

INDIAN
STATISTICAL
INSTITUTE

SIXTYFIRST
ANNUAL REPORT

APRIL 1992-MARCH 1993



203 BARRACKPORE TRUNK ROAD
CALCUTTA-700 035

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OF THE COUNCIL AS ON 31 MARCH, 1993**

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not employed in the Institute

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15. Prof. Prabuddha Nath Roy, Pro-Vice-Chancellor (Finance), Calcutta University.

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16. Shri Dilip Sengupta, Representative of the Scientific Workers.
17. Shri Swapna Sen, Representative of the Non-Scientific Workers.

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19. Prof. S. R. Ghankraborty, Professor-in-Charge, Applied Statistics, Surveys and Computing Division.
20. Prof. D. Ghondoo, Professor-in-Charge, Social Sciences Division.
21. Dr. D. K. Rudra, Professor-in-Charge, Physical and Earth Sciences Division.
22. Dr. (Smt.) G. Dutta Gupta, Professor-in-Charge, Biological Sciences Division.
23. Shri. S. C. Ghankraborty, Head, SQO & OR Division.
24. Dr. S. C. Bagchi, Dean of Studies.
25. Prof. Bhaskar Dutta, Head, Delhi Centre.

Shri P. K. Bandopadhyay, Chief Administrative Officer, Non-member Secretary.

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INDIAN STATISTICAL INSTITUTE
SIXTY-FIRST ANNUAL REPORT
April 1992 - March 1993

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INDIAN STATISTICAL INSTITUTE

HISTORY OF THE INSTITUTE

Research in the theory and applications of the new discipline of Statistics began in India in the early twenties through the pioneering initiative and efforts of the late Professor P.C. Mahalanobis. Soon after his return from England Mahalanobis began to carry on statistical studies in his own home with the help of part-time assistants engaged by him. A chance meeting with Dr. Annandale (the then Director of the Zoological and Anthropological Survey of India) led to Mahalanobis's first scientific paper on the statistical analysis of anthropometric measurements on Anglo-Indian population in Calcutta. This was followed by further researches on anthropometry, on meteorological problems and on problems of flood control in North Bengal and Orissa. Gradually, a small group of young scientists gathered around him in the Department of Physics, Presidency College, Calcutta, and this came to be known as the Statistical Laboratory.

On 14 December 1931, a notice was issued over the signatures of Professors P.N. Banerjee and N.R. Sen, both of Calcutta University and Professor Mahalanobis to convene a meeting on 17 December, 1931, to consider the steps to be taken towards the establishment of an association for the advancement of statistics in India. At this meeting 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-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 only Rs.238 and the number of workers were only two or three. From such a modest beginning, the Institute grew into an all-India organization which now has over 1600 workers, including about 500 scientific workers, thanks to the magnificent leadership of Professor Mahalanobis. It has its headquarters at Calcutta and two other Centres at Delhi and Bangalore. It also has a network of service units of Statistical Quality Control and Operations Research Division covering many major cities of India.

From the very beginning, Prof. Mahalanobis and his associates - Professor S.S. Bose, R.C. Bose, S.N. Roy, K.R. Nair, K. Kishen, H.C. Sinha and others worked unceasingly for the development of Statistical theory and methods, and promoting their use in 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 Editor, and soon gained international recognition. Pioneering research activities were carried out in many areas of statistical theory, especially in multivariate analysis, sample surveys and design of experiments. Such activities were strengthened by C.R. Rao and many others who joined the Institute in the 40's. The ISI also attended to many enquiries about the application of statistical methods, particularly Fisherian techniques, to agricultural research. This led to a large number of research publications and to the introduction of training activities offering short courses in statistics for officers in Government Departments or Scientific Institutions. The scientists of ISI helped in introducing the first postgraduate degree course in Statistics in India in the Calcutta University in 1941, and in securing a separate section for Statistics in the Indian Science Congress.

Activities of the Institute expanded rapidly from 1938. Professor Mahalanobis began his now classical sample surveys of the jute crop in Bengal in 1937; the scale of the exploratory work was increased from year to year culminating in a full-scale survey of the entire province

in 1941. Gradually, sample surveys of agricultural crops and other socio-economic surveys became the most important activity of the Institute. The Institute and Professor Mahalanobis earned international reputation in the field of sample surveys. After independence, Professor Mahalanobis was appointed Honorary Statistical Adviser to the Cabinet, Govt. 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. The sample survey department of ISI served as the Technical Wing of the NSS from 1950 to 1972, after which it was transferred to the Govt. of India.

The ISI played a pioneering role in starting the Statistical Quality Control (SQC) movement in India by organising the visit of Dr. 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 promotion 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 were 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 has since been regarded as major contributions to economic planning in India. Since then many economists of the Institute have worked in the 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.

The Institute has been one of the pioneers in the country in the design of electronic computers. An analog computer was assembled as early as 1953 to solve certain differential equations. Soon after, in collaboration with the Jadavpur University, work on the design of a computer with solid state central processor was started and a digital computer named ISIJU-1, was commissioned in 1966 by Shri M.C. Chagla, the then Minister of Education, Govt. of India. Since then, the computer scientists have diversified their research in other areas including Fifth Generation Computing Systems.

From the early days, the Institute has been in touch with and the host to 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. The late Sir R.A. Fisher, father of modern statistics, was a constant visitor to the Institute and lent it considerable support. The late Professor J.B.S. Haldane was a member of the faculty for several years beginning 1957. At the inspiration of these stalwarts and other world renowned scientists, the Institute began to undertake research activities in several natural and social science areas with the hope that collaboration under the same roof would foster the mutual development of statistics and other disciplines. In fact, Fisher had named Statistics as 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. Apart from research activities in statistics, probability and mathematics, which began since the inception, most of the other research groups which exist today started their activities in the fifties.

As the Institute expanded its research, teaching, training and project activities and earned national and international recognition, the Parliament of India enacted "The Indian Statistical Institute Act, 1959" (No.57) declaring the Institute as an Institution of National Importance and empowering it to award degrees and diplomas. It may be noted that Pandit Jawaharlal Nehru, the then Prime Minister of India himself piloted the bill in the Parliament. The already existing teaching programmes were then consolidated and expanded and courses

for the degree of Bachelor of Statistics (B.Stat.) and Master of Statistics (M.Stat.) were initiated. The award of Ph.D./D.Sc. degree was undertaken at the same time. Later on, M.Tech. courses 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, jointly with the ISI, the International Statistical Education Centre (ISEC), Calcutta, to impart training in Theoretical and Applied Statistics to selected participants from developing countries. The centre is run under the auspices of the UNESCO and the Govt. of India.

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

Thus the objectives of the Institute as laid down in the Memorandum of Association 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 of 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.

DIRECTOR'S REPORT

The Institute has its headquarters at Calcutta and two other Centres at Delhi and Bangalore. It has a network of service units in Statistical Quality Control covering many cities of India.

During the year under review the Institute organized several national and international conferences, workshops and summer and winter schools at different centres in a variety of subjects. Special mention may be made of a Winter School on Probability and Analysis (jointly with Sambalpur University) at Sambalpur, an international conference on Modern Analysis and Applications (jointly with IIT) at Delhi, a mini-Workshop on Analysis at Delhi, a Workshop on Probabilistic Methods in Differential Equations at Bangalore, and Second National Seminar on Theoretical Computer Science at Calcutta.

This year is special in the history of the Indian Statistical Institute being the birth centenary year of our founder, late Professor Prasanta Chandra Mahalanobis. His birth centenary falls on 29 June of the year. The Institute has planned several activities befitting the occasion. Several conferences were held during the year as a part of Mahalanobis centenary celebration and several others are planned next year. An international conference on Multivariate Analysis at Delhi and another conference on Quality through Engineering Design at Bangalore were held during December 1992 and January 1993 respectively. Another workshop on Social Movement, State and Democracy was organized at Delhi during October 1992 in association with Delhi University and Uppsala University. Several other workshops, summer and winter schools were organized by different units of the Institute. These include workshops on Generalized Inverses, Regression Techniques and Multivariate Statistical Methods, Probabilistic Methods in Differential Equations, Analysis, Novikov's Conjecture, Analysis and Probability, Theoretical Computer Science, Recent Trends in Speech, Music and Allied Signal Processing etc.

The fourth series of Mahalanobis Memorial Lectures were given by Professor Peter Hall of Australian National University during December 14-16, 1992, at Calcutta and on December 17, 1992, at Delhi. The Institute owes special thanks to Professor Hall for accepting our invitation to come here at a time when the country was going through turmoil and travel problems were formidable.

The Institute celebrated the birth centenary of late Professor J.B.S. Haldane who was one of the foremost quantitative biologists of this century and a prominent faculty member of this Institute. The purpose of this celebration was not only to pay tribute to the outstanding scientist but also to use the occasion to promote research and international collaboration in quantitative biology in general, and human genetics in particular. On the occasion an International Conference on Human Genetics, consisting primarily a set of invited lectures, was held during 15-19 December 1992.

A Summer School on 'Regression Techniques and Multivariate Statistical Methods' was organized at Calcutta during 4-6 June 1992.

Several senior faculty members of the Institute received well deserved recognitions and awards during the year. Professor K.C. Malhotra of Anthropometry and Human Genetics Unit was elected Fellow of the Indian National Science Academy and Professor R. Bhatia of Theoretical Statistics and Mathematics Unit at Delhi was elected Fellow of Indian Academy of Sciences. The prestigious Homi Bhabha Fellowship was awarded to Professor B.B. Chaudhuri

of Electronics and Communication Sciences Unit. Professor Sankar Pal of the same Unit was elected Fellow of IEEE. Several other younger faculty received Young Scientist Awards and fellowships from scientific bodies such as Indian Science Congress and National Academy of Sciences.

Regarding teaching and training activities, during the academic session 1992-93, 9,730 candidates applied for admission and were called for written selection tests for various courses offered by the Institute. A total of 5,216 candidates finally appeared for admission tests at 22 different centres all over the country and a total of 378 candidates who qualified in written tests were called for interviews. Based on the performance in the written tests and interviews, 222 candidates were offered admission to various courses besides Ph.D. programme in various fields. There were five foreign students who applied for admission to these courses. Admission tests were conducted for them through Indian High Commission/Embassy in Kenya, Dhaka and USA.

The Institute operates the International Statistical Education Centre (ISEC), which was established in 1950, jointly with the International Statistical Institute, under the auspices of the UNESCO and the Government of India. During the period under review, the centre conducted the Regular Course of the 46th term with 20 trainees from different countries in South and South-East Asia, the Middle East, the Far-East and the Commonwealth Africa. The Government of India have awarded 18 Fellowships to 18 foreign trainees - 1 under the TCS of the Colombo Plan, 10 under SCAAP, 6 under AID to Sri Lanka and 1 under ITEC. Two Indian Trainees are supported by their sponsors.

The printing and publication of *Sankhyā*, Series A & B, made satisfactory progress and all parts of volume 54 were published. A special volume in memory of late Professor Raj Chandra Bose also came out.

The Institute pursued its various interests in fundamental applied research. Active work is taken up on a number of inter-disciplinary projects by applied statisticians, sociologists, biologists etc. The work on the "Differential Impact of Modern Rice Technology in Favourable and Unfavourable Environments", sponsored by Rockefeller Foundation, is almost complete. Projects on "Study of Impact of Total Literacy Campaign in the Districts of Birbhum and Bankura" and "Internal Evaluation of Total Literacy Campaign in North 24 Parganas" were undertaken jointly by Units of Social Sciences Division. A study of this nature should help in the development of methods of evaluating the impact of recent activities on total literacy campaign throughout the country. The effect of new industrial development and urbanisation on child mortality is of considerable importance. Accordingly, a project on "Child Mortality in New Industrial Localities" is being conducted by the Population Studies Unit. Institute is invited to conduct a socio-economic survey under the National Sericulture Project by the Central Silk Board, Government of India. The project is aimed to study in quantitative terms the income, production levels, productivity, allocation of income among family members and especially women who provide much of the labour, social consciousness etc. of the beneficiaries. The project has just been launched in West Bengal.

The country-wide awareness for Quality System Requirement has opened up a new opportunity to which the SQC Division responded splendidly by (a) consolidating expertise available within the Division in the area of Total Quality Management (TQM) and ISO 9000 Quality Systems, and (b) initiating work for the Quality Mission project during the 8th Plan period. The Quality Mission project 1992-97 aims at near revolution in enhancing the executive awareness and participation on the TQM in Indian industries. The project is conceived to impart a multiplier effect in achieving this objective. The mission envisages

a Crash Programme to face the acute shortage of competent manpower to train and assist industries in the modern quality technology by orienting a 'Core Group' to implement a set of carefully designed measures under expert group in the Institute. The first phase of the project has already been launched. Projects involving SQC and OR methods were carried out in a large number of organisations involving various type of problems. The new thrust on quality management was reflected in the nature of services too. The Division has trained more than 80,000 engineers and managers in the short term programmes and assisted over 1,000 industrial units and service institutions over the years in various parts of the country in quality assurance and management.

A completely new time-domain approach for synthesis of singing has been developed by the speech and music group of the Electronics and Communication Sciences Unit. The Institute is included in an exclusive group of four research institutes doing high level synthesis. A multi-valued recognition system developed by the same Unit is successfully implemented for identifying ill-defined man-made objects such as airports, roads etc. from data obtained from IRS images.

Besides catering to the usual services, the Central Library of our Institute also functions as a Depository Library of World Bank publications. A separate collection of books and journals is being developed for a Regional Library for Eastern Zone as 'NBHM collection' funded by National Board of Higher Mathematics. The Institute, like all other institutes and universities all over the country, is facing resource problem due to severe financial constraints. The basic problem of having sufficient fund for acquisition of books and continuing subscription of journals, which is of paramount importance to research, remains. There are positive signs for an improved position in near future.

On the administrative side, the decisions of the Government of India on the long pending issues of pay-scales for nonfaculty staff of the Institute were received in March 1992. The decisions nearly settled the matter for existing workers of the Institute in a satisfactory manner, but unfortunately the Government withheld their decision on the pay-scales for the new entrants and advised the Institute not to appoint persons from outside until these decisions are made. In a very recent communication, Government agreed to release a few posts for a temporary period which are of essential nature. This will solve the problem partially.

Calcutta
31 March, 1993

B.L.S. PRAKASA RAO

Part I. Teaching & Training, Convocation, Research and Publications

1. TEACHING AND TRAINING

Degrees and Other Courses

A brief account of teaching and training activities during the period from April 1992 to March 1993 is given below :

During the academic session 1992-93, 9730 candidates applied for admission and were called for written selection tests for the various courses offered by the Institute, viz., 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, Fluid Mechanics, Anthropology, Geology, Applied Mathematics, Zoology, Physiology, Biochemistry, Electronics & 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 5246 candidates finally appeared for admission tests and a total of 378 candidates who qualified in the written tests were called for interviews. Based on the performance in the written tests and the interview, 222 candidates were offered admission to various courses during the academic session under review.

Apart from the above, for the Associateship in Documentation and Information Science (ADIS) course, candidates were chosen through an initial screening followed by a interview from about one hundred candidates and seven were finally selected.

There were five foreign students who applied for admission to these courses. Admission tests were conducted for them through the Indian High Commission/Embassy in Kenya, Dhaka and U.S.A.

The annual examinations for all the regular courses were held in May/June 1992. The 1992-93 academic session commenced on 8 July 1992.

Five trainees in Engineering and Technology from various Universities (Jadavpur, Banaras Hindu University) received a six-week practical training in the Electronics and Communication Sciences Unit and the Electronics Unit.

One hundred and twenty candidates received their degrees and diplomas at the Twenty-seventh Annual Convocation of the Indian Statistical Institute held on 12 March 1993 and Ninetyone candidates who passed the various regular courses of varying durations (One Year or less) received the certificates during the year. Eight Research Fellows were awarded Ph.D. degree of the Indian Statistical Institute. Also, during the same year four of the Research Fellows of the Institute obtained their doctoral degree from academic bodies other than the ISI.

The number of candidates admitted to the different degree, diploma and training courses in 1991-92 and 1992-93 and the number of students passed in the annual examinations in 1992 are given below.

**NUMBER OF STUDENTS ADMITTED AND PASSED DIFFERENT COURSES
APRIL 1992 - MARCH 1993**

	C o u r s e s	Number of students		
		enrolled	enrolled	passed in annual
		in 1991-92	in 1992-93	examination in 1992
(1)	(2)	(3)	(4)	
Degree				
1.	Bachelor of Statistics with Honours (B.Stat. (Hons.)			
	1st year	16	23	13
	2nd year	23	13	22
	3rd year	15	22	15
2.	Master of Statistics (M.Stat.)			
	1st year (M-stream)	9	9	7
	1st year (S-stream)	16	20	16
	2nd year	28	24	31
3.	M.Tech. in Computer Science			
	1st year	24	21	20
	2nd year	21	20	21
4.	M.Tech. in Quality, Reliability and Operations Research			
	1st year	17	17	13
	2nd year	17	13	16
Diploma/Certificate/ Associateship				
5.	Statistical Quality Control and Operations Research (1-yr.)*	*	*	1
6.	Course on Operation and Programming of Automatic Data Processing Equipment			
	1st year	13	12	5
	2nd year	14	5	12
SUB TOTAL :		213	199	192

* course discontinued

Contd.

	(1)	(2)	(3)	(4)
7. Part-time Certificate/Diploma in Statistical Quality Control and Operations Research (Bombay and Madras)				
Bombay - 1st year		+	+	+
2nd year		1		1
Madras - 1st year		10	10	4
2nd year		4	6	3
8. Associateship in Documentation and Information Science				
1st year		8	7	8
2nd year		6	8	6
9. Part-time Course in Statistical Methods and Applications				
(1) Calcutta		49	43	13
(2) Delhi		+	+	+
(3) Hyderabad		41	49	12
10. Six-month Part-time course in Statistical Quality Control				
Bangalore - Jan.- June		17	15	12
July - Dec.		13	18	16
Hyderabad - Jan.- June		13	41	8
July - Dec.		15	24	6
11. Intensive Course on Programming and Applications		15	21	17
12. Junior Certificate Course in Statistics (Jointly with C.S.O.)		6	+	+
13. Junior and Senior Research Fellows, Visiting Fellows in different disciplines		135	138	-
14. SDP Fellows		18	15	-
GRAND TOTAL :		558	590	298

† Course not offered

Ph.D./D.Sc. Degrees Awarded

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

- (i) Arvind Seth "Component Importance in Consecutive -k-out-of-n: F System".
Supervisor : K.G. Ramamurthy, ISI, Delhi.
- (ii) Dilip Kumar Ratha "Planning and Resource Mobilisation in a Developing Economy".
Supervisor : V.K. Chetty, Oakland University, Rochester, USA.
- (iii) Joydeep Bhanja "Contributions to the Neymann-Scott and Mixture Problems".
Supervisor : J.K. Ghosh, ISI, Calcutta.
- (iv) Manoj Kumar Panda "Planning for Basic Needs in India."
Supervisor : Bhaskar Dutta, ISI, Delhi
- (v) Anilesh Mohari "Quantum Stochastic Calculus with Infinite Degrees of Freedom and Its Applications".
Supervisor : K.B. Sinha, ISI, Delhi.
- (vi) Lalitha Sundaresan "Some Aspects of Multisource Satellite Image Processing".
Supervisor : D. Dutta Majumder, ISI, Calcutta.
- (vii) Sanjib Pohit "Indian's External Debt : Growth, Determinants and Impact".
Supervisor : A. Sharma, ISI, Delhi.
- (viii) Gautam Mukherjee "Equivariant Cohomology with Local Coefficients".
Supervisor : Amiya Mukherjee, ISI, Calcutta.

(B) Ph.D. degrees awarded by other Universities to the Scholars and Staff of the Institute :

- (i) **Susmita Sur-Koley** "Studies on Nonscible Floorplans in VLSI Layout Design".
Name of the University : Jadavpur University
Supervisor : B.B. Bhattacharya, ISI, Calcutta
- (ii) **M.K. Kundu** "On Image Data Compression and Related Processing Techniques".
Name of the University : Calcutta University
Supervisor : D. Dutta Majumder, ISI, Calcutta
- (iii) **T. Chakraborty** "Stratigraphy and Sedimentation of the Proterozoic Sullavai Group in the South Central Part of Pranhita-Godavari Valley, Andhra Pradesh, India".
Name of the University : Jadavpur University
Supervisor : A.K. Chaudhuri, ISI, Calcutta
- (iv) **Subroto Gangopadhyay** "Orthogonal Transformation in Linear Systems"
Name of the University : IIT, Kharagpur
Supervisor : K.B Dutta, IIT, Kharagpur
- (v) **Partha P. Pramanik** "Communication Architectures for Message Passing Multicomputer Systems using Some Regular Interconnection Networks".
Name of the University : Jadavpur University
Supervisor : P.K. Das, ISI, Calcutta
- (vi) **Sudeshna Banerjee** "On Some Radiation and Diffraction Problems in the linearised Theory of Water Waves".
Name of the University : Calcutta University.
Supervisor : B.N. Mondal, ISI, Calcutta
- (vii) **Susmita Mukhopadhyay (nee) Bandopadhyay** "Material Working Status and Health of Mother and Child".
Name of the University : Calcutta University.
Supervisor : A. Basu, ISI, Calcutta.
- (viii) **Soma Mukhopadhyay** "Some Thermal and Electrical Studies of Human Skin".
Name of the University : Calcutta University
Supervisor : A.B. Gupta, ISI, Calcutta.

International Statistical Education Centre, Calcutta

A brief report on activities of the International Statistical Education Centre during the year 1992-93 follows:

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, F.R.S., has been 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. Facilities exist for research work and advanced study by senior statisticians from abroad. Since inception, the Centre has provided training to 1196 trainees from 56 countries.

A total of 43 candidates from 19 different countries were nominated by respective Governments for admission to the 46th term of the regular course of this Centre. Of these 43 candidates, 25 were offered admission and 20 participants joined from 9 countries viz. Bhutan, Ethiopia, Gambia, Kenya, Malawi, Nigeria, Sri Lanka, Tanzania and 16 trainees were supported by fellowships awarded by the Government of India under the technical cooperation scheme of the Colombo plan, special Commonwealth African Assistance plan, Indian Technical and Economical Corporation and AID to Sri Lanka schemes; the remaining 2 were from Indian Air Force and were supported by their employer.

Teachers of Calcutta, Bangalore and Delhi Centres of the Indian Statistical Institute and Officers of the Government of India participated in teaching the regular courses during the year. 5 trainees went to Bangalore Centre of Indian Statistical Institute to undergo 8-week specialization in Economic Planning and SQC and OR respectively.

All the regular course trainees have been recommended for the award of Statistical Training Diploma.

Professional Examinations in Statistics

The Indian Statistical Institute holds professional examinations in statistics in the theory and practice of analysis of statistical data for the external candidates on the basis of some model guidance for the award of the following certificate and diplomas.

- (i) Statistical Assistantship Certificate
- (ii) Junior Diploma in Statistics
- (iii) Senior Diploma in Statistics

The Government of India recognises the Junior Diploma in Statistics as equivalent to a Bachelor's degree in Statistics and the Senior Diploma in Statistics as equivalent to a Master's degree in Statistics.

These examinations are separate from, and independent of the examinations held for the award of degrees, diplomas and certificates on the basis of training given in the Institute.

These examinations are held now-a-days twice in a year usually in or about the months of May/June and November/December at different cities in India (Bangalore, Bombay, Calcutta, Delhi, Hyderabad, Lucknow and Madras).

The details of the examinations for June 1992 and November 1992 terms are shown below.

Examinations	Number of candidates					
	registered		appeared		passed*	
	June	Nov.	June	Nov.	June	Nov.
1. Statistical Assistantship Certificate	23	24	15	12	3	4
2. Junior Diploma in Statistics	82	75	41	40	8	9
3. Senior Diploma in Statistics	13	7	5	4	Nil	Nil

* Passed in one or more papers only but not necessarily completed the examination.

The total number of candidates who have qualified for the award of the Certificate and Diplomas in the Professional Examinations in Statistics including the results of November 1992 term are 484 and 263 respectively.

2. TWENTY SEVENTH CONVOCATION

Indian Statistical Institute held its Twenty Seventh Convocation for awarding the Ph.D., M.Tech. (Computer Science), M.Tech. (Quality, Reliability & Operations Research), M.Stat., B.Stat. (Hons.) degrees, Post Graduate Diploma in Applied Statistics and Diploma in Statistics on 12 March 1993.

Shri P.N. Haksar, chairman of the ISI Council, welcomed the guests and recipients of the Degrees, Diplomas and Awards. Professor B.L.S. Prakasa Rao, FNA, Director of the Institute, presented annual review of teaching and training activities of the Institute. Professor M.G.K. Menon, FRS, President of the Institute, presided over the Convocation and awarded Degrees, Diplomas and Awards to the students. Professor R. Narasimha, FRS, Director, National Aeronautical Laboratory, Bangalore, delivered the Convocation address entitled "The Statistical Dynamics of Turbulence".

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

Degree/Diploma	Number of Candidates
Doctor of Philosophy (Ph.D.)	8
Master of Technology (M.Tech.) in Computer Science	21
Master of Technology (M.Tech.) in Quality, Reliability and Operations Research	16
Master of Statistics (M.Stat.)	31
Bachelor of Statistics (Honours) (B.Stat. (Hons.))	15
Post-graduate Diplomas in Applied Statistics :	
Post-graduate Diploma in Statistical Quality Control and Operations Research : i) Delhi	1
ii) Calcutta	3
Part-time Diploma in Statistical Quality Control and Operations Research : i) Bombay	1
ii) Madras	3
Diploma on Operation and Programming of Automatic Data Processing Equipment	12
Associateship in Documentation and Information Science, Bangalore	6
Professional Examinations in Statistics :	
Junior Diploma in Statistics	3
Total :	120

AWARDS 1992

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

1. K.R. Srikanth

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

B.Stat. (Hons.) : Angshuman Saha
M.Stat. : Pranab Kumar Mandal
M.Tech. (CS) : Rajan Gangadharan
M.Tech. (QROR) : G. Venkata Seshu

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; and Library, Documentation and Information Sciences. In addition, the National Centre for Knowledge Based Computing, jointly sponsored by Department of Electronics (D.O.E.) and United Nations Development Programme (U.N.D.P.), and located in the Institute at Calcutta, has been engaged in research work under FGCS/KBCS programme. There is also a well equipped programme 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 of Theoretical Statistics and Mathematics has Units at Calcutta, Delhi and Bangalore Centre besides one Unit at Hyderabad. The Division is basically engaged in research in different areas in theoretical statistics, probability theory, stochastic processes and mathematics apart from providing theoretical support for a number of applied problems that arise in various projects undertaken by ISI and other Institutions. The Division has a major role in teaching probability, statistics and mathematics in the B.Stat (Hons.), M.Stat, M.Tech (Computer Science), M.Tech (Quality, Reliability and Operations Research) and other courses in the Institute. The Division also conducts a course for 3-4 semesters at an advanced level for Research Fellows enrolled for Ph.D. degree of the Institute. During the period under review, eight Research Fellows in statistics and mathematics, four in each have been awarded the Junior Research Fellowships. A strong feature of the Division is to organise Summer/Winter Schools and Workshops in a variety of advanced and current topics in statistics, probability and mathematics. Besides, colloquium talks and seminar talks by faculty members and visitors are organised regularly.

The broad areas in which researches were carried out during the year are indicated below.

Theoretical Statistics and Mathematics Unit (Calcutta)

1. Probability Theory and Stochastic Processes

Invariant measures for Markov processes determined on $[0,1]$ by random applications of quadratic maps $f(x) = \lambda x(1-x)$. This seems to connect, in an interesting way, Markov processes with the theory of dynamical systems.

Investigation undertaken of polynomials in two variables associated with a given martingale which gives rise to a class of new martingales that characterize the original one. This gives interesting generalisations of the by now classical relationship between Hermite polynomials & Brownian motion. The discrete parameter case having been settled, the continuous case is now being examined.

For a semi-martingale (X_t) , $t \in [0, \alpha]$ on $(\Omega, \mathcal{F}, \mathcal{P})$ and a random closed optimal set $A \subset \Omega \times [0, \alpha]$, the existence of a local time for (X_t) in A and an associated Tannaka-type formula, are proved under suitable conditions.

Conditional U-Statistics, their almost sure uniform convergence, their limit distributions using multiple Wiener integrals, have been studied. The case of censored data has also been investigated.

2. Statistical Inference

Significant results have been obtained in the following areas : (i) Inference based on the geometry of data cloud, (ii) Robust estimation of location, (iii) Large sample theory of optimal parameter design under cost constraints, (iv) Efficient estimation in the presence of many nuisance parameters, (v) Problems concerning Neyman-Scott examples, (vi) Multistage selection procedures for Weibull populations, (vii) Paired and multiple comparison models, (viii) Improvements over Stein estimator, (ix) Inference in Stochastic Processes including non-parametric density estimation, (x) Analysis of directional data, (xi) Sequential estimation for a two-parameter exponential family of distributions, and (xii) Optimal design and inference based on likelihood in non-linear experiments.

3. Multivariate Analysis and related fields

The following areas have been studied in detail and important contributions are made : (i) Bivariate exponential models related inference, (ii) Monotonicity of tests for the Langevin distribution, (iii) Asymptotically minimax procedures for selecting the t-best multinomial cells, (iv) Bhattacharya - distance based linear discrimination, (v) Moment bounds for Stochastic processes, (vi) Mahalanobis D^2 , (vii) Decision rule for dimension in the context of MANOVA, (viii) Discovery of new categories, (ix) Multivariate location estimation using extension of R-estimate, and (x) Dispersion of the multivariate median.

4. Design and Analysis of Experiments

The main topics of research during the period under review include (i) Construction of robust run orders of treatments, (ii) E-optimal minimally connected block designs under mixed effect models, (iii) Universal optimality of row-column designs, (iv) Robustness of BIB and extended BIB designs, (v) Generalized Binary Proper Efficiency Balanced Block Designs, (vi) Optimal Block designs with fixed and random block effects, (vii) Discrimination between equivalent Designs, (viii) E-optimal block designs under heteroscedastic model, and (ix) Balanced incomplete block row-column designs.

5. Survey Sampling

(i) PPS sampling and multiple auxiliary information, (ii) Strategies admitting non-negative variance estimators, (iii) Multivariate sample surveys, (iv) Adjustments for auxiliary information in regression estimators, (v) Parameter estimation using Pitman-nearness criterion, and (vi) Estimation of mean based on paired observations.

6. Reliability and related fields

Most of the research work in these fields related to - class of life distributions, -adjustment factor in Industrial designs which have far reaching applications in Quality Engineering.

7. Mathematics

In topology, a general investigation of Combinatorial modeling of topological involutions

led to a very natural triangulation of real projective spaces & Kummer varieties. Use of fixed-point theoretic and homotopy techniques led to some nonlinear invariant Subspace theorems for maps between Grassman manifolds.

In equivariant Cohomology, several results have been obtained using constructions of the following kind : (1) Cohomology $H^*_{OG}(K, \lambda)$ of a G-simplicial set K with coefficients in an $OG - R$ module λ , (2) Eilenberg-Maclane objects in the category of G-simplicial sets, (3) universal OG -covering spaces of a G-space X.

In general topology, investigation is being conducted on the interaction of properties of a tychonoff space X and $C(X)$, the space of real-valued continuous functions on X, the latter space equipped with several related topologies (usually locally convex).

In descriptive set theory, a detailed study of closed convex-valued Caratheodory multifunctions has been made and some results concerning existence of their selectors, approximate selectors, fixed point properties etc. have been proved. Several results on extensions of semi-continuous, measurable & Caratheodory multifunctions have been established.

Some results on the properties of 2 additive cellular automata (CA) have been obtained. Using 2D CA, the no. of solutions of the 0 -game introduced by Sutner have been computed & the use of 1D CA has given a method for computing multiplication & inverse in a finite field.

The Hardy space H on the unit circle, being a separable conjugate space, is being examined in terms of its RNP properties. It is also proposed to study its dual space BMO, the functions of bounded mean oscillation, as an Asplund space.

8. Combinatorics & Graph Theory

The topics of research include : Chordal graphs, perfect elimination orderings, linear and polynomial time algorithms and Hamiltonian perfect chordal graphs, intersection graphs of paths in a graph structure theory of self-complementary graphs & digraphs, centre and diameter graphs of graphs with given properties, measuring reciprocity in weighted social networks and in partitioned networks.

9. Applications

In applications, mention may be made of the estimate of palaeoflow velocities from grain-size distribution of deposits in rivers preserved in geological records. For more detailed experimental work, a hydraulic flume is being installed at I.I.T., Kharagpur, in collaboration with I.S.I. (Calcutta) with financial support provided by D.S.T. Boundary absorption on axial dispersion in pulsatile flow have been investigated. Data collected from some natural rivers (Illinois, Mississippi) concerning turbulence generated by the movement of barge traffic, have been analysed.

Theoretical Statistics and Mathematics Unit (Delhi)

During the year the Unit worked on the following research areas :

(i) Statistics and Probability : Reliability, Inference, Quantum Stochastic Processes, Stochastic Processes, Percolation Theory and Particle Physics, Quantum Theory, Spectral Analysis, Probability Theory.

(ii) Theoretical Statistics : Distribution and Characteristic order Statistics, Designs of Experiments, Multivariate analysis.

(iii) Mathematics : Combinatorics, Linear Algebra, Analysis of Matrices and Operators, Matrix Theory, Game Theory and Global Univalence, Partial Differential Equations and Applied Analysis.

Theoretical Statistics and Mathematics Unit (Bangalore)

1. Probability theory : Applications of large deviations to Information theory, semistable measures and processes, diffusion processes.

A monograph dealing for the first time with Probability on Locally convex space is being written and part of it grew out of the lectures given in our M-Stat course.

2. Statistics : Sample surveys, Large samples theory, Bayesian inference, Bayesian non-parametric statistics, Bayesian non-parametric estimation, Robust Bayesian Analysis, Reliability theory, Optimality and Construction of experimental designs.

Some of the problems studied in the area of nonparametric Bayesian inference include considering data arising from smooth regression functions but contaminated by random noise. Here the function is modeled as the sum of a polynomial and a Gaussian random process by expanding it in a Taylor series. The problem is then formulated as a general linear model problems and a hierarchical Bayesian approach is used to study it.

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 space, 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.

Work continued on Geometry of operator spaces. It was proved that for a reflexive Banach space X , if the space of compact operators forms an M -ideal in the space of bounded operators then it is the minimal M -ideal. This extends the well known classical results about operators on Hilbert space. The M -ideal structure of the space of Banach space valued weakly continuous functions was investigated.

The best constant (complex) Grothendieck inequality was investigated with particular attention to lower dimensions and to the positive elements of the operator space $L(1(n), 1(n))$. This resulted in correcting and extending some of the results in the literature. Some of these ideas have also been applied to the study of Hilbert modules attached to complex domains.

The operator tuple of multiplication by coordinate functions based on a matrixball and acting on a twisted Bergmann space were investigated. The joint Taylor spectrum and the Wallach set where this tuple is bounded/subnormal was completely determined.

A classification and structure theorem for combinatorial d -dimensional spheres on $d+4$ vertices was obtained leading to a formula for the number of non-isomorphic spheres like this in terms of the dimension. For the first time number theoretic restrictions on parameters as typified by the Bruck-Ryser-Chowla Theorem were extended to a family of non-symmetric designs.

Investigation of the subgroup structure and the buildings associated with the group $F_4(k)$

continued.

Harmonic theory/Hodge theory over Singular Complex projective varieties is being studied with a view to carry over to arbitrary complex projective varieties and their intersection Cohomology/L - Cohomology the well-known "Kahler-Package" which obtains for compact Kahler manifolds.

A seminar was organised in 'Harmonic Analysis' where representation theory of the Motion Group, SL (2, IR), the Heisenberg Group, compact Lie Group were studied with a view to applying the theory to the Pompeiu problem and the uncertainty principle.

Applied Statistics, Surveys and Computing Division

The Applied Statistics, Survey and Computing Division consists of two Units i.e., Biometry Research and Computer Science. Faculty members of the Division were engaged in teaching and training in different courses like B.Stat. (Hons.), M.Stat., M.Tech. (Computer Science), M.Tech. (Quality, Reliability and Operations Research) and other courses besides research and project work. Researches carried out by these Units are indicated below.

Biometry Research Unit

The Biometry Research Unit is engaged in the pursuit of different Biomedical, Toxicological and Environmental problems with the generation of data in the laboratory. Studies on genetic marker isozymes, immunological and histopathological profiles of ailed human and rodents with particular reference to the quantification of stress factors involved, etiology of malnutrition related diabetes mellitus are the principal topics investigated in the Unit. Fabrication of mathematical models and their simulation on digital computers to predict human catabolic diseases autoregression analysis of the longitudinal data derived from fish growth experiments are current addition to the principal activities of the Unit. Some of the researches in different areas of Biomedical problems are given below.

1. Working on the problem of malnutrition related diabetes and specially fibracalculus pancreatic diabetes (FCPD). This study is made for the first time in Eastern India and West Bengal in particular. HLA-Studies, plasma insulin level and c-peptide level are estimated.
2. Multispecies first growth studies are made addressed from physical, biochemical and genetical point of view supported by autoregression analysis of the longitudinal data generated in the laboratory.
3. Investigation of Viscoelastic properties of blood of laboratory animals have been made. This has valuable medical diagnostic roles.
4. Growth pattern of IMC seeds has been studied from different sources e.g. Hatchery, Riverine and Bundth-bred. Toxicity studies are made on IMC carp fingerlings of some of the common pesticides usually used in the Agricultural field.

Water soluble fraction of alcoholic extract of leaves of the plants (*Azadirachta indica*, *Oscimum sanctum* etc.) have been formed to possess antihypen glycemc, antiinflammatory and hepato protective activity.

Projects

1. Modelling Viscoelastic properties of blood

This is an on-going project. A curvi-linear relationship has been formed to exist between

the structural viscosity and rabbit blood. Chemically-induced diabetic blood shown inverse relationship of viscosity with stress.

2. Development of hypoglycemic drugs from plant sources

In this on-going project, role of different extracts of leaves of different medicinal plants on experimental animal models have been performed and has been found that extracts possessed significant blood sugar lowering activity, anti-inflammatory property etc. Detailed study on this aspect and their actions on other biological parameters of the biological system are in progress.

3. An investigation into the young insulin dependent and adult non-insulin dependent malnutrition related diabetic patients

The work is in progress regarding prevalence of antigenic frequencies of DR3. The plasma insulin and c-peptide level in the diabetic patients reveal that they are much below the normal level in comparison with normal controls.

Externally funded Project

Determination of growth, mortality and reproduction rate of IMC seeds (sponsored by the Directorate of Fisheries, Govt. of West Bengal)

Species-specific variation of three variables were found to be significant from physical, biochemical and genetical point of view. Fitting of longitudinal growth data with linear regression was satisfactory. Qualitative isozyme patterns revealed from starch gel, electrophoresis were indicative of the individual carps resistance to adverse point-eco system.

Computer Science Unit

The activities of the Computer Science Unit mainly consist of research in statistical theory, methodology and applications, development of computer software for statistical purpose, providing statistical consultancy and services to individual researchers in various fields and organisations, conducting studies on topics of national interest requiring statistical techniques. The expertise of the Unit is in a constant demand by Government departments and organisations in the public sector. A brief account of research activities undertaken during the period is given below.

1. Sample Surveys

Model assisted predictors for finite population parameters with asymptotic design-based population parameters with asymptotic design-based properties are increasingly becoming popular in Survey Sampling. Several new model-cum-asymptotically design-based variance estimators of totals and means including distribution functions of Survey populations are proposed and their efficiencies are being examined numerically through simulations with evidences of encouraging results in numerous cases. Alternative estimators of multiple and partial correlation coefficients based on complex surveys are also being studied.

Controlled sampling designs using varying probabilities of selection and the corresponding unbiased estimators of population total, variance etc. have been investigated. Optimal strategies of population total and variance for finite population prediction under errors-in-variables super-population models have been examined. Bayes prediction of finite population

total and variance has also been explored.

For small domain totals appreciable gains in efficiency and reduction in lengths of confidence intervals are shown through simulations to be achievable by correct modelling for procedures based on generalized regression predictors with regression coefficients estimated from pooled samples as well as from domain specific samples compared to those on Horvitz Thompson estimators. Lahiri, Midzuno-Sen and Hartley-Rao's varying probability sampling schemes are applied for illustration. Effects for model mis-specifications are also examined.

2. Reliability and Life Testing

Software Reliability : The problem of estimations of the number of bugs in a software program and the estimation of component lifetime distribution in a parallel system have been studied. Analysis of competing risks data with missing failure type has also been made. Non-parametric estimation of component life-time distribution in a coherent system and that of survival functions for parallel systems under random censoring have been developed. Probability models : Aging property in reliability was investigated. Certain results on modelling and inference for relative aging of life distributions were found. Some results were obtained in the area of time-discrete survival analysis.

3. Regression

Generalised regression-kernel smoothing and crossvalidation were developed. Some study were made on regression diagnostics.

4. Multivariate-Analysis :

Analytical comparison of LMMPU and Rao's test was made. The admissibility and the best equivalent nature of the MLES of the mean direction vector of the Langevin density were established. Investigations on the theoretical validity of the currently prevailing estimation methods related to Cox's logistic discrimination procedure were undertaken and modified methods were sought. Optimal invariant tests were derived for the mixing proportion in symmetric wrapped stable mixtures and for homogeneity of concentration parameters for Langevin distributions. Results in predictive inference related to the mean direction vector of the Von Mises distribution were also obtained. Simple yet efficient estimators were derived for the parameters of several Bivariate Exponential distributions under a practically appealing generalized Type-1 censoring scheme.

Iterative scheme employed earlier in Analysis of Covariance Structures (ACOVs) for obtaining MLES of the parameters of a linearly structured covariance matrix (CM) based on Q procedure has been applied to partially structured CM which in partitioned form has some of the submatrices linearly structured. A structural condition has recently been obtained upon the pattern of the off-diagonal submatrix under which the MLES of the intraclass correlation parameters remain the same as the ones based on the entire CM. The asymptotic behaviour of posterior distribution has been studied under a general set-up which includes a wide variety of non-regular cases, optimum invariant test of independence of two sets of varieties and tests of homogeneity of variances of correlated variables when data remain incomplete have been obtained. Statistical analysis of dermatoglyphic data and imperfect supervision in pattern recognition have also been studied.

5. Design of Experiments

Successful research findings relate to (i) conditions for rotatability in first order regression designs under intraclass and compound symmetry covariance structures, (ii) connection between Analysis of Covariance structures and Design of Experiments, (iii) optimum mixture experiments where the purpose of the experimentation is to obtain optimum factor level combinations and (iv) construction of strongly balanced uniform repeated measurements designs.

6. Computer Science

A software package "Statistical Data System" has been developed for data handling and summarization to be used by trainees in microcomputers. Studies on the characterisation of two-dimensional Cellular Automata are in progress.

Project

1. Scientists' Attitude Towards Air Pollution in Calcutta

The analysis of the data collected in the first phase of the project is over. The analysis, based on data obtained from 96 scientists of ISI and BARC has been found to be quite useful in refining and establishing the psychometric properties of the tools of the enquiry. In ten recent months about 150 completed mailed questionnaires have been obtained from scientists employed in Saha Institute, All India Institute of Hygiene and Public Health, Calcutta University. The data are being scrutinized and certain internal consistency checks are being made with the help in the computer.

2. An Empirical Investigation on Effectiveness of Emerging Small Domain Estimation Procedure Compared to Traditional Methods in the Indian context

Postulated models have been simulated to examine relative performances, under various criteria of alternative estimators which 'do' and 'do not' borrow strength. A technical report presenting the findings has been prepared on the initial findings.

As the plan is to examine the performances of the procedures based on India data some live data from ISI accounts office have been collected.

Externally Funded Projects

1. Differential Impact of Modern Rice Technology Across Production Environments :

This project, sponsored by the Rockefeller Foundation, reached its final stage during the period. The final report is under preparation. The first part on the determinants of the adoption of modern rice technology in West Bengal and the impact of such adoption on the incomes on rural households as also on poverty and income inequality is going to be submitted soon. The report would also cover the impact of adoption of modern technology on cost of cultivation and on demand for household and hired labour. This project is being carried out in collaboration with the Deptt. of Economics, University of Kalyani. The project team of ISI included staff of CSU, ERU and PSU.

2. Socio-economic Survey of the Sericulturist

There are five states in India, (Karnataka, Andhra Pradesh, Tamilnadu, West Bengal and Jammu & Kashmir) states in India traditionally producing mulberry silk. Apart from these the Central Silk Board (CSB) is trying to extend silk farming in other 12 states of India under its National Sericulture Project.

For an assessment of the ground the CSB requested the ISI to conduct a socio-economic

survey of the sericulturists in all the 17 states of India. As the ISI did not any longer have a regular field wing all over India, ISI could not agree to take up the responsibility of conducting the survey over all the states. ISI had however taken the responsibility of designing the survey (sampling and schedule), coordinating the survey over all the states and conducting the survey in West Bengal. ISI was also requested to undertake the final reporting on all-India basis.

The survey aims at providing estimates of total acreage under mulberry, total production of cocoon by different genetic variation at the district level. It also envisages to provide estimates of total income generated from silkworming, income of the average household from silk farm, of the cost components of cocoon production, of the household especially female labour absorption in the silk farm. The survey also tries to examine the factors inhibiting promoting silk-worm farming.

Physical and Earth Sciences Division

The Division comprises of the Chemistry Unit, the Electronics Unit, the Electronics and Communication Sciences Unit, the Geological Studies Unit and the Physics Unit. Faculty members of the Division are engaged in teaching and training, besides research and project work. Research activities carried out in these units are described below.

Chemistry Unit

Research in Chemistry Unit is pursued through following two projects.

1. Distribution characteristics and reactions of allophanes in West Bengal soils

Amorphous inorganic materials called allophanes are thought to be important constituents of tropical soils. The laterites and the soils developed from acid rocks under heavy rainfall condition are the ones most likely to contain significant amount of these materials. Recent research abroad have highlighted the role played by allophanes on the soil properties relevant to both agricultural and non-agricultural uses.

No systematic investigation on allophanes in Indian soils has been reported so far. Pursuant to our earlier investigation on organic matter and clay constituents in West Bengal soils we have undertaken the investigation on this third most important soil constituent to offer a comprehensive picture of our soil resources.

A little above hundred soil profiles from suitably chosen locations have so far been subjected to physico-chemical scrutiny.

2. Absorption in solid solution interface

Absorption and dispersion of biochemicals in presence of surface active agents is presently under study. This work has important bearing on the application, effectiveness and retention of fungicides, herbicides and other pesticide. Absorption by soil particles, plant leaves and roots are being investigated at present.

Electronics Unit

The faculty members of the Unit were engaged in (i) research activities in various areas of Computer Science, Theoretical Physics and Fluid Mechanics/Applied Mathematics, (ii) guidance of quiet a large number of Ph.D. scholars from ISI as well as other institutions

including IIT's and (iii) teaching different courses in M.Tech. (Computer Science), M.Tech. (Quality, Reliability and Operations Research), B.Stat./M.Stat. programmes of the Institute and I.S.E.C. courses. Details of the research activities are described below :

A. Computer Science

1. Parallel algorithms and Parallel Architectures :

The objective of this project includes the following :

- i) Design of efficient parallel algorithms for various numeric, non-numeric and graph problems, problems on computational geometry and mapping them on suitable parallel architectures.
- ii) Design of fault-tolerant parallel architectures for different parallel algorithms.
- iii) Testing and Design for testability of systolic arrays.
- iv) Studies on tree-type architectures and their suitability for parallel processing.

The following results have been obtained during the current year,

- i) A fast parallel algorithm for ternary multiplication and its implementation using I2L technology have been completed.
- ii) A parallel high-speed algorithm for multiplication using redundant quarternary number system has been developed.
- iii) Parallel algorithms for interpolation in numerical techniques which are implementable on different systolic architectures have been developed.
- iv) A new methodology for testing bilateral bit-level systolic arrays has been developed.

2. Network Topology

The objective of this study is to find suitable topologies for computer networks in order to have a network with a low diameter, a small 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. During the current year, the following works have been performed.

- (i) Some optimality criteria have been proposed to minimize the diameter of loop networks.
- (ii) An algorithm has been developed to find maximal subcubes in a residual hypercube with some faulty nodes/links. (iii) Bridged and twisted hypercubes with reduced diameter and easy routing have been introduced. (iv) Optimal communication algorithms for double loop networks have been developed. (v) A family of generalized odd degree dense graphs have also been introduced.

3. Studies on Interconnection Networks

Different properties of MIN's such as their permutation capability, routing, equivalence, fault-tolerance etc. constitute the subject matter of our study. The problem of partitioning

a given permutation into an optimal number of subsets such that each subset is realizable in a single pass, has also been considered for investigation. The following results are obtained.

(i) It has been found that the set of all possible permutation can be partitioned into a number of equivalent classes. Some hierarchical relationship among these classes has been analysed. (ii) Several self-routing techniques on rearrangeable networks (Benes network) have been studied. Work has been done towards the classification of the permutations according to different self-routable techniques.

4. VLSI Layout Design - Phase II

One objective of this project is to design efficient floor plans of VLSI chips. The rectangular dualization method of floor planning is adopted and the novel concept of inherent nonslicing is proposed. A second issue under consideration is to investigate the transformation techniques for converting a nonslicing floor plan to a slicing with minimum violation of neighbourhood relations. This would greatly help the placement and routing in the latter phases of chip design.

Another area of our investigation includes the placement problems in the layout design cycle. Linear and circular placement of modules which minimize the wire length are considered. The following results are obtained.

(i) Graph theoretic characterization of inherently nonslicing (INS) floorplans has been explored. An entirely new family of INS floorplans has been discovered. (ii) Efficient algorithms for optimal linear placement of parallel graphs have been developed.

5. Development of an efficient data structure to support VLSI layout tools

One of the goals of this project work is to build an efficient geometric data structure on which most of the operations that might arise during VLSI placement problems can be answered in linear or subquadratic time. Secondly, given a nonslicing floorplan, our objective is to characterize valid slice paths and to develop algorithms for identification of all such paths. Other objectives include development of software for hierarchical decomposition of the floor plan geometry based on the strong connectivity of its channel graph and to develop efficient algorithms for VLSI design and verification using recent techniques of computational geometry. During the year, investigations on new models of channel routing e.g., diagonal-overlap and AI-based floorplanning are being continued. Some new results have already been obtained in this area.

6. Design of reconfigurable, fault-tolerant array processors/systolic arrays with emphasis on design for testability

The major goals of the project are

(i) design of reconfigurable, fault-tolerant parallel architecture constructed by interconnecting processors, (ii) development of algorithms for reconfigurability and routing in presence of faults in different networks, (iii) design for testability of unilateral/bilateral 1-dimensional/2-dimensional systolic arrays and their implementation, (iv) studies on 100 percent delay-fault testable combinational modules. The following results are obtained :

(i) We have studied models of 1-D bilateral systolic arrays and developed new techniques for their testing. (ii) The problems of fault-tolerance and reconfigurability and designs for reducing diameters in hypercube architecture have been undertaken and several new results have been obtained.

B. Theoretical Physics

7. Topological Aspects of Quantum Field Theory

Topological aspects of the internal symmetry of particles have been investigated. Topological field theory and its relationship with quantization and supersymmetry have been studied. The relationship of Berry phase with chiral anomaly has been demonstrated.

8. Quantization, Topological Field Theory and Supersymmetry

Topological field theory, particularly the Chern-Somons topology and its role in quantum field theory have been investigated.

9. Condensed Matter Physics

Chiral spin liquid states have been studied with reference to high TC superconductivity. Also, the relationship between quantum Hall effect and fractional quantum Hall effect with Berry phase has been demonstrated.

10. Quantum gravity

Gravity without the metric and topological gravity has been studied from the point of view of the origin of torsion.

11. Skyrmions and the static properties of Baryons

The static properties of baryons has been studied from the viewpoint of baby skyrmion model. There a hadron is considered to be a composite of baby skyrmions.

12. A gauge meretical formulation of various spin systems has been studied. Renormalization group equations have been formulated in gauge formulation.

13. Dissipative systems

Quantum field theory of a dissipative system and the field theoretical methods for irreversible processes have been investigated.

14. Supersymmetric Quantum Mechanics

Supersymmetric Quantum Mechanics has been studied to find exact solutions of some important problems in Quantum Mechanics and also to study SUSY breaking. Anions have been studied from the point of view of their symmetry behaviour.

15. Algebraic Approach and $1/N$ Expansion

We are also using Algebraic approach to two dimensional systems. Some hitherto unknown results for Coulomb-like potentials have been obtained. Also complete formulation for the application of $1/N$ expansion and algebraic method to Dirac equations has been achieved for the first time.

16. High Energy and Cosmic Ray Physics

An exhaustive and qualitative explanation for the anomalous high-multiplicity cosmic ray events at ultrahigh energies has been presented very recently and the quantitative check up of the same is now under progress.

17. Theory of Unsharp Measurement in Quantum mechanics and the trajectory of a particle

The classical nature of trajectory of a microparticle say the track of a-particle including chamber has been studied within the framework of unsharp measurement theory developed by Busch, Lahti and Mittelstedt.

18. Massive Photon hypothesis and non-dissipative nature of Quantum Fluctuation

The photon loses its energy when it propagates through a Maxwell vacuum with the conductivity coefficient $P=0$. The mass of the photon can be related to s and Hubble constant. This loss of energy can be related to the conformal fluctuation of the metric tensor of the space-time background.

19. Stochastic Acceleration mechanism for high energy cosmic Ray particles

The acceleration mechanism for ultrahigh energy cosmic Ray particles seems to be one of the challenging problems in high energy Astrophysics.

C. Fluid Mechanics/Applied Mathematics

20. Effects of helicity and rotation on turbulent motion

Recent experiments suggest that effects of helicity and rotation on different types of turbulent flows are highly important. As a part of the present programme deductive theory has been developed obtaining a closed set of equations and their solutions that exhibit the effects of helicity on a homogeneous turbulent flow.

21. Flow of a Thin Film of Liquid on a Rotating Disk

Works on the project of the 'Flow of a thin film of liquid on a rotating disk' has been started since 1989 and some remarkable progress has already been obtained.

A unique approach has been devised by which one can avoid directly the appearance of undesirable waves and cracks etc.

22. Blood Flow

One model has been considered for studying blood flow in a constricted artery. In this model the separation phenomenon of blood flow has been analysed.

23. Water Waves

i) *Scattering and radiation problems*

Advanced mathematical work on water wave scattering and radiation problems involving nearly vertical plate, nearly vertical wall, nearly circular cylinder, bottom deformation etc. has been studied within the framework of linearised theory of water waves.

ii) *Wavemaker problems*

Mathematical study of forced motion due to prescribed normal velocity on various types of wavemakers has been undertaken for both one-fluid and two-fluid regions. The wavemakers may be nearly vertical planes or vertical cylinders with nearly circular cross-sections.

iii) *Source potentials*

Problems on the generation of water waves due to a line source or line multipoles in the

presence of uneven bottom or for water of variable depth, with extension to two superposed fluids has been studied.

iv) *Wave motion due to initial surface disturbances*

Study of wave motion due to an explosion inside an ocean or in the atmosphere has been modelled with extension to two superposed fluids to study the effect of the presence of air on the wave motion.

24. Mathematical Methods

i) *Integral transforms*

The topic of study includes rigorous establishment of integral expansions of functions involving various special functions such as associated Legendre functions, spheroidal wave functions, Mathieu functions etc. with applications in the mathematical study of various water wave problems.

ii) *Integral Equations*

Dual integral equations involving associated Legendre functions and associated Weber-Orr transforms have been studied.

25. Inventory models and Quaking models

Deterministic inventory models with variable demand rates, linear trend in demand, cherishing items etc. have been investigated. Also studies on preemptive priority queueing model with two classes of customers for time-dependent solution by using Laplace transform technique in time and the method of generating functions have been undertaken.

Externally Funded Project

A project entitled "Integral transforms, integral equations and applications" was sponsored by the Council of Scientific and Industrial Research, New Delhi and was administered through the Calcutta Mathematical Society.

The research work carried out under this project is concerned with integral transforms, integral equations and applications. Some integral transforms involving associated Legendre functions together with their appropriate inversion formula have been established vigorously. These are somewhat related to Mehler Fock type integral transforms. Integral expansion of functions involving associated Legendre functions have also been obtained.

Regarding integral equations some works on dual integral equations involving associated Legendre functions and associated Weber-Orr transforms, Fredholm integral equations of second kind and singular integral equations involving a combination of logarithmic and Cauchy kernels in double interval have been carried out.

Also the classical Sommerfeld half plane diffraction problem in electromagnetic theory has been reinvestigated to reduce it to a singular integral equation of first kind with a Cauchy kernel, which is solved by a direct Fourier cum complex variable technique.

As applications of integral transforms and integral equations, a number of water wave problems arising in the linearised theory of water waves have been considered for mathematical study in which the techniques of integral transforms and integral equations play significant roles.

Electronics and Communication Sciences Unit

Apart from regular research activities, faculty members of the Unit regularly participated in teaching and training in M.Stat., M.Tech. (Computer Science), M. Tech. (Quality, Reliability and Operation Research Courses) of the Institute. They also were engaged in supervision of Ph.D. work. Many under graduate/post graduate students of Computer Science, Electronics and Telecommunication, Electrical Engineering, Master of Computer Application Courses from different Universities underwent their vocational semestral training under the supervision of the faculty members of the Unit.

Details of research activities undertaken by the Unit during the year are as follows :

1. Studies on Pattern Recognition, Pattern Classification and Learning Algorithm

i) A computer-based parallel system for automatic recognition of printed Bengali alphanumerics using various techniques (mathematical morphology, pattern decomposition, skeletonization etc.) and involving only local processing have been implemented and tested with a CCD camera. Ultimate goal of this scheme is to contribute to a reading machine for the blind.

ii) Biomedical studies related to automatic diagnosis of malignant cells and to find suitable algorithms for the detection of cancerous cells/sections are continued. Some work on histological section grading and cell classification, on the basis of image featuring the texture analysis, has been completed.

iii) Work on classification of satellite images into physical classes (like water, vegetation, man-made structures) has started. Our data bank includes images from IRS (Indian satellite) and SPOT (French satellite). Several statistical pattern recognition techniques (eg. robust estimation, testing of hypothesis) and neural networks have been found to be quite useful for the purpose.

iv) 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 reduce and/or represents the uncertainties involved in the conventional crisp procedures. A multi-valued recognition system has also been developed. Its theoretical performance (including the convergence properties) has been established. Successful implementation of this system in identifying illdefined man-made objects such as airports, seaports, road maps and beaches has been demonstrated on IRS image data.

A new concept of generalized guard zone (GGA) has been formulated for discarding unreliable patterns for parameter learning. Its convergence and selection of optimal guard zone have been established. Some applications on real life data have also been demonstrated.

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 density estimation procedure, which uses Parzen's results, has also been developed in this regard. This estimation procedure has been found to give satisfactory results on artificial as well as real life data sets. A split and merge clustering technique and a metric for higher dimensional data sets have also been developed.

2. Development of methodologies for Analysis and Understanding of Image, Shape and

Texture

i) Recoverable type of 2-tone parallel mode thinning algorithm for the extraction of 2-tone images have been developed and could be fruitfully utilized for data compression besides the extraction of structural features. The data compression of binary contour images as well as extraction of contours from gray images has been completed.

ii) Algorithms development for extreme detection and gray level ranking in moving window regarding texture analysis have been completed using statistical, fuzzy and deterministic methods. The application ranges from satellite imagery, microscopic image, and biomedical images. Work on problems such as human face detection from multiple images is continuing.

iii) Preprocessing part of the low cost parallel mode algorithms for image processing and analysis of fingerprint data have been completed.

iv) A library of satellite image processing routines on PC/AT based system was developed and implemented.

enhancement for making linear features more clear thinning for producing 1-pixel thick curvilinear patterns arising from the representation of thinned output in the form of a graph.

Directional masks have been used to enhance the linear structures like roads, small rivers etc. from gray level images and then certain segmentation techniques are used to isolate these structures from the background. They are based on statistical models for robust estimation and can be used for automatic preparation of road maps from the satellite images. The techniques developed will be of great use for civil/defence purposes.

v) A Single-pass Pragmatic Thinning Algorithm (SPAT) for regeneration of pen motion in handprinted script has been developed and tested for both printed and handwritten script. The results have been reported in international conferences.

3. Signal Processing, Microwave Propagation, Atmospheric Studies with Appropriate Application

i) Detailed investigations of microwave signal propagation and characteristic analysis of microwave signal propagation in beyond-the-horizon mode study and characteristic analysis of microwave signal (T.V. signal) transmitted from Khulna, Bangladesh 150 km away from Calcutta are being continued. Performance analysis of the received signals and correlational factor of these with the meteorological/climatological condition of the lower atmospheres during that period are being considered.

ii) Large volume of recorded radar data have been processed for different observations/analysis of lower atmospheric structures. Atmospheric modelling and detailed investigations on plume characteristic and stability/unstability criteria for the ABL are being processed and pattern recognition tech niques have been employed with some encouraging results.

iii) Procurement of laser unit and its accessories for setting up of constrained laboratory experiment on aerosol and other suspended particles sizes and their distribution in the atmosphere has been completed and plan program for this experiment is continued.

4. Speech and Music Analysis and Synthesis and ASR Research

i) Acoustic analysis and perceptual study of fricative sounds in Bengali language have been completed. Acoustic phonetic study of non-nasal consonants and diphthongs commenced for establishing a statistical data base speech synthesis, recognition and assistance for standard-

isation of phonetic quality. Acoustic phonetic study of vowels and consonants in Assamese language has been started.

ii) Microprocessor-based text to speech synthesis for Bengali speech sounds, called BANGA-BANI has been completed using signal concatenation method. Work in introducing intonation patterns and prosody are being continued for producing natural speech.

iii) Studies related to cues of nasality and their spectral characteristics of sung vowels in Hindusthani Shaastriya Sangeet have been completed. Identification of Indian 'ragas' is being continued. Extraction of notes from vocal songs have been completed and the software called SUROBITAN is ready for use.

iv) Phonetic transcription of 20,000 Bengali words have entered into lexical tree regarding the development of Bengali lexicon for ASR system. A manner-directed ambiguity driven lexical tree for word hypothesis verification and disambiguation related to AST is continued. An expert system for specific tasks in man-machine interaction like speech mode communication, script, and sketch for interaction and acquiring of a suitable knowledge engineering environment for the purpose is continued.

v) A new hypothesis for production of stress and new cues for perception has been proposed and experimentally established. The findings were reported in an International Conference.

vi) A new approach for time domain analysis for vowel sounds have been proposed, tested and a recognition score of 73

vii) A project on task specific speech recognition for Reservation and Enquiry using Speech Mode Interaction (RESMI) has been started.

viii) Synthesis of singing on any given voice with synthesised instrumental accompaniment has been completed. Radio and TV broadcast have elicited favourable responses. This laboratory has been included in a select group of four institutions in the World who works in the area of advanced singing synthesis. The group has been invited to synthesise the soprano part of the singing in an ensemble to be performed in SMAC '93 in Stockholm.

ix) Sound samples contraindicating the age old concept of perceptual categorisation of vowel and consonant through an analysis of formants have been created. The preliminary tests in this laboratory and in the Royal Institute of Technology has been very encouraging. If established this may lead to completely new concept in auditory perception.

x) The work on developing a reading machine for the blind is continuing and a preliminary model is expected to be ready this year.

5. Research in Computational Geometry, Computer Vision Technology

i) Algorithms for normalizing the orientation, symmetry identification, and size of simple 3-D objects have been developed as a part of 3-D shape description and matching project. In another scheme, a computer vision algorithms based on concept of differential geometry on a set of local features of shapes has been developed to locate/recognise partially occluded 2- and 3-D rigid objects. Both the scheme have potential applications as computer vision system in industrial environment.

ii) An algorithm has been developed to implement optimized error of fit for objects by fitting rectangles, ellipse and their 3-D version. A new fractal geometry based criteria was developed and was applied to the performance evaluation of digital image magnification techniques. The criteria will be applied in natural scene analysis and computer graphics.

New results have been obtained in regard to fuzzy shapes and concave fuzzy sets.

iii) Work on 3D digital topology and its application to image processing and pattern recognition has been going on. A major achievement in this field is a simple and efficient characterization of 3D simple points and its realization by an efficient algorithm. An extension of this work has resulted in 3D thinning and a novel method of decomposition of 3D objects.

iv) Ultimate aim of preprocessing technique should be computer based vision system based on human visual system (HVS). An automatic thresholding of edge detector was developed and different effects and types of transformation used were studied on the quality of extracted edges.

6. Artificial Intelligence and Expert System Methodologies

i) Creation of a large lexicon and some morphological/syntactic level of analysis of Bengali sentences were achieved in natural language processing (NLP) scheme, a major topic in AI.

ii) Based on approximate reasoning, a linguistic recognition system has been formulated and tested with real type data. This has been found capable of handling various imprecise/uncertain input patterns and provides a natural decision system.

iii) Artificial neural networks - a massively parallel interconnection of simple, robust and fault-tolerant processing elements, has been successfully employed in pattern recognition and computer vision. Work is also going on the rate of convergence of learning process of ANN's.

Fuzzy extension to the multilayer perception model and the self-organising kohonen's net model have been developed and found quite satisfactory to pattern classification problems as compared to Bayesian classifier.

7. Image Analysis 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 fingerprint data (using graph theoretic technique) have also been completed.

8. 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.

A connectionist model, namely, X-tron is developed for perception of mixed object categories. Necessary supervised and unsupervised learning algorithms are proposed. The model is used to build a psychologically motivated connectionist system for occluded object recognition. 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 in mid-level vision. Presently, a connectionist system for character recognition is being developed. 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.

9. 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 enable to reduce the uncertainties 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 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 capable of handling various imprecise/uncertain input patterns and provides 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. Properties of iterates of fuzzy circulant matrices under max-min operations have been investigated.

10. 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 multilayered 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 Bayes' classifier. Integration of multilayer perceptron and fuzziness measures has been made to develop an unsupervised system for object extraction.

11. 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 perceptron and cellular network has also been made. It relieves multilayer perceptron from using back propagation technique. A new mutation method called directed mutation is developed which accelerates the rate of convergence of the genetic algorithm to a great extent.

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.

Externally Funded Projects

1) Monsoon Through Boundary Layer Experiment (MONTBLEX)

The Unit successfully shouldered the dedicated task of installation of portable sound radar (Sodar) at BHU, Varanasi, in a national programme on this project funded by DST. The specially designed developed, and fabricated sodar system has been utilised for monitoring ABL dynamics and to relate those parameters with an aim to prediction the behavioural pattern of monsoon activities in northern India.

2) Procedures for spectral characterization

The goal of this DEAL (Defence Electronics Applications Lab.) sponsored of image data obtained from satellites, particularly Indian Remote-Sensing satellite (IRS-1A) having multiple spectral bands. The main thrust on the statistical pattern recognition aspects that are useful for the purpose discriminant and analysis, optimal selection of spectral bands principal component analysis and canonical analysis. Several land covers like water, vegetation, man-made structures, have been considered. The results of the project will be extremely useful for defence purpose.

3) Data compression and Automatic Feature extraction from remotely sensed data and topography

The project funded by ADRIN, Department of Space has two goals. One is the development of various data compression algorithms for digital images. The JPEG with Huffman and arithmetic coding as well as fractal coding approaches are being developed. The other goal is the development of algorithms for the detection of linear structures from satellite imagery. At present, detection of road from JRS imagery is the main concern.

4) Bio-Medical image processing

The main goal of this Indo-German collaborative project is to develop pattern recognition and image processing algorithms for applications to biomedical imagery. Applications of the algorithm to the detection and classification of cervical cancer cells have been tested. Work is in progress for biomedical image data base. Almost every year scientist from ISI visit GSF for 6/12 months. GSF scientists also visit ISI for a shorter period.

5) Workstation for the handicapped

The goal of this Homi Bhabha fellowship project is to develop a PC-based workstation for the blind to work in Indian language and to read books. Using software and transcript card, it is possible to print any Braille formatted characters in normal script characters. Suitable add-on platform over the keyboard is developed and work on Bangla OCR is in progress. The output would be connected to a speech synthesizer for the blind to listen.

Geological Studies Unit

During the year, researches were undertaken in the following broad areas by the Unit : Tectonostratigraphy of the Delhi Supergroup of Central Rajasthan ; Structure and Tectonics in the Early Proterozoic Cuddapah Sequence in A.P. ; Proterozoic Stratigraphy and Sedimentation in the P.G. Valley ; Stratigraphy, Sedimentology and Palaeontology of the Gondwana sequence ; Amphibians of the Satpura Gondwanas ; Jabalpur Lameta Stratigraphy and Sedimentation of Jabalpur ; Some aspects of Quantitative Geology and Computer Applications. The Unit is also participating in teaching of B.Stat. (Hons.) course of the Institute.

The important developments in the research are stated below:

1. Cover deformation in Cuddapah Basin

A new structure section on 1st = 1 mile scale across the Nallamalai Range West of Dignametta has been constructed. Foldthrust developments with Jura type decollement are common ; footwall deformation associated with thrusts on different scale calls for greater attention to 'Kimmeridge model' of fold-fault development.

2. Lower crustal processes simulated by the Late Archaean & Early Proterozoic Granulites

Work on the Eastern Ghats granulite terrain in Orissa has resulted in recording for the first time a high temperature mineral assemblage involving sapphirine. Peak P-T was recorded from the charnockitic as well as pelitic rocks. An isothermal decompression was indicated from the reaction, garnet + sillimanite - cordierite ; it is related to granulite reworking during F₂ - folding. In fact, a two stage decompression has been recorded from the granulite terrain.

Work on the transition zone granulites near Bangalore discounts the 'amphibolite to granulite incipient transformation' on structural grounds. The granulite episode has been found to predate the Peninsular - gneiss in the form of enclaves and xenoliths.

Geothermobarometers and geobrygrometers based on internally consistent thermodynamic data set - as an aid to numerical methods in petrology - has been formulated.

3. Origin of Glauconitic Peloids

It is interpreted that glauconitic minerals so widespread in the P.G. Valley Proterozoic sandstones consist of authigenic high K+ glauconite and ferric-illite. Glauconites formed in the shallow marine environments and ferric-illites formed in fluvial environments. Glauconites formed in warm, agitated environments with high sediment input, conditions which were earlier considered as impediments for glauconite authigenesis. The glauconitic peloids formed by inorganic replacement of detrital feldspar without any organic/organogenic influence. The proposed origin of the peloid offers an alternative for the origin of widespread Proterozoic

glaucconitic peloids.

4. Stratigraphy and Paleontology of the Gondwanas

The work on first-ever Middle Triassic fossil vertebrates from India has nearly been completed. The nine-member vertebrate community so far identified and studied in some detail will enable to locate and identify such strata elsewhere in India and facilitate intercontinental correlation.

Work on the last of the sauropod dinosaurs is press ready. It is hoped that the newly discovered dinosaurs will reveal new facts of this group which spread over several continents including India, South America and Madagascar.

5. Amphibians and Stratigraphy of the Satpura Gondwanas

Work on several excellent skull materials of amphibians that were unearthed from the Triassic Denwa red clays have been completed. Manuscripts are being prepared to get the work published in highly esteemed international journal(s). Along with the palaeontological work, the geological mapping of the Pachmari - Deuwa - Bagra sedimentary sequence has been completed in and around Matkuli, Hoshangabad District, Madhya Pradesh. The work suggests that while the Pachmari and its overlying Denwa Formations has a conformable gradational contact, the Bagra Formation lies on top of the Denwa Formation with a low angular unconformity. It is envisaged that while the Pachmari and the Denwa sequences represent sedimentary products of an interrelated fluvial depositional system, the Bagra sequence, particularly its conglomeratic facies, is the product of a debris flow system.

Physics Unit

During the period under review, the research activities of the Unit were conducted in the following areas :

1. Dermatophysics
2. Astrophysics
3. Quantum Probability
4. Multivariable system and Control Theory

Out of the above research areas, the work Dermatophysics has been in experimental nature while the other three areas have been theoretical in character.

Biological Sciences Division

The Biological Sciences Division is engaged in studying the varied biological processes

covering plant and animal kingdoms, including humans. It comprises the following units : Agricultural Science Unit, Anthropometry and Human Genetics Unit, Biochemistry Unit, Embryology Unit and Leaf Protein Unit. Activities carried out in these Units are described below.

Agricultural Science Unit

Faculty members of the Unit were engaged in teaching in B.Stat. (Hons.) course of the Institute and also in M.Sc. (Agriculture) course of Calcutta University. In research, with a focal theme on 'Cropping Systems under Rainfed Farming Condition' evaluation studies on farm based trials and village surveys in Giridih, Bihar, were undertaken during the period under review. Five ongoing research projects of the Unit related to sustainable productivity improvement in different cropping systems of Bihar plateau. Other three projects are related to studies on adaptation of coconut and oil palm, numerical anatomy and morphology of the family palmae (Arecaceae), including investigations on mangrove in the saline tracts of Sundarbans region. Brief details of the ongoing-projects are as follows :

1. Improvement of Cropping System

Field trials in Giridih experimental farm, Bihar, on up- and medium lands with Paddy, Maize and groundnut as Kharif crops followed by winter crops (Toria, Lentil, Barley etc.) were undertaken. Progressive soil moisture and evapotranspiration studies are in progress. Cropping sequence studies in medium land with residual soil moisture indicated successful rice based double cropping system with higher yield potential through organic nutrient management and mulching. Straw mulching proved to be very effective in yield increase. Rainfall data analysis is in progress to correlate paddy growth and yield related to critical dry spells as observed in the region. Climatological characteristics have been included as objects of study and thus weather-soil-crop relationship is being probed.

2. Intercropping studies

In intercropping studies under upland situation promising combinations in maize, pigeonpea and paddy based systems were on trials with different row arrangements to find out the optimum combination with maximum production potential. Results with maize based intercropping indicated maizegroundnut combination to be promising with 22-44% yield advantage over sole maize cropping.

In rice based intercropping trials best results obtained were from paddy-pigeonpea followed by paddy-soyabean. Nitrogen uptake and soil fertility changes were noted. Plant and soil data analyses are in progress.

3. Studies on the performance of different potential crops for eastern region of Bihar plateau

To find out the crop varieties suitable for growing in different land situations under resource constraint, mainly some improved varieties of drought resistant cereals, legume and oilseeds were cultivated and their performances are being analysed. A few short duration paddy and pigeonpea varieties, fitting well in double cropping sequence, have been identified.

The fourth and fifth generations of rice induced by different levels of X-ray and EMS treatments respectively were raised and harvested and the data analysis is in progress.

4. Exploratory work on palmas

This study deals with the various morphological and anatomical variation between left-spiralled (FSL) and right-spiralled (FSR) areca palm. Leaf samples from ten seedlings each of FSL and FSR were collected. Data were taken in respect of number of stomata, epidermal cells and trichomes per unit area, and their size. It revealed statistically significant variation between FSL plants. However, variations between successive leaves are yet to be found out.

5. Oil palm introduction and coconut improvement in Sundarbans

The seedlings of oil palm and 8 cultivars of coconut were transplanted in June 1987 at the 24 Patganas District Seed Farm, Manmathanagar. A few plants of oil palm and coconut have started flowering. Recommended doses of fertilizers have been applied twice in a year. Growth data in regards to height of plant, number of leaves and date of flowering are being collected at regular intervals. The leaf anatomy in the eight varieties of coconut revealed statistically significant variation of respective stomatal frequency, number of epidermal cells and number of trichomes per unit area. However, the variations in length and breadth of stomata, epidermal cells and trichomes are non-significant.

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

In the anatomical investigations, the structure, shape and size of leaves of 28 mangrove plants have been studied during this period and the studies on general anatomy of roots and stems are in progress.

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

In a collaborative work with SRU, 24 villages on Usri watershed of Giridih District were extensively surveyed, with the objective of assessing agro-sociological aspects of farming and data on various aspects affecting farming pattern were collected. Follow up studies are also being undertaken.

8. Crop-weed interaction studies

Field trials were undertaken with two main cereal crops, paddy and wheat, on upland soil situation in Giridih experimental farm, Bihar. Objective was to assess the effect of weeds in reducing main crop yield and nutrient exhaustion by the weed mass. Data at different stages of crop growth and yield were taken for necessary analysis.

Externally Funded Project

A project entitled "Perception, performance and potential of development in Usri watershed area of Bihar-Plateau - An eco-systemic approach." funded by ICSSR, progressed rapidly during the year. Survey work, data collection and tabulation as also laboratory analysis of soil data were completed. Data analysis and report writing have started. Data reveals the resource positions in the studied system. Studies were also made on perception behaviour and other socio-economic parameters affecting the studied agricultural system performance. Final report of this interdisciplinary project is expected to be submitted by October, 1993.

Anthropometry and Human Genetics Unit

Faculty members of the unit regularly participated in teaching in B. Stat. (Hons.) and M. Stat. courses of the Institute. They were also engaged in supervision of Ph.D. work.

Details of research activities of the Unit are as follows :

1. Human¹ Adaptability Programme : Within the general frame work of this programme, following projects were conducted:

(i) Health Status and Labour Productivity, Phase II

Demographic and anthropometric (including somatotyping) data have been collected from an Oraon agricultural population (on about 500 individuals). Analysis of the somatotyping data is in progress.

(ii) Effects of Microenvironmental Factors on Health in Rural Populations, Phase II

Diet surveys have been carried out on about 260 households in two seasons on a population of Howrah district, West Bengal. Analysis of demographic data on the same population is in progress.

Analysis of data on intra-household food distribution and related matters collected earlier is in progress.

(iii) Psychological Stress and Health of Mother and Child, Phase II

Reanalysis of the extant data is in progress.

Resurvey on anxiety score on a group of women studied before, along with a new group, has been completed. Data on 'Identification and General Information' are being collected from women executives working in various private sector organisations.

A pilot survey has been completed among the ISI retirees on 'Retirement planning'. A list of women teachers, 'already retired' and 'shortly to retire', of colleges under the University of Calcutta is being compiled for a broader study.

(iv) A Study on the Determinants of Fertility and Mortality in an Urban Setting: An Anthropological Perspective

Data on household census, reproductive performance, family planning, health, hygiene practices and socioeconomic status have been collected from 400 Muslims and 400 Hindu households from two Calcutta Slums.

Analysis of these data are in progress.

(v) Human Biology of Himalayan Populations

Data on demographic characteristics were collected from 100 Lepcha households; anthropometric and physiological (blood pressure, pulse rate) data as well as information on tobacco and alcohol use, salt intake etc. have also been collected from 170 Lepcha adults inhabiting 3 villages of Dzongue area, North Sikkim. Analysis of data, collected so far, are in progress.

2. Dermatoglyphics

(i) Development of new ridge counting techniques of palmar/plantar patterns, scoring of hypothenar triradial and design of a few new variables; (ii) population variation; (iii) bilateral asymmetry; (iv) sex variation; (v) inheritance of dermal traits; (vi) inheritance of bilateral dermal asymmetry; and (vii) genetic diseases.

The results obtained in population variations confirm that (a) the dermatoglyphic traits in general and palmar character in particular do help in understanding the biologic/ethnic affinities among different ethnic groups; (b) the different types of traits which are influenced by different genetic and environmental factors give rise to different clustering patterns; (c) toe prints also show inter-ethnicity just like finger dermatoglyphic; (d) recent interest in the study of asymmetry has been focussed towards understanding of the hypothesis of developmental homeostasis.

3. Growth Studies

Growth data of 600 urban school girls have been collected comprising 6 body dimensions. Data collection and preliminary tabulation in progress.

4. Population Variation Programme

The human variation programme was initiated with an idea as to how and why contemporary human populations differ in physical or biological characteristics. Primary emphasis is on traits that are controlled mainly by genes. A project entitled "Genetic survey of some endogamous groups of Northern India" was carried out under this programme with the following specific objectives :

(i) to examine the nature of the distribution of various biochemical and serological markers in blood among different populations, e.g., Brahmin, Rajput, Scheduled caste and Muslim, in Garwahl Region, Srinagar, U.P. The work was conducted mainly in Mandakini River Valley;

(ii) to examine genetic variation within and across population groups;

(iii) to measure the distance between population groups and to construct phylogenetic trees;

(iv) to study the relationship between genetic proximity and geographic distance of the populations.

About 400 blood samples were screened from the above populations. Some variants of biochemical markers were detected including G-6PD slow (new type), PGM1 (new type), and 6PGD-A-Bombay.

(v) Screening for the HTLV-I virus was performed from the sera.

5. All-India Data Analysis on Genetic Polymorphisms

A very large number of genetic polymorphism studies have been conducted in various Indian populations in the past several decades. However, no comprehensive attempt has been made to collate and to analyze these data to answer important anthropological questions regarding origins of and affinities among various Indian populations. Further, no comprehensive attempt has been made to quantitatively assess spatial patterns in gene frequencies. We have undertaken such a study. Collection of data is complete. All data have been entered into computer files. Data scrutiny is in progress.

6. Genetical Epidemiological Studies

(i) Epidemiology of Rheumatoid Arthritis

This a collaborative project taken up by this and the Bio-chemistry units, ISI, and National Institute of Orthopaedically Handicapped (NIOH) (under the Ministry of Welfare, Govt. of India).

Using a statistical design, 5000 families were selected. Data on these families have already been gathered. After screening the blood samples of the patients in the laboratory the following salient points emerged :

- a) Females are more frequently affected than males.
- b) ESR value is quite high in the active phase of rheumatoid disease.
- c) ESR value is moderate in the burnt-out case of rheumatoid disease.
- d) In case of rheumatoid arthritis, the W.B.C. count and Uric acid level are also high.
- e) The globin level, especially the gamma globin, of serum is high.
- f) Immunoglobulin levels (IgG, IgA, IgM) are also high.

Now the results are being statistically analysed.

The results of the Project would be helpful in formulating possible preventive measures of the disease and rehabilitation programme taken up by NIOH.

(ii) Blood Pressure

To investigate the genetics of blood pressure in contrasting ecosystems, enabling the identification of genenvironment interaction, we had undertaken a family study among Marwaris of Calcutta, as a sequel to our earlier study among agriculturists of Digha. The field work is complete. We have found that this population has 17 hypertensives, compared to 2 among the agriculturists. Comparison of blood pressure profiles of these two populations revealed significant differences, which vanished when the profiles were adjusted for variation in concomitants (e.g., age, weight, fatness). We have hypothesized that the "intrinsic" blood pressure profiles of both populations are similar and that genes influencing physical variables (e.g., fatness) do not directly influence blood pressure. Genetic analyses of these data are in progress. The findings of this study will be helpful to our understanding of the relative roles of environmental (e.g., diet, stress) and genetic factors in the determination of blood pressure.

(iii) Methodological Investigations

To understand the genetics of a complex disorder, one performs segregation analysis of family data. When multiple loci are involved in the pathogenesis of a disorder, a large number of families have only one affected individual, mimicking the pattern of a non-genetic disorder. A theoretical and computer simulation study was undertaken to quantify the nature and extent of familial aggregation of a multilocus disorder, and to investigate the statistical power of segregation analysis in discriminating between models. It was found that for a reasonable range of gene frequencies, the ratio of simplex to multiplex families for a two-locus recessive disorder is 60:40. In spite of this, with about 20-30 three-generation families, segregation analysis enables the identification of the correct model with a probability of 0.95. We are now investigating the increase in the probability of correctly identifying a model when

the analysis is assisted by data on a linked polymorphic marker. The results of this study will be helpful in designing a family study on the genetics of a complex disorder.

Biochemistry Unit

Faculty members of the Unit were engaged in teaching B.Stat. (Hons.) course of the Institute. Some were also engaged in teaching in M.Sc. courses of Calcutta University. The major thrust of research of the Unit was analytical and metabolic epidemiologic study towards prevention of diseases with emphasis given on diet nutrition and human uterine cervix cancer prevention and biology of mutagenesis and carcinogenesis.

Details of research activities are given below.

1. Cancer Chemoprevention: An approach towards cancer control

Three subprojects were ongoing on uterine cervix cancer prevention through nutrient intervention, since uterine cancer is the major female cancer in India. These included :

i) Development of biochemical/immunological assay system for nutrient analysis, mainly folic acid. During the year a highly sensitive and specific antibody against folic acid has been raised. An immunoassay method for the determination of folic acid is also in progress. This work is being done in collaboration with the Indian Institute of Chemical Biology (CSIR), Jadavpur. Two manuscripts are in preparation.

ii) In depth study for possible epidemiologic and dietary 'risk factor(s)' for the development of uterine cervix cancer.

(a) Data collected and analysed on women who were attending the OB&G outdoor at the Calcutta Medical College Hospital during February 1989 and March 1991. Parity (P), early ACM (age at the consummation of marriage) and EP (sexual exposure period) came out as potential 'risk factors' for the development of cervix dysplasia. Manuscript is in preparation.

(b) 500 women (Muslim=50; Scheduled Caste=50; Hindu=400) have been screened in different villages around Domjur, Howrah. Aged between 17 to 80, all subjects were married, had parity 3 & above and most had persistent leukorrhoea and vaginal infection/ inflammation. Incidence of dysplasia was approximately 3%. The data is currently being analyzed.

(c) In Domjur group of 33 'high risk' sex professionals (sp) was screened and followed up for a period of one year. Epidemiologic and clinical data collected on them is currently under analysis. One manuscript is in preparation and another has been communicated.

(d) A study has been initiated at the Bagha Jatin State General Hospital in 1992 in collaboration with B.J.S.G.H. & University College of Medicine, Calcutta. The phase I of the study has been completed and a report has been submitted to the Government of West Bengal.

iii) Establishment of a model cell culture system for uterine cervix for in depth biochemical/molecular studies.

Externally Funded Projects

i) Cytotoxicity of heavy Metal

An evaluation on plant and mammalian system examines the cytotoxicity of heavy metals, e.g., tin in order to screen the occupational health hazards (environmental /industrial pollution etc.).

In vivo studies were done on *Mus musculus* (animal) and *Allium cepa*, *Vicia faba* (plant) systems. In animal, dose and duration dependent occurrence of chromosomal abnormalities (including chromatid and chromosome breaks), dicentric, ring, centromere fusion etc. were observed in 60 Swiss albino mice treated intraperitoneally with different doses of trimethyltin chloride for various durations. Chromatid breaks were prevalent over other aberrations. [Communicated, Mutation Research (U.S.A.)]. In plant system, aqueous solutions of the chemical in different concentrations resulted in somatic chromosomal aberrations, e.g. breaks, diplochromosomes, polyploid, lagging, stickybridge in metaphase and anelophasic separation in both kinds of monocotyledonous and dicotyledonous plants, where the former plant appeared to be more vulnerable over the latter (manuscript in preparation).

ii) Genetic Epidemiology of Blood Pressure Phase II

The study is being carried out in order to study the determinants of hypertension. Survey work on Marwari families (each family with at least one hypertensive patient) has been started. From April '92, anthropometric measurements, blood pressure and other relevant informations have obtained from families mostly engaged in trade & business and living in Calcutta for at least 200 years or more. Dietary information have also been noted with a special emphasis on intake of fats and oils. Biochemical estimation of blood-sugar, serum urea and total lipid profiles in the serum in 150 subjects, have also been done during 1992-'93.

Embryology Unit

Faculty members of the Unit took part regularly in teaching of Biomathematics and Biostatistics in B.Stat. (Hons.) and M.Stat. courses of the Institute. Four research scholars were also guided by them for Ph.D. degree. In research, major thrust was on Biomathematical modelling of embryological, ecological and epidemiological processes. Brief accounts of two ongoing projects and a newly proposed project are given below :

The study on Mathematical and Stochastic modelling of cellular growth, differentiation and morphogenesis and Carcinogenesis has been undertaken for understanding the mechanism of self-organisation and spontaneous emergence of dissipative structure in non-equilibrium biological conditions during embryonic growth or during carcinogenesis. It is expected that they will shed light in understanding the complex mechanism of normal and cancer cell growth. This is an ongoing project of the Unit.

A mathematical and experimental study on interaction was undertaken, in collaboration with other Units of the Institute, in order to explore the existence, properties and transport mechanism of certain putative catalytic (chemical) factors in the root exudates. Root exudates have the potentials to be known as the chemical communication in plant kingdom like

pheromones/semiochemicals of the animal kingdom.

3. A new project is proposed for establishing the bodyplan of an early embryo with the help of suitable mathematical and computer models. The most important aims of this project are

(a) to find the primary gradient Anterior-Posterior axis and Dorsal-Ventral axis of an early embryo

(b) to find out the effects of Retinoic Acid (R.A.) as well as Hydroxyl Amine on the axis formation in the early embryo; and

(c) to study the interaction of Homeobox genes and morphogens.

The problem deals with one of the fundamental aspects of morphogenesis and consequent pattern formation and is thus a challenging one. This will be a collaborative study among ISI, Jadavpur University, Calcutta, and University of Copenhagen, Denmark.

Leaf Protein Research Unit

Faculty members of the Unit participated in teaching in B.Stat. (Hons.) course of the Institute. In research, the major thrust of the work done in the Unit was on the proper selection of suitable sources for leaf protein production, their quality parameters, experimentation on animals and humans to judge its effectiveness for supplementation in diets, economics of production and utilization of the two main by-products – the whey and fibrous residues. Brief details of the ongoing projects are as follows :

1. Screening and agronomic studies on various plant species including fodder crops, tree leaves and aquatic weeds for leaf protein production. A number of plants have been found to be promising.

2. Agronomic studies on the sugar beet crop as an alternative source of sugar, alcohol and leaf protein as a byproduct. Varietal trials are being conducted.

3. Biochemical and nutritional studies on leaf proteins prepared from the above mentioned sources followed by protein quality studies on identified promising sources. Amino acid composition of promising aquatic weeds & tree leaves have been studied. A chick growth assay has recently been completed on leaf protein extracted from a promising tree leaf, *Ailanthus excelsa*.

4. Human feeding trials to study the improvement in health and economic status of two communities by intervention programme using leaf concentrates. A baseline survey has been completed while the actual feeding programme is now under progress in Purulia, West Bengal. This project is funded by Find Your Feet, London.

5. Utilization of the fibrous residue left after leaf protein extraction :

i) As a source of fodder material in-vitro dry matter digestibility (IVDMD) tests on goats using fibre samples of a promising tree, *Samanea saman* will commence.

ii) For mushroom production. Encouraging results were obtained using fibrous residues from tree leaves for the production of a number of edible mushrooms e.g. *Pleurotus sajor-caju*, *P. florida*, *P. ilabellatus*, *Volvariella volvacea*. The effect of different fertilizer doses for making

suitable compost from the fibrous residues for fruitbody production of *Agaricus bisporus* is under study.

iii) Studies on isolation of Cellulolytic enzymes from soil microbes : Encouraging results on the production of cellulase in the culture filtrate of *Trichoderma reesei* has been achieved. This cellulase enzyme will be used for saccharification of pretreated fibrous residue. This study will commence soon.

Social Sciences Division

The Social Sciences Division includes the following Units : Economic Research Unit, Economic Analysis Unit, Planning Unit, Population Studies Unit, Psychometric Research and Service 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 continued its teaching and training activities at various levels and research work covering different areas of theoretical and applied economics and econometrics.

Members of the scientific staff shouldered the responsibilities of teaching economics, economic statistics and econometrics in the degree and research courses in economics as well as in other training courses conducted at ISI, Calcutta. Several faculty members participated in the teaching programme of other universities also. There were, in addition, a number of research fellows working for the Ph.D. degree under the supervision of faculty members of the Unit.

The research activities of the Unit during the period under review covered fields like economic theory, economic planning and policy, industrial economics, welfare economics, demand analysis, income distribution, level of living and poverty in India, agriculture, economics of informal sector, economic development etc., besides other investigations in applied economics and methodological studies in econometrics. Some members participated in the study on internal evaluation of total literacy campaign (TLC) in North 24 Parganas.

Projects

1. The second and final report on the Pilot Survey of Income, Consumption and Savings carried out by NSSO was prepared during the period in collaboration with the CSU and some officials of the NSSO. The report will be submitted soon. This study would be useful for evolving an appropriate methodology for household income surveys in India.
2. The project aiming at the evolving of simple criteria for identifying the rural poor, undertaken at the instance of the Dept. of Statistics, Govt. of India, reached the concluding stages. The report on the project was under preparation at the end of March 1963.

3. Several studies have been started on the basis of NSS 38th round (January-December 1983) household budget data. One study examines the effect of the reference period used for data collection on the estimates of Engel elasticities for item groups like clothing, footwear and consumer durable. It appeared that the elasticity for clothing, falls considerably when the last year reference period was used instead of the last month period. Another is concerned with the variation in level of living and poverty across the States and regions of India.

4. Project entitled "Locational Pattern of Industries in India"

The purpose of the present project is to suggest an efficient location and interregional flow pattern of Indian industries on the basis of a certain set of criteria and to work out the sensitivities of the location pattern and interregional flow to the variation in the degree of self sufficiency of various regions of India. The data bases suitable to meet the requirements of the two alternative versions of the proposed exercise had already been organised.

5. Project on Growth and Instability in Crop Production in Eastern India

The study attempts to examine empirically the pattern of agricultural development in Eastern India in terms of growth and instability during the period 1950-51 to 1987-88. It examines in detail the growth rates of production, area and yield of foodgrains and its constituents and of some other important cash crops. It also examines the trends in instability in production, area and yield of foodgrains and other crops. Results of analysis suggest a stagnation in the growth of agricultural production in Eastern India even in the so-called green revolution period. The study further reveals the increasing trend in instability in production in this region, mainly brought about by area instability. The results reported in a research paper will be published soon.

Economic Analysis Unit (Bangalore)

The Economic Analysis Unit carried out research in certain areas of economic theory, econometric methods and applications during the year. Important problems and areas in which the faculty remained actively engaged are : State-wise analysis of rural poverty in India, growth, variability and stability of cereal crop yields in India; Bayesian analysis of forecasting, monetary policy in India and Kaleckian economics. In addition to research, some members of the faculty participated in the teaching of the M.Stat. (M-Stream) course conducted in Bangalore.

Planning Unit (Delhi)

During the year 1992-1993, the Planning Unit was engaged in research in the disciplines of Economics and Sociology. Research in Economics covered a large number of areas, both theoretical and empirical. Theoretical research revolved broadly around problems of Optimal Tax Enforcement and Corruption, Public Goods, Implementation Theory, Macro theories of Administered Prices and Input-Output Theory. Empirical and applied work covered the areas of Industrial Sickness, Supply Response Functions in Agriculture, Input Decisions in the face of risky Agricultural Production, Construction of Input-Output Tables etc.

Apart from publishing scientific papers in journals and books, the economists were also

engaged in project work. Amongst these were the projects on Economic Impact of Tourism in India, Migrant Tibetan Carpet Weavers, India's Exports to EC and Fiscal Reforms in India. Also the annual Conference on Economic Theory & Related Mathematical Methods was organized as a project approved by the ISI.

In Sociology, the areas of research included Social Conflicts in India, Nationalism and Nation-building, Market, Movement and Marginal Strata etc. An ICSSR project on Agrarian Conflict and Rural Labour was carried also out.

The scientists undertook the supervision of Ph.D. students. One student was awarded the Ph.D. degree and two others submitted their theses. The members continued teaching in different courses at various levels both in the Institute and outside.

Linguistic Research Unit

During the period, the Linguistic Research Unit continued its programme of research in the areas of Theoretical and Applied Linguistics. There are six main areas headings 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 and (c) Cultivation of Mother-tongue.
2. Sociolinguistic aspects of Convergence.
3. Language, Class and Cognition.
4. Bengali Syntax and Semantics.
5. Application of Statistics in Linguistic problems.
6. Pedagogical aspects of literacy.

Theoretical Research

A survey of the articulatory and acoustic structure of the Tamil language is in progress. Theoretical research on the Comparative Suprasegmentals of Bengali, Hindi, Oriya, Gujarati and Telugu is in progress.

Applied Research

Studies are in progress on : (a) Development of articulation of speech sounds during the period of language acquisition in the pre-school age child.

(b) Factors leading to convergence between the numerous major and minor languages belonging to the three major language families in India, namely Indo-Aryan, Dravidian and Munda, from a sociolinguistic perspective.

Studies are continuing on the academic achievement of hearing impaired children attending general schools with normal hearing children.

Studies are in progress on the comparative intonation patterns of Indo-Aryan and David-

ian languages as well as between languages within the broad Indo-European group. Studies on pitch and intensity are being carried out, utilising the Visi-Pitch. In-depth statistical studies, initiated almost four decades ago on the vocabulary of Tagore's short stories, and stylistic studies on other contemporary Bengali authors are in progress. Research has been initiated in the areas of language and cognition in the context of class, code, control and also in Bengali syntax.

Ongoing Projects

(i) Study of Suprasegmentals of the Hindi Language : Syllable stress in words, sentence melody and intonation patterns have been studied and some preliminary analysis have been carried out.

(ii) Study of the Suprasegmentals of the Telugu Language : Syllable stress in monosyllabic, disyllabic and polysyllabic words has been studied and some preliminary analysis has been carried out on the Visi-Pitch and Apple-II Interface.

(iii) Comparative Suprasegmentals of the Slavic, Indo- Aryan and Dravidian languages : In the first phase data on suprasegmentals of Hindi, Telugu, Bangla and Serbo-Croatian have been collected and awaiting analysis depending on availability of necessary equipment. Data on the Gujarati language have also been collected.

(iv) Statistical studies of the vocabulary of Tagore's short stories : Data for a quantitative analysis of unique vocabulary of each volume of Galpaguccha have already been completed.

(v) Study of the phonetic structure of the Tamil language : Preliminary data have been collected for the purpose of identifying the phonemes of Tamil. Acoustic analysis of Tamil speech sounds is in progress.

(vi) Survey of the articulatory norms in Bengali speaking children of Pre-school age : Special tests for articulatory evaluation of children under the age of four years have been compiled.

(vii) Educational problems of hearing impaired children attending schools for normal children : School texts have been analysed with a view to obtain a realistic picture of the linguistic requirements of the school going child. A questionnaire has been developed to assess the problems faced by both parents and teachers of hearing impaired children.

(viii) Sociolinguistic aspects of convergence : A quantitative study : Some preliminary surveys have already been conducted in Hyderabad - Secunderabad and in some border areas between Andhra Pradesh and Orissa, and Orissa and West Bengal.

(ix) Verb-centric Parsing of Bangla Sentences in Computer : Verb centric parsing of Bangla sentences has been done. Verbs have been categorised in a way that the categorisation will trigger the structure of sentences, including compound verbs and composite verbs. This categorisation will determine the valency of each listed verb. Attempts are also being made to develop an NLP software for parsing the Bengali language. This is a pioneering work in Natural Language Processing as far as South Asia is concerned.

Population Studies Unit

Faculty members of the Unit were engaged in teaching Demography in B.Stat. (Hons.), M.Stat. courses of the Institute. They also delivered lectures in ISEC Course, Diploma and Health Statistics Course of All India Institute of Hygiene and Public Health and Masters'

programme of Kalyani University on Population Economics. They also acted as guide in dissertation projects on Population.

Details of research activities undertaken by the Unit are indicated below.

Projects

1. Effects of socio-cultural and behavioural factors on proximate determinants of fertility

Approximately 85 percent of the households and female schedules have been coded.

Information from the code sheets has been entered into the computer file. Data processing work is going on.

2. Micro regional statistical surveys in India upto 1875

Microlevel data on area, population and their castes, occupation, houses, stocks and implements and land use etc. are being collected from the records of the old surveys conducted by the Britishers during the 19th Century. Analysis will be done to reveal the growth pattern of the earlier period on the basis of contemporary data. A number of analytical studies have been done using such materials.

3. Study of incidence of Nepali migrants to India and to West Bengal

The final report has been prepared.

Externally Funded Project :

Attainment level of primary school children at the end of Class IV

The project was taken in collaboration with SCERT, Government of West Bengal, to cover all the aspects of primary syllabus, viz., Language, Mathematics, Environmental Studies, Creative Productive and Physical education. The study was held during the years 1990-91 and 1991-92 covering all the 17 districts of West Bengal. Scoring and evaluation of the data are on progress.

On completion of coding and scoring manually, raw scores (based on binary system) were entered in computer. Following a two parameter logistic model, a computer programme has been developed to transform and combine the item scores for each child. A simple linear transformation is being then made so that the scores lie within a range of 0-100. These transformed scores will now be used to compute mean and other statistics.

Psychometric Research & Services Unit

Research work done by the Unit during the period is briefly summarised below :

Projects

1. Potential Entrepreneur School-leavers

The objective of the project is to identify potential entrepreneurs among the school students who are fit to start business or manufacturing unit independently. Certain personality characteristics viz., need for achievement, risk taking ability, independence, leadership and

innovative activities influence the behaviour of the entrepreneur. In India family background plays an important role. Taking all these points into account, a suitable instrument will be developed which can be profitably utilised. Pilot study of the project is complete. Development of the scale is going on.

2. Motivation to work for primary level workers

The objective of the study is to develop a scale to measure 'Motivation to work' for the primary level workers. The sample group for this study will be Clerk, Typist, Factory Workers, etc. Literature review and construction of the primary form of the scale are complete. Pilot study has been started.

3. Personality pattern of different occupational groups

The objective of the study is to develop the personality profiles of different occupational groups viz., teachers, doctors, executives, artists, with the help of 16PF, a standardised personality inventory.

Preliminary analysis of the data reveals that (a) the profiles of different professional groups vary widely; (b) not all the 16 factors are equally important in discriminating the professional groups.

4. Consequences of Social and Economical Deprivation on Academic Achievement

The objective of the study is to investigate the effect of prolonged socio-economic deprivation upon the scholastic achievement of school going children studying in class X. The important findings are as follows : (a) Though intelligence is the most important determinant of academic achievement yet the influence of some non-cognitive factors such as achievement motivation, prolonged socio-economic deprivation are never negligible, (b) prolonged deprivation adversely affects academic achievement, development of intelligence, etc., (c) the nature of this relation varies across sex and region. Report writing is going on.

5. Assessment of Minimum Learning in Primary education

The scoring and analysis of the data collected during the previous years are in progress. Report on the first part of work has been published in January 1993.

6. Social Impact Study of Mass Literacy Programme in Midnapore District

This study was undertaken at the request of the Vice Chancellor of Rabindra Bharati University to the Director, Indian Statistical Institute, to give them technical assistance and expert guidance for this study. The field study has been done in collaboration with the Literacy cell of Rabindra Bharati University, Calcutta, in the district of Midnapore. Evaluation and analysis of data is almost complete. Report writing has been started.

Sociological Research Unit

Faculty members of the Unit participated in the teaching programme of B.Stat. (Hons.) course, and provided guidance to seven Ph.D. scholars and rendered consultancy services in data processing. Research activities carried out by the Unit are as follows :

1. Counter development in agriculture at micro-level : A case in some Purulia villages

The objective of the study is to identify the factors contributing to the under-utilization of land in the Purulia district of West Bengal. The study seeks to analyse the causal relation-

ships taking into account all the socio-economic, agro-economic, agronomic and management factors. It also seeks to suggest ways and means for greater and fuller utilization of land resources.

Literature review, formulation, pre-testing and finalization of questionnaire schedule, selection of villages and households have been completed. A report is under preparation.

bf 2. Dissemination and adoption process of new technology in agricultural activities of tribals in the village situation

The objective of the study is to identify the process of diffusion of new technology in agriculture among backward tribal communities and to suggest what should be proper extension technology to be used among the tribals.

Village selection, listing of agricultural practices - traditional and new - preparing checklist and pilot study in three villages have been completed. Data collection is going on.

3. Pressure from below : A study of the impact of the popular movements in the 1940s

Data collection from five types of source materials : (i) the records of the District Courts, (ii) the files on F.I.R. shelves in the relevant Police Station, (iii) the old journals of the districts, (iv) the organisation reports of the Krishak Sabha and (v) the tape-recorded interviews of the leaders and participants in the Tebhaga Uprisings in Birbhum are over. Such primary records would give us direct acquaintance with the basic data, both official and non-official, relevant for the explication of the grass-root popular movements in Birbhum across the 1940s.

A report incorporating the details of the five types of source materials, as mentioned above, has been prepared in order to systematise the collection of relevant data.

4. Haldia : A study in the linkage of population and development in an industrial complex

Some key persons of different industries in Haldia have been contacted. Chloride India and Hindustan Fertilizer Corporation have agreed to help us. 20 of workers belonging to different categories at Chloride India would be surveyed. Collating the list of workers of Calcutta Port Trust is going on.

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

Household listing of 13 villages out of 44 having artisan groups have been completed. Some preliminary enquiries were done in respect of several cases.

6. Agro-sociological constraints of technological adaptation in subsistence farming of Bihar Plateau region

Literature review and data collection have been undertaken.

7. Inequality and distribution of gains in tribal societies : A pilot study

Literature review, selection of villages, preparation of tools for data collation and data collection in two villages were completed. Further survey would be undertaken.

Externally funded projects

1) Guidance and consultancy services in Data processing

Since 1988, the Unit has taken this project under the auspices of the Indian Council of Social Science Research (ICSSR), New Delhi. The faculty staff of the Unit have been providing guidance to Ph.D. scholars from different Universities in eastern India. Services were provided to scholars from various Universities of Orissa, Bihar and West Bengal.

ii) Evaluation of Rainfed-farming Project

Sponsored by the ODA, U.K., in consultation with the Overseas Development Group (ODG) of the University of East Anglia at Norwich, U.K., the IIFCL has taken a project to explore the possibilities of low cost sustainable agricultural development under farmers' own rainfed conditions of East Indian plateau region in 6 districts of three States - West Bengal, Bihar and Orissa. The objectives of the project are : farmers' participatory sustainable system-evolutionary nature with poverty focus.

As requested by HFCL and ODA, ISI carried out a baseline survey and has been carrying annual evaluation surveys for evaluating the impact of these activities since 1989. Besides, ISI proposes to evolve an appropriate methodology of evaluation of such action projects. Social scientists, agronomists, biochemists and statisticians of ISI are working collaboratively.

Reports of evaluation for the first three years : 1989-90, 1990-91, 1991-92 have been submitted to IIFCL and fourth year's work is in progress. In connection with the project, ODA provided financial support and arranged a course for three researchers of ISI at University of East Anglia, Norwich, UK, during March-June, 1993.

iii) Perception, performance and potential of development in Usri water-shed area of Bihar Plateau - An eco-systemic approach

The study, sponsored by ICSSR, was taken up in the watershed of Usri flowing through Giridih district in South Bihar plateau. The study intends to explore linkages between human ecology and system ecology in socially and economically backward area with an objective to suggest ways and means for improving man-environment relationships in accordance with perception of the people inhabiting the area and to ensure their participation.

iv) Study of impact of Total Literacy Campaign in the district of Birbhum and Bankura

This study was undertaken in response to the similar request of the Secretary, Deptt. of Mass Education Extension, Govt. of West Bengal, to the Director, to give them reports on the basis of social impact of Mass Literacy Programme in the districts which had already been declared as total by literate districts by National Literacy Mission. Data collection in Birbhum and Bankura districts are over. Scoring and evaluation of data is in progress.

v) Internal evaluation of Total Literacy Campaign (TLC) in the district of North 24-Parganas

This project was undertaken in response to the request of the Secretary, Deptt. of Mass Education Extension, Govt. of West Bengal, to the Director, to take up the responsibility of conducting internal evaluation of TLC in the district of North 24-Parganas. Preliminary work and field study was done with the help of other scientific and technical personnel from different units of social sciences division. Field study was done in all the four subdivisions of the district. After scoring and evaluation of the gamut of data, the final report was handed over to the Govt. of West Bengal.

Statistical Quality Control and Operations Research Division

The Division continued its activities in developing professionally competent specialists in Quality Control, Reliability and Operations Research (QCROC), imparting inplant appreciation and technical training in the tools and techniques of QCROC, undertaking project studies and service assignments in addition to theoretical and applied research to develop and improve methodologies in the relevant fields.

The Division also pursued the following activities during the year :

- (1) Training of Division staff in Lead Assessors Programme by Batalas and QC Training Programme by RWTUV.
- (2) Helping the industries for registration under ISO-9000 series of Quality System Standards.
- (3) Organisation of a number of courses on TQM and ISO-9000 and making progress in the selection of candidates for the job of Quality Mission Executives for work in Quality Mission Project.
- (4) Organisation of an international conference titled as "Quality through Engineering Design - An Indo-US-Japan Conference" at Bangalore, and a satellite conference at Hyderabad as part of Professor P.C. Mahalanobis birth centenary celebrations.
- (5) Initiation of a Research Cell in Bangalore.

There has been an all-round increase in the various activities of the Division in response to the growing demand for our services.

During the period under review, 26 plants became new clients and a total of 112 organisations were taking our consultative services at the end of March 1993. About 160 projects were carried out in different organisations. The problem areas involved :

Optimisation of process parameters, Improvement in productivity, Improvement in quality and reliability, Reduction of cost, Introduction of quality system, Development of software for various systems etc.

Consultancy services are now being rendered to a number of organisations desiring to achieve registration for ISO-9000 services of Quality System Standards.

Highlights of some of the projects undertaken during the year are as follows:

Development of new model of compressors using Quality Engineering.

Gas management through optimum impeller and valve plate design.

Implementation of Quality System based on ISO-9000 Series of Standards.

Upgradation of the design of oil filtration system in special propose machine.

Opinion survey to assess customer requirement in new model of cordless telephone.

Reduction of wave soldering defects etc.

During the period, 16 papers by the scientific staff were either published or accepted for publication in national and international journals. Another 38 papers were presented at conferences or submitted for publication. 25 manuals and technical reports were prepared. Some of the areas of work are

Bayesian acceptance sampling plans, Continuous sampling plans, Fuzzy goal programming in acceptance sampling, Life Test experiments, Reliability optimisation, Parametric design and global optimisation, Linear complementarity problem, Convex function, Invex and pre-invex functions, Characterisation of P-matrices, etc.

Apart from the academic (M.Stat. and M.Tech. In Quality, Reliability and Operations Research) and professional courses at Bangalore, Hyderabad and Madras and some general

courses on quality, inplant training programmes for Managers, Executives, Supervisory staff and operators were continued during the period under review. A total of 9489 persons at various levels had undergone training through 345 inplant, general and other courses. The increase in the number of courses has been quite phenomenal.

The cell for Specialist Development Programme (SDP) has been organising relevant input programme for SDP fellows and newly inducted Technical Officers of the Division.

Division's scientific staff gave 189 lectures and paid promotional visits to 74 organisations. Staff Development Programmes

The Division sponsored 10 of its scientific staff for training in the Lead Assessors course conducted by BATALAS and organised by C II at Delhi during July. Another 4 persons have been nominated to attend a programme by BSI. Efforts are under way to cover more staff of the Division under such programmes.

A five day programme on ISO 9000 Quality Systems and Auditing was conducted for the scientific staff of the Division during January 1993.

Programme for Small Industries

In Madras, 6 training programmes were organised for the small scale industries. In all 186 supervisors, executives and entrepreneurs were trained. The Division is providing faculty members in the 3 month's (Part-time) training programme being organised by SISI, Madras.

Quality Mission 1992-97 Project

The Quality Mission Project aims at strengthening the efforts of SQC and OR Division for enhanced executive awareness and implementation of TQM and ISO 9000 series of standards on Quality Management in the Indian industries. The Mission aims at developing a core group of professionals who will be utilised for organising large scale training programmes through standardised modules. The recruitment of the first batch of about 20 Quality Mission Executives is nearing completion. It is planned to start the orientation programme for the Quality Mission Executives in August 1993.

Library, Documentation and Information Sciences Division

Documentation Research and Training Centre (DRTC), Bangalore

The main areas of research in which members of the DRTC Faculty were engaged during the year 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 Sciences and Technologies";
3. The 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- structures/Formats" from the point of view of their impact 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 Notational 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 a 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, serial 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 Science" with view to accommodate essential contents pertaining to the use of the machines and equipment which are all results of advances in information technologies;
16. The development of a Computerized Tutorial for CDS/ISIS (Mini-Micro Version);
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.

Programmes of Activity

The activities of DRTC have been organised into several programmes, such as the following

1. Research Programme;

2. Advisory Service Programme;
 - i) Extension Programme;
 - ii) Publication Programme;
3. Educational and Training Programme;
4. Employment Information Programme;
5. Continuing Educational and Training Programme; and
6. Faculty Development Programme.

Training in Documentation and Information Science

1. Course leading to "ADIS" Award

Under its Education and Training Programme, DRTC conducts a course of 24-month duration leading to the award "Associateship in Documentation and Information Science" (ADIS). This award is recognized by the Government of India as equivalent to a Master's Degree in Information Science.

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 (DSIR), Government of India, New Delhi, DRTC has been conducting a six-week course on "Computer Applications to Library and Information Work" since 1986.

Libraries

Bangalore

1. Additions to the library during the year

- i) Book Acquisition :

300 books were added to the library by purchase. 22 books were received on gratis.

- ii) Stock position :

The total stock position as on 31st March 1993 is as follows:

Books - 12818 : Books on gratis - 860 : Bound volumes of periodicals - 5100 : Number of periodical titles subscribed - 271 : Number of periodicals received on gratis - 26.

- iii) Technical Processing :

About 800 books were classified and catalogued during the year. Nearly 4000 catalogue cards were filed.

2. Circulation Statistics

During the year library facilities were enjoyed by 175 readers. 110 of them availed the lending facilities. 5 Visiting Professors to different units of ISI were also provided with the lending facilities. A total of about 8368 books and periodicals (including loose issues) were circulated by the library. The inhouse use of books and periodicals was around 28,368. About 230 inter library loan transactions were registered.

The membership includes ISI Staff, Research Scholars, Project Assistants, M.Stat. Students, M.Tech. Students, SDP Fellows, DRFC Students, Trainees of DRTC Short-Term Computer Course etc.

3. Inter Library Loan Service

i) Inter library loan facilities were availed of by ISI, Bangalore Centre Library for users from the following local libraries:

- a) Indian Institute of Science, Bangalore
- b) Tata Institute of Fundamental Research, Bangalore
- c) Indian Institute of Management, Bangalore
- d) British Library, Bangalore

ii) Indian Statistical Institute, Bangalore Centre Library extended inter library loan facilities to :

- a) Tata Institute of Fundamental Research, Bangalore
- b) Indian Institute of Science, Bangalore

4. Reprographic Service

The Library provided 2,86,312 Xerox copies to the users during the academic year 1992-93.

5. Documentation Service

The following publications were brought out regularly from the library:

- i) Bimonthly additions to library list of books
- ii) Monthly list of current periodicals
- iii) Current contents of journals
- iv) List of periodical holdings.

6. Professional Development Activities

Mr. M. Krishnamurthy, Asstt. Librarian, participated workshop on 'Library and Information Management' during 7-9 August 1992 at DRTC, Bangalore.

Calcutta

With the addition of 672 books and 27 new journals to the stock, the total collection of the Library rose to 1,04,831. Details of the activities are given below :

1. Acquisition Unit

The Unit accessioned 672 books during the period under report, out of which 499 were purchased and 173 were received as gift.

2. Periodicals Unit

The Unit received 1,118 periodicals out of which 211 received as gift, 423 against subscription and 455 on exchange arrangement with national and international organizations. The Unit also acquired 27 new journals. 29 journals were subscribed under NBHM grant. It accessioned 601 journals and completed the technical processing of 1130 journals.

3. Circulation and Stack Maintenance Unit

The Unit issued 16115 books and journals to the users on loan and reference. The total membership of the Library was 2320. The membership includes ISI staff, research scholars, project assistants, B.Stat. & M.Stat. students, ISEC trainees etc. as well as outside students and institute members. 649 readers were given special permission to use the Library for a short period. 49 books and journals were borrowed from other libraries and 10 books and journals were given on loan to other libraries under the inter-library loan arrangement.

4. Reports & Records Unit

The Unit accessioned 171 titles and processed 137 titles. 219 titles were issued to the borrowers for reference use during the period.

5. Circulating Library

The Workers' Circulating Library acquired 21 new titles bringing the total collection to 34,742. It issued 23,592 books to the members.

6. Technical Processing Unit

The Unit classified 714 books and catalogued 944 books.

7. Documentation Unit

The Unit has been issuing Current Contents List Services on the following group of subjects :

- i) Statistics and Mathematics
- ii) Electronics and Communication Science
- iii) Geology
- iv) Life Science, Anthropology and Demography
- v) Economics
- vi) Recent addition of books to ISI Library

8. Reprography and Photography Unit

The Unit provided 5,51,106 xerox prints for the users during the period under report.

351 frames of photographs of different nature, 4,235 prints of photographic enlargements, 182 frames of lecture slides were made during the period under report. 582 frames of photographs of drawings, diagrams charts etc. and 4,28,400 pages of off-set prints were done during the period under report.

Delhi

During the period the Delhi Centre Library performed the following activities :-

1. Acquisition

Due to budget constraints, only 234 new books could be purchased and added to the stock, thus incurring an expenditure of Rupees 2,30,714.32. 83 publications were received as gift from various sources and agencies. 348 sets of loose issues of periodicals duly bound have been added to the stock, thus raising the stock to 31160 volumes. 46 publications have also been procured by the acquisition section for personal use of the students and researchers of the Institute. About 250 Technical reports/Discussion papers/Reprints etc. have been received during the period from Institutes :-

2. Periodicals

223 titles of journals, both foreign as well as Indian have been approved for renewal for the year 1992-1993. During the period April 1992 to March 1993, an expenditure of Rupees 24,60,325.00 has been incurred on renewal of 200 titles of journals. In addition, 28 titles of journals were received as complimentary and against exchange programme. 348 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 against exchange of *Sankhya*: Indian Journal of Statistics.

3. Circulation

During the period 107 members availed the lending facilities as permanent members. Approximately 7266 publications were circulated during the period among the members. Under the inter-library program, about 42 publications were lent out to the neighbouring institutes and libraries and 59 publications were borrowed from them.

4. Reprographic Services

25443 Photocopies were made during the period. Reprographic facilities have also been provided to 150 researchers of other institutes on a nominal payment.

5. Other Activities

Like every year this year too, Library Trainees with remuneration were 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*. National Sample Survey Organisation (NSSO) and Central Statistical Office (Industrial Statistics Wing), Govt. of India, are also using the computational facilities available in the centre. There are external users from other scientific institutions also. CSSC maintains an archive of NSSO survey data for users in the eastern region of the country. E-mail facility is available in the centre.

Statistical and computational consultancy services are provided by CSSC. During the year under report the Centre provided statistical and computational services to 18 users, organised two courses on programming languages and application packages.

The staff members of CSSC also served as faculty in various courses of the Institute and

guided projects carried out by students. They also conducted research in the areas of Object Oriented Data Base Management, Computer Vision and Image Processing, Interconnection Network and Distributed Operating Systems, Computational Geometry and VLSI layout design, Knowledge Acquisition for Image Data etc.

National Centre for Knowledge Based Computing

Funded under the FGCS/KBCS programme, sponsored jointly by the Department of Electronics (DoE) and the United Nations Development programme (UNDP), the National Centre for Knowledge Based Computing (NCKBC) in the Institute is engaged in active research and development work in the field of Pattern Recognition, Image Processing, Computer Vision and Artificial Intelligence, with a view to developing Knowledge-based application softwares in these areas. It is one of the six premier research centres in India that have been designed as Nodal Centres under the FGCS/KBCS programme. Apart from providing teaching and training to the students of various courses of the Institute as well as the students from other Institutes, members of the Centre have undertaken the following researches during the year :

1. Industrial Application Projects

- (i) Vision-based Printed Circuit Board (PCB) inspection system.
- (ii) Fast recognition of handwritten and printed characters.
- (iii) Vision-based inspection for Coal Quality Analysis (with Geological Survey of India).
- (iv) Ferrogram Analysis for predictive maintenance.

2. Social and Medical Applications Projects

- (i) Analysis of Drinking Water Quality in the context of Public Health.
- (ii) Visualization in Biomedical Imaging.
- (iii) Cytological Image Analysis for Cervical Cancer.

3. Analysis of Satellite Imagery

- (i) Classification of ground cover types.
- (ii) Detection of curvilinear structures.

4. Related subproblems, like

- (i) Cluster analysis for the study of remotely sensed images.
- (ii) Shape-based object recognition.

- (iii) 2D and 3D occluded object recognition.
- (iv) Connectionist (neural-network-based) approach to object recognition.
- (v) Expert system development, including.
- (vi) Expert system for boiler tube leakage detection in power (with WEBEL and Mishanti).
- (vii) Expert system for breast cancer detection (with WEBEL and Mishanti)
- (viii) Object recognition from range images using different geometry.
- (ix) Biomedical imaging.
- (x) Semantic net representation of visual data.
- (xi) Mathematical-morphology-based approaches.

In the following paragraphs a brief outline is given about the important results that were obtained during 1992- 1993.

1. Applications of Image Processing and Pattern Recognition

(i) Printed Circuit Board (PCB) Inspection : A fast and easily implementable algorithm has been implemented for automatic detection of defects in printed circuit boards from their images. Although demonstrated on the micro VAX, the software is implementable in any platform having an image acquisition facility.

(ii) Coal Quality Analysis : Statistical Pattern classification techniques have been used to estimate the constituents of coal from microscopic image samples. The software results in automatically ascribing a quality ranking to the sample set, thus eliminating tedious and time consuming human effort for the same exercise. Impressed by the initial results, Geological Survey of India has collaborated in this project.

(iii) Ferrogram Analysis : Images of ferrograms are used for analysis of machine wear in industries. A database system for searching characteristic ferrographs has been devised to facilitate image comparison. This software is due to be transferred to industry. A demonstration expert system based on VPX Expert System Shell has been developed. A set of linear feature extractors have been designed to identify materials from an RGB - tristimulus color space, preprocessing techniques to neutralize intensity variation among images is being worked upon. More work is under way to automatically analyse ferrograph images.

(iv) Determination of Drinking Water Quality in Public Health Application : As recommended by the WHO, the number of Escherichia coli in water is a parameter of its Quality. The E. coli content in a water sample is estimated by counting the number of yellow spots (bacteria colonies of E. Coli) on a membrane filter. For processing large numbers of samples, the manual counting process normally used becomes rather tedious and error-prone. The system being developed here will perform the counting process automatically and specifically, and hence will be extremely helpful for our health centres for monitoring water quality.

(v) Classification of Ground Cover Types from Satellite Imagery : An attempt has been made to relate pixel groups in satellite images with actual earth surface cover types e.g., vegetation, soil, water, urban area etc. An unsupervised classification scheme has been used where spectral classes are found at first and then their relationship with the earth surface cover type is established using map and ground truths. In this work, images of Calcutta obtained

from IRS-1A were used and it was found that Vegetation, Water River, Soil, Concrete, Semi-concrete and Asphalt formed different clusters in the four dimensional spectral space. The results of classification have reasonably good correspondence with these surface cover types.

(vi) Detection of Curvilinear Structures from Satellite Imagery : Using a spatial approach, curvilinear or line-like structures (like roads, canals, small streams etc.) have been isolated from satellite images. To enhance such curvilinear structures from a gray level image, local operations with an additive score are normally used. Here a multiplicative score is used instead which gives better results than the additive one. The problem of segmenting the image of the multiplicative score is then dealt with where the threshold value can be automatically selected using certain statistical model. A parallel algorithm has been developed for this purpose.

2. Application of Artificial Intelligence

(i) CANSCAN : This expert system gives advise to female patients suspecting breast cancer. It is a cheap PC- based software using a standard expert system shell. It is already being used in hospitals for cancer screening.

(ii) Boiler Tube Leakage Detection : A similar PC based expert systems has been designed to locate leakage areas of boilers in a power plant. It can be operated by any non-expert and thus reduces the repair time of boilers.

The following programmes in NCKBCS project were undertaken during the period :

- 1) Parallel architectures and algorithms for image processing, pattern recognition, and computer vision.
- 2) Model studies for high level vision system (HLVS) and the application of HLVS in remote sensing studies.
3. Simulation of lower level vision system (LLVS) for geological application, algorithms for middle level vision system (MLVS) for geology and natural resources management.
4. Development of algorithm for industrial inspection system with special attention to occlude 2D 3D scene recognition.
5. Acquisition of state-of-the-art computing resources and the setting up a well-equipped machine vision laboratory.

4. EXTERNALLY FUNDED PROJECTS

A. Ongoing Projects

1. Name of the project : Determination of survival, growth and reproduction rates of fresh water Indian carps with particular reference to Bundh-bred, Hatchery and Riverine sources.
Name of the project leader : T.K. Basu.
Unit involved : Biometry Research.
Funded by : Directorate of Fisheries, Government of West Bengal.
2. Name of the project : Socio-economic survey of the Sericulturists.
Name of the project leader : T. Maitra
Unit involved : Computer Science Unit
Funded by : Central Silk Board.
3. Name of the project : Procedures for spectral characterization.
Chief Investigator : S.K. Parui.
Unit involved : Electronic and Communication Sciences.
Funded by : Defence Electronics Applications Lab. (DEAL), Dehradun.
4. Name of the project : Monsoon through boundary layer experiment (MONTBLEX).
Chief Investigator : J. Das.
Chief Adviser : D. Dutta Majumder.
Unit involved : Electronic and Communication Sciences.
Funded by : Department of Science and Technology, Government of India.
5. Name of the project : Data compression and Automatic Feature extraction from remotely sensed data and topography maps.
Chief Investigator : B.B. Chaudhuri.
Unit involved : Electronic and Communication Sciences.
Funded by : ADRIN, Department of space, Hyderabad.
6. Name of the project : Bio-Medical image processing (Indo-German collaborative project).
Project Leader : B.B. Chaudhuri.
Unit involved : Electronic and Communication Sciences.
Funded by : GSF (Munich).
7. Name of the project : "PC-based workstation for the visually handicapped".
Name of the Principal Investigator : B.B. Chaudhuri.
Unit involved : Electronics and Communication Sciences.
Funded by : Homi Bhabha Fellowship Council.
8. Name of the project : Fifth generation computer system and knowledge based computing system (FGCS/KBCS).
Project Leader : B.B. Chaudhuri.
Unit involved : National Centre for Knowledge Based Computing.
Funded by : Department of Electronics, Government of India and UNDP.

9. Name of the project : Perception, performance and potential of development in Uri watershed area of Bihar Plateau - An eco-systemic approach.
Name of the Project Leader (S) : D. K. Bagchi and A.K. Maiti.
Unit involved : Agricultural Sciences and Sociological Research.
Funded by : I.C.S.S.R., New Delhi.
10. Name of the project : Evaluation of metal toxicity on plant and mammalian system.
Name of the Project Leader : C. Dutta Gupta.
Unit involved : Biochemistry.
Funded by : CSIR, New Delhi.
11. Name of the project : Improvement of Health and Economic status of two communities by Intervention programme using Leaf Concentrate (LC).
Project Coordinator : S. Matai.
Unit involved : Leaf Protein.
Funded by : Find Your Feet (FYF), London.
12. Name of the project : Differential Impact of Modern Rice Technology Across Production Environments (Jointly with Kalyani University).
Chairman, ISI Project Committee : N. Bhattacharya.
Project Coordinator : R. Chowdhury.
Units involved : Computer Science, Computer and Statistical Service, Economic Research, Population Studies, Stat-Math.
Funded by : Rockefeller Foundation, USA.
13. Name of the project : Industrial sickness in India.
Project Leader : O. Goswami.
Unit involved : Planning (Delhi).
Funded by : Ministry of Industry, Govt. of India.
14. Name of the project : "India's export to EC : Constraints and prospects".
Project Leader : A. Sarma.
Unit involved : Planning (Delhi).
Funded by : International Development Research Centre, Ottawa, Canada.
15. Name of the project : Attainment of primary students at the end of class IV.
Name of the Project Leader : S. Guha Roy.
Units involved : Population Studies and Psychometric Research.
Funded by : SCERT, Government of West Bengal.
16. Name of the project : Evaluation of Rainfed-farming project.
Project Leaders : S. Bandopadhyay, A.K. Maiti and C. Duttgupta.
Units involved : Sociological Research and Biochemistry.
Funded by : Overseas Development Administration (ODA) of Government of U.K. and the Hindustan Fertilizer Corporation Limited (HIFCL).
17. Name of the project : Guidance and Consultancy services in Data Processing.
Project Leader : P. Chakrabarti.
Units involved : Sociological Research, Computer and Statistical Service, Psychometric Research and Services and Economic Research.
Funded by : Indian Council of Social Sciences Research (ICSSR), New Delhi.

18. Name of the project : Study of impact of total literacy campaign in the districts of Birbhum and Bankura.
Project Leader (S) : S. Guha Roy and A. Dasgupta.
Units involved : Sociological Research and Population Studies.
Funded by : Department of Mass Education Extension, Govt. of West Bengal.
19. Name of the project : Short term training programme computer applications to library and information work.
Project Leader : M.A. Gopinath.
Unit involved : DRTC (Bangalore).
Funded by : National Information Systems for Science and Technology, (NISSAT) CSIR.

B. Completed Projects

1. Name of the project : Fish Farmer's Development Agency Survey.
Project Leader : S. Bandopadhyay.
Unit involved : Computer Science.
Funded by : Department of Fisheries, Government of West Bengal.
2. Name of the project : Integral Transforms, integral equations and applications.
Project Leader : B.N. Mandal.
Unit involved : Electronics.
Funded by : CSIR, New Delhi.
3. Name of the project : Internal Evaluation of total literacy campaign in the District of North 24 Parganas.
Project Leader (S) : S. Guha Roy and A. Dasgupta.
Units involved : Sociological Research, Population Studies, Economic Research, Psychometric Research and Services and Linguistic Research.
Funded by : Department of Mass Education Extension, Government of West Bengal.

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

The Symposia, Conferences, Workshops, Lectures and Seminars organised by the Institute during the year 1992-93 are mentioned below.

National and International Conferences organised or/are planned to be organised in connection with the birth centenary of Professor P.C. Mahalanobis are reported separately.

Symposia, Conferences, Workshops

A Winter school on "Analysis and Probability" was organised by Stat-Math Unit, Calcutta, at Department of Mathematical Sciences, Sambalpur University, during 07.12.93 to 03.01.93. A.K. Roy and B.V. Rao were the course Directors. There were 24 registered participants and several others audited the lectures.

A Workshop on "Novikov's Conjecture" was held at Stat- Math Unit, Calcutta, during December 7-22, 1992. A.K. Mukherjee was the Chairman and A.B. Raha was the coordinator of the organising committee. The Workshop was attended by 45 participants.

A summer school on "Regression Techniques and Multivariate Statistical Methods" was held at Stat-Math Unit, Calcutta during June 4-6, 1992. It was organised by S. Dasgupta, B.K. Sinha and A. Bose. There were seven participants.

A workshop on "Generalized Inverse of Matrices" was organised by Stat-Math Unit, Delhi during December 11-16, 1992.

An international conference on "Multivariate Analysis" was organised by Stat-Math Unit, Delhi in collaboration with Delhi University and Indian Agricultural Statistics Research Institute at ISI, Delhi, during December 18-23, 1992.

An international conference on "Modern Analysis and Applications" was jointly sponsored by Stat-Math Unit, Delhi and Indian Institute of Technology, Delhi, at ISI, Delhi during December 10-14, 1992.

A mini workshop on "Analysis" was organised by Stat- Math Unit, Delhi (with partly sponsored by S.N. Bose Centre for Basic Research) at ISI, Delhi during December 14-18, 1992.

A workshop on "Probabilistic Methods in Different Equations" was organised by S. Ramasubramanian, Stat-Math Unit, Bangalore at ISI, Bangalore, during June 8-20, 1992.

A summer school on "Use of Statistical Software" was organised by Computer Science Unit of Applied Statistics, Survey and Computing Division, in collaboration with Stat- Math, Economic Research and Anthropometry and Human Genetics Units, Calcutta during June 1-19, 1992. Twelve participants from Indian Universities and Research Organisations attended the school.

A national symposium on "Soil Resource Vis-a-Vis Sustainable Land Use" was held under the auspices of Chemistry Unit, ISI, Calcutta, Indian Association for the Cultivation of Science and National Bureau of Soil Survey and Land Use Planning at Calcutta during March 12-14, 1993.

A national seminar on "Theoretical Computer Science, 1992" was organised by Electronics Unit, ISI, Calcutta, at Calcutta during June 17-19, 1992.

An international conference on "Human Genetics" was organised by Anthropometry and Human Genetics Unit, Calcutta in connection with J.B.S. Haldane Birth Centenary Celebration at ISI, Calcutta, during December 15-19, 1992. P.P. Majumder was the Organising Secretary. Seventy participants from U.K., U.S.A., Japan, China, Chile, France, Germany and India attended the conference. Professor C.R. Rao, F.R.S. delivered the J.B.S. Haldane Centenary lecture on the inaugural day entitled "J.B.S. Haldane's Contributions to the Growth of Quantitative Biological Studies in India".

A Seminar on "Role of Women in Decision Making" was held under the auspices of the Bio-chemistry Unit, Calcutta. The speaker was Marry Tennings, Consultant, Overseas Development Group.

An international conference on "Biotechnology in Agriculture & Forestry" was organised by Leaf Protein Unit, Calcutta at ISI, Delhi during February 15-18, 1993.

A short term course on "Forecasting Techniques" was held at ISI, Karnataka Branch during the period. N.S.S. Narayana and Surekha Rao of Economic Analysis Unit, ISI, Bangalore, and T. Krishna Kumar of Institute of Social and Economic Change organised the course.

A three-day conference on "Economic Theory and Related Mathematical Methods" was organised by Planning Unit, Delhi at ISI, Delhi during February 15-19, 1993.

A Seminar on "Common Communication Format for Library" was organised by DRTC, Bangalore on 8 May, 1992. The leading presentations were given by M.A. Gopinath, I.K. Ravichandra Rao, A.R.D. Prasad and Biswaranjan Padhi. About 40 participants attended the Seminar.

A Workshop on "Energising Library and Information Sciences" was organised by DRTC, Bangalore, as a part of its regular academic programme and Ranganathan Centenary Celebrations during 20 - 22 May, 1992. M.A. Gopinath presided over the Seminar. 50 participants attended the Seminar.

A Seminar on "Telecommunication and its Applications to Library Networks" was held at DRTC, ISI, Bangalore during 4-5 June 1992. The leading presentation was given by A.D. Kulkarni, Officer-in-Charge, INSDOC, Bangalore. M.A. Gopinath presided over the Seminar. About 25 persons attended the Seminar.

A Seminar was arranged on "Artificial Intelligence and Expert systems" on 17 June 1992 at DRTC, ISI, Bangalore. The leading presentations were given by B.V.S.R.K. Prasad, Ashish Jain and V.N.K. Ramesh, all from Centre for Artificial Intelligence and Robotics, Ministry of Defence, Bangalore. I.K. Ravichandra Rao presided over the Seminar.

Ranganathan Centenary Seminar on "Trends in Librarianship" was jointly sponsored by DRTC, ISI, Bangalore, British Council Division, Madras, and British Library, Bangalore on 28 August 1992. The leading presentations were given by Ross Shimson, Chief Executive, The Library Association, U.K.; Mike Freeman, Director of Information Science and University Librarian, University of Sterling, U.K.; Bruce Royal, Birmingham, U.K. I.K. Ravichandra Rao presided over the Seminar. About 25 participants attended the Seminar.

DRTC, ISI, Bangalore, in collaboration with DRTC Alumni Association organised the Five Laws Lecture series on 27 September. The theme of the lecture was "What is wrong with our libraries". P. Jayarajan, Regional Librarian, British Council Library, New Delhi, was invited to deliver this year's lecture. About 60 participants attended the lecture.

A Workshop on "Library and Information Management" was held at DRTC, ISI, Ban-

galore, during 7-9 August, 1992 in connection with the Centenary Celebration of S.R. Ranganathan. A. Neelamegham and S. Parthasarathy conducted the Workshop. There were 66 participants in the Workshop.

Lectures and Seminars

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

Theoretical Statistics and Mathematics Division Calcutta Unit

Bhattacharya R.N., Indiana University, USA (31.12.92) : Edgeworth Expansions in Statistics.

Burman Prabir, University of California, Davis, USA (27.7.92) : Robust Model Fitting and Model Selection.

Chaubey Y.P., Concordia University, Montreal (4.3.93) : Improved Estimation of a Finite Population Mean Based on Paired Observations.

Datta Somnath, University of Georgia, USA (31.8.92) : Expansions for Families of Markov Chains with Applications to Bootstrap.

Hall Peter G, Australian National University, Canberra (14.12.92) : Statistical Estimation of Fractal Dimension.

— (15.12.92) : Development of Bootstrap Method – An Illustration of Interface between Theoretical Insight, Statistical Theory, and Statistical Practice.

— (16.12.92) : Non-parametric Estimation of the Covariance of a Continuous Spatial Process.

Huda S, King Saud University, Saudi Arabia (29.7.92) : Optimal Designs with Circular String Property.

Kallianpur G, University of North Carolina, USA (6.1.93, 7.1.93 and 8.1.93) : Infinite Dimensional Stochastic Differential Equations, Chaos Expansions and Feynman Integral (three lectures).

Komatsu T, Osaka City University, Japan (11.1.93) : Limit Theorems for Jump Processes with Ergodic Driving Processes.

Kundu Debasis, IIT, Kanpur (20.7.92) : Some Recent Results on the Detection and Estimation of the Two Important Signal Processing Models.

Kundu S, of IIT, Delhi (13.7.92) : On Some Remarks on ARHANGELSKII's $cO(x)$.
Lahiri S.N., IOWA State University, USA (28.12.92) : The Rate of Bootstrap Approximation for the Normalized and the Studentized Sample Mean of Lattice Variables.

Madan Sobha, IIT, Kanpur (23.3.93) : Rudin-Shapiro Polynomials and the Hilbert Transform.

Majumder Aniket, Purdue University, USA (30.7.92 - 10.8.92) : Some Covering and Packing Parameters on Graphs (Four lectures).

Mohari A, Rome University (22.2.93) : An Algebraic Formulation of Markov Processes.

Myjak J, University of L'aquila, Italy (19.1.93) : Generic Properties in Fixed Points and Differential Equations Theory.

Nadkarni M.G., Bombay University (11.3.93) : Weakly Wandering Sets and Compressibility in Descriptive Setting.

Pal N, University of Southwest Louisiana, USA (3.7.92) : A Sequence of Improvements Over the James Stein Estimator of a Multivariate Normal Mean.

Prasad Phoolan, Indian Institute of Science, Bangalore (28.4.92) : Hyperbolic Conservation Laws.

Raviudra G., RCE, Mysore (19.5.92 and 21.5.92) : Perfect Graphs and Strongly Perfect Graphs (three lectures).

Ramkrishnan S., University of Miami, USA (2.11.92) : Randomness and Kolmogorov complexity.

Sethuraman J., Florida State University, USA (14.12.92) : The Coverage of the Markov Chain Simulation Method.

Simonovits M., Hungarian Academy of Science, Hungary (21.1.93) : Some Old and New Results in External Graph Theory.

Styan G.P.H., McGill University, Montreal, Canada (2.2.93) : Shorted Matrices, and their applications in Linear Statistical Models - A Review.

Delhi Unit

Chatterjee S.K., Calcutta University (24.11.92) : Detained Statistical Inference, A Non Bayesian Approach : Two Decision Problem.

Chaubey Y.P., Concordia University (10.3.93) : A Smooth Estimator of the Survival Function and Some Associated Functionals.

Dani S.G., TIFR, Bombay (16.2.93) : Flows on Homogeneous Spaces and Application to Values of Quadratic Forms.

Elsner L, University of Bielefeld (2.2.93, 5.2.93, 9.2.93) : The QR Algorithm and the TODA Flow.

Fazekas I, Kossuth University (20.1.93) : Complete Convergence in Law of Large Numbers.

Gustafson K, University of Colorado, Boulder (22.12.92) : Probabilistic Description to Deterministic Dynamics.

— (28.10.92) : A Statistical problem arising in optics.

Horowitz J., University of Massachusetts (20.10.92) : Statistical problems in the Analysis of Images from the Hubble Space Telescope.

Masani P.L., University of Pittsburgh (25.1.93) : The Homogeneous Chaos from the Standpoint of Vector Measures.

Mukhopadhyay N., University of Connecticut (3.4.92) : Recent Advances in Sequential Estimation Theory.

Nair Vijay, AT & T Bell Laboratories (22.1.93) : Design and Analysis of Industrial Experiment for Quality Improvement.

- Punanan S., University of Tampere (27.1.92) : Some Matrix Properties Related with Regression Diagnostics.
- Sastry Swati, Institute of Mathematical Sciences, Madras (6.10.92) : Upper Bounds on the Value Distribution of Quasimeromorphic Maps.
- Schreiber Bert, Wayne State University (1.11.93) : Multilinear Forms Over Locally Compact Groups.
- Sengupta Amber, Louisiana State University (11.1.93) : Stochastic Parallel Translation in Quantum Gauge Theory.
- Shantaram R., University of Michigan-Flint (13.10.92) : Computational Geometry - An Introduction.
- Singh V.P., IBM Corporation, San Jose, California (12.2.93) : Automated Design of Experiments Package.
- Styan George P.H., McGill University (27.1.92) : On the Efficiency of a Linear Unbiased Estimator and on a Matrix Version of the Cauchy Schwarz Inequality.
- Tutsche (2.4.92) : Generalized Analytic Functions and Their Applications to PDE.

Bangalore Unit

- Aravinda C.S., TIFR, Bombay (29.10.92) : Bounded Geodesics and Hausdorff Dimension.
- Athreya K.B., Iowa State University, USA (31.7.92) : Markov Chain Methods in Gibbs Sampling.
- Balasubramaniam R., Institute of Mathematical Science, Madras (8.7.92) : Some Problems in Number Theory.
- Basak Gopal, IISC, Bangalore (22.10.92) : A Class of Limit Theorems for Singular Diffusions.
- Cowsik R.C., University of Bombay, Bombay (29.5.92) : Maximal Commutative Subalgebras.
- Curras Eurik, Academician of the Royal Doctor's Academy of Madrid and Professor, Toledo Royal Academy of Fine Arts and Historical Science, Madrid, Spain (20.8.1992) : Systems Science and Information Retrieval.
- Dani S.G., TIFR, Bombay (8.10.92) : Flows on Homogeneous Spaces and Diophantine Approximations.
- Farrell F.T., Columbia University, New York, USA (5.2.93) : Topological Versus Smooth Rigidity.
- Janwa H, Bombay University, Bombay (5.5.92) : Error Correcting Codes From Algebraic Geometry.
- Kshirsagar Anant, Department of Biostatistics University of Michigan, USA (11.3.93) : Use of Canonical Correlations in Estimation of Relative Potency from Multivariate Bioassays.
- Kumar P.R., University of Illinois, USA (21.5.92) : Simulated Annealing.
- Levi Sandro, University of Milano, Italy (6.4.92) : Hyper Spaces in Normed Linear Spaces-I (Spaces of closed or closed convex subsets).

- Madan Shobha, IIT, Kanpur (9.6.92) : Ergodic Hilbert Transform and its Commutator.
- Mukunda N., Iisc, Bangalore (16.4.92) : Geometric Phases in Quantum Mechanics.
- Ramadas T.R., TIFR, Bombay (9.4.92) : Holomorphic Vector Bundles of Curves : Connections with physics.
- Ramkrishnan S., University of Miami, USA (28.1.03) : Random Sequences and Kolmogorov Complexity.
- Rajput B.S., University of Tennessee, USA (17.6.92) : Prediction of Infinitely Divisible Processes.
- Sane S.S., Bombay University, Bombay (28.5.92) : An External Problem in Combinatorics.
- Sethuraman J., Florida State University, USA (11.12.92) : The Convergence of Markov Chain Simulation Methods.
- Saha Riddhi, TIFR, Bombay (12.1.93) : Semi-Stable Measures and Limit theorems on Real and p-ADIC Groups.
- Singh Avinash, Carleton University, Canada (16.11.92) : Multivariate Composite Estimator for Rotating Panel Surveys.
- (27.11.92) : Mean Squared Errors for Small Area Estimators : A Bayesian Solution to a Non-Bayesian Problem.
- Srinivas V., Department of Statistics, Bangalore University (18.3.93) : Bayesian Estimation of Parameters in M/G/1 Queue and Related Problems.
- Stroch U., Ruhr-University, Germany (10.3.93) : Divisions on Toric Varieties.
- Sujatha R., TIFR, Bombay (21.10.92) : Unramified Witt Groups.
- Sutradhar C., Memorial University of Newfoundland, Canada (2.7.92) : On Cluster Regression and Factor Analysis with Elliptical T Errors.
- Vasudevan M., Curtin University of Technology, Perth, Australia (2.12.92) : Convergence of Kaplan Meier Process.
- Yogananda C.S., IISc, Bangalore (30.7.92) : The Circle Method and the Waring's Problem.

Applied Statistics, Surveys and Computing Division

Computer Science Unit

- Basu Sanjib, University of California, Santa Barbara, USA (10.8.92) : Bayesian Robustness - An overview and Some New Directions.
- Burman Prabir, University of California, Davis, USA (28.7.92) : Variable Transformations.
- Dutta Somnath, University of Georgia, Athens (21.7.92) : A solution to the Compound Estimation Problem with Certain Nonregular Components.
- Jamil Mamnoon, Rutgers University, Camden (13.1.93) : The 1-Centre Problem with Queing.
- Lahiri Chaudhury D.K., Rabindra Bharati University (1.3.93) : Problem of Elephant Census in India.

Majumder Aniket, Indiana University, Fort Wayne (11.8.92) : A Paradigm to General Linear Algorithms for Graph parametrica.

Mukherjee Joydeep, Price Waterhouse Associates (21.4.92) : Railway Time Table Scheduling and Signal Data Generation for London Underground Limited.

Pal Chandranath, Kalyani University (9.3.93) : Optimal Tests in Possibly Non-regular Mixture Models.

Puntanen Simo, University of Tampere, Finland (1.2.93) : On the Invariance of some Matrix Formulac with Respect to Choice of a g-Inverse.

Rosenberger J.L., Pennsylvania State University, University Park (15.12.92) : Analysing Unbalanced Multifactor Experiments - Diagnostics and Modelling.

— (16.12.92) : Training Applied Statisticians and the Role of the Statistical Consulting Centre.

Roy Tara Sankar, Jawaharlal Nehru University, New Delhi (29.7.92) : Application of Cellular Automata (CA) in Pattern Generation, Recognition etc.

Sen Pali, University of North Florida, Jack Sonvilla (18.8.92) : Stochastic Differential Equations and its Applications to a Compartmental Model.

Sen P.K., University of North Carolina, Chapel Hill (28.12.92) : Simultaneous Spike-Trains and Stochastic Dependence.

Physical and Earth Sciences Division

Electronics Unit

Bandopadhyay Subir, University of Windsor, Canada (1.1.93) : Systolic Architecture with Cells of Controllable Complexity.

Bera R.K., A.B.H. College, North Bengal University (3.11.92) : Large Deflection Analysis of Plates and Shallow Shells.

Bhattacharya Debasish, Yale University, USA (12.11.92, 17.11.92) : Delay-Fault Test Generation.

Bhattacharjee Jayanta Kumar, IIT, Kanpur (23.7.92) : Convective Instabilities.

Bose U., Calcutta University (5.5.92, 12.5.92, 19.5.92, 14.7.92, 15.9.92, 22.9.92, 29.9.92) : Dynamical System

Das J.N., Calcutta University (7.4.92) : Electron-Atom-Ionozation Collisions.

Dey S.K., Eastern Illinois University, USA (24.11.92) : Massive Parallel Computation for Nonlinear Models.

— (24.11.92) : Numerical Analysis.

Electronics and Communication Sciences Unit

Das Subhudev, University of California, Riverside, USA (20.1.93) : Scene Exploration with Active Vision.

Jain Anil Kumar, Michigan State University, USA (28.9.92) : Segmentation.

Bandopadhyay Somprakash, IIT, Bombay (15.5.92) : Natural Language Processing.

Dasgupta P., Hyderabad Central University (29.9.92) : Some aspects of Natural Language Processing.

Sen S.K., IISc., Bangalore (20.5.92) : An inequality sorting algorithm for a class of linear programming problems.

Biological Sciences Division
Anthropometry and Human Genetics Unit

Sarkar Sahotra, Boston University, USA (19.8.92) : Haldane and Luria Delbruck Problem.

Social Sciences Division
Economic Research Unit

Bag Parimal, Cornell University (3.9.92) : Optimal auction design and R and D.

Bera Anil Kumar, University of Illinois, USA (4.3.93) : Specification Test for a Linear Regression Model with ARCH Process.

Chaudhuri Basudeb, University of Paris (4.9.92) : Theory of Interest Groups and Endogenous Government in Indian Economic Policy.

Francois Patrick, University of British Columbia (7.1.93) : Price Rigidities when quality is uncertain.

Ghosh Ambar, Presidency College, Calcutta (6.5.92) : Inflation, deficit financing and growth in LDCs.

Kumbhakar Subal, University of Texas, Austin (3.7.92) : Estimation of efficiency in production.

Olson Mancul, University of Maryland (27.5.92) : How per capita income in India could be made double in ten years.

Economic Analysis (Bangalore)

Krishna Kumar T., Institute for Social and Economic Change : Poverty Measures.

Tendulkar Suresh D., Delhi School of Economics, Delhi : Structural Reforms in India.

Population Studies Unit

Mitra Samar, Emory University, USA (17.12.92, 18.12.92) : Modelling Life Table Functions.

Sarkar B.N., Survey Research Centre, Calcutta (17.3.93) : Under Enumeration of Females in Bihar.

Witten Mathew, Centre for High Performance Computing, University of Texas (4.12.92) : Mathematical Gerontology.

Library, Documentation and Information Sciences Division
DRTC (Bangalore)

Gupta B.S.S., General Manager, IIFCO, New Delhi : Wide Area Networks and their Implications.

Mahajan S.G., Poona University (17.2.93) : Punenet.

Vishwanathan T., Director, INSDOC, New Delhi (9.8.92) : Library as a Growing Organism.

6. PUBLICATIONS

Sankhyā

Professor Prasanta Chandra Mahalanobis founded *Sankhyā*, the Indian Journal of Statistics in 1933 and he was the Founder-Editor during 1933-1972. Since its inception, eminent scholars all over the world have contributed articles for publication in *Sankhyā*. This prestigious and internationally renowned journal is now published bi-monthly in two series, one on Probability and Mathematical Statistics and the other on Statistical Methodology and Applications, including sample surveys and quantitative economics. The Editorial Board was reconstituted during the year.

Editorial Board of *Sankhyā* Series A and B (upto October, 1992)

Editors : J.K. Ghosh, G. Kallianpur, S.K. Mitra,
K.R. Parthasarathy, C.R. Rao,
B.L.S. Prakasa Rao.

Co-Editors : Series A : G. Jogesh Babu, K.K. Roy,
Bimal Kumar Sinha.

Series B : Arijit Chaudhuri, Dipankar Coondoo,
Bikas Kumar Sinha.

(From November, 1992)

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

Co-Editors : Series A : Arup Bose, Prabal Chaudhuri,
Moham Delampady, R.L. Karandikar,
Bimal Kumar Sinha.

Series B : Probal Chaudhuri, Dipankar
Coondoo, S.K. Mitra, T.J. Rao,
Bikash Kumar Sinha.

Managing
Editors : Series A : R.L. Karandikar.

Series B : T.J. Rao.

The following issues of *Sankhyā* were released during the year 1992-93

Series A, Vol. 54, Parts 2 and 3

Series A, Vol. 55, Part 1

Series B, Vol. 54, Parts 1, 2 and 3

A special volume (No.54) of *Sankhyā* on "Combinatorial Mathematics and Applications" was brought out in memory of Late Professor Raj Chandra Bose. A.R. Rao acted as the Editorial Secretary for the special volume.

Other Publications

1. Proceedings of the Seminar on "Problems of Large Scale Sample Surveys in India" held at ISI, Calcutta during 26-27 December, 1990 (Published by the Computer Science Unit in December 1992 and edited by Anup Dewanji and A.K. Adhikari).
2. "J.B.S. Haldane : A Tribute" (Published in November, 1992 by ISI).
3. "Some Applied Problems in Fluid Mechanics" (Published in November 1992 and edited by H.P. Majumder. The volume has been dedicated to Prof. Ambarish Ghosh on the occasion of his sixtieth birth day).
4. Proceedings of the third International Conference on "Informatics - 91" held at ISI, Bangalore during 9-12 August 1991 (Published by DRTC and edited by I.K. Ravichandra Rao).
5. Proceedings of the Conference on "Game Theory and Economic Applications" held at ISI, Delhi in December, 1990 (Published by Springer-Verlag Publishing Company and edited jointly by Dilip Mookherjee, Bhaskar Dutta, T. Parthasarathy, T.E.S. Raghavan, D. Ray and S. Tijis).

7. SCIENTIFIC PAPERS AND PUBLICATIONS

Books Published

Theoretical Statistics and Mathematics Division

1. Bapat, R.B. (1993) : *Linear Algebra and Linear Models*, Hindustan Publishers.
2. Bhatia (1993) : *Fourier series*, Hindustan Books Agency, New Delhi.
3. Ghosh, J.K., Mitra, S.K. and Parthasarathy, K.R. (Ed.) (1992): *Glimpses of India's Statistical Heritage*, Wiley Eastern.
4. Karandikar, R.L. and Ghosh, J.K. (with Cambanis, S. and Sen, P.K.) (Ed.) (1993) : *Stochastic Processes*, Kallianpur Festschrift, Springer-verlag.
5. Parthasarathy, K.R. (1992) : An introduction to *Quantum stochastic Calculus*, Birkhauser.
6. Ramchandra Rao, A and Dhimsankaram, P (1992) : *Linear Algebra*, Tata McGraw-Hill Publication Co. Ltd., New Delhi, 459 pages.
7. Rao, B.L.S.P. (1992) : *Identifiability in Stochastic Models*, Academic Press, Boston, pages 253.

Applied Statistics, Surveys and Computing Division

1. Chaudhuri, Arijit (with Stenger, H.) (1992) : *Survey Sampling : Theory and Methods*, Marcel Dekker, Inc., New York, pages 376.

Physical and Earth Sciences Division

1. Pal, S.K. (with Bezdek, J.C.) (Ed.) (1992) : *Fuzzy Models for Pattern Recognition : Methods that search for Structures in data*, IEEE Press, New York.

Social Sciences Division

1. Dutta, Bhaskar, Gangopadhyay, S., Mukherjee, D., and Ray, D. (Ed.) (1992) : *Theoretical issues in Development Economics*, Oxford University Press.
2. Mukherjee, D., Dutta, Bhaskar, Parthasarathy, T, Raghavan, T.E.S, Ray, D (with Tijs, S) (Ed.) (1992) : *Selected Papers in Game Theory and Economic Applications*, Springer- Verlag Publishing Company.