refresher courses and conferences with extensive interaction from academics of various organizations both in India and abroad, funded by external agencies as well as by the Institute, the details of which for the year under review are given elsewhere.

Some of the areas of research and contributions from various units are given below:

Calcutta Unit

Mathematics

1. Topology and Set Theory :

The determination of the exact position of Buchwalter's topology in the hierarchy of all natural topologies of $C(X)$ has been settled.

Some Equivariant problems of algebraic topology and differential topology were investigated.

Borel isomorphism theorem, continuity of group multiplication were studied.

2. Functional Analysis :

Banach space properties of BMO and its subspace VMO with special emphasis on the extremal structures of their unit balls.

The analytic continuation of certain twisted Dirichlet series associated to Siegel modular forms of degree 2.

Harmonic analysis on Euclidean spaces and Symmetric spaces.

3. Graph Theory :

A Markov chain simulation method for generating random $(0, 1)$ - matrices with given marginals has been developed and used for the study of social networks.

Application of chordal graphs, intersection graphs, degree sequences, centres of graphs and digraphs, rectilinear graphs, spanning trees in weighted connected graphs and self-complementary graphs.

4. Theoretical Computer Science :

Exact and approximate algorithms for hard problems and approximability.

Statistics

1. Statistical Methods :

Graphical association methods, Optimal predictive selection, Bivariate Gini methods and Gini correlation have been studied. Semiparametric approaches used to fit models to software reliability data have been developed.

Non-parametric quantile regression was used for analysing data with random censoring. Invariant procedures for multivariate analysis using adaptive transformation approach were developed.

2. Inference :

Bahadur representation for generalised M-estimators, Robust Multivariate Inference.

Inference in Social Networks.

Bayesian Inference and Asymptotics.

Test procedures for testing proportionality of multivariate dispersion structures,

Goodness of fit problems involving Regression quantiles in nonparametric regression.

Tests for the order of finite Markov chains.

Partial and Multiple regression for circular data.

Frequentist validity of highest posterior density regions, Bayesian route to higher order comparison of tests.

3. Design of Experiments :

Optimal continuous designs for estimation and prediction, Inverse prediction problems in random coefficients regression models, Analysis, connectedness and optimality of row-column designs and block designs.

4. Sample Surveys :

Allocation of sample size in stratified sampling, Use of ancillary information in sample designs and inference.

5. Probability and Stochastic Processes :

Marcinkiewicz-Zygmund strong law for general statistical functions with applications to L-statistics.

Itô's formula for discontinuous semimartingales in higher dimensions.

Convergence rates in CLT for general nonlinear statistics.

Random walks in finitely additive set up, random iterations of affine maps.

Projects

Two projects entitled "Robust Multivariate Inference" and "Exploratory Generalised Regression" were undertaken, the primary goal being to develop exploratory techniques that enable one to discover patterns and unmask low dimensional structures in high dimensional noisy data. These techniques have been used for analysing data coming from industrial, medical and other scientific experiments as well as various kinds of survey data. The methodology involves extensive use of computer graphics. A part of the research involves theoretical investigations into the performance of the techniques developed. This is an ongoing project and major results and findings have been reported in the technical reports and several articles published in scientific journals.

Delhi Unit

Statistics and Probability

1. Statistical Inference :

Global Cramer - Rao type inequalities; Inference under order restrictions as applied to survival analysis and reliability problems; Stochastic modelling and partial orderings of distributions; Nonparametric tests for competing risks.

2. Design of Experiments :

Optimality of designs under resource constraints using Graph-theoretic methods; Construction of asymmetric orthogonal arrays.

3. Probability :

Uniqueness and robustness of Fujisaki - Kallianpur - Kunita and Zakai equations of non-linear filtering under a general framework; Disproof of a conjecture of Kertesz and Vicsek in percolation theory.

Mathematics

A new proof of Krein's trace formula; Perturbation bounds for matrix factorizations; Spectral radius formula for joint spectra of commuting matrices; Study of Q-matrices; Regularity of solutions of elliptic systems.

Bangalore Unit

1. Statistics :

Sample surveys, Large sample theory, Bayesian inference, Bayesian non-parametric statistics, Bayesian non-parametric estimation, Robust Bayesian Analysis, Reliability theory, Optimality and construction of experimental designs;

2. Probability theory :

Applications of large deviations to Information theory, semi-stable measures and processes, diffusion processes;

3. Mathematics :

Groups of exceptional Lie type, Coxeter groups and the Monster group, Combinatorics (Bruck-Ryser type theorems for quasi-symmetric designs and strongly regular graphs), Functional Analysis, Geometry of Banach spaces, Ergodic theory, Operator algebras and Operator theory, Harmonic analysis, Differential Geometry and Topology, Spectra of Laplacians (especially on vector bundles), Spectral theory for partial differential operators, Finitely additive measures, G-inverses.

Applied Statistics, Surveys and Computing Division

The Applied Statistics, Surveys and Computing Division consists of Biometry Research Unit (BRU) and Computer Science Unit (CSU). Faculty members of the Division are engaged in project, research, teaching and training programmes. Summary of activities are given below unitwise.

Biometry Research Unit

Research workers of the Unit are engaged in studies related to : 1) growth of Indian Major Carp (IMC) fed with selected nutrient diets ; 2) Visco-elastic properties of blood under stress conditions, including chemical stress ; 3) the effect of hypoglycemic extracts from plant sources on blood sugar, using different experimental models ; 4) the young insulin dependent malnutrition related diabetic patients (MRDP); and 5) implication of serum lipid profiles in atherosclerosis and glucose intolerance. Toxicological studies, with some organophosphates which are widely used in agricultural fields, are undertaken in the unit. Some salient findings are 1) exposure of IMC to pesticidal pollutants significantly lowers the protein and glycogen contents in them; 2) growth studies of IMC indicated distinct species-specificity; 3) water soluble portion of the alcoholic extract of *Vinca rosea* when subjected to separation in silica gel chromatography with different solvents, such as, ethyl acetate : methanol, ethylacetate : chloroform : benzene revealed the presence of eight fractions; 4) the FCPD patients who are subsets of MRDM, despite suffering from a secondary form of diabetes, are as frequently and as severely afflicted with retinopathy as those with primary forms of diabetes and need similar ocular surveillance and 5) variation of diet is responsible for the variation of cholesterol turnover in body tissues and high level of cholesterol in body often leads to atherosclerosis and other cardiac ailments.

1. Visco-elastic properties of blood

Study target was to assay biochemical and haematological properties as a result of the stress induced by chemical and radiological sources on experimental animals.

As a routine procedure chemical stress was induced by injecting 50 mg/Kg i.p. of streptozotocin (σ) to normal healthy rabbits. The experimental design involved the treatment of two separate batches of age-matched (6 months) normal healthy rabbits ($n=6$ each) with chemical stressor (streptozotocin) to one batch and equal volume of saline (placebo) to the control batch. The weights of the animals ranged from 1.25 - 1.5 kg for which records were also kept on individual rabbit basis. Short term and long term effects of the chemically - induced stress was investigated on various blood parameters, e.g. viscosity, protein fraction and general haematological indices. Comparable experiment was performed by applying known shear stresses e.g. 20, 30, 40, dynes/cm². The results revealed that highest viscosity was obtained with least force applied (20 dynes/cm²); i.e. the lower the shear stress, higher was the viscosity.

Radiological stress was also induced by wholebody X-irradiation by a machine operating at 250 kvp with a 2mm Cu filter. The dose was adjusted by trial. Two sets of age matched normal healthy rabbits ($n=6$), one for control and the other for treated batches were used. The X-irradiation procedure was followed by applying two schedules. In one, various doses (50, 75 and 100 Gy) were tried keeping the time fixed (1 min)

and in other, keeping the dose fixed (50 Gy), experiments were performed as before. The results revealed a time related and not dose-specific variation of the blood viscosity of animals.

The experiments on radiation dosimetry, were performed to evaluate the exact dose at which the animals were subjected. This portion of the project was conducted with the help of J.C. Mondal of Biophysics Laboratory of the Saha Institute of Nuclear Physics, Calcutta.

2. Hypoglycemic drugs from plant sources

The water soluble portion of alcoholic extract of *Vinca rosea* was subjected to separation in silica gel chromatography. Trials using different solvents such as, ethylacetate : methanol, ethylacetate : chloroform : benzene revealed the existence of eight fractions. Further work to isolate these fractions and to study the effect of these fractions on experimental animal models is in progress.

3. Carp growth with selected nutrients

Target activities were

- i) Selection and collection of feed ingredients and preparation of trial feed.
- ii) Laboratory investigation to be conducted with the trial feeds to determine growth rate and food conversion rate.

The experiment is designed to cover the lag phase of growth of the DMC spawns : i.e. from 5th day to 12th day of growth of the species. Two types of supplementary feed have been prepared, one containing animal derivative ingredients like fish meal and the other containing plant derivative ingredients ; i.e., groundnut oil cake.

It has been observed that better growth is possible by applying animal derivative feed rather than plant.

4. Histopathological changes of airbreathing fish

Air-breathing teleost like *H. fossilis* of average weight 8.15 mg. and average length of 4.75 inches and *A. testudineus* of average weight 21.5 gms. and average length of 3.85 inches were exposed to different concentrations of phosphamidon commonly known as dimescron for 96 hours to determine the LC_{50} . 50% mortality has been observed at 47 ppm for *H. fossilis* and 8 ppm for *A. testudineus*.

Fresh batch of 10 fishes of *H. fossilis* (av. weight and length were 8.15 mg and 4.8 inches respectively) and *A. testudineus* (av. weight and length were 21.5 mg and 3.85 inches respectively) were exposed to sublethal concentration of phosphamidon i.e. 15.7 ppm for *H. fossilis* and 2.7 ppm for *A. testudineus*, to investigate the histopathological changes in terms of short and long term effects of phosphamidon on different tissues like liver, kidney, gill, etc. The water of the ambient medium were changed every day and the concentration of the pesticidal pollutant was also monitored to maintain identical experimental conditions. No mortality was observed during the experiment.

5. Investigation into the young insulin dependent MRDM

We have been working on this project for more than 6-7 years to find out the causative factors behind the malnutrition related young diabetic patients, particularly the patients of fibrocalculeous pancreatic diabetes (FCPD). This is a peculiar disease confined to certain zones of the countries within the tropical belt.

The aetiology of it is thought to be environmental, though the agents are not yet fully known. Protein energy malnutrition (PEM) may be an important environmental factor, but the data we have so far do not implicate this in all cases. Besides, not all members of the population groups exposed to PEM, develop this disease. Even the question of genetic predisposition probably does not arise since in our cases only 11.2% of the affected individuals have positive family history.

In this context we made HLA - class II antigen studies to link up the susceptibility of HLA - antigens with MRDM patients in general and FCPD patients in particular. Our HLA studies reveal some interesting information which are somewhat different from other studies. Next we studied B-cell functions in our patients to assess the fasting and post glucose C-peptide and insulin levels in the plasma where we observed that these levels have varying BMR (Basal Metabolic Rate) and the nutritional standards of the patient.

6. Lipid profile in diabetic atherosclerosis

In the light of recent knowledge as reported in literature, it is revealed that diabetic people are more prone to atherosclerosis and heart stroke. Also lipid profiles are thought to play a major role in the causation of heart attack. Saturated fatty acids (SFA) as a whole are implicated in hypercholesterolaemia and reduction of HDL - cholesterol in atherogenesis. Surprisingly this does not apply to medium chain SFA and stearic acid.

In a preliminary effort to fill this information gap, it was thought that dietary analysis would reveal the preponderance of which fatty acids in the food lead to diabetes and whether they have different roles in the recent onset of diabetes and in the long duration of diabetes. We have also collected data from similar socioeconomic non-diabetic subjects. We are now working to correlate the fatty acid intakes with the prevalence of atherosclerotic diseases and glucose intolerance. Thus if any defects in the patterns of total fat and various fatty acid intakes can be revealed, suitable corrective guidelines may be laid down. Since there is dearth of information on the intakes of various fatty acids and their impact on cardiovascular status and glucose intolerance in the low middle and middle class people in this region, our work would be helpful to fill this information gap by examining the dietary patterns of large number of such people and find out clinically and electro cardiographically prevalence of ischaemic heart disease, peripheral vascular disease, strokes, glucose tolerance, and defects in serum lipid profiles in them.

Projects

A Winter school on the Application of Biometric Techniques on the Biology of Fish Growth and Reproduction was conducted jointly with the Department of Zoology, Visva-Bharati University, Santiniketan, during 27th October to 8th November, 1994. A workshop on the separation of carp LDH - isozymes by starch gel electrophoresis was also conducted besides lectures on statistical concepts and biological aspects of fish growth. Professor J.S. Dutta Munshi, Bhopalpur University, gave a lecture on "Diffusing capacity of the gills and accessory respiratory organs of airbreathing fishes and Professor T. Subramoniam, Madras University gave invited lectures on i) Cryopreservation of crustacean gametes and embryos and ii) Crustacean reproduction and aquaculture, to the participants of this school. Eight participants from different universities in India attended the school.

Computer Science Unit

The scientific workers of the Computer Science Unit are engaged in research, teaching and training activities of the Institute. The main areas of research are Sampling, Design of Experiments, Multivariate Analysis, Directional Data Analysis, Reliability, Regression Analysis and studies in 2-D Cellular Automata & Optical Processing. The faculty takes active part in teaching in the regular B.Stat. M.Stat. M.Tech. in both Computer Science and Quality, Reliability & Operations Research and International Statistical Education Centre's regular and specialisation courses. Besides, the unit also conducted the 30th session of the Intensive Course on Programming and Application of Electronic Computers from 22nd August to 4th November 1994. The faculty also took part in ISS probationers and officers training programmes of the Department of Statistics, conducted at Calcutta. Development of computer software for directional data analysis is currently in progress at CSU. The unit organised a UGC sponsored Refresher course in Statistics (November 15 - December 5, 1994) and a Winter School on Directional Data during December 12-17, 1994.

1. Sampling Studies

Encouraging theoretical and empirical research is continuing in the areas of randomised response models, efficiencies of estimators and their measures of privacy protection, emerging field of Small-Domain Estimation, optimal estimation under superpopulation models.

2. Design of Experiments

Research in this area are confined to designs with repeated measurements over varying time periods, development and study of designs for their optimality in the field of medical experiments, biostatistics etc. and designs under mixed effects models.

3. Multivariate Analysis and Inference

Studies in Reliability modeling, Inference for two sample survival data, existence conditions of a limit of suitably normalised and centered posterior under general set up, asymptotic behavior of Bayes estimates in multiparameter discontinuous densities and densities with singularities, asymptotic expansion of posterior distribution for a family of nonregular cases and computational methods and diagnostics for collinear data are some of the research topics. Characterization of densities admitting Cox's semi-parametric Logistic Discrimination Rule - the multivariate multiparameter case; Semi-parametric optimal estimation of Cox's LGD Rule ; Robust test for the intra class correlation coefficient in symmetric multivariate elliptically contoured symmetric family; χ^2 -tests for no mixture against the multivariate normal mixture family ; estimating functions, p^* - and L-optimal tests for no mixture.

Directional Data Analysis : Robust predictive densities for the mean direction for circular and spherical random variables; Admissibility of simultaneous MLE of the mean directions in several independent Langevin distributions, Monotonicity and Admissibility of some standard tests in the Langevin distribution; Robust test for uniformity of directions in the wrapped stable circular uniform mixture family with applications; Tests for change point with directional random variables.

Statistical interpretation of updates for data/model changes in terms of linear zero functions provides a good understanding of updates. Efforts are on to study alternatives to ridge regression from the statistical and computational point of view. Fitting suitable linear regression models for infant mortality rate predictors from a choice of economic and demographic regressors are being tried out.

Studies in geometric algorithms with VLSI applications and Bayesian object recognition approach for automatic counting of bacterial colonies from images of the bacterial colonies applying Markov chain Monte Carlo simulations are also of interest to the faculty.

Projects

1. Application of 2-D cellular automata

A Cellular Automata (CA) is characterised by its geometry, set of cell values, neighbourhood specification and evolution rules. Evolution of CA proceeds over one time step by application of respective local rule to each cell. This leads to a new configuration. Successive new configurations are evolved. A general technique for synthesizing a CA was developed for a special class of CA having one cycle of length one and all other cycles of length L. The enciphering and deciphering techniques were studied with respect to the robustness against cryptanalytic attacks. Synthesis of maximum length CA was done by starting with primitive polynomials and using Lenczos algorithm in finite field. This scheme while retaining the advantage of uniformity in enciphering and deciphering is conceptually more simple with respect to key management. This is an improved cryptographic scheme. A cellular automata simulator was also developed. The package can perform simulation of any binary CA on a two dimensional grid.

Concept of compositeness is introduced for a class of self generating automata. Its dynamical behaviour is fully analyzed. The results are found to hold good for the class of CA. Its application to private key cryptosystems and to generation of long period integer sequence generation is established.

Cellular architectures for modulo operations on polynomials are developed. Presently, polynomial division is performed by using LESRS. For designing polynomial design circuits, the usefulness of the homogeneous and uniform structure of CA was shown.

Work is in progress on

- i) A scheme to generate test vectors for a given CA, and
- ii) A fast systolic structure for modulo multiplication.

2. Generalized linear models

Work on this project, focused on understanding and quantifying the roles of observations and variables in collinearity and examining the usefulness of some of the popular remedies of collinearity.

The effect of an observation on collinearity can be judged by comparing the condition numbers of the design matrix. This option is computationally demanding. Hadi (1988) provided some approximations to the change in the condition number. During this project, it is found that these approximations are actually from the lower side. So a sharp upper bound on the change was obtained. Due to limitations of the condition number in depicting the overall state of collinearity, in the linear regression context, some new case wise diagnostics of collinearity were derived. Similar results for analyzing the impact of an additional observation on collinearity were obtained.

The variances proportions table is used to describe the roles of the regressor variables in collinearity. Studies indicated that the variables involved in the various modes of collinearity are better identified by the table of right singular vectors of the design matrix. The role of variance proportions table as a diagnostic tool for collinearity is also defined.

3. Small domain estimation

The project is entitled "An empirical investigation on effectiveness of emerging small domain estimation procedures compared to traditional methods in the Indian context".

An application of empirical Bayes and Kalman filtering techniques is reported, using live data from Indian Statistical Institute, Calcutta, to illustrate how initial small domain estimators may be vastly improved upon. A stratified two stage sampling procedure is adopted, allowing selection of first stage units with unequal probabilities but of second stage units with equal probabilities. Standard design based estimators for domain totals are initialized based on domain specific survey data alone. Strength is then borrowed across domains and from past surveys. The resulting gains in efficacy are numerically demonstrated, through replicated sampling from official records.

4. Study on rural indebtedness in West Bengal (1993-94)

This is an ongoing project. The aim of the project is to make a comprehensive study of data supplied by institutional sectors like Reserve Bank of India, Planning and Development Department of West Bengal and National Sample Survey Organisation and data collected from household surveys. A household survey was conducted in two districts of West Bengal. They are Hoogly (near Calcutta) and Murshidabad (away from Calcutta). Altogether 2560 schedules were filled in. Four blocks were selected from each district using Rao-Hartley-Cochran scheme. The actual field work was completed in September 1994. The scrutiny, editing of computer data files and analysis of data are in progress.

5. Software development for the analysis of directional data

The analysis of directional data does not conform to standard statistical techniques. This calls for special tools. Now such tools are emerging on sound theoretical basis. The need for appropriate computer packages for the analysis of such data is, therefore, thought worthwhile.

The package being developed is planned to work in an interactive environment. The package is modular. Each command module draws on a global data structure and executes the command. As and when new command modules are developed and tested, they are added to the main package.

So far, commands like READ, SAVE, RESTORE, SHOW, ERASE, INSERT, DELETE, QUIT, EXECUTE for creating the worksheet, saving and editing of the data in the worksheet have been incorporated into the package. Also work in developing the modules for graphical representation of directional data has been tested but not integrated with the main module. This way about 80% of work we have planned for 1994-95 has been completed. The project will continue for 1995-96 also.

6. Software development on Cellular Automata

- i) Module for simulation of CA. This can simulate any binary CA on a 2D grid with null or periodic boundary condition.
- ii) CA based encoding and decoding system.
- iii) Modules on thinning algorithms and other utilities.

7. Winter School on Analysis of Directional Data

This winter school was held at ISI, Calcutta during 12-17 December 1994. The school was attended by 36 participants with diverse areas of specialisations. They included scientists from Defence Research Development Organisation/Laboratories, Indian Institute of Science, Bangalore, Indian Meteorological Society, Pune and Calcutta, Geological Survey of India, Zoological Survey of India, Centre for Pollution Studies and faculty members from Universities specialising in Electronics, Biology, Environmental Sciences and Statistics.

The course content was : Introductory level exposure to recent developments, Descriptive Statistics and Regression for Directional Data, Basic Distributions and Inference, Non-parametric methods and discussion and demonstration of Software for DD analysis. Short lectures were given on Optimal properties of tests, Model selection and Goodness of fit tests, Classification and Discrimination techniques and Change-point and Slippage problems.

Externally funded project

A project on "Differential Impact of Modern Rice Technology Across Production Environments" was conducted jointly by Indian Statistical Institute and University of Kalyani. The study was sponsored by the Rockefeller Foundation as a part of a larger study covering several countries in Asia.

The primary data was collected during 1989-91 period in West Bengal and its analysis was taken up subsequently. Now the report is published. A few of the salient findings of the study are outlined below :

- i) Modern Variety (MV) rice technology reduces the duration of a crop on the field and enables the farmer to grow additional crops leading to increase in cropping intensity.
- ii) MV technology created 33 per cent higher demand for labour per acre compared to Traditional Variety (TV) technology in pre-kharif/kharif season.

- iii) The analysis of factor shares showed a twofold increase in the level of farm family income of owner cultivators as a result of change over to MV technology and that of tenant cultivators is fourfold.
- iv) Per acre cost of production of rice is higher in MV than in TV, but due to more than proportionate increase in yield per acre, the cost per kilogram of rice output is less in MV than in TV.
- v) With the increasing MV adoption rate of households not only the per acre income from rice increased but the per acre non-rice crop income also increased. Taking the household as a unit, incomes from rice and non-rice crops and area per household, have all showed an inverted U shape i.e. increase with adoption rate, reaching a maximum and then a decrease. This pattern is less pronounced for crop income than for crop area per household.
- vi) Relationship between farm size and MV adoption reveals that small farms tend to specialise. The agro climatic factors determine their 100 per cent MV adoption or no adoption at all. Larger farms have greater physical diversity and permit a more mixed cropping pattern.
- vii) Total income per household shows moderate rise over adoption classes. The direct impact of technology change in rice cultivation shows increasing inequality in rice income per household with increasing adoption of MV rice technology. However, this has been largely neutralised by the other components of income, particularly income generated in the hired labour market which may be an indirect impact of the MV technology.
- viii) Income determination functions shows a positive effect of MV adoption on rice and crop income.
- ix) Incidence of absolute poverty declines largely with increasing adoption of MV rice technology. However, the MV rice technology adoption has not consistently increased the inequality in household income while increasing its variability, to some extent, in absolute terms.

Physical and Earth Sciences Division

The Division comprises of Chemistry Unit, Computer Vision and Pattern Recognition Unit, Electronics Unit, Electronics and Communication Sciences Unit, Geological Studies Unit, Machine Intelligence Unit and Physics and Applied Mathematics Unit. Faculty members of the Division are engaged in teaching and training, besides their research and project work. Research carried out in these units are described below :

Chemistry Unit

1. Allophanic Materials in West Bengal Soils

A large number of West Bengal soils was found to contain an elusive constituent mainly in the clay fraction. This substance produces modification in the clay properties such as exchange capacity, aggregate formation, water permeability etc. This material was suspected to be non-crystalline, allophanic in nature and has been little studied in our soil so far.

Identity of these allophanic substances was established by spectroscopic technique. These were found to bind strongly to organic matter which could explain the accumulation of organic matter in the subsoils in regions where such allophanes were found. Experiments have been carried out to explore the nutrient potential of this constituent.

2. Source, availability, nutrient value and toxicity potential of some heavy metals in soil

Some of the so-called heavy elements are often beneficial to life when present in small amount but highly toxic above a certain level. There are however some such elements as As, Cd, Hg and Pb which are dangerously toxic even in small quantity. Proximity to industrial belt and consequent effluent and solid discharges contaminate fertile soils. Application of city wastes as manure and indiscriminate use of pesticides without any preventive measures have been causing heavy metal toxicity for quite some time. We have been trying to measure the heavy metal population in the potentially contaminated soils and pinpoint the offending source of contamination. Experiment is on to suggest ameliorative measures and prevention of the fresh contamination.

The project also envisages the evaluation of the level of micronutrient supply in agricultural land and identify the deficient and also overfed soils.

Computer Vision and Pattern Recognition Unit

The Computer Vision and Pattern Recognition Unit was formed in November 1994 to carry out research work in the field of Computer Vision, Pattern Recognition and Knowledge Based Computer Systems, and to collaborate with industry in the area of Computer Science. The collaboration with industry includes manpower development, execution of turnkey projects as well as applications oriented research and development work.

1. Mathematical Morphology, Dot Pattern and Cluster Analysis

a) An efficient approach based on mathematical morphology has been developed to detect circular objects in a scene. It works even if the objects are highly occluded by one another. Extension of the work to gray level regular geometric shapes is being carried out.

b) The task of shape identification of dot patterns has been considered. One of the problems here is the automatic detection of the perceptual boundary which has been solved by a parallel algorithm. The approach can take care of multiple dot patterns of different densities in the same scene.

c) A new algorithm for detecting representative seed points from a pattern set in multi-dimensional space has been developed and its properties have been established.

d) A new definition of neighborhood of a point in a multi-dimensional space has been defined that captures both the notions of proximity as well as symmetric placement. Some applications of the proposed neighborhood have been demonstrated.

e) A multi-seed data clustering algorithm has been proposed. It has been demonstrated that the algorithm works very well. Detection of clusters is being worked out.

2. Computational Linguistics, Natural Language Processing and Speech Analysis

a) From a large corpus, statistical analysis of Bangla text has been done. Statistical analysis of phonemic representation of the data has also been done.

b) Morphological processing of Bangla words is being continued and the methods developed earlier are being improved.

c) A generalised lexical functional grammar has been proposed for syntactic analysis of Bangla text. A present tree adjoining grammar is also being generalised for the syntactic processing.

d) Some work on Bangla compound verb has been started and rules are being formulated for parsing of compound verbs.

e) A spell checker prototype has been designed for non-word error detection in Bangla text. A correction strategy has been formulated. It is being extended to take care of some real word error detection.

f) Computer implementation of grapheme to phoneme conversion rule has been worked out. Work is in progress to produce speech mode output of OCR and spell checker already developed. The work will be useful for the visually handicapped.

3. Optical Character Recognition and Document Processing

a) The prototype Bangla OCR system already developed is being improved to recognise multi-font Bangla documents.

b) A Devanagiri (Hindi) OCR system is being developed. Work is continuing to integrate Bangla and Devanagiri OCRs.

c) Separation of scripts in a multi-lingual document has been worked out presently with Bangla, Devanagiri and English languages.

d) Work is in progress for automatic identification of tables and mathematical expressions in a complex document. Automatic merging, appending and restructuring of tables are also being worked out.

4. 3D Digital Geometry and Biomedical Image Processing

a) Topological problems like Euler characteristics computation in 3D digital space has been worked out. Efficient algorithms to find skeleton as well as segmentation of objects using skeletal discontinuities have been proposed.

b) The problem of confocal microscopic (CM) image processing is considered. Multiple layers of CM images are being combined to make a 3D cellular representation.

c) Texture has been used for the first time for automatic classification of cell images using fractal textural features.

5. Neural Networks

a) An adaptive method has been developed to update, in an autonomous way, the learning rate of the backpropagation algorithm for a multilayer perceptron. This method assumes each individual weight has its own learning rate parameter and updates it on the basis of the steepest descent principle. In this context a new concept, namely, the effective value function of the learning rate, has been defined. The new adaptive algorithm has been applied to a number of benchmark problems and has produced much better performances in terms of convergence speed than the original backpropagation algorithm. It has been successfully applied to two high dimensional astronomical data analysis problems.

b) A modification of the self-organising neural network model of Kohonen has been proposed. The number of processors in such a network is normally fixed. A dynamic version of the network has been proposed where this number can grow or reduce during the learning process depending on the data. For this, some criteria are proposed for insertion and deletion of processors during learning. The dynamic network has been applied for shape representation and a unified approach to skeletonization of patterns (binary or gray level images or dot patterns) has been proposed.

During the period 1994-95, the faculty members of the Unit were engaged in research in the field of Computer Science. The research areas include Parallel Algorithms and Parallel Architectures, Network Topology, Interconnection Networks, VLSI Layout Design, Logic Synthesis and Design for Testability, and Computational Geometry.

1) Parallel Algorithms and Parallel Architectures

The objective of research in this area includes the following :

- i) Design of efficient parallel algorithms for various numeric, non-numeric and graph-theoretic applications, problems on computational geometry, mapping these algorithms on suitable parallel architectures.
- ii) Design of fault-tolerant parallel architectures for different numeric and non-numeric problems.
- iii) Testing and design for testability of systolic arrays.

New parallel algorithms for fast multiplication in redundant quaternary number systems have been developed. Algorithms for Lagrange's interpolation with a) $O(\log n)$ time and $O(n^2)$ processors, and b) $O(n \log n)$ time and $O(n \log n)$ processors have also been developed. A parallel algorithm for power series manipulations have been developed.

2. Network Topology

The objective of this study is to substitute topologies for computer networks in order to have a network with small diameter, low number of communication links, incremental extensibility, fault-tolerance and ease of routing in both fault-free and faulty situations. Many of these requirements are mutually conflicting in nature. An optimal design is still called for.

A new network topology called Fractal Graphs based on fractal geometry has been developed for designing a parallel-processing architecture. The graph is planar, recursive, self-similar, has a sub-logarithmic diameter and admits a hamiltonian. The proposed architecture has many beautiful combinatorial properties and will serve as a potential processor interconnection structure for parallel processing.

Another new network architecture with the maximum node degree of 3 has been proposed. This network uses trees as the basic building blocks which are interconnected in a suitable manner. Algorithms for bitonic sort and DFT have been efficiently mapped on this architecture.

3. Interconnection Networks

A general graph-theoretic approach has been studied for establishing the rearrangeability of a given multistage interconnection network. A general class of rearrangeable interconnection networks have been defined. Different self-routing algorithms have been developed for these networks to route different classes of permutations. New group transformation rules have been proposed for rearrangeable networks that enable us to route a large class of permutations in $O(\log N)$ time in an $N \times N$ rearrangeable network. Some fault tolerance properties of this class of rearrangeable networks have been studied and specific fault tolerant routing algorithms have been developed for routing permutations in presence of typical classes of faults. Some new fault detection techniques have been proposed for detecting these faults.

A new concept of output buffering has been introduced which is useful in the performance analysis of MIN's. Simulation results of this technique are currently under study.

Fault-models for detecting and diagnosing short-circuit faults in Benes network as well as Clos network have been developed. Test vectors for locating these faults have also been designed.

4. VLSI Layout Design

The objective of this project is to develop algorithms for efficient design of VLSI layout. Our area of investigation includes :

i) Floorplan Optimization

Floorplan topology generation and sizing problem have been unified for efficiently dualizing an interconnection graph. We use an AI-based graph search technique. For general floorplans, we introduce the concept of Z-cuts, which is a powerful tool to handle general nonsticking floorplans. Experimental results show that the proposed technique outperforms the existing tools.

ii) Routing

Routers with manhattan and $\pm 45^\circ$ moves have been designed both in the non-overlap and overlap models. Results indicate that any arbitrary VCG-acyclic channel can be routed with $d+1$ tracks, where d is the density. The router terminates in linear time. For acyclic VCG, the router also performs very well. Benchmark channels and switchboxes show excellent results when the proposed router is used.

iii) Partitioning

A new concept of monotone-geometric partitioning of chip floor has been developed that is helpful in routing. An efficient search technique has been formulated based on depth-first branch-and-bound (DFBB). Experimental results show very encouraging results.

5. Computational Geometry

Location of the maximum area isothetic rectangle among arbitrary-shaped rectangles in polynomial time remained unsolved for a long time. A new technique based on matrix-searching has been used to solve this problem in $O(n \log^2 n)$ time and $O(n)$ space.

6. Logic synthesis and Design-for-Testability

i) Isomorphic redundancy in sequential logic circuit is a mysterious property and whether or not there exists a real circuit that exhibits this kind of redundancy remained an open problem for a long time. We have studied this problem in detail and found a series of examples of such circuits and their underlying properties. Currently we are working on their identification and removal.

ii) Novel techniques for inducing design for testability in non-scan synchronous sequential circuits have been developed. The proposed testable design generates elimination of all sequential redundancies in a random sequential machine. This technique is simple and its hardware overhead is much less compared to that of conventional LSSD design.

iii) Reiming of the sequential circuits for faster operations, and its effect on redundancy are studied. A suitable synthesis-for-testability technique has been developed, such that the machine design remains resistant to redundancy under reiming.

iv) Built-in-self testing of CMOS stuck-open faults has been implemented using a new technique. An adaptive testing technique based on the application of pseudo-exhaustive test patterns has been developed.

7. Design of Reconfigurable Fault-Tolerant Array Processors/Systolic Arrays

This is a research as well as a developmental project. The major goals of this project are as follows :

- i) Studies and subsequent design of reconfigurable, fault-tolerant parallel architectures constructed by interconnecting processors;
- ii) To develop algorithms for reconfigurability and routing in presence of faults in different parallel processing environments, e.g., hypercube, cube-connected cycles, mesh, de Bruijn network, etc.;
- iii) Studies on algorithmic fault tolerance in the context of parallel processing;
- iv) Studies on design for testability of unilateral/bilateral 1-dimensional/2-dimensional systolic arrays and their implementations;

We have studied models of 1-D bilateral systolic arrays and developed new techniques for their testing. The problems of fault-tolerance, reconfigurability and design for reduced diameters in hypercube architectures have been completed.

Electronics and Communication Sciences Unit

The faculty members of this unit are engaged in teaching of the different courses like M.Stat., M.Tech. (CS) and M.Tech. (QR & OR) conducted by the Institute. A number of project/dissertation works of the M.Tech. (CS/QR & OR) students have been supervised by the ECSU faculty members. At present research scholars (funded by ISU/CSIR/UGC) carry out their Ph.D. work (research/thesis writing) under the guidance of the ECSU scientists/faculty members. Ten engineering & technology students from various universities (six from BE College IMPACT programme, one from J.U. one from Dibrugarh University and two from NERIST - Arunachal Pradesh) received their vocational training for about 6 to 8 weeks in ECSU. Two MCA students from South Gujarat University and Utkal University completed their final project works and dissertation of 6 months duration in ECSU and got their degrees.

Research activities carried out by the unit during the period were :

1. Development of methodologies for analysis, understanding and processing of image and shape
 - i) 2D/3D parallel mode thinning algorithms for 2 tone images have been developed and are successfully applied for extraction of structural information and data compression. The algorithm is based on extraction of well defined shape patterns using 3D digital topology. A major achievement is defining 3D simple point and its efficient implementation. An already developed thinning algorithm for regeneration of pen motion in handprinted script is refined for better performance on printed and handwritten script.
 - ii) Algorithms for extraction of contours and other continuous linear structures from gray level images is completed. The algorithms are based on search techniques and neural network methodologies. Methodologies for color image enhancement have been developed and are reported.
 - iii) Pattern-spectrum is well known technique for shape size representation of an object. A fast algorithm for computing pattern-spectrum using mathematical morphological concept has been developed. This P.S. has been used to estimate radius of circular objects, which in turn is used to isolate those circular objects in cluttered scene even in case of significant occlusion.

2. Research in computational geometry & C.V. technology

i) Geometrical and topological properties of 2D digital objects are investigated using mathematical morphological tools. A new definition of digital convexity has been suggested. Digital convexity of objects resulting from various morphological transformations are studied under the light of this new definition. Ortho convexity and ramp convexity, which are very useful concepts in discrete domain and computer vision methodologies, are also used to generate ortho convex hull and ramp convex hull.

ii) A series of research projects are being conducted on scale space image analysis for detection of corner points of 2-D digital curves. Several new results are already reported in international journals. Recently the wavelet concept is being fused with scale space analysis of 2-D images.

3. Research on fuzzy logic, approximate reasoning and neurofuzzy computation

A series of research projects are being conducted on different theoretical aspects of approximate reasoning using fuzzy logic. A new interpretation of multidimensional fuzzy reasoning has been developed and used for neurofuzzy computation for speech recognition, pattern recognition and occluded object recognition. A new learning scheme to train the neural network is being developed using genetic search technique.

4. Biomedical image processing

Biomedical studies related to knowledge based expert system framework that would combine medical images of different modalities (sources) and visualization that help in presenting the anatomy, physiology and disease pathology in 3D are being conducted. A review of mathematical techniques of image registration of all the major medical imaging modalities (sources) are continued. Another important piece of work is the registration of images obtained from multiple sources [e.g. x-ray computed tomography (CT) and MRI (magnetic resonance imaging)] into a single frame of reference known as the canonical frame of reference. Shape of anatomical structures in biomedical images is another important research area of this group. Shape matching of images of such structures obtained from two different sources, CT and MRI has been carried out using shape specific points. A 2D shape metric has been implemented to irregular shapes in biomedical images and the possibility of studying the progress of pathology (e.g. tumor) with the help of this shape metric, is being explored.

5. Wave propagation, signal processing & atmospheric science

In the field of wave propagation, signal processing and atmospheric sciences we have four ongoing projects. In wave propagation studies, analysis of VHF/MM wave fade duration was completed and classification of 3 typical modes of propagation was ascertained. More statistical work including clustering technique will be continued. Rain attenuation characteristics on wave propagation is continued. Role of water vapour density in attenuating wave propagation has been investigated and reported. Encouraging work is done and continued in the knowledge-based system development for recognition and interpretation of atmospheric patterns. Dot like structures recorded in sodar imageries were identified and reported. Segmentation of ABL imageries using different mask techniques is continued and results communicated. Moreover some semi-automatic methods have been developed for the segmentation of sodar image boundaries and the observations communicated. Detection of their boundaries and their mathematical representations have also been communicated. Though the overall system is not fully automated, our aim is towards that. In the field of atmospheric modelling some studies have been continued to observe/detect the chaos and turbulence occurring in the ABL from the lower (meteorological) data which would have some bearing on the qualitative prediction of the monsoon dynamics formation and the results obtained from this analysis have been communicated. ABL inversion breaking phenomena recorded in sodar pattern have been analysed, modelled and reported. Results of the analysis of cloud images (INSAT ID-satellite data) have also been communicated. In atmospheric aerosol size and distribution project, mechanical/fabrication of the experimental set up is almost completed but the procurement of some optical accessories is in progress. For the restriction of laser power (mw range) limited scattering experiment on low altitude fog/layer and other suspended particles present in the lower atmosphere would be possible to continue on regular basis.

6. Speech and music research

Acoustic and phonetic studies of some major Indian languages such as Telugu and Bengali have been completed. Acoustic phonetic studies of Assamese and Oriya languages have been started. Perception experiment for searching cues for fricative consonant identification has been completed. Perception experiment is continuing to discriminate voiced/unvoiced plosive consonants. Preliminary work has been started for word recognition using neuro-fuzzy classification technique. Neuro-linguistic approach is adopted for Bengali and Assamese vowel recognition. Procedure and software for synthesis of singing have been developed using temporal approach.

Geological Studies Unit

Since its inception in mid 1950s, the Geological Studies Unit (GSU) has been pursuing research on the Proterozoic and the Gondwana geology of the Pranhita-Godavari Valley. In the last few years, however, the research activities on the Proterozoic have been extended to the Cuddapah basin, the Chattisgarh basin and the Eastern Ghats, with an aim to work out the history of the crustal development of the southeastern part of the Indian peninsula, integrating the studies on stratigraphy, sedimentology, structural geology, magmatism and metamorphism. A similar approach, integrating the studies on stratigraphy, palaeontology and sedimentology, has also been adopted for the research on the Gondwanas and the activities on the same have been extended to the Satpura basin (including Jabalpur area), with an aim to reconstruct the history of the Gondwana sedimentation.

In 1994-95, nineteen research projects were taken up, and the broad areas of activities of the Unit are given below in short.

1. Proterozoic (Structure, Tectonics and Stratigraphy)

Structural geology of the Proterozoic and the Archaean rocks, Kharwa, Rajasthan; Structural features of the arrested charnockites vis-a-vis the amphibolite to the granulite transition; Cover deformation in Cuddapah; Sedimentation of the middle Proterozoic Pakhal group; Geology of the Chattisgarh basin in the early stage of the basin development.

2. Gondwana (Palaeontology, Sedimentation and Stratigraphy)

Crocodyliform remains of the Kota Formation; Infratrappean dinosaurs; Stratigraphy and palaeontology of the Motar Formation; Denwa stratigraphy and palaeontology; Lithostratigraphy and sedimentology of the Bijori Formation; Endothiodont and Cistecephalus from the Pranhita-Godavari Valley; the Lameta beds and the K-T extinction.

Quantitative geology/computer application

CPO in impure quartz tectonite.

The important developments in the research activities of the Unit are as below :

Proterozoic Research

1. Cover Deformation in Cuddapah

The details of the structures in key sectors of the Nallamalai Fold Belt are analysed for understanding the kinematic framework of deformation in this Proterozoic intracratonic basin. Geological mapping and structural analysis in the central part of the Nallamalai ranges around Diguvaicetta have been completed. Mapping around Vonimitta-Rajampet is under progress. Analysis of structures in these two sectors demonstrates a combination of LPS strain and buckle shortening. Mechanical stratigraphy within the Nallamalai group determines the spatial location of detachments and faults cutting up-section. The accumulated data indicate that the longitudinal variation in structures from north to south along the

Nallamalai Belt may be related to differential thrust transport controlled by transverse faults. Some of the latter are reactivation structures following extensional state normal faults as evidenced by their control on facies distribution within the Cumbum Formation.

Mapping along the eastern margin of the Nallamalai Belt around Sitarampuram suggests the so called "Dharwar Schists" separating the main Cuddapah outcrop and the outliers such as at Udaigiri and Bhairavani Kooda (Nellore dt.) are only metamorphosed and deformed rocks derived from protoliths having direct affinity with Nallamalai Group. Preliminary results obtained from micro-structure and fabric data from around Sitarampuram are equivocal in relation to westward thrust transport along the eastern margin.

2. Orissa - Karnataka Precambrians

Postulated gneiss to charnockite transformation at Kabbaldurga, Karnataka, is invalidated by the new findings of older granulite enclaves in the migmatitic gneisses. The pegmatitic charnockite veins (so-called insity charnockites) are mineralogically incompatible to have been produced from Peninsular gneiss.

In the northern boundary region of Eastern Ghats Orissa, massif-type charnockites predating granulite facies even have been identified. This clearly refuted the proposition of charnockitisation and points to probable magmatic protoliths.

Thermal modelling of the Eastern Ghats granulite belt. From structural studies an early compressional regime resulting in thickened crust by homogeneous shortening is envisaged. This, together with geothermobarometric data from the Eastern Ghats are utilized to constrain the inverse thermal model. Also important gaps in the existing models have been identified, e.g., heat transfer by conduction alone is inappropriate and lateral heat transfer is also important.

3 Proterozoic Stratigraphy and Sedimentation.

The work on the Proterozoic Penganga Group of the Pranhita-Godavari Valley, and Chattisgarh succession brings into focus close association of shallow marine and deep marine deposits, and the finding contradicts generally accepted model of shallow marine sedimentation in all the Proterozoic basins of Peninsular India. A suite of volcanic and pyroclastic rocks has been identified both in the Pranhita-Godavari Valley basin and the Chattisgarh basin. Different types of pyroclastics, viz., ignimbrites, ash flow and ash fall deposits have been identified. This is the first report of ignimbrites from the Proterozoic basins, and it opens up the possibilities of radiometric age dating, as well as correlation of different Proterozoic successions. Further, occurrence of pyroclastics at different stratigraphic intervals is a clear indication of unstable condition of the basins, and informations from the analysis of the pyroclastics may not be integrated with the sedimentological informations to interpret the tectonic setting of the basins, and their evolution.

Proterozoic alluvial fan related deposits were studied around Ramgundam area, Andhra Pradesh. Critical examination of the large scale architectural elements and details of internal sedimentary structures reveal that many of the features of the fan-deposits are common with that of bruided stream deposits. Due to the absence of vegetation covers the channel-confined fine-grained sediments in the Proterozoic setting, response of flood flow in alluvial fan feeder channels and high gradient braided rivers could be very similar. This observation is in sharp contrast to the newly proposed alluvial-fan sedimentation model constructed on the basis of present day fan building processes and underlines the importance of stratigraphic study of pre-silurian alluvial sediments.

Gondwana Research

1. Gondwana Stratigraphy, Palaeontology and Sedimentation

The red bed sequence of the Maleri Group, a part of the Gondwana succession, is interpreted as the deposit of an anastomosed river system. In contrast to the widely accepted models of laterally migrating meandering stream or bruided stream sedimentation, the anastomosed fluvial systems are characterised by multiple stable channels which periodically, switch their courses avulsively. The sedimentation is characterised by vertical aggradation of channel deposits and overbank deposition by sheet floods.

The analysis of the lithofacies and the facies association strongly indicate that the anastomosed system developed in an arid to semi-arid climate, and was dominated by sheet flood deposits, constituted mainly of intrabasinal caliche derived material. A facies model of arid zone anastomosed river deposition has been presented. The palaeoclimatic interpretation, supported by the stable isotope analysis of the calcrete fragments (in collaboration with PRL, Ahmedabad) indicate gradual climatic transition from glacial, marked by the Talchirs at the base of the Gondwanas to the arid to semi-arid arc through a warm humid regime, marked by the coal bearing Barakars. The palaeoclimatic interpretation opens up possibilities of classifying the Gondwanas on the basis of climatic changes, and also to study the changing palaeogeosition of the Indian peninsula through the Mesozoic time.

On the basis of abundance of wave-generated structures and mid-dominant lithology, Bijori Formation has been interpreted to have been deposited mostly in a lacustrine basin. Gondwana sediment has been broadly referred to as fluvio-lacustrine deposits but documentation of actual lacustrine sequence is hitherto unknown. Recognition of the lacustrine sequence from Bijori Formation gives a realistic touch to the vaguely defined palaeogeographic set-up of continental Gondwana basins.

A new titanosaurid dinosaur has been described from the late Cretaceous infra Trappan rocks of Dongargao, Maharashtra. This nearly complete, associated and articulated skeleton of titanosaur enabled us to diagnose the genus Titanosaurs; the other known Indian titanosaurid genera have also been reevaluated.

The lower Gondwana rock sequence comprising Talchir, Barakar, and Motur Formations of Satpura basin were mapped around Parasia, Chhindwara dist., M.P. covering an area of about 300 sq. km. with special emphasis on the stratigraphy and sedimentation of Motur formation. The lateral variation from clay dominant Motur formation in the eastern part of the mapped area to the sand dominant Moturs in the western part is documented by several lithologies. Large wood fossils and plant impressions of Permian Motur have been collected.

Mapping of the Upper Gondwana rocks of the Tawa Valley of Satpura basin is in progress. A comparative study in the eastern part of the basin shows that the typical denwa facies is not developed in Tawa Valley while the Pachmaris has more red clay within it. Moreover, the sediments of Motur and Bijori formations of lower Gondwana of Tawa valley has also lost some of their distinctive characters which are found in the eastern part. Fragmentary amphibian bones has been found from the Pachmaris red clay near Tamia for the first time.

Research programmes on Triassic vertebrate biochronology, review of the Indian metoposaurid amphibians, their morphometrics and other biometric studies of Indian temnospondyls have been carried out. Results of the above mentioned work will be submitted for publication within a short time.

The other Gondwana research primarily involves working out of the stratigraphy and sedimentation of Late Cretaceous Jabalpur - Lameta sequence at Jabalpur. This also involves collection and analysis of data for finding a solution to the enigmatic extinction of the dinosaurs 65 million years ago alongside with a stupendous volcanic eruption (Deccan volcanism) that happened simultaneously. The research is in its penultimate stage with the data suggesting a massive meteoric impact on the surface of the Earth near the Bombay coast 65 my ago.

Quantitative Geology/Computer Applications

1. CPO in Quartz, Influence of Impurity Phase

Crystallographic preferred orientation (CPO) measurement in quartz tectonites from zones with non-coaxial deformation (e.g., in the Singhbhum Shear Zone) shows that the type of preferred orientation is dominantly a type-I cross girdle, occasionally grading to a single girdle or a small circle girdle around z, the minimum principal strain axis. CPO is known to be influenced by several parameters, notable of which are temperature, type of deformation (coaxial vs. noncoaxial), strain rates, and the quartzites by the presence of a second phase, notably phyllosilicates. A quantitative evaluation of the influence of phyllosilicate impurities for the above types of CPO in quartz tectonites is the objective.

C-axis orientation with respect to specimen coordinates and known kinematic framework and ambient of deformation in about 40 deformed quartzites and quartz-mica-schist (1-s tectonites) was measured. The phyllosilicate/quartz ratio in about half of these specimens has been estimated. The orientation tensor matrix (OTM) corresponding to a set of 200 or more C-axes orientations in each of the above specimens has been computed; the eigenvalues corresponding to these OTM's have also been computed.

The ratio of the maximum and the minimum eigenvalues is regarded as a non-parametric estimator of the intensity of quartz CPO. Linear and non-linear regression analyses were done to assess the nature of dependence of intensity of quartz CPO on the phyllosilicate content using data obtained from 15 of the above specimens. A quadratic relationship seems to explain the variance among samples. Regression using a larger data set and/or incorporating a third variable (a measure of strain intensity) will be attempted.

2. Microemulsion

Photochemical investigation of systems which mimic membrane functions is an extremely active area of current research. The compartmentalized environments formed by the aggregation of amphiphiles as in micelles, monolayers, vesicles, liposomes and micro-emulsions have been the most exploited membrane mimetic agents. In addition, they have potential uses and applications in various fields. In these systems, the core water and the amphiphilic interface are in special physical states and can affect the physicochemical processes occurring therein. Photophysical processes, viz., fluorescence, phosphorescence, luminescence and electron-transfer etc., have been found to be interesting in compartmentalized conditions.

The charge-transfer (CT) interactions are one of the most fundamental processes in chemistry and biology. During the period under review, the CT-interaction between an electron donor (HA) and an acceptor (TCNQ) and the fluorescence behaviours of the CT-complex were studied in nonaqueous as well as in reverse micellar and micro-emulsion media (stabilized by AOT). A 1:1 CT-complex between HA and TCNQ was found and its binding strength was estimated by Bensi-Hildebrand equation. The CT-complex was found to fluoresce, which was kindered by (AOT) and higher concentration of (HA). The results were analyzed in terms of Stern-Volmer equation. The role of waterpool and (AOT) on the CT- and the quenching processes have been ascertained. The photophysical processes were influenced by the water/oil interface containing AOT and the medium polarity did not have a correlative say on them.

Machine Intelligence Unit

The faculty members of MIU are engaged in teaching and training in M.Stat. and M.Tech. (Computer Science) courses of ISI. They are also engaged in the supervision of M.Tech. projects/dissertations besides the supervision of Ph.D. works. Many undergraduate/postgraduate students of Computer Science, Electronics and Telecommunication, Electrical Engineering and MCA courses from different universities undergo their vocational/semestral training under the supervision of the faculty members of MIU.

During the period under report, research activities were carried out in the following areas with satisfactory progress.

1. Pattern Recognition

Algorithms have been developed for determining multiclass (fuzzy) boundary and shape of a pattern class in both R^2 and R^n from its sampled prototypes. This reduces and/or represents the uncertainties involved in the conventional crisp procedures. Multivalued recognition system has been successfully implemented in identifying ill-defined man-made objects such as airports, seaports, road maps and beaches from IRS image data.

A minimal spanning tree based criterion for the selection of seed points has been proposed and its utility has been demonstrated on various data sets. A split and merge clustering technique and a metric for higher dimensional data sets have also been developed. A modification in k-means algorithm has been suggested for reducing the number of computations. A minimal spanning tree based criterion for finding α for the construction of α hull has been found.

Pattern classification using genetic algorithms is currently under investigation.

2. Image Analysis/Processing and Computer Vision

New definition of classical entropy based on exponential behavior of gain, and the definitions of various image entropies have been introduced along with their properties. The image entropy measures include local, conditional, positional, hybrid and higher order fuzzy entropy. These information measures take care of the dependency of pixel intensities, probability and possibility distributions of pixel, collective pixel property and location of an object in the scene. Various algorithms for image segmentation, quantitative scene analysis and robot vision problems have been developed using these measures. Mathematical theory of fuzzy image thresholding has also been developed.

Techniques for data compression of binary contour images as well as extraction of contours from gray images have been developed. Preprocessing part of the low cost parallel mode algorithms for image processing and analysis of finger print data (using graph theoretic technique) have also been completed.

A new smoothing algorithm for digital images using isotropic and anisotropic diffusion processes has been developed. Gray level image coding using the modified Bezier - Bernstein approximation has been developed.

Data compression of binary contour images using discrete circular geometry is now under investigation. Its merits over other conventional techniques are also being studied.

An attempt is being made to recognize & classify planar polygons using a new set of local shape descriptors, namely *extended angle* and *extended ratio*. These together with a proper measure of the direction of the extended lengths make the feature set translation-rotation-scale invariant and also help in complete reconstruction of the unknown polygon.

3. Artificial Neural Networks

Principles of neural computing have been successfully employed in Pattern Recognition, Image Processing and Computer Vision fields.

Neural networks (NN) have been used to find the maximum-a-posterior probability (MAP) estimate of a scene modeled as a Gibb's random field. The MAP estimation problem which is computationally prohibitive has been solved using a modified version of Hopfield's neural networks. Relaxation type algorithms for object extraction have been developed which optimize objective functions that can be mapped as the energy function of a Hopfield-type network. Kohonen's model of self-organizing feature map has been modified to solve object extraction problems. The algorithms work well in noisy environments. A mathematical model for investigating the robustness of neural network based systems under component failure has also been developed in this context. An application of this model for making connectionists' learning systems robust is also demonstrated.

A connectionist model, namely, X-tron is developed for perception of mixed object categories. Necessary supervised and unsupervised learning algorithms are also proposed. The principle of X-tron has been used to build a psychologically motivated structured connectionist system for learning and simultaneous recognition of multiple objects (PsyCOP). Application of Hopfield model has been studied for graphical matching of different structures. The cooperative and competitive properties of neural networks are also exploited to link different edge and line segments. A connectionist system for learning and recognition of linear structures and its application to handwritten character recognition has been developed. Principle of Hough transform is used in this development. The effectiveness of neural networks is being studied for thinning in gray level images. Some efficient algorithms based on cellular neural networks have also been developed for object extraction problem.

The generalizations of Kohonen's LVQ model have been proposed and used in clustering and image processing problems. In this context, relations between LVQ and various c-means type algorithms are established.

4. Fuzzy Logic and Uncertainty Analysis

Various fuzzy set theoretic operators are developed for soft data analysis. These include index of area coverage (IOAC), fuzzy medial axis transformation (FMAT), bounds for membership functions, divergence between fuzzy sets and spectral fuzzy sets. The bound functions and spectral fuzzy sets are used in reducing the uncertainty in assessing membership value and to make the fuzzy set theoretic approach enough flexible. FMAT is useful for both skeleton extraction and exact reconstruction/representation of images without committing ourselves to a specific hard thresholding. The divergence measure between two fuzzy sets provides an amount of discrimination between them and has been successfully utilized in image segmentation problem.

Based on approximate reasoning, a linguistic recognition system has been formulated and tested with real life data. This has been found to be capable of handling various imprecise/uncertain input patterns and provide a natural decision system.

A new measure of total uncertainty for Dempster-Shafer framework has been suggested. This new measure takes care of uncertainty due to non-specification and randomness and is free from several drawbacks of earlier attempts. An axiomatic approach has been used to define a measure of conflict for Dempster-Shafer framework. Unlike other measures of uncertainty which generalizes Shannon's information measure the proposed one is a generalization of Vazda's quadratic entropy and it considers only the conflictual aspects of total uncertainty that arises due to the randomness in the system. For possibility distribution new metrics have been defined using different measures of non specificity. Properties of iterates of fuzzy circulant matrices under max-min operations have been investigated. Characteristics of determinants of fuzzy matrices under general S-norm and T-norm have been investigated. A shape estimation procedure has been developed with the help of fuzzy α hulls.

5. Neuro-Fuzzy Processing

Attempts have been made to integrate the merits of fuzzy logic and artificial neural networks for designing an efficient decision making system. Concept of fuzzy sets has been incorporated at various stages (e.g., input, output, learning and neuronal level) of Kohonen's network and multi-layered perceptron to handle imprecise, incomplete or linguistic input data and intractable pattern classes for recognition. Its extension to connectionist expert system for rule generation and inferencing has been made along with applications to real life data. This shows how pattern description in terms of linguistic properties and membership values can be processed by a neural net for fuzzy and crisp classification, and their merits over conventional networks and Bi-yes' classifier. Utility of such architectures for generating non-convex decision regions is also demonstrated. A generalized framework for integration of multilayer perceptron and fuzziness measures has been developed to design an unsupervised system for object extraction. Implementation of fuzzy set theoretic operators using neural networks and the utility of these networks in pattern classification and rule generation have been demonstrated.

One important project in this area entitled "Neuro-fuzzy system : design and implementation" is being conducted under the leadership of S.K. Pal who is a Jawaharlal Nehru Fellow. This project is being fully financed by the Jawaharlal Nehru Memorial Fund as part of the Fellowship award.

6. Genetic Algorithms and Fractals

Genetic algorithms - which are adaptive, parallel and robust search techniques have been used in Pattern Recognition and Image Processing problems. Their applications in the automatic selection of optimal image enhancement operators have been established successfully. The selection of optimal parameter values of multilayer perceptrons and cellular networks has also been made. It relieves multilayer perceptron from using back propagation technique. An attempt is also made to determine the optimum Hopfield type NN architecture for object extraction using GAs. A new mutation method called *directed mutation* is developed which accelerates the rate of convergence of the genetic algorithm to a great extent. A new genetic operator named

substitution is introduced which replaces the existing worst chromosomes by randomly selected better ones so as to enhance the performance of the existing GAs. Efforts are being made to determine criteria for measuring fitness by incorporating the effect of fitness of the predecessors or ancestors. Attempts are also being made to find the optimal stopping time for GAs.

Fractal dimension has been found to be a useful tool to segment an image. Attempts are being made to improve upon the methods of calculating fractal dimensions of images. Attempts are also being made to find the IFS (Iterated Function System) code automatically for digital images.

Physics and Applied Mathematics Unit

Apart from research activities, faculty members of this unit are engaged in teaching various courses in ISI as well as in guiding research students towards the Ph.D. degree. Major areas of research are :

1. Quantum and topological field theory, Berry phase, Skyrmions, Statistical systems, High T_c Superconductivity and Superfluidity, Quantum and Topological gravity, Quantum cosmology.
2. Quantum mechanics and Quantum field theory by Stochastic quantization approach, Quantum dissipative systems, Blackhole Physics.
3. Anyon Physics
4. Primordial Universe, Fluctuation of Maxwell Vacuum.
5. High energy phenomena : The problem of baryonic dictatorship at high and ultrahigh energy, Properties of correlation phenomena amongst the secondaries produced in high energy collisions, aspects of 'intermittency' phenomena in high energy collisions, charge-neutral ratios, underground muon flux, anomalies related with photoproduced showers.
6. Astrophysics : Neutrino energy spectrum, magnetic field decay in pulsars.
7. Sine Gordon field theory in curved space-time, Gaussian approach, modified $1/N$ approach in Dirac field, Supersymmetric quantum mechanics, Solitary waves in plasma.
8. Rapid distribution theory and Coriolis rotation on a turbulent flow. Modelling of turbulent flows with nonlinear terms, deductive theory for a homogeneous turbulent flow in presence of helicity, acceleration correlation in turbulent flow, calculations of turbulence energy spectra.
9. Uniform thin film on a hot/cold rotating disk. Effect of magnetic field on film thinning.
10. Scattering and radiation problems, wave-maker problems, two-layered fluid problems, problems with bottom deformation, integral transforms, integral equations, inventory models.
11. Sediment transport, dispersion processes, navigation hydraulics, MHD flow and heat transfer.
12. Blood flow through artery, two layer model, hematocrit dependence, temperature dependent viscosity, effects of magnetic fields, Blood flow in cardiovascular system.
13. Multivariable system and control theory, realization, identification and decoupling of multiinput multioutput systems.

Biological Sciences Division

The Biological Sciences Division is engaged in studying the varied biological processes covering plant and animal kingdoms, including humans. It comprises of the following units : Agricultural Sciences Unit, Anthropometry and Human Genetics Unit, Biochemistry Unit, Embryology Unit and Leaf Protein Unit. Activities carried out in these units are described below.

Agricultural Sciences Unit

Two students submitted Ph.D. dissertations entitled (1) Certain aspects of morphology, anatomy and palynology of some mangroves and their associates of Sundarbans, West Bengal, and (2) Studies on paddy based cropping systems under different agronomical practices in east Indian plateau, to the University of Calcutta.

The unit conducted 8 ongoing internally funded research projects and 2 externally funded projects during this period. Project studies were mainly carried out in two distinctly different agroclimatic regions, namely Giridih region of South Bihar plateau and coastal Sundarbans area of 24-Parganas, West Bengal.

Farm based studies were carried out in Giridih experimental farm of ISI with the focal theme on improvement of cropping system in rainfed farming. Agro-sociological studies were also undertaken to probe agro-ecological and socio-economical parameters affecting farming systems at Usri watershed region of Giridih. Overall objective is to evolve systems suitable for the small and marginal farmers of South Bihar plateau areas.

In the coastal region, studies were conducted aiming at (a) introducing suitable cultivars of coconut and oil palm and (b) detailed botanical studies particularly in respect of palynology, ecology and anatomical characteristics of mangrove vegetation in the saline areas of Sundarbans of West Bengal.

1. Sustainable cropping system studies

Studies undertaken since 1989 included farm based designed trials to establish suitable sequential cropping systems with low input eco-friendly management systems suited to eastern plateau of South Bihar. Long term rainfall data analysis of the area along with other meteorological characteristics indicated scope and constraints of rainwater use in crop management. Long term experiments on medium land could identify promising paddy based double cropping sequences on the basis of rational rain water utilization in this monocropped area. On low land, long term trials demonstrated the usefulness of indigenous rock phosphates in sustaining paddy productivity while maintaining soil phosphorus in different areas. Now organic matter recycling experiments are being carried out to sustain productivity and soil health. Final project report will be submitted by 31 March 1996.

2. Intercropping studies

Initiated in 1989, field studies along with subsequent laboratory work have already established maize, paddy and pigeonpea based hopeful crop combinations to utilize monsoon rain effectively in difficult mid-upland and eroded upland situations. Studies could suggest few interesting indices for evaluation. Paddy, maize and red grain were put on trials to establish optimum row arrangements and fertilizer nutrients in augmenting productivity in a stable optimum way, with the objective of increasing cropping intensity without degrading soil health status.

Presently studies on mixed cropping of Sorghum and Pigeonpea are being carried out and approximately 80% work is already finished. Project report will be submitted by 31 March 1996.

3. Crop/variety performances

This is intended to carry out continuously for effective crop/variety choice in a seemingly uncertain rainfall situation with degraded soil resource. Trials could establish promising varieties of important crops suited to rainfall quantum and distribution. Already short/medium and long duration paddy varieties are identified on the basis of long term yields under varied conditions. A few important crops and varieties of legume crops like groundnut, soyabean, oil seeds like niger, linseed and mustard as also millets like barley have indicated their promise as ideal ones suited to fragile ecosystems. These trials will continue.

4. Exploratory work on the family palmaceae (Arecaceae)

This is an on-going project, dealing with various aspects of morphology, anatomy and phytology of different palms. A comparative anatomical study of leaf, root and stem between young and adult palms revealed wide interesting variations. Ontogenetic study of stomata and trichomes of some palms received much appreciation among the botanists. A statistically significant variation was observed between the left and right-spiralled palms in respect of their number of stomata per unit area of leaf. The physiological anatomy of two important estuarine palms *Nypa fruticans* and *Phoenix sylvestris* of Sundarbans are in progress.

5. Introduction of oil palm and high yielding coconut cultivars in the Sundarbans area of West Bengal

The project was initiated in 1986 in collaboration with the Department of Agriculture, Government of West Bengal. The *taeora* variety of oil palm established well in the area and has started fruiting at regular intervals. Both tall and dwarf cultivars of coconut (collected from Kerala) were transplanted in 1987. Some of the cultivars have started flowering. Their growth, adaptability and intervarietal performances are being studied. Some comparative anatomical work of the cultivars are in progress.

6. Eco-floristic and anatomical investigations on mangroves of Sundarbans

This is an on-going project, aimed at in-depth study of the mangroves of Sundarbans with respect to morphology of seed and seedling, floristic survey, anatomy of leaf, root and stem and palynology towards understanding of their correlation in taxonomic and saline ecological condition of the taxa. Seedling morphology, leaf and wood anatomy and palynology of some dominating flora of Sundarbans have been completed during this period. Further anatomical study of tracheary elements of wood of mangroves from different ecological habitats are in progress.

7. Agro-sociological constraints of technological adaptation in subsistence farming of Bihar plateau region

This interdisciplinary project was undertaken on subsistence farming in Giridih region of Bihar plateau. Work was done to assess the feasibility of adoption of new technological resources by the poor farmers. Already technology assessments through resource utilization efficiency, productivity and stability are being worked out. This is comparatively a new project initiated since 1992.

8. Studies on weed crop interaction in upland soil conditions of Bihar plateau

Work on survey of specific weeds in different land situations, particularly in high land tracts of Giridih experimental farm, was made. Trials with principal crops like rice and wheat were undertaken to assess the yield deficit due to different species of weeds. To find out an efficient system for the control of weeds in the rice and wheat fields we plan to perform more experiments in the future. Our plan is to evolve one composite system to control the weed problem in the crop fields.

Anthropometry and Human Genetics Unit

Faculty members of the Unit regularly participated in teaching in B.Stat.(Hons.) in anthropology and M.Stat. in ASDA, BSDA, SQC & OR (Statistical Methods in Genetics) courses offered by the Institute. One

faculty member is also teaching Anthropology at Calcutta University. Some of the faculty members are also engaged in supervision of Ph.D. theses. One Research Fellow has been awarded, one has submitted, and 5 fellows are working for their Ph.D.

Faculty member of AHGU are also engaged in active research in different areas of Biological Anthropology and Human Genetics. The details are as follows :

Human Adaptability Programme : Within the general framework of this programme, the following plan projects are being conducted.

1. Health status and labour productivity

Empirical studies outside India reveal that an individual's health status play an important role in determining his/her labour output. On the basis of above the objective of the project is to examine the health - productivity relationship in different occupational groups of Oraon labourers of Jalpaiguri district, West Bengal.

Data collected from the Oraon agricultural labourers of Jalpaiguri district, West Bengal, reveal that both fertility and mortality are comparatively lower in this population comparing with their tea garden counterparts. There is less prevalence of hypertension and lung diseases in the Oraon agricultural population compared to the tea labourers.

2. Effects of microenvironmental factors on health in rural populations

Data analysed so far reveal that both fertility and mortality have decreased over a short span of 10 years in Chakpota village.

From the data on reported ailment symptoms and treatment it was found that in all the groups and subgroups of Kayastha, Poundrakshatriya and Oraon of South 24 parganas district, West Bengal, the percentage of adult males not affected by any ailment is higher than that of adult females and the difference is statistically significant. Gender difference in education is marked. In all the groups and subgroups, the percentage of not attended school is higher among females than that among males and the percentage of continuing school is higher among males than among females. The differences are statistically significant.

3. Psychological stress and health of mother and child

The overall purpose of the project undertaken was to evaluate the health status of females over their entire life span, divided into phases. In their prime working age urban middle class educated women face both physical and psychological problems resulting from constant exposure to day to day stress and strain. Ageing add a more difficult dimension to this, as women generally live longer compared to men. Information on biological, psychological and social characteristics of women who are at prime adult working age and who are at post-adult working age (at or about their retirement age) are being collected from the city of Calcutta.

A part of the data collected so far has been analysed, where a comparison is made between a group of college teachers and a group of women secretaries and executives from public and private sector organisations. The executives show higher anxiety scores (31.78, SE = 1.99) compared to the college teachers (32.0, SE = 2.60) though the difference is statistically non-significant.

As a part of the ongoing project, data on socio-economic characteristics and anxiety levels were collected from a culturally/ethnically different group of women, engaged as gazetted officers in different departments of the Government of Sikkim. It is intended to find out whether economic factor, and/or cultural/ethnic factors per se (i.e., independent of the economic factors generally associated with the latter), affect the traits discussed above.

4. A study on the determinants of fertility and mortality in an urban setting : An anthropological perspective

The major thrust of the project is to investigate the correlates of infant and child mortality among the Hindu and Muslim slum dwellers of Calcutta city.

Almost 75% of the work has been completed. The results show that the Muslims have higher fertility and mortality compared to the Hindus, and that the Hindus are economically better off, literacy rate is higher and the overall hygienic condition is better than the Muslims. The results also show that the adoption rate of family planning methods as well as perception levels are higher among the Hindus than the Muslims. The study demonstrates that the desire for additional children is the result of a strong gender preference (son) as well as lower survival prospect especially among the Muslims. The study also reveals that the expectation of life at birth is slightly higher among both male and female Hindus compared to the Muslims. The higher fertility among the Muslims may perhaps reflect the perceived threat of existence of a minority community.

5. Human biology of Himalayan populations

The objective of the project is to evaluate the effects of socio-cultural factors associated with modernization on the demographic and health status (measured in terms of fertility, mortality, selected biological traits, health perception and health care practices) among the Lepchas of Sikkim Himalaya.

Data collected earlier from the Lepchas inhabiting 3 rural Revenue Blocks of Dzongu area, North Sikkim on anthropometry, blood pressure and behavioural traits (e.g. tobacco use, alcohol use, etc.) have been analyzed. Analysis of the data reveals that while significant effects of age, alcohol intake and triceps skinfold thickness (among the females) on blood pressures exist among the study population, effects of smoking, tobacco chewing, oral contraceptive use on the trait are not discernible. Moreover, a high prevalence of essential hypertension (males : 30.8%, females : 25.8%) is found to occur. The above finding clearly indicates that compared to many other rural Indian populations, rural Lepchas of Dzongu area have much higher prevalence of hypertension.

6. Genetics of complex traits

Primary focus is research in the area of genetic epidemiology of complex disorders (disorders with variable ages at onset that aggregate in families but do not segregate in a clear Mendelian fashion). Together with a Ph.D. student, we have developed likelihood-based methods for determining modes of inheritance of such disorders. We were able to propose and cross-validate a multilocus model using family data on a dermatological disorder (vitiligo) and also study robustness properties of the proposed methods. We were able to establish, contrary to traditional belief, that vitiligo is not a single-locus disorder but is controlled by epistatically interacting recessive alleles at three unlinked autosomal loci.

In collaboration with the Biochemistry Unit, we completed a genetic epidemiological study on blood pressure and lipid and lipoprotein levels among Marvaris living in Calcutta. Using a path model, for familial data, that takes genetic and environmental factors into account, we have found that : (i) the genetic effects on blood pressure are indirect and are perhaps mediated by genetic factors controlling adiposity, (ii) the genetic heritability of HDL-cholesterol level (the so-called good cholesterol, higher levels of which are protective for vascular diseases) is about 80%, and (iii) the genetic heritability of Triglyceride level is about 55%. The implication of these findings is that control of body fat by regular physical exercise and lowering the intake of saturated fats and oils can significantly contribute to lowering the risk to cardiovascular diseases. While this conclusion is not novel, quantitative estimates of heritability from populations with non-Western life styles are very few. In fact, this is the first family study conducted in India with the explicit objective of estimating genetic and environmental components to lipid and lipoprotein levels.

7. Human Ecology

(i) The changing patterns of resource use and its cultural and biological implications are being studied among a Kuki tribe called Gangte, who are currently living in the hills of Manipur and are undergoing rapid transition from shifting cultivators to the urbanized mode of subsistence.

The results obtained so far suggest general improvement in the economic situation and literacy and reduction in child mortality. A trend of decline in the availability of biological resources and increase in admixture with non-Gangies is also apparent.

(ii) Human impact on biodiversity

(iii) Interphase between forest dwelling communities and forest resources.

8. Population structure and human variation

Statistical analysis of different data sets collected earlier, are being pursued. As part of this, we have so far synthesized all-India data on (i) the inbreeding effects on reproductive outcome, and (2) finger ridge count variation of the Indian populations. We have also analysed (1) genetic differences between migrant populations and their parental counterparts, (2) effect of life styles on blood pressure variation, and (3) dermatoglyphic and anthropometric affinities of some local clusters of populations, in the light of ethnohistorical and geographical backgrounds.

9. Dermatoglyphics

Dermatoglyphic data on toe, sole, finger and palm of a large number of nuclear families (500) from five different ethnic groups have been collected and partly analysed. Bilateral asymmetry (directional and fluctuating) is the main emphasis of the project which is considered to be a direct reflection of developmental homeostasis in humans. The study aims to evaluate: (1) genetic and common family inheritance components of planar dermatoglyphics. (2) Genetic component of phenotypic relationship between toe and finger, sole and palm as well as between characters within the planter and palmar dermatoglyphics. (3) Nature and extent of variation within and between ethnic groups; in genetic disorders and on twins.

The study between toes and fingers reveals that (i) the same genetic influences might be exerted on both the dermatoglyphic regions but produces differential effect for different functions in their independent courses of evolutionary specialization (ii) Laterality may be useful for ethnic comparisons.

10. Human growth

A cross-sectional growth study on 26 body dimensions on the boys and 9 dimensions on the girls from Calcutta city was undertaken in order to assess their growth performance in the context of the Indian population. The study also evaluates the influence of sociodemographic variables on growth by univariate and multivariate analysis. Curve fitting techniques have also been used to estimate the biological parameters of the growth process.

11. Population variation program

(i) Statistical sampling design involve a two-step design. The first stage sampling units are Panchayats and the second stage units are villages within sampled Panchayats. At each stage simple random sampling with replacement was done. We have done the field survey under Ranaghat block, Nadia District.

About 3,000 families have been surveyed comprising about 16,204 individuals. Out of these individuals 90 individuals have been suspected as Rheumatoid Arthritis (RA). Suspected R.A. individuals were clinically examined and their blood was collected for laboratory investigation. Out of 90 (0.56%) suspected R.A. patients only 63 RA patients were examined. Out of these 63 patients clinically 20 (12.6%) patients are positive Rheumatoid Arthritis and by laboratory investigation 11 (6.93%) patients are positive.

The prevalence of Rheumatoid Arthritis in the surveyed area (Ranaghat) is much more than North 24 Pgs.

(ii) A field work was conducted in Varanasi, U.P. About 350 blood samples were collected from four different endogamous populations: Brahmin, Rajput, Chamar & Muslim. In the field Hb% estimations, G-6PD deficient test, ABO & RH blood groups have been done. The following biochemical markers have been

screened - AK₁, ADA, G-6PD, 6PGD, PGM₁, ESD, Acid Phos, CA₁, CA₂, LDH, MDH, Hb type, Hp, Cp-Tg & ALB etc. in our Institute.

From the laboratory screening, few new variants have been observed - G-6PD (New slow variant), PGM₁ and MDH.

(iii) Two predominant alleles - HbE and HbS of beta globin gene cause haemoglobinopathy among a considerable proportion of populations of India. Molecular character of these alleles are known and these alleles show a wide range of clinical manifestations. Distribution of these alleles are limited to specific populations. Frequency of HbE in some populations has been found upto 85% and HbS upto 45%. Despite these alleles are known to be deleterious and these are maintained in populations in such a high frequencies but how it spread through a wide area is not known. Objective of this study is to throw some light on the mechanism of maintenance and spread of these alleles.

- (a) spread of HbS in the region due to wide range of migration of the tribes;
- (b) excess of homozygotes and prevalence of high frequencies due to practice of consanguinity and random drift among populations;
- (c) similar Hb levels and longevity of homozygotes compared to that with normal or carrier individuals observed in the data. This is possibly due to interaction with high frequencies alpha thalassemia in the region.

Study on HbE has been conducted among three subdivided groups of Deshi population in two districts of Malda and North Dinajpur of West Bengal. A total of 521 individuals belonging to three generations were studied for 17 genetic markers, Hb and haematocrit levels, information about marriage pattern and marriage distance have been collected. Results reveal that (a) allele frequencies fluctuate between generations of each subpopulation, (b) significant asymmetry exists in marriages between generations in each population, (c) a large difference is observed between estimates of inbreeding level from genetic data systems - ACP and TF in one of the three subgroups which are not common among the populations of the region, and (c) a correlation between haematological profile variation and alpha globin content variation observed.

12. Epidemiological and clinical studies

(i) Epidemiological profile survey data on "Diabetes" has been collected through family studies on Bengali Hindu population by enumerating the number of persons belonging to a Municipal Corporation/Panchayat Wards in three habitats: Rural (471 families), Industrial (487 families) and Urban (361 families). Analyses of primary data and confirmation of disease status are in progress.

(ii) Surgically incised organs - Appendix, Gall Bladder and Hernial Sac collected on Hindu Bengali individuals have been analysed to study histopathological and genetical changes. Associations of organ tissues with 4 polymorphic (PGM, ESD, AK and ACP) genetic loci have been studied. Further 6 monomorphic loci (LDH, MDH, 6PGD, G-6PD, CA₁, CA₂) have also been screened for detection of variants. In respect of Hernial sac significant association was found with Esterase D (ESD) and for Gall Bladder with Acid phosphatase (ACP).

Externally funded project

"Genetics of Quantitative Traits of Commercial Importance in the Silkworm" (funded by: Central Silk Board/Department of Biotechnology, Govt. of India), Principal Investigator: Partha P. Majumder.

A detailed and controlled breeding-rearing protocol has been finalised and implemented. Appropriate data are being collected.

Members of the unit participated in teaching in the B.Stat. (Hons.) course of the Institute. A scholar is working for her Ph.D. under the guidance of a faculty member.

Cancer chemoprevention : An approach towards cancer control : Following projects are ongoing on Uterine Cervix Cancer Prevention.

Development of assay systems for folic acid (Pteroylglutamic acid)

- a) A 96-well microplate based microbiological assay using *Streptococcus faecalis* as assay organism has been developed for folic acid and the culture volume reduced to 33-fold. The sensitivity of the assay has been increased by 10-fold over the conventional microbiological assay. This is highly suitable for vitamin formulations assay.
- b) A highly sensitive and specific antibody against folic acid has been obtained by coupling Folic Acid with E-amino caproic acid modified bovine Serum albumin. Using this antibody an ELISA method for multivitamins formulation and for human serum has been developed. Serum from various cancer and precancerous subjects are under investigation.

Epidemiologic data from Domjur Population and also from the Sex Professionals have been analyzed and currently in preparation for communication.

The BAI (Biological Aging Index) that has been developed on the evolution of dysplasia, based on *Caecilia* Medical College and hospital data needs to be validated on other hospital samples. Currently we are exploring possibility of developing a collaborative project with Nagark Swastha Sangha to work on a hospital as well as population based study.

The construction of tissue culture laboratory has just been completed and the cell culture related work is about to begin.

In Phase II of the Genetic Epidemiology of blood pressure study in collaboration with AHGU dietary and other epidemiologic survey work has been started on marwari families alongwith biochemical parameters (as in phase I). The criteria for selection of family is that there should be at least one hypertensive patient (proband) in the family. During the past year, dietary and biochemical estimation of blood sugar, serum-urea and total cholesterol, lipid fractions were done on 200 subjects. Special nutritional data on each subject including family has been started currently. These will be utilized in order to find out whether any dietary risk-factor(s) can influence the development of hypertension.

In metal-metal interaction in higher organisms effects of (i) mitomycin c (ii) dimethyl-sulfoxide (DMSO) and (iii) triphenylin chloride have been observed in mice (*Mus musculus*) following bone-marrow chromosomal analysis in vivo. Detailed microscopical observation, data management and statistical analysis are being carried out in the aforesaid experimental sets. This work is under CSIR-RAship programme.

Analysis of buccal mucosal epithelial cells from pan and khaini users focussed that the frequencies of karyolytic, pyknotic and micronucleated cells were estimated in 55-60 subjects during the year. A relatively higher incidence of the above indicators have been noted amongst the khaini users along with local ulceration compared to the pan chewers. Occasional appearances of these abnormalities were noticed in control samples.

In the project semiochemical of mammals, analysis of fatty acid data in the marking fluid of the tiger (a source of pheromones) has been continued. The presentation of these data is considered as a sort of biochemical individuality characterizing each tiger. This is under CSIR-RA-programme.

A collaborative project has been initiated with Bengal Veterinary College, Kalyani on exploring the non-volatile and volatile pheromones and their lipid fixatives, if any, in the vaginal secretion of goats.

Externally funded project

Annual evaluation of rainfed farming project, ODA-HFCL. The involvement of the Unit is to evaluate any change in the dietary habit/pattern as part of impact of RFP in the east Indian plateau.

Embryology Unit

The Unit has done some further work on the following ongoing projects :

1. Mathematical and stochastic modelling of cellular growth differentiation and morphogenesis during embryonic development and carcinogenesis.

New nonlinear reaction diffusion mathematical and stochastic models of pattern formation and morphogenesis during embryonic development have been constructed on the basis of some experimental evidences. It has been pointed out by experimentalists that cyclin which is identified as embryonic protein encoded by *cdc 13+* gene regulates mitosis and another important protein, chalone, which is a glycoprotein compound plays the role of autonomous self inhibition of mitosis by a negative feedback mechanism. Thus, in formulating mathematical model of auto regulated cellular development and morphogenesis during embryonic growth one should incorporate on the one hand, the synthesis of the protein cyclin, which activates the mitotic promoting activity (MPF) to induce mitosis and on the other hand the simultaneous feedback inhibiting effect of chalone which regulates mitosis. Global stability is one of the important features of these model systems. The global stability has been proved by constructing suitable Liapunov functionals. Size adaptation of embryo is also another challenging problem in this context. This problem has been overcome by some control mechanisms existing in real biological systems through apparent diffusion coefficients.

2. Intercrop interaction - a mathematical study on agricultural ecology

Repetition of field experiments on intervarietal interaction between two pairs of rice varieties namely, Subarna and Pankaj was conducted in Giridih Farm, Bihar. Allelopathic interaction between the two varieties have been studied. Root exudates (RE) of Subarna inhibit the germination and growth of the seedling of Pankaj and vice-versa. RE of both Subarna and Pankaj contain phenolic compounds, amino acids and presumably a fatty acid. The putative fatty acid appears 15-20 days following germination and disappears after 2 months. Only one phenolic compound was detectable in the later stages and two others in young seedlings. The RE of all three were far below those of eight standard phenolics (syringic acid, caffeic acid, ferulic acid, 3-4 dihydroxy benzoic acid, vanillic acid, 4 - hydroxy benzoic acid, coumaric acid, sinapic acid). The synergistic effect of RE is inhibitory but when chromatographically separated, two inhibitors and three stimulators have been found in RE of two month old Subarna.

By considering a two species competition model the effect of inhibitors on row-intercropping system have been observed. This model has been verified by experimental data. It has been found that the inhibitors play an important role to shape the dynamical behaviour of the system.

3. Mathematical and computer modelling of the cellular and molecular details of how the animals embryonic body plan is established

It is observed in nature that the embryonic developments of different organisms require different types of environments. A simple mathematical model of embryogenesis has been constructed taking into account the environmental effect in the form of some signals. Model analysis shows that these signals which are generated at the extra cellular space of the embryo, are well capable to deform any existing pattern within the embryo.

Drosophila embryonic pattern evolution via gap genes has been a very recent experimentally established fact. We have investigated about the giant gap gene expression from physical as well as a simple mathematical view point. It is also observed that the distribution pattern for the giant gap gene within the embryo very much resembles the actual giant gene expression pattern obtained for the *Drosophila* embryo.

Structural and functional aspects of aminoacyl-tRNA in the transcriptional context has been discussed from physical view point, because t-RNA molecules are most fundamental for the identification of different genes which govern the specific patterns within the embryo.

The *modus operandi* for the genes seems to be not only very complicated but at the same time it is beyond the reach of a rational mind. Until now, genes are identified from its functional activities. Attempt has been made to understand the genes from its configurative structures as genes are most fundamental molecules in the pattern forming mechanism during embryonic development.

4. Mathematical epidemiology

Mathematical and stochastic models of the dynamics of Japanese encephalities (JE) have been proposed and studied analytically by modifying the existing ones. The frequency of occurrence of JE during different months of the year 1986-1990 in Burdwan of West Bengal, India, has been studied with the help of a mathematical model using a third order harmonic Fourier series having a linear trend in the previous year. This model seems to have a wide universal application where predominant seasonal effects prevail. Now by incorporating the seasonal variation in the diffusion coefficients of SIRS model in the form of $D_1 = D_1 + b \sin(\omega t)$, the model has been further analysed. It has been observed by using Floquet's theory, this periodic variation makes the system more stable than in the model involving constant diffusion coefficients.

The stochastic modelling of JE based on mean field description of fluctuation using local fluctuation theory having a well defined range have been studied. It is important to note that the first moment equations are independent of diffusion which is in full agreement with the requirement of macroscopic homogeneity. The contribution of diffusions is explicitly to the evolution of the fluctuations. Stochastic stability of the system and the criteria for spontaneous emergence of dissipative (ordered) patchy structure have been investigated.

The development of immunity in the susceptible class by a continuous low level of infection is a commonly observed phenomenon in many infectious diseases. This important feature has been incorporated in an SIRS epidemiological model with both the rates of incidence and increase of immunity being nonlinear in nature, instead of being bilinear. The local and global behaviour of the dynamics of the model have been investigated.

Leaf Protein Unit

One student submitted a thesis entitled "Trec leaves as a non conventional protein source for feed" to the Calcutta University. Three students are working in the Unit towards their Ph.D. degrees.

Crude protein analysis of leaves from many trees and shrubs was done. From nutritional point of view it has been reported that ruminants do not use more than 9-13% protein in their feed while uree leaves and other vegetation have 16-25% crude protein. The idea is to extract the protein for consumption by monogastric animals including human beings and also to improve the food quality simultaneously. It may be appreciated that the underlying principle of choosing monogastric animals over the ruminants is that the former gives a return of 33 to 40% in comparison to 13-15% return only by the latter ones. A systematic study on cell wall composition and in vitro dry matter digestibility was carried out using a good number of fibre residues, the major by-products of LP technology.

To evaluate the protein quality of leaf protein concentrate from *Ailanthus excelsa*, a chick test was carried out, the results were recorded (like weekly body weight, gain in body weight weekly food consumption etc.), the statistical analysis that followed for broiler experiment are i) Analysis of variance ii) Fitting of logistic growth law iii) Fitting of linear regression equation.

A broiler experiment was performed from 0-8 weeks by using four types of experimental diets using leaf protein from *A. excelsa*. The results show that LPC of *A. excelsa* could be included in the broiler diet at a level of 3.38 per 100g without an adverse effect in performance.

Work done in ongoing projects are described below.

1. Microbiological and other technological aspects of leaf protein.

In recent years considerable attention has been focussed on efficient utilization of wastes through mechanical, chemical and biological conversion. Cultivation trials were rendered on a good number of lignocellulosic wastes with *Pleurotus* spp for fruit body production and cellulose and lignin biodegradation. The percentage of cellulose degradation was 5-60% while lignin degradation percentage was 20-35% due to mushroom cultivation were recorded *Pleurotus sajor-caje* and others grown on a variety of lignocellulosic wastes (biological efficiency 50-120%) were analysed for their proximate composition. According to our recent study the value of crude protein lies between 26.0-30%, CHO 41-44%, fat 5-7% and minerals 8-10%.

Particle boards were prepared with fibrous by-product of LP Technology as the basic raw material. Two methods were followed (1) Boards with urea formaldehyde resin adhesive. (2) In situ-system, chemicals such as urea and formalin were used in place of urea formaldehyde resin.

2. Relationship between aquatic weed growth and water quality in ponds.

Extensive literature survey and review work were completed. In-house training was obtained in the laboratories and workshop for learning techniques and analytic methods being used for water quality assessment in USA.

3. Total utilization of sugar beet (*Beta vulgaris* L.) crop.

Field trials were conducted on different sugar beet varieties namely Hill - 2 virtus, Raspoly, Hilma Donar, Mezzanopoly, I.I.S.R. II, L.S.6 and I.I.S.R. Comp 1 in rabi season of 1994-95 at agricultural experimental fields of ISI. In this experiment, out of ten selected varieties 4-5 varieties showed their potentiality for sugar and LP yield. Fertilizer NPK were fixed for all the varieties and data were collected for various yields at an interval of 20 days starting from 80 days of the crop and up to 160 days. Encouraging sugar yield was given by varieties, Raspoly, L.S.6 and Donar at later growth stages whereas at early growth stages maximum LP yield was given by I.I.S.R. Comp 1, Hilma, Virtus. Optimum sugar and LP yield were given by varieties Raspoly and virtus though individually highest sugar and LP yields were given by the varieties Raspoly and virtus respectively. It has been observed from the experiment that monogerm varieties namely Raspoly, Virtus, L.S.6 could be compared with the standard polygerm variety Ramanaskaya 06.

4. A study on cellulose, lipase and protease producing microbes from soil.

The production of microbial enzymes either pure or partially purified is an important aspect of industrial microbiology. The search for new proteolytic and lipolytic organisms from different alluvial soils of West Bengal continued. The physical and chemical composition of soil as well as environmental conditions were noted to determine the relative abundance of the microbes in soil.

In the present investigation one hundred soil samples were plated in Tween 80 Agar medium. Lipase producing strains were detected on agar plates by appearance of turbid zones of Ca-salt of free fatty acids. Thirty prospective streptomycetes were screened from tea garden areas of Jalpaiguri district and ten from Gangetic alluvial soil of Nadia district. For all microbes Ca-salt ppt zones were recorded (65-75 mm). Results were obtained after 72-96 hours of growth. Dry wt of mycelium were also recorded (0.08-0.095g/100 ml substrate). Enzymatic saccharification of fibre residue by cellulase from *Aspergillus fumigatus* was recorded (32-40%).

Two Kharif crops were sown. Cowpea was sown on 15.6.94. Two plots (4 x 3m) of 12 sq.m. were charged with 15 kg/ha seeds broad costed and with NPK 20, 40, 20 kg/ha. The vegetative growth was harvested after 55 days and plots irrigated and left for regrowth. Similarly Amarnath sp. was laid in two 8 sq/meter (4 x 2) plots with NPK 50, 50, 20 and a seed rate of 4 kg/ha. The crop was sown on 10.7.94 and 1st harvest made after 30 days. Yields in both crops were poorer than expected due to regular attack of goats, cows and dogs.

The Social Sciences Division includes the following units : Economic Research Unit, Economic Analysis Unit, Planning Unit, Population Studies Unit, Psychometric Research and Services Unit and Sociological Research Unit. The Economic Analysis Unit is located at Bangalore, the Planning Unit is located at Delhi, while the remaining five units are located at Calcutta. Faculty members of this division were engaged in teaching and training activities at various levels, including Ph.D. supervision. The research work done in these units during the year under review is described below.

Economic Research Unit

This unit is engaged in research work covering different areas of theoretical and applied economics and econometrics and also in teaching and training activities at various levels. Several faculty members served in many technical and expert committees of Government and other organisations.

Research in the following areas may be highlighted for the period under review.

1. Economic theory

Research work has been going on over the past several years on various areas in economic theory. Mention may be made of industrial economics, economic efficiency and welfare economics. Attempts have been made to formulate cost indices that measure absolute changes in total and marginal costs between two periods when factor prices change. The class of cost functions that generate equal total and marginal cost indices is characterized. Another work interprets the Kullback minimum discrimination information statistic as an index of mobility. Its use for testing alternate hypotheses concerning mobility has been analysed.

2. Macro-economic policy in India

Several analytical works in this area have been undertaken. One study considers the issues in financial liberalization. In another, an attempt has been made to examine the role of money and public finance under structural adjustment. Attempts have also been made to examine the relationship between technology, efficiency and industrial liberalization in LDCs with special reference to India.

3. Economic development

A study has been undertaken to examine the patterns of socio-economic development in India during 1960-90. Attempts have also been made to examine the components of inter-temporal changes in balance of trade of India during late seventies and early eighties. Another study highlights the role of income distribution and especially the size of a mass consumption goods sector in determining technical progress.

4. International trade

Research work is going on to examine the role of foreign capital and technology in the economic development of transition economies. This also contains some work on liberal trade policies and their impact on real income and employment.

Another study focuses on co-operative and non-co-operative R and D behaviour of competing firms, financial joint ventures and risk sharing by business partners across international borders.

5. Agricultural economics

Several analytical and empirical studies have been going on over the past several years on various issues in Indian agricultural economics viz., farm efficiency, market efficiency, land, labour and credit relations in agriculture etc. During the period under review, a study has been undertaken to examine some of the conceptual and theoretical issues of farm efficiency advanced by various scholars working in this field and have identified some limitations of these works in relation to its applicability in Indian situation.

There is an empirical observation (made by Bhaduri and others) that in Indian agricultural markets fluctuations in market arrivals of output coexist with fairly stable prices and vice versa. This is an interesting observation because apparently it violates the laws of demand and supply. An attempt has been made to explain the phenomenon theoretically (within a demand - supply framework) in terms of lower risks faced by traders and hence greater arbitrage by them when there is an early arrival of a larger fraction of the output.

6. Studies on consumer behaviour and level of living

A methodological study on estimation of Engel elasticities of items like clothings from NSS 38th round household budget data was continued during the period. It had been found earlier that the elasticities changed dramatically if one utilizes data for the last year reference period, in place of data relating to the last month reference period. During the period under review, attempts were made to apply instrumental variables estimation to last month data to overcome the problems created by seasonality and other short-run factors.

The second and final report on the pilot survey of income, consumption and savings was submitted to the NSSO. The report was prepared by a team of ISI scientists in collaboration with some officers of the NSSO. It throws valuable light on the methodology to be adopted for conducting household income surveys in rural and urban India.

As a part of the research project on strategies and financing for human development sponsored by the Government of India and UNDP, a study has been taken up entitled "Employment, level of living and utilisation of public distribution system" during the period under review.

Work on the analysis of time trends of the extent of inequality, poverty and agricultural growth, rural-urban disparity in level of living in India, absolute level of living and poverty continued during the year and some results have been released.

Some faculty members of the unit have undertaken a study on "Demand for the rural industries product in India" sponsored by the South Asia multi-disciplinary advisory team, International Labour Organisation (ILO), New Delhi. The purpose of the study is to estimate demand functions for different types of commodities turned out by rural industries in India. For this purpose, household level consumer expenditure data thrown up by the NSS enquiry for the 38th round are used and Engel elasticities of demand for these commodities are estimated separately for rural and urban sectors for the whole of India as well as for different states of India. The implications of the empirical results are then examined from the point of view of a strategy for rural industrialisation.

7. Econometric methods and applications

A considerable amount of research has been carried out on various topics in Econometrics, e.g., (i) shrinkage estimator in the context of linear regression models with multi-collinearity, (ii) vector autoregression and cointegration, (iii) hypothesis testing in non-regular cases in econometrics, (iv) linear regression modelling, (v) the measurement of child cost and, (vi) application of frontier production functions to examine the performance of Indian industries.

8. The report on the study on "Differential impact of modern rice technology on favourable and unfavourable environment" was finalized in the light of suggestions and comments received from different experts. This project was sponsored by the Rockefeller Foundation and carried out in collaboration with the University of Kalyani, West Bengal. The study based on 60 sample villages in West Bengal aimed at identifying the determinants of modern rice technology adoption and also at assessing the impact of such adoption on cropping intensity, factor shares, labour use and household income, poverty and inequality.

The report on Gitanjali of the statistical linguistic analysis of Rabindranath Tagore's works was published during the period. This was the first report of a collaborative project taken up by ISI and the Institute of Languages and Cultures of Asia and Africa (ILCAA), Tokyo University of Foreign Studies.

Economic Analysis Unit

The Unit faculty are actively engaged in their research on growth, variability and stability of cereal crop yields in India, macroeconomic modelling with time series and analytic framework to examine macroeconomic reforms in India, agricultural reforms and their impact on Indian economy, Bayesian analysis of forecasting, Monetary policy in India, Kaleckian economics and history of economic thought. There are also a number of projects and collaborative ongoing research.

A project on "Government operations in foodgrains : Research project on strategies and financing of human development", UNDP/Government of India, is in progress. Another project funded by University of Manitoba, involved a survey on "Determinants of contraceptive use and sexual behaviour" in a Northern Karnataka village.

There is also a collaborative research with RBI on financial sector modelling.

Planning Unit (Delhi)

The Planning Unit conducts social science research in both theoretical and applied areas. Though the major focus is on economics, areas in other social sciences are also covered. Theoretical work includes game theory, planning processes, environmental economics, public economics and financial markets. Applied work includes inflation, agriculture, restructuring of industries, poverty measures and banking.

Linguistic Research Unit

The Linguistic Research Unit continued its programme of research in the areas of fundamental/applied linguistics and computational linguistics with special emphasis on speech pathology, psycho-linguistics, socio-linguistics, syntax and text analysis.

There are seven main topics under which the Unit's research projects may be grouped, namely :

1. Studies on the phonetic structures of major Indian languages and application of the results in the areas of : (a) speech pathology, (b) second language acquisition; (c) cultivation of mother-tongue; (d) language standardization; (e) comparative suprasegmental studies on Indo- Aryan and Dravidian.
2. Socio-linguistics : (a) Study of language attitudes; (b) Language maintenance and shift and (c) Measurement of bilingualism.
3. Socio/psycho-linguistic aspects of cognition in relation to language, class and creativity.
4. Bengali syntax and semantics related to natural language processing.
5. Quantification of data and use of computational techniques in various areas of applied linguistics and text analysis.
6. Archæology of Bangla grammar : Using post-structuralism to understand the problems of Bangla grammar under colonial rule.

7. The Unit also carried out habilitation programmes for the hearing impaired children with related speech disorders.

The details are given below :

1. Linguistics, Statistics and Cybernetics - an integrated approach to quantitative linguistics

(1) A system was developed for Bangla sentences to enable a machine to parse simple sentences depending on the valency and morphophonemics of Bangla verbs. The rules for compound verbs and other verb combinations are also incorporated for better parsing, (2) practical tools to measure bilingual ability and language attitudes in multilingual settings, have been developed. Some of the tools developed include (a) the measurement of the threshold of bilingualism, (b) quasi integrative approaches to the measurement of language dominance, (c) correlation matrices in language use, (d) measurement of linguistic stereotypes and (e) opinion scales and stability in response patterns, (3) development of software tools for text analysis. We also aim to evolve a system of computational analysis of text, keeping in mind the huge data bank on Bengali prose and poetry available with the Unit. On the theory of word length, collaboration is underway with quantitative linguists at Ruhr and Trier Universities, Germany. Collaborative research is continuing with linguists at York University in the area of language attitudes from the perspective of language maintenance.

2. Assessment of articulatory performance in hearing impaired children

The relevance of the Kestic classification : A sample of fifty children between the ages of 5 to 10 years with Bengali as L1 were tested in Calcutta using the Kestic-Mitter (1982) test for articulatory evaluation of Bengali speech sounds. Preliminary analysis showed that the performance of the subjects varied according to the group they belonged to. Obviously Group IV subjects who had a fairly good perceptible hearing range performed better as compared to Group I or Group O subjects who have very little or no hearing remnants at all. The age of onset of hearing loss, the criteria upon which the groups were further sub classified was also found to be important as subjects with congenital hearing loss had very poor articulation as compared to those subjects whose hearing was affected during the language acquisition period, probably due to severe illness. The usefulness of the Kestic classification in the isolation of subjects who can be identified with a certain group can go a long way in monitoring an appropriate habilitation programme for them. Since another set of 25 children between the ages of 5 to 10 years with Telugu as L1 were tested and classified using audiometric tests and articulatory tests of Telugu speech sounds the analysis of the same will help us to make some useful generalisations which will contribute substantially to the habilitation of hearing impaired children.

3. Comparative suprasegmentals of the Indo-Aryan and Dravidian languages

The stress patterns of 60 isolated Hindi disyllabic words containing combinations of long and short vowels were studied, in order to analyse whether the length i.e. duration of syllables is a significant one for the presence of stress in Hindi words. For this study 20 subjects all native Hindi speakers were tested. The main aim here is to study the consistency of the occurrence of stress in disyllabic morphemes. Similar data was collected from 20 native Bengali speakers to study the difference in duration and frequency of similar lexical items from the two languages in question. Data were collected from 50 Bengali speakers in order to investigate the role of juncture in the process of coarticulation. A part of the results were then analysed on the visi-Pitch. Syllable stress studies were further extended by collecting data from Telugu and Tamil speakers.

4. Study of the phonetic structure of the Tamil language

Data on Tamil phonemes was processed to obtain the first set of spectrograms of Tamil speech sounds from which the acoustic structure of Tamil phonemes is in the process of being established. As an extension of this study to cover research on speech impairment, crucial areas in the acoustic structure of Tamil speech sounds will be isolated to help the habilitation of hearing impaired children with Tamil as their mother tongue.

5. Survey of the articulatory norms in Bengali speaking children of pre-school age

Fifty pre-school children between the ages of 2 and 4 years were tested using the Kozic and Miner (1982) test for articulatory evaluation of Bengali speech sounds, in order to study the norms of articulation for each age in that age group. Natural generative phonology framework (Venacemmann, 1970 and Hooper, 1976) was used for analysis. After going through the data it was observed that within the range of 2-4 years of age there was a wide difference in the speech development of the subjects. For example an average 2 years old child does not develop all the speech sounds whereas as expected an average 4 years old had developed all the speech sounds. Cases where normal four years old subjects had poor performance will be investigated further to ascertain the reasons for either poor articulation or deviation with the intention to establish the type of speech disorder and to determine the physiological and psychological aspects contributing to such disorders.

6. Educational problems of hearing impaired children attending school for normal children

A set of questionnaires to test the attitude and awareness of parents and teachers on the process of habilitation and education of hearing handicapped children attending general schools in Hyderabad was undertaken on similar lines as was done in Calcutta. We used the same strategy and the questionnaire was administered on 50 parents and 50 teachers of hearing handicapped children. The tests were also supported by interviews of both teachers and parents. The results of the test are meant to highlight the shortcomings of both the social and the academic establishment, on their approach to habilitate the hearing impaired child. Preliminary results from the Calcutta round show that there is a need for thorough language research to assess the actual curricula linguistic requirements of hearing impaired children and to help them achieve the requisite scholastic progress. Methodical language research is being carried out based on two important Bengali school primers.

Population Studies Unit

The faculty members and research scholars participated in teaching of demography, vital statistics and health statistics in the degree as well as in other training courses conducted in ISI, Calcutta. One of the faculty members participated in the short term teaching programme of other universities and institutes also, and served in many technical and expert committees of Government and other organisations. A few research fellows and technical staff have been working for the Ph.D. degree under the supervision of faculty members.

The broad areas of research include demographic and epidemiologic transition in India, development of disability statistics and indicators, proximate determinants of fertility, demography of West Bengal, bias and sampling variability of fertility estimates, etc. Other investigations like quality of life of some communities were conducted under the leadership of the Unit. Research in the following areas may be highlighted:

1. Demographic and epidemiologic transition

The study undertakes a situation analysis of demographic and health transitions in India and focuses on variations in health care utilisation among older people by age and gender. It examines whether prolongation of life was all free from chronic illness and disabilities.

2. Disablement statistics

Working on the framework of the World Health Organisation, the study explains the linkages between the three levels of impairment, disability and handicap at which the consequences of diseases are observed by set theory and venn diagram. It shows that since 'disability' is a subset of 'impairment' and there are impairments without any disability, the screening techniques that are disability - specific will underestimate impairments.

For the first time a few disability indicators in the form of disability - free life expectancy are estimated for India. These are derived both in terms of overall physical disability and separate dimensions of visual and locomotor disabilities.

3. Bias and sampling variability of fertility estimates

It has been shown mathematically in this study that the fertility estimates given by the Sample Registration System (SRS) of the Registrar General of India are biased. The estimators of these biases are proposed. The confidence interval of the estimate of, say, total fertility rate (TFR) is also given by using the probability inequality

$$P(|TFR_c - TFR| < 1) \geq 1 - \text{MSE}(TFR_c)M^2$$
 (subscript c denoting corrected estimate),
which can be derived from Markov's inequality for positive random variables.

Psychometric Research and Services Unit

Research work done by the unit during the period is briefly summarized below.

1. Potential entrepreneur school leavers

The objective of the study is to identify potential entrepreneurs from among the young boys and girls who can independently start some business or manufacturing units for their livelihood after completing their high school education.

Data from trainees attending entrepreneurship development programme from different parts of West Bengal have been collected. Data from some entrepreneurs, who have small scale manufacturing units, have also been collected. On the basis of these two, an instrument for measuring entrepreneurship potentiality is being developed to identify potential entrepreneurs from among the school leavers.

2. Motivation to work for primary level workers

The objective of the study is to develop a questionnaire for assessing the motivation level of four different groups of workers, e.g., Clerk, Typist, Account Assistant and Factory worker. Pilot study has been done on a group of 52 clerical workers with a preliminary questionnaire. On the basis of the pilot study the questionnaire has been revised and data collection from different groups of workers has been started.

3. Attainment level of the non-scholastic ability of the primary students at the end of class IV

This was originally a part of the project 'Attainment level of the primary children at the end of class IV' funded by Government of West Bengal which was confined to the 'scholastic' aspects only. The present study focussed on the 'non-scholastic' aspects and used the data collected from all the 17 districts of West Bengal in 1991, covering about 1000 primary schools. The data include the curriculum, e.g., games, physical education and healthy living, work by direct participation, socially useful productive work and creative expressions.

Sociological Research Unit

The unit carried out a number of projects during the year. Brief descriptions of these projects are given below.

1. Pressure from below : a study of the impact of the popular movements in the 1940s

A detailed project report, containing the genesis and growth of the popular movements in the 1940s and their impact on the transfer of power in the subcontinent as well as on the developments in post-independence era, has been completed. The report, with some additional data, has been accepted for publication as a book by National Book Agency.

2. A study of the process of religious conflict and convergence in West Bengal

The occasional resurgence of religious intolerance, which was witnessed in some parts of West Bengal in December 1992 along with other regions of the country, requires an in-depth analysis which would involve explication of the current societal stress and strains as well as unfolding of the opposite historical trends of religious conflict and syncretism in Bengal. The project has been taken to analyse the different facets of this problem.

3. Agro-sociological constraints of technological adaptation in subsistence farming of Bihar plateau region

The focus of the study taken up in collaboration with the Agricultural Sciences Unit of the Institute, is to identify the socio-economic relations under which technologies are being operated by the practising farmer. The area of study covers 24 villages in 5 clusters spread over 8 tehsil subdivisions of 'Uasi' water-shed of the DVC. Data on farm-size, productivity, input-output, cost-benefit, labour relations, land relations, credit relations have been already collected.

4. Inequality in tribal societies : A pilot study

Data on allocation of development inputs through CD Block, Panchayat, NGOs working in the area, both at village and household level, household level occupation, asset and income structure etc. have been collected in two tribal villages in Midnapore District in order to analyse the problem.

5. Appraisal of total literacy campaign (TLC) programme : Methodological considerations

On the request of West Bengal Government two studies - the evaluation of total literacy campaign (TLC) in North 24 parganas district in June-July 1992 and the appraisal of the impact of TLC in Birbhum and Bankura district in January-March 1993 - were conducted by ISI. It is felt that in-depth evaluation studies are necessary for taking corrective measures in order to achieve the goal within a reasonable time period under given constraints and available resources. In evaluation of the programme, the following aspects have been considered : (a) appraisal of various categories of participants involved in imparting and receiving literacy, (b) suggestions for alternative measures to increase retention of learners to improve the learners' achievement and to mobilize hard core group in the programme, (c) development of proper evaluation methods for learners' achievement, (d) identification of indicators of programme achievement, (e) review of efforts undertaken to provide post-literacy continuing education facilities to neo-literates.

The project has already started with a reconstruction of the evaluation of TLC programme through secondary sources, such as the ISI studies in the three districts of the State and base-line data collected by Zilla Saksharata Samities. The progressive evaluation of the various phases of the programme was continued in 1994-95, using the secondary data as well as conducting exploratory surveys.

6. Haldia : a study in the linkage of population and development in an industrial complex

This study is to identify the linkage between population demography and industrial effect with regard to the potentiality and carrying capacity of the growing industrial complex, Haldia.

The socio-economic interplay between core and fringe group with respect to the quality of life is being studied.

7. Social ecology of minority/marginal groups of eastern India

This is a study of the inter-connection between the socio-condition and the emergence of social-economic polarization and/or differentiation, if any, between ethnic groups of different strata.

8. Dissemination and adaptation of new technology in agricultural activities in tribal village situation

The findings of the study indicate that the amount of land holding tends to influence the adoption of technology specially those which are costly. Secondly, such adoption of technology is mainly influenced by the friends, kins and neighbours. The institutional sources are still marginal.

It is also observed that higher the number of technology in the packages, the higher is the rate of adoption. Further it is observed that the behaviour of tribal farmers in adoption of technology is not different from that of non-tribals.

9. Baseline assessment study of DPEP in West Bengal

The objective of the project, entrusted by Dept. of School Education, Govt. of West Bengal is to provide methodology for baseline assessment of District Primary Education in West Bengal.

One of the faculty members Dr. Ashoke Maity was associated with the project entitled "Socio-economic Survey of villages surroundings Salboni foddar farm" undertaken by Rural Development Association and submitted a report.

The Unit also conducted a number of externally funded project during the year.

Academic activities of Giridih Branch of Sociological Research Unit :

Sociological Research Unit has also undertaken research projects on social ecology of minority communities and marginal groups (like SC, ST and OBC) in south Bihar (district of Giridih, Hazaribagh, Palamau and Ranchi in particular). Along with this, micro-watershed based intensive studies have also been conducted on potentials and constraints of local agro-sociological development. The long term objective is to integrate the two aspects and put social ecologic findings in the perspective of processes of local development. Besides, case-studies on 'child labour' and the 'Chamas castes' have also been done in Giridih town and the villages surrounding the township.

Statistical Quality Control and Operations Research Division

The Division continued its activities in the following areas :

1. Development of professionally competent specialists in Quality Control, Reliability and Operations Research (QCROR).
2. Imparting inplant appreciation and technical training in QCROR for different levels of personnel.
3. Undertaking project studies and service assignments.
4. Promoting the use of quantitative tools and adoption of modern methods of Quality Management.
5. Undertaking theoretical and applied research in the relevant fields.

The special activities pursued by the Division included :

1. Providing thrust on helping the client organisations to obtain ISO - 9000 certification with the result that more than 15 organisations have been awarded the certifications with the assistance of the Division's specialists.
2. Development of software for solving Linear Programming Problems.
3. Providing training in Lead Assessor Programme to 10 Quality Mission Executives and 17 specialists of the Division.
4. Organising the second batch of 3-day programme on behavioural aspects in management interface for the staff of the Division conducted by Indian Institute of Management, Bangalore. 31 specialists from the Division attended.
5. One day seminar on Frontiers in Quality and Optimisation was organized during last DCSW meetings at Bangalore. Dr. T. Parthasarathy spoke on LCP and LIPACHITYIAN property, Dr. T.S. Arthanari spoke on Travelling Salesman Problem. Dr. G.S.R. Murthy spoke on Fully Semimonotone Matrices, Dr. V. Rajendra Prasad spoke on Economic Design of Control charts, Dr. P. Mandal spoke on Classification of Process Control Methods, Mr. D.K. Manna spoke on Variance Minimization Scheduling and Dr. G. Ravindran spoke on Copositive Semimonotone Matrices.
6. Ms Nicola Jane Cameron and Ms Victoria Jane Harding of University of Southampton, UK were deputed to SQC Unit, Bangalore for their projects in partial fulfilment of requirements for M.Sc. (O.R.) by instructional course by Dr. D.K. Sahani, M.Sc. projects Coordinator, University of Southampton. They took up the project at Bharat Electronics Ltd., during August - October 1994.

Projects

179 project studies were carried out by the Division. Salient features of selected project studies/research projects are presented below :

1. Optimisation of the process parameters and control at their respective levels helped Alloy Steel Casting Foundry to bring down rejection from 40% to 4%.
2. Quality Engineering was deployed to develop a new compressor design for a low temperature application in the Company.
3. Optimal Selection of Circuit parameters for maximising Circuit Efficiency. A filter circuit of floppy disk drive consists of components - capacitors, inductors and resistors. The circuit efficiency which depends on parameters of the components is maximised by optimally selecting the values of the parameters. The problem is to maximise, over a very large discrete set of solutions, a function which is not explicitly known but can be evaluated for at any given solution. The problem is solved by a two-stage heuristic method involving iterative search. The concepts of quality engineering are also used in the efficiency improvement.
4. Software has been developed for Linear Programming Problem. It has also been tested thoroughly. Copies of the software were distributed to all participants of the Winter school on Mathematical Programming and its Applications held by SQC and OR Division during December 1994.
5. The special project work at West Bengal and Delhi for Department of Posts, Govt. of India, on sample enumeration for estimation of postal traffic continued. The enumerators were trained and the work of enumeration began. The project work is expected to be completed by August, 1995.
6. Variation of Burst strength was reduced by 2/3rd and also curing rejection of Air and Oil Filter for Automobile and Power Industry was brought to zero through experimentation.

7. As a part of collaborative work with University of Pune, an user-interactive software was developed, which helps to fit the appropriate distribution to the failure data and evaluates the reliability of the Components/Subsystem/Total system.

Quality Mission 1992-1997 project during 1994-95

1. The project was taken up with the objective of developing and deploying trained professionals to impart large scale training for personnel from industry and service organisations in Quality systems and related improvements.

2. 20 Quality Mission Executives are deployed in various SQC and OR Units after 3 months, intensive training programme, to carry out training, consultancy and promotional activities. 28 General Training Programmes covering 524 participants from various industries, service organisations and 78 implant programmes covering 3893 participants right from managerial staff to shop floor workers, were conducted as a part of Quality Mission Project. Implant programmes were conducted in varieties of Industries - Textiles, Garments, Gem and Jewellery, Leather, Engineering, Petrochemical, Plastics, Electronics, etc.

3. Quality Mission Executives, under the guidance of scientific staff of SQC and OR Division have been helpful in obtaining ISO 9000 certification in 6 industrial establishments.

4. Quality System exclusively for export oriented Gem and Jewellery industry has been developed by Quality Mission Executives.

5. Specially designed course materials have been developed for short term training programmes on

- i) Workshop on ISO-9000 implementation
- ii) Quality Audits
- iii) Statistical Process Control and Quality Management
- iv) Statistical Techniques for ISO 9000 Quality Management

In addition, depending upon specific needs of organisations, course materials have been developed for implant programmes.

6. The project's progress is periodically reviewed by the Coordination Committee under the chairmanship of Head, SQC and OR Division.

7. Plans are initiated to focus on thrust areas such as (1) Marine Products, (2) Gem and Jewellery, (3) Garment and Apparel, (4) Leather products and small scale institutions. Group certification programme was initiated through their associations and affiliated institutions.

8. 10 Quality Mission Executives have been sent to Lead Assessors Certification Programme and have become certified Lead Assessors.

Library, Documentation and Information Sciences Division

Documentation Research and Training Centre (DRTC), Bangalore

The activities of DRTC have been organised into several programmes, such as (a) Research Programme, (b) Advisory service programme, (c) (i) Extension programme, (ii) Publication programme, (d) Educational and training programme, (e) Employment information programme, (f) Continuing educational and training programme and (g) Faculty development programme.

1. Training in documentation and information science

Under its education and training programme, DRTC conducts a course of 24 months duration leading to the award "Associateship in Documentation and Information Science" (ADIS). This award is recognized by Govt. of India and several other Universities. The academic session, 1994-1996 (24 months) commenced on 1st September 1994. There were 15 students selected for this session.

2. Short term course on computerized information work and service

Under the sponsorship of the National Information System for Science and Technology (NISSAT) forming part of the Department of Science and Industrial Research Research (DSIR), Government of India, New Delhi, DRTC has been conducting a six-week course on Computer Applications to Library and Information work since 1986. Normally, two such courses are conducted during each financial year. The 16th course was conducted in the month of November 1994.

3. The main areas of research in which the different members of the DRTC faculty were engaged are furnished below. (1) The preparation of a Manual for the construction of a Classaurus; (2) The designing of a Classaurus for the depth indexing of micro subject going with the base, agriculture and related science and technologies; (3) Demonstration of the use of the above mentioned classaurus; (4) The application of the Colon Classification, Ed.7, for the purpose of (a) arranging documents; and for (b) documentation work and service; (5) The designing of Multi-Access Thesaurus; (6) The study of the varieties of Thesaurus structure formats from the point of view of their impacts on information retrieval; (7) The study of various methods of knowledge representation, such as, semantic nets, frames and predicate calculus, and of their related features to ascertain their co-relation with the classificatory language of colon classification; (8) The designing and development of National Depth Classification schemes, thesauri and classauri for the depth indexing of micro subjects going with various recognized disciplines; (9) The application of the modern scientific management techniques to the planning and management of information systems, centres and services; (10) The study of the methodologies of information analysis and consolidation; (11) Preparation of state-of-the-art report on performance standards in the field of secondary information work and service; (12) The development of bibliometric measures for evaluating the use of library and information services; (13) The preparation of guidelines for developing software and application packages for house keeping operations of information centres, such as, circulation control service control and acquisition control; (14) The development of a computerized manpower planning model for information centres; (15) Restructuring of Curricula and syllabi specially for the advanced courses on Information Science including Documentation and Library Sciences with a view to accommodate essential contents pertaining to the use of the machines and equipment which are all results of advances in information technologies; (17) Natural language processing and vocabulary control for information retrieval; (18) Development of PROLOG-based vocabulary control devices.

Externally Funded Project

There is one externally funded project under the control of DRTC. This project is the short term training programme of computer applications to library and information work. It is specially meant for the professionals in the field of information work and services. It is fully financed and sponsored by the National Information Systems for Science and Technology by the Department of Scientific and Industrial Research, Govt. of India, New Delhi.

Libraries

Bangalore

1. Additions to the library during April 1994 to March 1995.

Book Acquisition : during the above period 450 books were added to the library by purchase, 30 books were received on gratis.

Stock position : The total stock position as on 31st March 1995 is as follows :

Books - 13618, Books on gratis - 915, Bound volumes of periodicals - 6102, No. of periodical titles subscribed - 251, No. of periodical received on gratis - 26.

2. Technical processing

About 600 books were classified and catalogued during the year. Nearly 3000 catalogue cards were filed.

3. Circulation statistics

During the year library facilities were enjoyed by 195 users. 122 of them availed of the lending facilities. 10 Visiting Professors of different units of ISI were also provided with the lending facilities. A total of about 11000 books and periodicals (including loose issues) were circulated by the library. The in-house use of books and periodicals were around 33000. About 250 inter-library loan transactions were registered.

4. Inter-library loan service

Inter-library loan facilities were availed of by Bangalore Centre Library, and the library also extended similar facilities to other users.

5. Reprographic service

Library provided 3,00,000 xerox copies to the users during the academic year 1994-95.

6. Documentation service

The following publications were brought out regularly from the library. (1) Bimonthly additions list of books, (2) Monthly list of current periodicals, (3) Current contents of journals, (4) List of periodical holdings, annually.

Calcutta

With the addition of 1250 books to the stock, the total collection of the library rose to 1,98,442.

1. Acquisition Unit

The unit accessioned 1250 books during the period under report, out of which 1066 were purchased and 130 were received as gift. The unit also acquired 54 floppy diskettes.

2. Periodicals Unit

The Unit received 812 periodicals out of which 160 were received as gift, 452 against subscription and 200 on exchange arrangement with national and international organisations. The Unit also acquired 14 new journals. 26 journals were subscribed under NBHM grant. It accessioned 2713 journals and completed the technical processing of 2343 journals. The network version of Math SCI CD-ROM has been added in the current year.

3. Circulation and Stack Maintenance Unit

The Unit issued 58943 books and journals to the users on loan and reference. The total membership of the Library was 2817. 524 readers were given special permission to use the Library for a short period. 52 books and journals were borrowed from other libraries and 61 books and journals were loaned to other libraries under the inter-library loan arrangement.

4. Reports & Records Unit

The Unit accessioned 226 titles and processed 301 titles. 1094 titles were issued to the borrowers for reference use during the period.

5. Circulating Library

The Workers' circulating library acquired 400 new titles bringing the total collection to 35,638. It issued 24,574 books to the members.

6. Technical Processing Unit

The Unit classified 1264 books and catalogued 1498 books. The Unit has undertaken the construction and development of information retrieval thesaurus on statistical science and its applications as a project work and the work is in progress.

7. Documentation Unit

The Unit has been issuing current contents list services to the users on the following group of subjects (a) Statistics and Mathematics, (b) Electronics and Communication Science, (c) Geology, (d) Life Sciences, (e) Economics, (f) Recent addition of books to the ISI library.

8. Reprography and Photography Unit

The Unit provided 7,33,199 xerox prints to the users during the period under report.

549 frames of photographs of different nature, 2755 prints of photographic enlargements, 430 frames of lecture slides were made during the period under report. 3,93,175 pages of off-set prints were done during the period under report.

Delhi

During the period April 1, 1994 to March 31, 1995 the Delhi Centre Library acquired 311 new books. It received 80 publications as gift from various sources. 302 sets of loose issues of periodicals duly bound has been added to the stock, thus raising the stock to 32242 volumes. About 250 Technical reports/discussion papers/reprints etc. in Economics have been received during the above period.

1. Periodicals

223 titles of journals, both foreign as well as Indian have been approved for renewal for the year 1995-96. In addition 28 titles of journals were received as complimentary and against exchange programme. 302 sets of loose issues of journals duly bound were added to the stock. Journals/technical reports have been received under the exchange programme established with different institutions.

2. Circulation

During the period April 1, 1994 to March 31, 1995, 130 members availed of the lending facilities as permanent members, and 32 members availed of the reference facilities as temporary members. Approximately 6818 publications were circulated during the period among its members. Under the inter library loan program, about 61 publications were lent out to the neighbouring institutes and libraries and 44 publications were borrowed from them for use by Delhi Centre library members.

3. Reprographic services

Approximately 31000 photocopies were made during the period on the request of users of library. Reprographic facilities have also been provided to researchers of other institutes.

4. Other activities

- (i) National Board of Higher Mathematics, Department of Atomic Energy, Govt. of India, has recognised Indian Statistical Institute, Delhi Centre Library as the Regional Library to serve the Northern Region w.e.f. 1.4.1994 with an annual grant of Rupees 6.00 lakhs.
- (ii) Out of N.B.H.M. grant a total number of 125 books were purchased and some back volumes of journals were acquired.
- (iii) Like every year, this year too library trainees with remuneration had been appointed. At the end of their training, each trainee was given an experience certificate.

Computer and Statistical Services Centre

The Computer and Statistical Services Centre (CSSC) manages the central computing facility of the institute at Calcutta. It serves about 400 users - students, research scholars and scientific workers - with the inhouse computer system VAX 8650 and SUN SPARCSTATION 1. N.SSO and CSO (I-S wing), Govt. of India, are using these facilities as well. E-mail and fax facilities are also available at the centre.

Statistical and Computational consultancy services are provided by CSSC. During 1994-95, the centre offered a course on object-oriented programming and GUI using C++ and MS-windows for its users. On the request of the Director, CSSC trained about 75 non-faculty staff on a PC-based database package. The centre completed the first phase of the project to develop a database for technical manpower in West Bengal, given by the West Bengal Academy of Science & Technology. The 2nd phase of the project is under progress.

This year CSSC purchased two PC-based packages Fuzz-C and Matlab. It has also procured the Borland C++ compiler.

The VAX 8650 system has been augmented by another 16 MB of memory, 1 GB disk drive and 4 MB cartridge drive this year.

Considering the load on the only laser printer, CSSC has procured another laser printer with postscript facility.

This year CSSC has purchased a 486-based multi-media system as well. This is the first multi-media system for the CSSC users at ISI.

The M.Tech.(CS) students can take parallel-processing as a special paper in their final semester. So far there was no lab facility for this subject. CSSC has procured a transputer based 486-PC/AT to provide this support. The system is still not adequate for all the students, but the lab can be started.

Like all other years, the staff members of CSSC have served as faculty in various courses of the institute and supervised projects carried out by the students. The staff members of CSSC are also involved in research covering the areas like, database and knowledge bases, image processing, computational geometry, VLSI design etc.

4. EXTERNALLY FUNDED PROJECTS

A. Ongoing Projects :

- Name of the Project :** Automatic Feature Extraction from Satellite Images and Image Data Compression.
Name of the Project Leader : B.B. Chaudhuri.
Unit involved : Computer Vision and Pattern Recognition.
Funded by : Advanced Data Analysis Research Institute, Hyderabad.
- Name of the Project :** Studies on the PBL dynamics using SODAR and tower data and to predict a scalar transport model for the monsoon period.
Name of the Project Leader : J. Das.
Unit involved : Electronics and Communication Sciences.
Funded by : Dept. of Science and Technology, New Delhi.
- Name of the Project :** A Knowledge Based Computing
Principal Investigator : D. Dutta Majumder.
Unit involved : Electronics and Communication Sciences.
Funded by : CSIR, New Delhi.
- Name of the Project :** Development of Computer algorithm for recognition and interpretation of Sodar patterns.
Name of the Chief Investigator : J. Das.
Unit involved : Electronics and Communication Sciences.
Funded by : Dept. of Science and Technology, New Delhi.
- Name of the Project :** Deformation, matamorphism, antaxis and magmatism across the northern boundary of the Eastern Ghats mobile belt around Rangali, Orissa.
Name of the Project Leader : S. Bhattacharya.
Unit involved : Geological Studies.
Funded by : Dept. of Science and Technology, New Delhi.
- Name of the Project :** A neuro-fuzzy image recognition system : Methodology development for forensic applications.
Chief Investigator : S.K. Pal.
Unit involved : Machine Intelligence (in collaboration with State Forensic Lab., Belgachia).
Funded by : CSIR, New Delhi.
- Name of the Project :** Development of Software Package - Handling Uncertainties for Machine Interpretation of Ill-defined Structures Present in Gray-level Images.
Chief Investigator : S.K. Pal.
Unit involved : Machine Intelligence.
Funded by : Defence Electronics Applications Laboratory, Dehradun.
- Name of the Project :** A study of mathematical techniques in water wave problems.
Name of the Project Leader : B.N. Mandal.
Unit involved : Physics and Applied Mathematics.
Funded by : CSIR, New Delhi.

9. **Name of the Project :** Unsteady, surface water waves in ocean.
Name of the Project Leader : B.N. Mandal.
Unit involved : Physics and Applied Mathematics.
Funded by : University Grants Commission, New Delhi.
 10. **Name of the Project :** Livelihood strategies and knowledge systems under environmental stress.
Project Coordinator : D.K. Bagchi.
Unit involved : Agricultural Sciences (jointly with School of Development Studies).
Funded by : University of East Anglia, Norwich, U.K.
 11. **Name of the Project :** Genetic of Quantitative Traits of Commercial Importance in the Silkworm.
Project Coordinator : P.P. Majumder.
Unit involved : Anthropometry and Human Genetics.
Funded by : Central Silk Board/Department of Biotechnology, Govt. of India.
 12. **Name of the Project :** Improvement in health and economic status of two communities by intervention programme using leaf concentrate (LC)
Project Leader : Shyam Matai
Units involved : Leaf Protein Research.
Funded by : Find Your Feet, U.K.
 13. **Name of the Project :** Socio-economic Surveys on the Quality of Life.
Name of the Project Leader : S. Guha Roy.
Unit involved : Population Studies, Economic Research and Sociological Research.
Funded by : West Bengal Commission for other Backward Classes.
 14. **Name of the Project :** Attainment level of primary school children at the end of class IV.
Name of the Project Leader(s) : S. Guha Roy, S.K. Mitra and Surjo Sankar Roy of SCERT.
Unit involved : Psychometric Research and Services, Population Studies (in collaboration with State Council of Educational Research & Training, West Bengal)
Funded by : Dept. of School Education, Govt. of West Bengal.
 15. **Name of the Project :** Evaluation of 'Rainfed Farming Project' (REF).
Name of the Project Coordinator : Atis Dasgupta.
Units involved : Sociological Research and Agricultural Sciences.
Funded by : Hindustan Fertiliser Corporation Ltd. (HFCL).
Sponsored by : Overseas Development Authority (ODA), U.K.
 16. **Name of the Project :** Evaluation of Total Literacy Campaign (TLC) in Calcutta Metropolitan District.
Name of the Project Coordinator : Atis Dasgupta.
Unit involved : Sociological Research and Population Studies.
Funded by : Calcutta Municipal Corporation.
 17. **Name of the Project :** Guidance and Consultancy Services in Data Processing.
Name of the Project Coordinator : Prafulla Chakrabarti.
Unit involved : Sociological Research.
Funded by : Indian Council of Social Science Research, New Delhi.
- B. Completed Projects :**
1. **Name of the Project :** Socio-economic Survey of the sericulturist
Name of the Project Leader : T. Maitra.
Unit involved : Computer Science.
Funded by : Central Silk Board.

2. **Name of the Project : India's export to EC : constraints and prospects.**
Name of the Project Leader : Atul Sarma.
Unit involved : Planning (Delhi).
Funded by : International Development Research Centre, Ottawa, Canada.

3. **Name of the Project : Fiscal Reform and Structural Adjustment.**
Name of the Project Leader : Atul Sarma.
Unit involved : Planning (Delhi).
Funded by : International Development Research Centre, Ottawa, Canada.

4. **Name of the Project : Refresher course in Statistics for post-graduate teachers of various universities and colleges.**
Name of the Project Leader : Mausumi Bose, Arijit Chaudhury.
Unit involved : Computer Science.
Funded by : University Grants Commission. ,

5. SYMPOSIA, CONFERENCES, WORKSHOPS, LECTURES AND SEMINARS ORGANISED

The Symposia, Conferences, Workshops, Lectures and Seminars organised by the Institute during the year 1994-95 are mentioned below.

Symposia, Conferences, Workshops

A "SERC School on Stochastic Process Modelling" was organised at Stat-Math Unit, Calcutta during 19 October 1994 to 1 November 1995 by B.V. Rao (Stat-Math Unit) and S.P. Mukherjee of Calcutta University. This was sponsored by the Science and Engineering Research Council of DST.

A Winter School on Discrete Mathematics was organised at Stat-Math Unit, Calcutta by A.R. Rao and S.B. Rao during 19 December 1994 to 8 January 1995. There were 32 registered participants who were lecturers and research fellows in various Indian universities and colleges.

The Stat-Math Unit and the Computer Science Unit jointly organised a Workshop on Regression Analysis at Calcutta during February 13 to February 22, 1995. This was sponsored mainly by DST. The Course Directors were B.K. Sinha and P. Bhismasankaram and Course Coordinators were Debapriya Sengupta and Debashish Sengupta.

The West Bengal regional Mathematical Olympiad sponsored by NBHM for students of classes 9, 10 and 11 was conducted by ISI, Calcutta on 4 December 1994 at various centres in West Bengal.

A three week workshop called "NBHM Summer School on Non-Commutative Harmonic Analysis" was jointly organized by Stat-Math Unit, Bangalore and IIT, Kanpur during June/July 1994 at Bangalore under the sponsorship of NBHM. As a follow up of the above workshop a Winter School on Non-Commutative Harmonic Analysis was held at ISI, Delhi during December 94.

A Winter School on Mathematical Programming and its Applications was organised at the SQC and OR Division during December 1 - 14, 1994 at Bangalore for scientists, research scholars and faculty members from different institutions and universities. A one-day appreciation programme on ISO was organised by the SQC and OR Unit, Calcutta, for senior executives from industry at Bengal Chambers Hall on 28 May, 1994. The SQC and OR Unit, Calcutta also organised a One-day Seminar on Statistical Implementation for ISO 9000 for industrial participants at Hotel Taj Bengal on 16 June, 1994.

Annual Seminar 1994 on Teaching, Research and Practice in Classification and Indexing Languages was organised by DRTC, Bangalore.

Lectures and Seminars

Lectures/Seminars organised by the Institute and delivered by outside members and Visiting Professors are given below :

Theoretical Statistics and Mathematics Division

Calcutta Unit

Ali Almech, Jahangirnagar University, Dhaka (20.2.95) : Moments of Order Statistics and Related Results.

Bagh Somnath, Sambalpur University (18.7.94) : On Real Roots of A Random Algebraic Equation.

- Ghosh, S., Presidency College, Calcutta (27.3.95) : Some Generalisations of Stone-Weierstrass Approximation Theorem for Application to the Problem of Identification of Distribution Functions.
- Hauser, Kai, University of California at Berkeley (2.1.95 to 6.1.95) : Forcing Methods in Descriptive Set Theory.
- Paül, P.N., Australian National University, Canberra (9.12.94) : Wavelet-Based Nonparametric Curve Estimation.
- Rao, C.R., Penn State University, USA (26.12.94) : Fuzzy Sets.
- Ray-Chaudhuri, D.K., Ohio State University, USA (24.12.94) : Some Combinatorial Inequalities.
- Stute, W., Justus-Liebig University of Giessen Germany (10.1.95) : Nonparametric Model Checks and Kaplan Meier Integrals.
- Suresh, R.P., University of Poona (2.3.95) : Some Measures of Improvement due to Selection in Genetics.
- Suresh, R.P., University of Poona (6.3.95) : Total Time on Test Transforms and its Application to Reliability Theory.
- Yor, M., University of Paris (5.12.94 to 21.12.94) : Brownian Motion and Stochastic Calculus.
- Yor, M., University of Paris (21.12.94) : Symmetric stable variables, Matrix transposition and Ciesielski-Taylor identities.
- Zielinski, Ryazard, Polish Academy of Sciences (6.2.95) : Robustness : Stability of Statistical Procedures.

Bangalore Unit

- Bala Krishnan, Palapre, Indian Statistical Institute, Bangalore (20.3.95) : The Reforms, The Economy and The Union Budget for 1995-96.
- Bhat, B.V. Rajarama, University of Pisa, Italy (25.7.94) : An index theory for quantum dynamical semigroups.
- Guruprasad, K., Indian Institute of Science, Bangalore (5.5.94) : Invariant functions on Lie groups and the symplectic structure on the parabolic moduli space.
- Karandikar, R.L., Indian Statistical Institute, New Delhi (20.3.95) : On Invariant Distribution for Perturbed Markov Chains.
- Krishnapriyan, H., Drake University, DesMoines, Iowa (10.1.95) : Eulerian Polynomials and Faulhaber's Result on Sums of Powers.
- Muralidharan, T.K., ISI, Bangalore (2.2.95) : Spectral Synthesis.
- Paranjape, Kapil, TIFR, Bombay (20.10.94) : Elliptic Curves : Geometry and Number Theory.
- Paranjape, Kapil, TIFR, Bombay (5.1.95) : On the work of Zelmanov.
- Rao, Subba T., University of Manchester Institute of Science and Technology, UK (10.1.95) : Analysis of Non-linear Time Series-Bilinear Time Series Models.

Samuel, Joseph, Raman Research Institute, Bangalore (19.5.94) : Introduction to Topological Geom.

Vannianathan, M., TIFR, Bangalore Centre (19.1.95) : On the Work of P.L. Lions.

Applied Statistics, Surveys and Computing Division

Computer Science Unit

Bandyopdhyay, Tathagata, University of Calcutta : Multistage ranking models : a brief review.

Basak, Indrani, Pennsylvania State University, USA, (4.10.94) : Robust Estimation : The approach based on influence function.

Ghosh, Ajay, University of Calcutta, (30.8.94) : Optical Information Processing and Its Applications.

Maitra, Ranjan, University of Washington, (6.9.94) : Markov Random Field Priors in Bayesian Synthetic Magnetic Resonance Imaging.

Nanthakumar, A., University of Tennessee at Martin, USA, (23.6.95 and 24.6.95) : Test for treatment effect in the presence of non-responders and stress-strength reliability for designs based on large values of stress.

Paul, Sudhir R., University of Windsor, Canada, (14.2.95) : On the use of $C(\alpha)$ Optimal Test of Homogeneity.

Ryszard Zielinski, Institute of Mathematics, Polish Academy of Sciences, Warsaw, Poland, (21.2.95) : A non-parametric quantile estimator.

Som, R.K., Consultant in Population & Statistics, United Nations, (2.8.95 and 4.8.95) : Use of Computers in Survey Sampling and Recall Analysis.

Physical and Earth Sciences Division

Electronics Unit

Chakrabarty, Samar, TCIL (17.8.94) : LAN Technology.

Pal, A., Dept. of Computer Science & Engg., IIT, Kharagpur (28.10.94) : LAN Technology : State of the Art.

Ramanujam, Krithi, Dept. of Computer Science, University of Massachusetts, Amherst (22.2.95) : Scheduling Algorithms and Operating Systems : Support for Real-Time Systems.

Sarkar, Faiguni, Dept. of Computer Science, North Texas University, USA (13.12.94) : Discrete Event Simulation.

Sen, Arunava, Dept. of Computer Science, University of Arizona, Tempe, USA (7.7.94) : New Network Topologies : Analysis and Comparative Study.

Electronics and Communication Sciences Unit

Das, Amitava, Dept. of Electrical and Computer Engg., University of California, Santa Barbara, USA (25.1.95) : Visual speech and speech coding.

Machine Intelligence Unit

- Bose, N.K., Dept. of Electrical and Computer Engineering, Pennsylvania State University, U.S.A., (15.12.94) : Neural Networks, Graph, Algorithms and Applications.
- Kundu, S., Dept. of Computer Science, Louisiana State University, U.S.A., (21.7.94 and 29.7.94) : Problems with Defuzzification and an alternate representation method by Fuzzy Set and Programs, Rules, Decision Tree and Expert System.
- Mabendra, S., Citybank, N.A., Bombay, (15.12.94) : Portfolio Management, Financial and Banking : Neural Networks and Genetic Algorithms Applications.
- Sarbadhikari, S.N., School of Biomedical Engineering, B.H.U., (24.3.95) : A Neural Network Confirms that Exercise Reverses EEG Power Spectra in Depression.

Physics and Applied Mathematics Unit

- Banerjee, R., S.N. Bose National Centre for Basic Sciences, Calcutta, (23.11.94, 30.11.94 and 7.12.94) : Constrained Hamiltonian Dynamics and its Applications.
- Bhattacharya, Jayanta, IIT, Kanpur, (6.5.94) : On Turbulance.
- Bose, Indrani, (14.9.94 and 21.9.94) : Strong Correlation and High Temperature Superconductivity.
- Chakraborty, A., I.I.Sc., Bangalore (16.9.94) Solution of Singular Integral Equations.
- Islam, Jamal N., Research Centre for Mathematical Physical Sciences, University of Chittagong, Bangladesh, (5.1.94) : Schrodinger Functional Equation for Yang Mills Theory.
- Kumar, Krishna, IIT, Kanpur (3.5.94) : Zero Prandtl Number Convection.

Biological Sciences Division

Anthropometry and Human Genetics Unit

- Chakraborty, Ranajit, University of Texas, U.S.A. (December 1994 - January 1995) : Theory and Applications of VNTR Polymorphisms (4 lectures).
- Chakravarti, Aravinda, Case Western Reserve University, U.S.A. (17.11.94) : Genetics of Hirschprung Disease.
- Malik, S.L., University of Delhi (8.3.95) : Exposure to Stone Dust : Some Health Implications.
- Mulvihill, John J., University of Pittsburgh, U.S.A. (19.12.94) : Clinical Genetics of Cancer.

Social Sciences Division

Economic Research Unit

- Acharyya, Rajat, Burdwan University (2.3.95) : Devaluation, black market for foreign exchange and employment.
- Bagchi, Amiya Kr., C.S.S.S, Calcutta (23.2.95) : Economic Reforms and Industrial Growth in India.

- Basu, Parantap, Fordham University (18.8.94) : Explaining behaviour of velocity and nominal interest rates in optimizing models of money demand.
- Bera, Anil Kr., University of Illinois, USA (6.2.95) : Diagnostic tests for spatial dependence.
- Bose, Amitava, IIM, Calcutta (23.2.95) : Economic Reforms and Industrial Growth in India.
- Chakraborty, Pinaki, North Bengal University (22.6.94) : Technological Progress and long run comparative advantage.
- Chowdhuri, Kaushik, State University of Hong Kong (2.2.95) : A common trend in long run real exchange rate.
- Dasgupta, Suddipta, Hong Kong University of Science & Technology (23.12.94) : Pricing strategy and financial market.
- Ghosh, Arabinda, State Institute of Panchayats, W.B. (27.10.94) : Role of Panchayati Raj Institutions in development planning.
- Mallick, Saumitra, Indian Institute of Social Welfare and Business Management (6.7.94) : Market failures in insurance markets with costly information and the role of wealth distribution.
- Marjit, S., Monash University, Australia and Jadavpur University, Calcutta (5.7.94) : Explaining differences in real return to capital across international borders.
- Poddar, Sougata, CORE, Belgium (10.11.94) : Network Structure and Entry in the Deregulated Airline Industry.
- Roy, Santanu, Erasmus University, Rotterdam (18.8.94) : On conservation of renewable resources with stock-dependent return and non-concave production.
- Sengupta, Sarbajit, Visva-Bharati (14.7.94) : Trading with partners.
- Sengupta, R.P., Jawaharlal Nehru University (24.6.94) : Economic Reforms Infrastructure and Indian Steel Industry.
- Bhaskar, U., Delhi School of Economics (7.6.94) : Sustaining inter-generational altruism when social memory is bounded.

Economic Analysts Unit

- Enghe, Leon, LUC, Diepenbeek, Belgium, (18.4.94) : Sensitivity of Concentration Measures to Transfers.
- Halli, Shiva S., University of Manitoba, Canada, (29.7.94) : Land Reclamation and Transmigrant Farmers in Southern Sumatra, Indonesia.
- Jha, Raghavendra, Indian Institute of Management, Bangalore, (28.10.94) : The Design of Conditional Grants as a Principal - Agent Problem : An Integration of Optimal Tax and Regulation Theorem.
- Pushpangadan, K., Centre for Development Studies, Trivandrum, (21.4.94) : Total Factor Productivity Growth in Indian Manufacturing.
- Rath, Kali P., University of Notre Dame, USA (21.7.94) : Equilibrium in Hotelling's Model of Location.
- Subramanian, A., Centre for Development Studies, Trivandrum, (31.5.94) : The Behaviour of the Intersectoral Terms of Trade in the Indian Economy.

Suresh Babu, M., Centre for Development Studies, Trivandrum, (2.6.94) : The Role of Industrial Sector in Inflation : The case of India.

Population Studies Unit

Blakie, Piers, University of East Anglia, U.K., (8.7.94) : Problems and challenges of linking micro - and macro determinants of marital fertility.

Sociological Research Unit

Basu, Rathindra Narayan, Vice-Chancellor of Calcutta University, (16.11.94) : Recent advances in Biotechnology : Trade and ethical issues.

De, Barun, Director of Maulana Abul Kalam Azad Institute for Asian Studies, Calcutta, (6.10.94) : Threats to secularism in India today.

Mitra, Ashok, M.P., (20.10.94) : India and the World.

Mukherjee, Ramkrishna, National Fellow of ICSSR, (8.9.94) : Genesis and growth of sociological research in ISI.

Library, Documentation and Information Sciences Division

Bekete, Rahel, Lecturer, School of Information Science of Africa, Addis Ababa, Ethiopia (7.9.94) : Computer Assisted Instruction for Bibliometrics.

Bhattacharya, G., Former Professor, DRTC, (25.7.94, 27.7.94 and 6.9.94) : Five Laws of Library Science, Current Trends Classification and Index Languages and Study of Subject.

Eghe, Leo, LUC, Dipebock, Belgium and Rousseau, LUC, Dipenbock, Belgium, (12.4.94 and 15.4.94) : Informetrics.

Hood, William, Lecturer, School of Information, Library & Archive Studies at University of New South Wales, Australia (7.11.94) : Analysis of Indexing Used on LISA Databases.

Jambhakar, Ashok, Librarian, Indian Institute of Management, Ahmedabad, (28.4.94) : Resource-Sharing Among Management Libraries.

Noelameghan, A., Visiting Professor, DRTC, (18.7.94) : Quality Assessment in Education for Information Professional.

Noelameghan, A., Honorary Professor, DRTC, (15.9.94 and 16.9.94) : Information Support for Development Planning and Government and Administrative Information Support Systems.

Parthasarathy, S., Director, Institute of Information Studies, Madras, (26.9.94 and 27.9.94) : Technology Transfer.

Prabhakar, N.D., AT & T Laboratory, USA, (21.7.94) : Some Considerations for Computer Networking.

Sanjivi, Amba, Documentation Officer, Central Leather Research Institute, Madras, (27.10.94) : Performance Measures and Libraries held in memory of Dr. S.R. Ranganathan.

Sanjivi, Amba, Documentation Officer, Central Leather Research Institute, Madras, (26.9.94) : Cluster-based Thesaurus for Information Retrieval.

Sanjivi, Amba, Documentation Officer, Central Leather Research Institute, Madras, (28.9.94) : Expert System for Information Processing and Organization.

- Sanjivi, Amba, Documentation Officer, Central Leather Research Institute, Madras, (28.9.94) : Expert Systems for Information Retrieval.
- Seity, Unapathy, Public Library System, Pennsylvania State University, U.S.A., (9.12.94) : Marketing of Public Library Services.
- Urs, Shalini, Chairman, Dept. of Library & Information Science, University of Mysore, Mysore, (7.5.94) : Paradigm Shifts in Information Science.

6. PUBLICATIONS

Sankhyā

Founded and edited by Professor P.C. Mahalanobis in 1933 *Sankhyā*, the Indian Journal of Statistics and the official organ of the Indian Statistical Institute is now published bi-monthly in two series - Ser. A on Probability and Mathematical Statistics, and Ser. B on Statistical Methodology and Applications including Sample Surveys and Quantitative Economics. Since its inception, eminent scholars from all over the world have been contributing research articles for publication in *Sankhyā*, one of the most prestigious and internationally renowned journals.

Journal Committee:

Editors: Somesh Das Gupta, G. Kallianpur, K.R. Parthasarathy, B.L.S. Prakasa Rao and C.R. Rao.

Co-Editors: *Sankhyā* A : Anup Bose, Probal Chaudhuri (upto end of 1994), Mohan Delampady,
R.L. Karandikar and Bimal Kumar Sinha.

Sankhyā B : Probal Chaudhuri, Dipankar Coondoo, S.R. Mohan, T.J. Rao and Bikas Kumar Sinha.

Managing Editors: Series A : R.L. Karandikar
Series B : T.J. Rao

The following issues of *Sankhyā* were published during the year April 1994 to March 1995 :

- a) *Sankhyā* Ser. A : Volume 56, Parts 1 and 2
- b) *Sankhyā* Ser. B : Volume 56, Part 1.

Other Publications

The Institute has undertaken the publication of selected papers of the internationally renowned statistician and National Professor C.R. Rao. Two volumes have come out and are being distributed by Wiley Eastern. Third volume has been printed. Work on volumes IV and V will be taken up in the next year.

The Institute, under a collaborative project with the Institute of Languages and Cultures of Asia and Africa (LCAA), Tokyo University of Foreign Studies, published a book containing statistical linguistic analysis on Rabindranath Tagore's GITANJALI during the period.

7. SCIENTIFIC PAPERS AND PUBLICATIONS

Books Published

Theoretical Statistics and Mathematics Division

Calcutta Unit

Ghosh, J.K. : *Higher Order Asymptotics*, American Statistical Association and Institute of Mathematical Statistics, 1994.

Delhi Unit

Rao, B.L.S. Prakasa (ed.) : *Statistics and its Applications*, Special issue of Indian J. Pure & Appl. Maths, Indian National Science Academy, 1995.

Meester, R. and Rahul Roy : *Continuum Percolation*, Cambridge Univ. Press, 1994.

Biological Sciences Division

Anthropometry and Human Genetics Unit

Danda, A.K., Basu, A. and Basu, A. (eds.) : *Frontiers of Anthropology: Biology, Culture and Human Development in Retrospect and Prospect*, Indian Anthropological Society, 1994.

Ramkrishnan, R.S., Campbell, J., Demierre, L., Gyi, A, Malhotra, K.C., Mehdiratta, S., Rai, S.N. and Sashidharan, E.M. : *Ecosystem Rehabilitation of the Rural Landscape in South and Central Asia, An Analysis of Issues*, UNESCO, New Delhi, 1-29, 1994.

Social Sciences Division

Economic Research Unit

Chakravarty, S.R. : *Issues in Industrial Economics*, Avebury, Hants, U.K., 1995.

Chattopadhyay, K. : *Economic Impact of Tourism Development - An Indian Experience*, Kanishka Publishers, Delhi, 1995.

Mallik, B.P., Nara, T. and Bhattacharya, N. : *Gitanjali : A Linguistic-Statistical Analysis (in Bengali)*, Indian Statistical Institute, 1994.

Planning Unit

Kumar, D. and Mookherjee, Dilip (eds) : *D. School : Reflections on the Delhi School of Economics*, Oxford University Press, 1995.

Mookherjee, Dilip (ed.) : *Indian Industry : Policies and Performance*, Oxford University Press, 1995.

Sociological Research Unit

Chattopadhyay, K. : *The Desperate Delta : Social Ecology at Sundarbans*, Gyan Book (P) Ltd, New Delhi, 1995.

Names of non-ISI authors have been indicated in New Courier Font