INDIAN STATISTICAL INSTITUTE

FIFTYFIFTH ANNUAL REPORT

April 1986—March 1987

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0. INTRODUCTION[1]

In recent years the Institute has been facing financial problems of various sorts. The year 1986-87 was no exception. Not only was the grant approved less than what was the bare minimum necessary for proper functioning but there was also a serious ways and means problem in the disbursement of funds granted. As a result even the library had been affected. It is possibly true that all institutions of higher learning experienced a substantial cut in their budget in recent years, this being but a reflection of the serious resource gap faced by the Government. Certainly the Institute must trim its expenses and learn to live with the new dispensations. But if the grant for this year is not raised to a satisfactory level next year or, worse, if there is a further reduction, the Institute's problems will assume the proportions of a crisis.[2]

So far, because of past traditions, the Institute's teaching and research activities have not been affected too badly by the financial constraints. As in the past, it has been again a year of many achievements. Attention will be drawn to some of these. Others as well as the details of the continuing activities appear later in the report.

Though research is the primary activity of the Institute, teaching and training responsibilities are taken very seriously. So it is quite appropriate to begin with an account of these activities.

Bangalore is the youngest Centre of the Institute. The M.Stat. course which was previously offered only at Calcutta and Delhi, is being offered in Bangalore for the first time this year. Eight students were admitted.

The Institute is specially proud of the training provided by *the Division of Statistical Quality Control and Operations Research*. More so, because the Prime Minister declared November, 1986 as the Quality Control and Maintenance month. The specialists in the Division actively participated by delivering key-note addresses in numerous seminars and conferences organised as part of the programme of Quality Control and Maintenance Month by the industry and other professional bodies. During the period under review more than two thousand managers and technologists received training. Beneficiaries include public sector giants like BHEL and SAIL. Incidentally, for the first time, the Institute extended service to an engineering

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[1] Based on the Annual Review presented by the Director at the 21st Convocation of the Institute held on 5th March 1987.

[2] Fortunately the Government is now considering these problems sympathetically.

consultancy organisation, namely Metallurgical and Engineering Consultants (India) Limited, last year.

The Institute conducts external examinations for students interested in Statistics and on the basis of satisfactory performance awards Junior Diploma and Senior Diploma in Statistics. Since August 1978, the Indian Statistical Institute had been trying to get recognition of Junior Diploma and Senior Diploma in Statistics from the Government of India. In a recent communication, the Department of Education, Ministry of Human Resource Development has conveyed to the Institute that for the purpose of recruitment to posts under the Central Government, the Junior Diploma may be treated as a Bachelor's degree in Statistics and the Senior Diploma as a Master's degree in Statistics, subject to the fulfilment of some conditions, which have been accepted by the Institute.

The International Statistical Education Centre (ISEC) is operated jointly by the International Statistical Institute and the Indian Statistical Institute for the benefit of students in the third world countries. Most of the students are supported by the Government of India under the Colombo Plan, SCAAP, ITEC etc. and a few are supported by the respective Governments. Altogether twenty four foreign trainees received training last year in what was the fortieth term of the ISEC.

In addition to all these, the Electronics and Communication Sciences Unit imparted training on analog, digital and microprocessor systems to undergraduate and post-graduate students from I.I.T., Kharagpur and other engineering colleges and universities.

The purchase of a fourth generation computer, Vax-8650, was approved in 1986 after floating a global tender. Its acquisition will be a major event for the Institute with far-reaching effects on teaching and research. It may be pointed out in this connection that the Institute has been declared as one of the Nodal Centres for Fifth Generation Computer Systems Research with Professor D. Dutta Majumder as the National Co-ordinator in the areas of Artificial Intelligence, Pattern Recognition, Image Processing and Computer Vision System Research.

In many ways fundamental research has been an enduring source of strength for the Institute. Over the years recognition has come from the general scientific community in India and abroad. Some that came last year and deserve special mention are the following.

Professor A. Maitra, was elected Fellow of the Indian National Science Academy for his fundamental work on dynamic programming, stochastic games and selection theorems. In certain cases Professor Maitra's selection theorems will remain the last word in the subject for a long time to come. Under his leadership there has grown in the Institute a very active school of descriptive set theory and mathematical logic.

Professor T. Parthasarathy received the prestigious Shanti Swarup Bhatnagar Award for Mathematical Sciences for the year 1986 for his work on stochastic games and the relation between matrix games and global univalence of functions. Stochastic games are a special case of repetitive games which economists and mathematicians use to model rational behaviour in situations of recurring conflict. Though these games have been shown to have a value in the usual technical sense, the solutions involve far more than stationary strategies. Professor Parthasarthy has made a major contribution by providing a finite algorithm for finding good strategies for each player for a certain class of games.

The following are some of the notable achievements in research done in theoretical statistics, mathematics and physics and economics at Calcutta, Delhi and Bangalore : A solution of a long standing problem in the theory of ranking and selection, justification of Bootstrapping in the context of time series, a new proof that every Tiechmüller space of Riemann surfaces is a complex analytic manifold, proofs by coding-theoretic techniques of non-existence of extendable biplanes of order 9, settling the first open case of Cameron's theorem, development of quantum stochastic calculus in Fock space, which was the focal theme of a Bourbaki seminar in 1986 by the celebrated French probabilist Professor Paul Andre Meyer, discovery of Heisenberg type inequalities in the context of abstract harmonic analysis, and application of stochastic field theory to formulate equilibrium conditions in finite temperature quantum field theory. In economic theory a significant achievement was the construction of a new theoretical framework and rigorously proved theorems which provide a quite new explanation of persistent unemployment in developing countries. In this theory malnutrition and lack of assests are not only a conseqence of unemployment but a vital determinant of it.

This enumeration should be taken as a representative sample rather than an exhaustive list.

The Institute has made many major contributions to sampling theory. One of the most active workers in this area is Professor A. Chaudhuri whose important new book with J. W. E. Vos on *Unified Theory and Strategies of Survey Sampling* will be brought out in 1987 by Elsevier. The book explores in depth the inferential issues that arise in sampling finite populations and takes the view that both purposiveness and randomisation are needed to utilise background information as well as satisfy various criteria of inference.

In January 1985, the Institute organised an International Conference on Quantum Statistics and Foundational Problems of Quantum Mechanics to celebrate the sixtieth year of Bose Statistics and honour the memory of Professor S. N. Bose who had been closely associated with the Institute. The proceedings of that conference appeared this year in the Hadronic Journal Supplement (Volumes I and II), Hadronic Press Inc., Massachusetts, U.S.A.

People interested in theoretical physics are aware that the theory of elementary particles is undergoing some very exciting development owing to the impact of the subject of superstrings. This involves a completely new way of looking at elementary particles which are assumed to behave not like points, but as strings which have extension and can vibrate. There is hope among theoretical physicists that this may lead to an intuitively acceptable theory for the different kinds of strange behaviour of the elementary particles and unify all the four physical forces in nature within the compass of a single theory. Not only has this great epistemological significance, but it has also led to some very elegant, dazzlingly beautiful and surprising mathematics. It so happens that the mathematics requires a deep study of Teichmüller spaces and one of the most competent persons in India is Dr. Subhashish Nag. His monograph on the complex analytic structure of these spaces, written at the request of the Canadian Mathematical Society, will be published by John Wiley, New York, later in 1987.

During the year the Institute held several advanced summer and winter schools in statistics. One was on probability and analysis, two were on reliability, one was on sample surveys and one on the computation intensive methodologies in statistics, the last being supported by a grant from the UGC.

Immediately after the last World Congress of Sociology in Delhi in 1986, the Institute organised a satellite symposium on "Ideology, Social Formation and Transformation". Shri Jyoti Basu, Chief Minister of West Bengal, delivered the inaugural address. Among those who participated were the renowned sociologists Professor Orlando Fals Borda and Dr. (Mrs.) M. I.. Pereira De Queiroz. The deliberations at the symposium have evoked much interest in sociological circles, the proceedings is likely to go the press in 1987.

The Institute undertakes many projects, often at the request of the Government or industries in the public sector. It is working on a project sponsored by the Planning Commission on "Regional Model for Agriculture"—the object is to build up models at the state level which would make the final planning more realistic. The final report on an earlier project of the Planning Commission on "Studies on Multisectoral Planning Model" was submitted this year. An ILO funded project on a comprehensive analysis of changes in the standard of living and incidence of poverty was completed and a final report was prepared.

Department of Agriculture and Co-operation under the Ministry of Agriculture, Government of India sponsored a scheme for conducting techno-socio-economic surveys of fishermen through various State Governments. The Institute took-up a project under this scheme at the request of the Directorate of Fisheries, Government of West Bengal, during 1985-87. The sampling scheme adopted by the Institute was circulated in a book form and was appreciated by the Central Government and they advised other agencies/State Governments to follow the ISI design for their projects under this scheme.

Many surveys have been undertaken in India in the area of family planning but not from a motivational or behavioural point of view. Recently such a pioneering survey was completed under the sponsorship of the ICMR. The findings are important but other agencies have to be persuaded to take-up several large scale follow up surveys in collaboration with the Institute to check whether the findings hold at a national level and therefore have policy implications in this difficult area.

Most of the sponsored projects are undertaken by the Division of Applied Statistics, Surveys and Computing and the Social Sciences Division. In addition, they are engaged in theoretical and methodological studies and projects funded directly by the Institute. Important projects of this sort include one on a methodological study to improve the NSSO operations and another on a new way of handling non-response. It is noteworthy that Professor B. S. Minhas of the Institute has been appointed Chairman of the Governing Council of the NSSO for a second term.

Two other important pioneering projects of this type are briefly described below. Both are concerned with different aspects of social welfare or lack of it in the Indian countryside—both will enhance and add a new dimension to the Institute's role as a leader of research in the areas of consumption, poverty and inequality. In one project the objective was to generate longitudinal data by *revisiting* households covered in the 27/28 rounds of the NSS. In the other, the object is to study demographic imbalance which has resulted in social tension, economic hardship and ecological mismanagement in selected regions of Eastern India (e.g., Manipur, Tripura). The study aims at evolving a general framework for analysing such issues. The analysis of the Tripura part has been completed.

A few important and useful projects undertaken by the Biological Sciences Division are briefly described below.

The group on Anthropometry and Human Genetics has been conducting surveys on the Sherpas in the Darjeeling-Kalimpong area to study the impact of altitude and other factors on health and activity patterns. Field work had to be abandoned this year owing to political unrest in the area but a comprehensive report of the earlier work has been prepared.

A socio-ecological survey of the use of avenue trees in Calcutta has important implications for social forestry. Another project on cultural ecology of domesticated elephants reveals that if the present policies of the Government regarding conservation of elephants is not changed, the cultural tradition of elephant keeping will disappear from the country.

It is also worth mentioning that the data collected jointly with the Soviet scientists in the survey in 1983 on South Indian populations have been extensively analysed and six papers have been published so far.

Though it has been known for quite some time that good quality protein can be extracted inexpensively from a leaf, this knowledge has not been put to any social use. The Institute, which is a pioneer in research on leaf protein has prepared a comprehensive project on utilisation of leaf protein in rural India, in collaboration with the I.I.T., Delhi. Money is expected to come from the D.S.T.

The ONGC sponsored project on a model for oil discovery and optimum investment has completed its first phase. A tentative model for discovery has been built, compilation and clearing of data has begun. The search for an optimum or near optimum strategy is likely to begin next year. The methodology developed should apply to exploration of other natural resources which are not in abundant supply. Incidentally this is an inter-disciplinary project involving statisticians, economists and specialists in operations research. In another interdisciplinary project undertaken a few years ago at the request of the North Eastern Council, the data on the occurrence of earthquakes in the North East region of India have been thoroughly analysed, leading to a mathematical model and a method of prediction. A paper incorporating this analysis will appear in the proceedings of an international conference held at Poona.

A few words are in order about the Institute's construction activities. Construction of the last few floors of the library building in Calcutta is now complete. Work on the Senior Boys' Hostel is progressing smoothly. The new office building and staff quarters at Hyderabad are now ready for occupation. Work on an additional floor of the guest house at Delhi has begun. The Institute has felt for some time the need for a new guest house and more quarters for staff of all categories in Calcutta, but the Government has not yet sanctioned any money for this.

1. TEACHING AND TRAINING

Degree and Training Courses

During the period under review, 8900 candidates applied for admission and were called for written selection tests for the following courses : B.Stat. (Hons.), M.Stat. (M-stream and S-stream), M. Tech., One-year Post-Graduate Diploma in SQC and OR, Two-year Part Time Post-Graduate Diploma in SQC and OR (Bombay and Madras), Research Fellowships in Statistics, Mathematics, Economics, Theoretical Physics, Physics, and Geology, One-year Evening Course in Statistical Methods and Applications and the Course on Operation of Automatic Data Processing Equipment. Admission tests were conducted at 12 Centres all over the country. A total of 5054 candidates appeared for admission tests and a total of 509 candidates were called for interviews for final selection for admission to various courses during the academic session 1986-87.

Two foreign applicants who applied directly for admission to our courses were given special admission tests conducted through the Indian High Commission or Embassies of France and Ghana. They did not, however, qualify for admission.

The annual examinations for the B.Stat. and M.Stat. courses were held in May/June 1986. The 1986-87 academic session commenced on 7 July 1986.

Ninety candidates received their degrees and diplomas at the Twenty-first Convocation of the Institute held on 5 March 1987. One hundred seventeen candidates who passed the various regular courses of varying duration (one year or less) received the certificates during the year. Seven candidates were awarded the Ph.D. degree of the Institute. Seven Ph.D. theses were submitted to the Institute/other Universities during the period.

The certificate course on Operation of Automatic Data Processing Equipment was upgraded from one year to two years course and the course content was revised. The course title was changed to Certificate and Diploma courses on Operation and Programming of Automatic Data Processing Equipment.

One Egyptian scholar has been undergoing Advanced Studies in Statistics and Mathematics for a year since December 1986 under the Indo-A.R.E. Cultural Exchange Programme.

Five trainees in Engineering, of which 2 from the Banaras Hindu University and two from the Jadavpur University received six-week practical training in Electronics and Communication Sciences Unit and the Electronics Unit respectively.

The number of candidates admitted to the different degree, diploma and training courses during 1985-86 and 1986-87 and the results of the examination, held during the period are given in the following table.

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NUMBER OF STUDENTS ADMITTED AND PASSING IN DIFFERENT COURSES

APRIL 1986—MARCH 1987

Courses	Number of Students			Number passed in annual examination in 1986
	enrolled in 1985-86	as on November 1986	enrolled in 1986-87	
(1)	(2)	(3)	(4)	(5)
1. *Courses leading to a Degree in Statistics*				
1.1 Bachelor of Statistics with Honours B. Stat. (Hons.)				
1st year	31	18	14	17
2nd year	12	12	17	12
3rd year	12	12	12	12
1.2 Master of Statistics (M. Stat.)				
1st year	31	26	43*	25
2nd year	20	19	26	19
1.3 Junior and Senior Research Fellows,				
1.4 Visiting Fellows**	71	71	80	—
2. Specialised Courses in Applied Statistics leading to Diplomas				
2.1 Statistical Quality Control and Operations Research (One-year)	14	13	12	13
3. Courses in Statistics for persons in Employment (jointly with C.S.O.)				
3.1 Junior Certificate Course in Statistics	11	11	12	11
3.2 Indian Statistical Service Probationers' Training Course	30	30	18	30
4. *Evening Courses*				
4.1 Statistical Methods and Applications Calcutta	31	11	37	9
4.2 Two-year Post-Graduate Diploma in Statistical Quality Control and Operations Research (Bombay and Madras)				
Bombay —1st year	7	4	7	1
2nd year	—	—	—	1
Madras —1st year	29	19	6	10
2nd year	12	13	10	12
4.3 Six-month Evening Course in Statistical Quality Control (Bangalore and Hyderabad)				
Bangalore —January-June 1986	17	17	22	16
July-December 1986	14	Results not yet declared	25	14
Hyderabad—January-June 1986	5	5	18	5
July-December 1986	7	7	7	3
5. *Computer Courses*				
5.1 M. Tech. in Computer Science—1st year	13	13	15	8
2nd year	13	13	8	13
5.2 M.Tech. by Dissertation	—	—	—	1
5.3 Intensive Course on Programming and Applications	36	36	28	37
5.4 Course on Operations of Automatic Data Processing Equipment	13	13	12	10
6. Associateship in Documentation and Information Science	9	9	8	14
Grand Total	476	372	437	293

*Including the figure of Delhi and Bangalore.

**In the following areas : Statistics, Mathematics, Economics, Theoretical Physics, Communication Science, Anthropometry and Human Genetics, Computer Science, Embryology, Geology, Biometry, Chemistry, Physics, Leaf Protein and 2 CSIR Fellowships in Theoretical Physics. The figure includes 16 Research Fellows and Associates at Delhi Centre and 4 at Bangalore Centre.

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International Statistical Education Centre (ISEC), Calcutta

A brief report on activities of the International Statistical Education Centre, Calcutta, during 1986-87 is presented below :

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 with the representatives from the International Statistical Institute, the 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 Professor C. R. Rao has been the Chairman of the Board.

Major training programme of the Centre is a 10-month Regular Course. In addition, Special Courses of varying duration are also organized on an individual basis depending on the need and background of a candidate. Facilities exist for research work and advanced study by senior statisticians. Trainees are from the countries of the Middle East, South and South-East Asia, the Far East and the Commonwealth countries of Africa, sponsored by respective Governments.

Since inception, the Centre has provided training to 1059 trainees from 52 countries.

Three trainees of the 39-th Term were renominated for Special Courses, two of them joined. One trainee continued under ITEC programme of the Government of India and the other was an Indian national. Both the trainees attended a 8-week Special Course on Advanced Data Processing at Calcutta.

A total of 58 candidates from 22 different countries were nominated by respective Governments for admission to the 40-th Term of the Regular Course of this Centre. Of these 58 candidates, 32 were offered admission and 28 participants from 17 countries joined. Twenty 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, and Indian Technical and Economic Cooperation scheme. Remaining 8 received support from respective employers and Governments.

The Micro-computer acquired during last year is finding increased use for training. Eleven trainees of the 40-th Term opted for 9-week specialization in Data Processing, all of them were trained on the Micro-computer.

Fortyseven teachers of the Indian Statistical Institute at Calcutta and 38 officers of the Government of India participated in teaching the Regular Course during the year. In addition there were 7 Guest speakers.

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Both the Special Course trainees completed their training programme success-
fully. Of the 28 Regular Course trainees, 27 have been recommended for the award
of Statistical Training Diploma and the remaining trainee for the Certificate of
Attendance.

Members of the Board of Directors, continue to show their active interest in
ISEC teaching programme.

Professional Examination in Statistics

During the period under report, the Statistical Assistantship Certificate, Junior
Diploma in Statistics and Senior Diploma in Statistics examinations were held at
Bangalore, Bombay, Calcutta, Delhi, Hyderabad, Lucknow and Madras centres
during April 1986 and October 1986 terms respectively.

The total number of candidates and their results for both April 1986 and October
1986 terms are shown below :

| Examination | Number of Candidates | | | | | |
| | Registered | | Appeared | | Passed | |
	April	October	April	October	April	October
1. Statistical Assistantship Certificate	31	45	18	29	7	7
2. Junior Diploma in Statistics	28	36	11	14	6	4
3. Senior Diploma in Statistics	17	11	14	9	7	6

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

The total number of candidates who have qualified for the award of Certificates
and Diplomas in the Professional Examinations in Statistics including the results of
October 1986 term are 476 and 241 respectively.

Since August 1978, the Indian Statistical Institute was trying to get recognition
of Junior Diploma and Senior Diploma in Statistics from the Government of India.
In a recent communication (No. F.18-53/78-T.7 dated 15th December 1986) Depart-
ment of Education, Ministry of Human Resource Development, Government of India
has conveyed as follows :

(i) "A pass in the Junior Diploma in Statistics examination conducted by the
Indian Statistical Institute may be recognised for the purposes of recruitment to
subordinate posts under the Central Government wherever Bachelors' degree in Statis-

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tics is prescribed as the educational qualifications". This recommendation is subject to fulfilment of some conditions.

(ii) "A pass in the Senior Diploma Examination in Statistics conducted by the Indian Statistical Institute may be recognised for the purposes of recruitment to superior posts and services under the Central Government wherever a Master's degree in Statistics is prescribed as an educational qualification" subject to the fulfilment of some conditions.

(iii) "Those who obtained the Senior Diploma in Statistics from the Indian Statistical Institute prior to the re-organisation of the syllabus as recommended", also will "be recognised for the purpose of recruitment to superior posts and services under the Central Government provided they have to their credit at least 3 year's experience in Statistical work after obtaining the Senior Diploma in Statistics".

The Examination Committee has decided to accept all the conditions laid down and is in the process of implementing them.

2. RESEARCH WORK

A brief account of the progress of research in different divisions and units of the Institute is given below :

Theoretical Statistics and Mathematics

Calcutta

The Division of Theoretical Statistics and Mathematics bears the bulk of the teaching of theoretical statistics and mathematics in the B.Stat., M.Stat. and other courses of the Institute. Besides this, the Division runs a two-year course at an advanced level of doctoral students to prepare them for research.

Nature and description of work done during the current year :

1. *Probability Theory* : A prediction process approach to the study of general step processes was undertaken. A complete structure of Markovian motion of a particle moving on the line with 0—1 velocities was carried out. It is proposed to continue this study and link it up with prediction processes as well as semi-group approach.

Characterization of Brownian motion generalizing Levy's was worked out. Various formulae connecting sojourn times and crossings for continuous square integrable martingales were worked out. A proof of a version of Levy's down-crossing theorem was obtained and it is proposed to analyze this theorem for continuous square integrable martingales.

2. *Inference* : The Bartlett correction to the likelihood ratio statistics is classical, but the reason why it works is not well understood. existing proofs (e.g.,

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those due to Lawley or to Barndorff-Neilsen and Cox) either involve long calculations or assumptions involving ancillary statistics. A new Bayesian duality argument is being explored. It makes the Bartlett phenomenon transparent and leads to several new results. In asymptotic theory, results were also obtained on advantages of bootstrapping for moving average and autoregressive time series, problems of local asymptotic minimax estimation, analogues of the Bernstein- von Mises theory for the non-regular cases and classification problems when variables are subject to error. Further results on distributional optimality and second-order efficiency of statistics in the sense of Bahadur's efficiency were obtained. Asymptotic properties of m.l.e. from dependent observations and of Rao's test for testing hypotheses in discrete parameter stochastic processes were studied. Among other things, weak convergence of the residual median process was studied.

The variance of the minimum variance unbiased estimates in the multiparameter exponentials was identified as the limit of the Bhattacharya bounds, with applications to reliability theory.

An invariant SPRT was used for an identification problem of multivariate populations.

For given K normal populations with unknown means and common known variance, K. Alam (1970) suggested a two-stage procedure to select the population having the largest mean. He conjectured that under this procedure, the least favourable configuration (L.F.C.) would be the slippage configuration. This procedure has been subsequently studied by Tamhane and Bechhofer (1977, 1979) and Miescke and Sehr (1980) while in the latter another two-stage procedure has been given and similar conjecture is made about the L.F.C. Both these conjectures are proved.

3. *Design and Analysis of Experiments* : During the current year, work on incomplete block designs for asymmetrical parallel line assays and orthobalanced block designs was continued and simpler approaches to analysis of non-orthogonal data were outlined. Orthogonal factorial designs were discussed and the D-optimality of a class of saturated main effects plans was obtained. Work was continued on symmetric and asymmetric factorials, cyclic semi-regular G-D designs and optimal statistical designs with circular string property.

4. *Multivariate Analysis* : Research in probability inequalities, measures of dependence and concentration measures continued. Characterizations of bijective and bimeasurable transformations for bivariate normal variates were obtained. The concepts of correlation and regression for spherical and higher dimensional directional data were further studied.

5. *Sample Surveys* : Utilisation of auxiliary information was discussed in the construction of unbiased product estimators and in obtaining improved estimators for population mean based on double sampling. The problem of estimation of popu-

lation mean using multiple auxiliary information was further discussed. Domain estimation on two occasions was considered. During the year under review, consultation work on sampling designs for certain projects of other scientists of the Institute was done.

6. *Descriptive Set Theory* : Several measure-theoretic and category-theoretic results of Kechris, Tanaka and others at the first level of analytical hierarchy were generalized. Under projective determinacy, appropriate generalizations of these results to the higher level were obtained. It was shown that an effective hierarchy of Hinmanon W^ω does not exhaust subsets of reals recursive in E_1.

Some applications of descriptive set theory to measurable flows will be studied.

7. *Analysis, Geometry and Topology* : Silov resolutions for Hilbert modules were studied and unitary invariants found. K-spectral sets and completely K-spectral sets (respectively Contractive and Completely Contractive) for Hilbert space operators were investigated and in particular it was shown that Contractive operators need not be completely Contractive. It is proposed to study unitary representations (particularly the discrete series) of certain semi-simple Lie groups with the aid of the curvature technique introduced by Cowen and Douglas.

Intersection properties of balls in tensor products of Banach spaces were studied and the use of quasi-martingales in the study of closed bounded convex sets in Banach spaces looked at. The latter work will continue. In Ergodic Theory, previous work on a conjecture of Banach and Roxhlin was continued.

The problem of the existence and classification of contact structures on compact manifolds was studied.

In Complex and Hypercomplex Geometry, a new and explicit proof that every Teichmüller space of Riemann surfaces is a complex analytic manifold, was obtained. The technique of the proof was used to deduce some generalised Bers-type reproducing formulae. It was proved that $S^{2p} \times S^{2q}$ allows almost complex structure if and only if $(p, q) = (1, 1), (1, 2), (1, 3), (3, 3)$, (assuming $p \leqslant q$). It is expected that questions of local and global factorisation of moduli spaces of Riemann surfaces will be investigated in the coming year.

8. *Combinatorics, Group Theory and Graph Theory* : Previous group-theoretic characterisations of classical inversive planes were sharpened. The codes associated with generalised polygons were investigated with special emphasis on regular polygons. The non-existence of extendable biplanes of order 9 was established by coding-theoretic techniques, thus settling the first open case of Cameron's theorem. The conjecture that unitals must have prime-power order was disproved by constructing a unital of order 6.

In the area of applications of Graph Theory to Sociology, work continued on the study of within-strata and between-strata reciprocity in a network with a strati-

fication. Theoretical results have been obtained which give a measure of reciprocity in a network with weights attached to the arcs. These are currently being applied to data on migration between various states in India.

Delhi

The faculty members of the Unit have worked on several important areas in Mathematical Statistics, Probability, Quantum Probability, Linear Algebra, Functional Analysis.

The specific topics in which the work led to significant results, and is reported in publications listed later are : Cost optimal integration of surveys, partial orders induced by generalized inverse of matrices, permanents, schur functions, perron root, global univalence, stochastic games, perturbation of eigenvalues of matrices, unitarily invariant norms, mathematical theory of scattering, quantum stochastic calculus in Fock space, white noise calculus, non-linear filtering theory, finitely additive probability theory.

The work on quantum stochastic calculus in Fock space done at the Unit has received a lot of attention and was the focal theme of a Bourbaki Seminar in November 1986 by Professor Paul Andre Meyer. This work includes (i) introduction of stop times, (ii) a non-commutative version of Dynkin-Hunt property, (iii) Martingale characterization of classical, fermionic and bosonic Brownian motions, and (iv) Local times and Tanaka formula for Quantum stochastic processes.

Bangalore

Research was carried out in the following areas of mathematics, statistics and probability theory : harmonic analysis, functional analysis and the geometry of Banach spaces, Lie Group theory, limit theorems for urn models, large deviations theory, semi-stable measures and processes, diffusion processes and the theory of sample surveys.

Applied Statistics, Surveys and Computing

The Applied Statistics, Surveys and Computing Division is one of the Scientific Divisions of the Institute. The Division consists of two units : Computer Science Unit and Biometry Research Unit. The Computer Science Unit covers the areas of applied statistics and computer science. In addition, this unit has the responsibility of management of the Institute's in-house Computer System. The activities of the Division were in the following areas : (1) Teaching and Training, (2) Research, (3) Projects, and (4) Statistical and Computing consultancy.

1. *Teaching and Training* : Members of this Division participated in teaching B.Stat. (Hons.), M.Stat., M.Tech. in Computer Science, Operation of Automatic Data Processing Equipments, Intensive Course on Programming and Application of

Electronic Computer, Junior Certificate Course in Statistics (for Govt. Officers), ISS and ISEC Courses.

In addition, members supervised students of other universities placed at the Institute for practical training.

The division is responsible for organizing M.Tech. in Computer Science, Operaration of Automatic Data Processing Equipments, and Intensive Course on Programming and Application of Electronic Computer.

2. *Research Activities* : Research activities include both theoretical investigation of methodology and application of the existing methods to the solution of practical real life problems. A brief account of the more important research activities is given below :

Research Activities in Computer Science Unit

Sample Survey : Studies on optimal strategies and theoretical and practical aspects of Randomized Response Techniques have been advancing very fruitfully and have produced some outstanding publications including a book. In estimating finite population totals for sensitive variables optimal sampling strategies based on randomized responses have been investigated under certain setups. Alternative strategies when conditions of optimality may not hold have also been considered and compared. Variance estimates have also been proposed. Results under alternative setups have been derived allowing randomized responses as linear functions of quantitative data. with random coefficients.

An exact unbiased estimator for the exact mean square error (m.s.e) or the ratio estimator based on SRSWOR has been obtained. This m.s.e has been shown to be less on an average under a model than that of the ratio estimator based on Lahiri's scheme of sampling.

Earlier work on optimal double sampling strategies with varying probabilities have been extended to cover regression type estimators.

Some results have been obtained about IPNS technique to show the efficacy of choosing the replicates without replacement rather than with replacement.

In pps-circular systematic sampling a stipulated sample size can be realized only under certain conditions connecting the size-measures and the sampling interval. Such a simple condition extending a corresponding one for an equal probability CSS has been worked out.

Relative efficiencies under wide classes of models have been reported connecting unbiased regression and regression type estimators on the one hand and the classical biased regression estimators for a finite population mean on the other.

Results have also been obtained on the effect of sample size on unbiased sampling strategies estimation of a finite population mean under exchangeable general linear

model, robustness of some sampling strategies under polynomian regression models and on asymptotic properties of a generalized predictor of finite population variance under probability sampling.

Empirical studies in sample survey have been going on through a number of socially significant projects like techno-socio-economic conditions of fishermen in West Bengal, relative features of educations imparted in Vernacular and English-medium schools, socioeconomic classification of students in institutions of higher learning, design of block plans, etc.

Design of Experiments and Combinatorics : Sufficient conditions for optimal designs in the context of nested row column set up based on specific and universal optimality criteria have been worked out and some series of optimal designs have been constructed. Optimal designs so constructed in this set up are found to be always non-binary. The theory of optimality of designs in the presence of two factor interactions between nuisance factors has been developed and some series of universally optimal designs in the set up have been constructed. Construction problems of optimal designs have been taken up in the context of three-way elimination of heterogeniety with non-orthogonal incidence structure of the type a (J-I) for every two directions. A mapping called covering morphism between nets has been defined and its existence established. The method leads successfully to the construction of optimal designs called balanced youden hyper cubes in the multiway heterogeneity set up.

Recent research in combinatorics and related areas includes study of symmetric graphs related to existence and construction, characterisation of certain classes of graphs in terms of their eigenvalues, characterisation of certain designs in terms of the underlying graphs, study of error connecting codes that could be constructed with the help of some combinatorial structures, computer construction of group divisible designs and generalized Bhaskar Rao designs, computer generation of isomorphic subgroups of a graph etc.

Multivariate Analysis, Reliability, Inference : Asymptotic distributions (null and non-null) of test statistics for testing independence of two sets of variates with missing data have been derived. Large sample test of construction of confidence intervals has been proposed for the analysis of magnitudinal model in multivariate analysis. Further, the efficiency of prediction in future sample with correlated observations has been studied with an application.

Derivation of an optimum invariant test for testing independence of two sets of variates with additional information on covariance matrix is under investigation.

A new interactive procedure has been obtained for solving maximum likelihood equations arising in the analysis of covariance structures. A multivariate study of distributions of Zooplankton in space and time in Hooghly estuary has been completed. Results have also been obtained for estimation and testing of Toeplitz covariance

structures as well as convergence of maximum likelihood solution for structural analysis and patterned covariance matrices.

Results have been obtained on locally optimal tests for multi-parameter hypotheses, optimal tests for correlation coefficients in a symmetric multivariate normal population and tests under order restrictions in reduction of dimensionality. Generalizations have been achieved for Bartlett's and Hartley's tests of homogeneity using overall variability. Work on LMP test for the mean direction of the von-Mises-Fisher's distribution has also been reported.

Psychometry : Investigations have resulted in a generalized method of image analysis from an inter-correlation matrix which may be singular. Investigations on social attitude towards air pollution and scientists' attitude towards environmental pollution in and around Calcutta are in progress.

Econometrics : Theoretical studies are in progress in the areas of growth, estimation of parameters in variable models, income distribution and measurement problems in economics, empirico-theoretical investigations on optimization model for the allocation of available resources of ONGC and discovery cost of oil based on ONGC data have been undertaken.

Biostatistics : *Anthropometry, Human Genetics* : Some results have been obtained and some statistical tests have been designed for detecting non-random segregation of alleles from parents to offspring in the context of detection of linkage between a disease locus and marker locus. The test designed is much simpler and involves much less computation than the existing extensive computation-based tests. Studies on motor development of Bengali infants by nutritional status in the first year of life have been reported. Results have also been published on age and ethnic variation of haemoglobin level in 14 endogamous groups of Rajasthan, Panjab, Himachal Pradesh. Work is going on blood pressure data for finding the effects of such variables as education, occupation, smoking status etc. Work to-date indicates that standardized blood pressure values are unaffected by such variables. There seems to be strong correlation between blood pressures for certain pairs of relatives. Studies have also been made on adult body dimensions from some populations of Eastern Himalayas and have shown that attitude has a significant effect on body dimensions.

It is acknowledged that most of the contributions in this area have been made in collaboration with the Institute's Biological Sciences Division.

Pattern Recognition with Imperfect Supervision : Investigations have been proceeding on a series of problems on statistical pattern recognition where the training samples are subject to various kinds of supervisor imperfection. Two situations of such imperfection are : (1) a deterministic classification albeit subject to error ; (2) a stochastic classification. These situations arise in many applications of pattern

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recognition such as medical diagnosis and remote sensing. Two distinct aspects of this problem have been engaging our attention : (1) estimation of the discriminant function ; (2) efficiency of these estimates, that is, the information contained in such imperfect samples vis a vis a perfect sample. A realistic but tractable modelling of the situation itself has been a major problem.

The entire area of research is wide open. Estimation procedures have been developed via the EM algorithm and also efficiencies computed for somewhat simple models for both the deterministic and stochastic situations mentioned earlier. This work is continued and attempts are being made to develop more realistic models and estimation methods. These techniques are also being applied for analysis of data relating to wild life classification.

These techniques will have important applications in analyzing remote sensing data where invariably field classifications of training samples have supervision errors.

Stochastic Modelling : A stochastic model for earthquakes and prediction via b-values has been formulated on the basis of earthquake data from the North-Eastern region of India.

Fault-tolerant Computing, Graph Theory : The new concept for representing the test outcome for system diagnosis with the help of a special class of graphs termed as Diagnostic logic (DL) graphs was introduced by scientists of the Division in 1984. As a consequence it is being worked out presently whether there exists a diagnosis algorithm for a general T-diagnosable system having n-processors with $O(n^2)$ complexity which seems to be optimal.

Studies on the possible characterization of the inadmissible class of DL graphs for any T-diagnosable system are now in progress.

In-house Software Packages : The applied statisticians and computer software specialists of the Division have successfully collaborated in developing a graphic software package for graphical presentation of data and another package of parameter driven software for cleaning and tabulating survey data.

Simulation : The Biometry Research Unit and the Computer Science Unit have through collaborative work, developed a three-compartment model for glucose homeostasis. The model is more general and additionally takes into account the role of glucagon in contrast to the usual two-compartment models which consider only insulin and glucose. Work is in progress for further extension of the model.

Statistical Information System : Model of a computerized statistical information system relating to real estate data is being worked out.

Research Activities of Biometry Research Unit

Investigations on biochemical, immunological and genetical variables relevant to tropical diseases, specially malaria have been carried out. The laboratory-based data

obtained are very significant in terms of dieto-theraphy for the control of the disease. It is expected that this will also facilitate the assessment of epidemiology of malaria.

Studies of human glucoregulatory functions in health and disease are progressing. Data generated in our laboratory have been fitted to the mathematical models developed to gain an insight into the system concerned. The effects of anti-diabetic drugs at the immunoglobulin levels of maturity-onset human diabetics are being studied for the last couple of years. The results which have some diagnostic values suggest that the natural immunity, as far as IgM (a particular type of immunoglobulin) is concerned, may suffer as transient proliferation in the system of the maturity onset human diabetics subjected to a short-term treatment by oral drugs. Whether this proliferation is due to degradation or new synthesis of IgM is currently under study.

Visco-elastic properties of blood are being studied in relation to disease. Diseases are interpreted as stress conditions which change the laws of blood flow dynamics. The unit is in the process of developing mathematical models which may predict the degree of infection with viscosity of blood known from laboratory measurements.

Study on the influence of diet on cardiac ailments, specially on ischaemic heart diseases, has been progressing satisfactorily. A number of interesting results have been obtained in this area. Study on the influence of diets on the unfed, underfed and poorly fed young diabetic patients will be undertaken this year.

3. *Projects* : The Division executes various projects mainly at the request of Government/Semi-Government organisations. During the year under review, following projects were being executed and were in various stages of completion.

Externally funded Projects :

1. *An Optimization Model for the Allocation of Available Resources of ONGC* : ISI entered into a collaborative research project with ONGC in February 1986. It is expected to be completed within a total span of two years. Besides ASSC, the other divisions of ISI involved in the project are Social Sciences, Stat-Math and SQC and OR.

The project consists in developing (i) suitable models for estimating discovery cost and production cost for future projection and (ii) an optimization model for the allocation of available resources into two major areas of ONGC activities, viz., exploration and development.

A model for estimating discovery cost has been finalised and the relevant data have been collected. Data clearing and processing have been undertaken. The model developed conceptually will be fitted to the data and necessary modifications will be incorporated into the model in the light of the performance observed.

2. *Techno-Socio-Economic Survey of Fishermen in West Bengal* : (Sponsored by Govt. of West Bengal). The report was completed and submitted to the sponsors.

3. *A Pilot Study of Social Attitudes Towards Air Pollution in Proper Calcutta* : (A project sponsored by the Department of Environment, Ministry of Environment and Forests, Govt. of India, New Delhi). The problem of air pollution in Calcutta has become increasingly important in recent years. Most individuals living in different areas of Calcutta where there is air pollution know that it can be a nuisance as well as an expense, and they are familiar with the discomfort it can cause. In order to know the manner in which the community or people residing in an area conceives of air pollution in terms of (a) seriousness of the problem, (b) effect of air pollution on health and indoor air quality, and (c) knowledge of the nature and sources of air pollution, the present survey was undertaken.

The main purpose of the present study, therefore, is to obtain general and specific data concerning the level of awareness and knowledge of the sample residents regarding air pollution in Calcutta and their attitudes towards the quality of air and atmosphere of the locality where they presently live. The study also aims at investigating into the people's perception of the effects of air pollution, their opinions regarding the possibilities of combating it and their willingness to pay for its abatement. A knowledge of these social and psychological aspects of air pollution is likely to facilitate the continued education of the public and the implementation of any legal controls since any further programmes of air pollution abatement in Calcutta must recognize the present level of awareness and attitudes of the population for whom the actions are being taken.

For the present survey, the population of adults (18 years old and above) belonging to the selected 56 NSS urban blocks of proper Calcutta was subdivided into six substrata, namely, (1) Illiterate males, (2) Illiterate females, (3) Literate males, (4) Literate females, (5) Educated males, and (6) Educated females. Earlier these 56 NSS blocks were drawn randomly (at the first stage) from a total of 5,787 NSS blocks located in 19 pollution zones of Calcutta proper. These 19 zones vary in different degrees of air pollution. From each pollution zone, two or multiples of two NSS blocks were selected by SRSWOR method in the first stage. A fixed percentage (ten per cent) of adults was then randomly selected in the second stage from each substratum within a sampled NSS urban block. In the second stage also, the SRSWOR procedure was followed to select approximately 1800 adults for the present survey.

Data have been collected so far from about 1,740 respondents. From almost every block one or two sampled respondents could not be approached even after 3 call-backs.

These data are thoroughly being scrutinized for incompleteness, duplication, erroneous recording, missed entry, wrong coding and other errors. Special computer

programs have also been written to check the sequence of records, range verification and other internal consistency checks. Programs are also being written for obtaining an unbiased estimate for each NSS block of the proportion of adults who are aware of air pollution, their felt-concern about the problem, and their willingness to pay for the abatement. These estimates will then be suitably pooled to obtain an estimate for the Calcutta as a whole.

Preliminary analysis shows that about 80 per cent of the residents of Calcutta proper are aware of the air pollution problem. About 40 per cent of the residents think that the Government is taking some measures to control air pollution in Calcutta. About 90 per cent believe that it is essential to employ air pollution abatement measures in Calcutta as a whole.

Additional analyses using the BMDP package programme are being planned to establish relationships, if any, between *concern* about air pollution with a few personal socio-economic characteristics of the respondents and to classify the suggestions of the public concerning steps which need to be taken immediately to control air pollution in Calcutta.

4. *Positive and Negative Effects of Family Planning Adoption in West Bengal* : (Project sponsored by Indian Council of Medical Research, New Delhi). A good deal of KAP surveys have been undertaken in recent years in the area of family planning but little attention has been given to the motivational and perceived cost-benefit aspects of family planning adoption. The present study was undertaken with the hope that a better understanding of the adopters' perception, beliefs and attitudes with respect to the consequences of contraception would have practical implications for programme improvement as well as policy decisions.

The study was conducted on a sample basis in 10 villages located in Hooghly district and 24 Parganas district of West Bengal. A total of 308 adopters and 70 non-adopters were randomly selected using a two-stage sampling design. Personal interviews were canvassed from each of these 372 respondents to obtain data on their socio-economic and demographic status, health conditions, perception of health, economic, social and psychological benefit of family planning adoption, complaints of side-effects and other adverse consequence, if any, of contraception adoption, perceived advantages and disadvantages of family limitation. Two trained married investigators, one male and one female, canvassed the interviews. The data were processed in the Reyad EC 1033 computer mainly to generate a number of bivariate tables and for computation of measures of association and several univariate statistics.

One of the most important findings of the present study is the sampled respondents low sensitivity in perceiving the health benefits of family planning. Although the adopters are aware of the consequences of too many pregnancies on the mother's health, not many of them could perceive the health of the mother as an important benefits resulting from practicing contraception. The adopters seemed to perceive, on the other hand, some economic gains of family planning adoption more than non-

adopters. They thought that family planning adoption would probably help in eschewing the expenditure on children and help in saving more money.

Another important finding of the present study is the identification of fear and apprehension on the part of many sterilized cases so far as their personal health is concerned. The study clearly indicate that for the nonadopters, the public campaign with its great emphasis on the health benefits of family planning does not seem effective since the health reason for spacing and family limitation still appears to be obscure to most of them. It also seems doubtful if the perception of children's economic and practical utility has changed significantly in the expected direction.

Internally funded Projects

1. *Survey on a Socio-economic evaluation of education in English medium and Vernacular schools, Calcutta,* 1985 : This survey with a focus on the distinctive features, if any, among 544 English and Vernacular medium Secondary/Higher Secondary schools in Calcutta and its close neighbourhood was carried out in 1985. The schools were divided into 23 groups according to medium of instruction, sex, affiliation, level and reputation. Only 72 schools and 760 students completing classes, V, X and XII were sampled and surveyed. For each group the extent of efforts needed for upbringing, and studies, performances, inclinations towards various forms of career-building and views of guardians and grown-up students were examined. Standard errors of estimated averages and percentages were estimated through half-sampling. Socio-economic background of the families to which the various groups of students belong were also investigated.

The detailed findings are contained along with tables and diagrams in the Reports of this Survey which have been prepared.

That education is more expensive in English medium schools which again spend more than the vernacular ones which are cheaper is of course supported by this survey. Higher percentages of guardians of English medium schools are satisfied with the progress of their children than those of the vernacular ones. More students of the latter suffer from frustrations than those of the former.

Viewing TV and film is the most popular pastime for every category of students. The boys with few exceptions are interested in developing skills in fine arts and music. Details may be found in the report published.

2. *Survey on a Socio-economic classification of medical, engineering and post-graduate students, Calcutta,* 1986 : As a follow up of the Calcutta 1985 School Survey this survey has been carried out in order to investigate various aspects of the states of affairs connecting the final year medical, engineering and post-graduate students pursuing various courses of study in Calcutta and the adjoining Engineering College in Sibpur. Thirteen groups were formed over the various courses and about 850

samples of students were chosen and surveyed. Our interest is to examine the socio-economic backgrounds of the families to which they belong including a mobability over three consecutive generations, to study how they spend times in studies and extra-curricular activities, what plans supported by efforts they have to build their immediately before careers and their past academic records.

Standard errors of averages and percentages relating to various domains of studies are planned to be estimated through half-sampling. An innovation in this survey was that randomized response techniques was applied to get both qualitative and quantitative data and estimate relevant parameters.

The survey data are being analysed using computer facilities.

3. *Data Processing of the Block Plan Project* : The project is continuing.

4. *Model of a Computerised Statistical Information System in Relation to Real Estate Data* : A broad systems study has been initiated. A code list has been prepared. Negotiation is going on for getting a suitable DBMS package. Data bank system is characterised by the fact that the data produced in different community activities (e.g. property unit formation and registration) are recovered directly at source.

5. *Studies on the impact of common oral antidiabetic drugs at the Immunoglobulin and haptoglobin levels of maturity on set diabetic people* : The objective is to observe human immunity constrained by stress condition in the farm of disease with possible rectification by infusing oral drugs. Data have already been collected from Calcutta urban area and Jamshedpur industrial area. Preliminary analysis has pointed out on elevation of Immunoglobulin M which may have some far reaching consequences.

6. *Modelling viscoelastic properties of blood* : Diseases are supposed to be a stress condition which will change the general laws of Fluid dynamics in case blood is considered to be a non Newtorrian fluid flowing through veins. Mathematical models are being developed which will predict the degree of infection if viscosity of blood can be measured in the laboratory.

7. *Attitudes of Scientists and Professionals Towards Environmental Pollution* : Environmental consequences of population explosion and urban development are now evident to most residents of Calcutta proper. However, there is still no clear public concern that air pollution, water pollution and solid waste are some of the important environmental problems of the city which must be solved on a war footing. Are the scientists and professionals engaged in medicine and other health related areas also less concerned about the present state of environmental degradation in Calcutta ? If they are at all concerned, are they optimistic about solving these problems ? Is their concern about air pollution, for example, backed up by the willingness to pay for cleaner air ? What does air pollution mean to most scientists and professionals ?

What is their attitude towards air pollution in Calcutta ? Who do they think is responsible for the control of air, water and other environmental pollution in Calcutta? How much importance do they attach to the preservation of good air quality in and around Calcutta ? In their opinion, what needs to be done immediately to control air pollution in Calcutta ? These are some of the specific research questions which the present study attempts to answer.

Although the present study will deal with 'soft data' connected with scientists' attitudes, beliefs, opinions, values, and suggestions, these will have a great bearing upon policy decision making and socially imposed ordered change. By comparing the results from various probes into the scientists and professionals' attitudes, it is hoped to develop a general picture describing how an important section of the society feels about environmenental pollution and what they feel should be done about it. Their technical suggestions for the abatement of pollution in Calcutta can be very useful to the governmental agencies dealing with environmental preservation.

For the purpose of the present study, data have been collected so far from about 100 scientists employed in Bhabha Atomic Research Centre, Saha Institute of Nuclear Physics, and Indian Statistical Institute, Calcutta. These data are presently being processed manually for verification and editing. Additional data will be soon collected from All India Institute of Hygiene and Public Health, Calcutta and Jadavpur University. If the study is further extended, data will be also collected from the scientists working in Indian Association for the Cultivation of Science, and Calcutta University.

The main tool for the present study is a 23 page booklet containing 134 precoded questions purported to obtain information on each scientist's technical background, knowledge and awareness of various aspects of environmental pollution, his/her perception of the health hazards and views concerning various anti-pollution measures. Every scientists of the above-mentioned institutes will be requested to respond to these questions in the booklet and return.

The data gathered from the scientists will be processed in the ISI computer to generate bivariate tables as well as compute various univariate and multivariate statistics. Apart from studying the differences, if any, in the pattern of attitudinal structures, values, beliefs and perception held by scientists of one institution to another, an attempt will be made to ascertain within each institution the relationship between the scientists' academic and social position on the one hand and their perception of the phenomena of air pollution, their values for environmental preservation and their willingness to pay for it.

8. *Development of field research for tropical diseases on the basis of epidemiological techniques with four profiles : Socio-ecological, economic, nutrimetric, biochemical and immunological profiles to prevent, control and eradication of tropical diseases :*

Important features of the Project : A total of 149 blood samples (100 male and 49 female) from different age groups were collected from the three interior villages

of Singhbhum district along with their socio-economic informations in the State of Bihar during the year 1984.

Laboratory investigations on biochemical, immunological and genetical parameters for all collected samples were completed. Following highlights of some interesting findings presented in national conferences and also communicated in different publications.

A comprehensive summary of the data analysis have been highlighted here on some important findings so far generated out of a field research conducted in some villages of Singhbhum district in the State of Bihar.

Highlights of the important findings : (1) Malaria infection caused an increased levels of total protein, Eosinophils and Immunoglobulin (IgG). Thus the findings exclude the possibility of protein malnutrition but high values of eosinophils and immunoglobulin (IgG) and the low values of C_3 complement-component under malarial endemicity indicate the possible existence of an active parasitic infection with immunological consumption of the complement through the conventional pathway in the population. (Reported at the 73rd Session of the Indian Science Congress Association, 1986).

(2) Thymus and Bone-marrow associated lymphocytes responsible for producing the specific antibodies against malarial antigen are significantly low. Low value of thymus associated lymphocytes and simultaneously high value of immunoglobulin (IgG) under malarial endemicity further substantiate the persistent activation of thymic lymphocytes under constant stress on the immune system. (Reported at the 73rd Session of Indian Science Congress Association, 1986).

(3) Low range of cholesterol concentration of the tribal population under this study gives an apparent indication to an underlying metabolic connection. This finding is very important in terms of parasitic infection which is significantly different from chronic bacteriological onslaught where the cholesterol level is usually high.

(4) Analysis of data on child population (1 to 12 years) under this study revealed the lower levels of cholesterol results in swelling of the infection parameters. Further, the negative correlation between cholesterol and thymus associated lymphocytes pinpoints the fact that low cholesterol could be a measure of the intensity of the infection.

(5) It has been observed that low cholesterol level in serum bears positive indication of the susceptibility of the diseases (Malaria). Thus nourishment and survival of children seem to depend on this factor.

(6) Analysis of association with ABO blood-groups between nutritional and infective parameters were performed and the association of globulin with the individuals of A antigen as observed may have the clue to the mystry of a paradoxical situation reported by P. Inder Singh *et al.* that Anopheles mosquitoes having a tendency to bite individuals of A antigen could induce the infection through their greater susceptibility to malaria in comparison to other types.

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7. *Computer Simulation of Blood Glucose homeostasis* (1985-86) : The project was undertaken to test the mathematical model developed in order to explain glucose homeostasis in the face of an oral glucose challenge involving the two polypeptide hormones insulin and glucagon. The model when simulated on a computer convincingly explained the renewed 'biphasic secretion of insulin against glucose challenge. Hypothetical ingestion of glucagon and insulin resulted respectively in a stimulation of glucose and insulin, and glucagon and insulin. The results were supported by other workers in this field (Cramp and Carson—The dynamics of short term blood glucose regulation in Carbohydrate metabolism : Quantitative physiology and Mathematical modelling, Eds. Cobelli and Bergman, 349-367, 1981, Wiley, (Grichester).

4. *Statistical and Computing Consultancy*

Statistical and computational help have been provided by the member of this Division to a large number of research workers needing such help.

Physical and Earth Sciences
CHEMISTRY

During the year research work was conducted in the following projects :

(a) *Colloid Chemical Properties of Humus and its role in profile development* : Pursuant to considerable work done earlier in this unit on distribution and forms of humus in soils of West Bengal this programme was undertaken to study the role of organic matter in the horizon formation. This necessitated collection of virgin profiles of representative soils. Colloidal properties of the humus and chemical nature of non-humified organic matter were determined. Binding abilities of the respective substances towards metal oxides, clays and silts have also been measured. Distribution of humus down the profiles and changes in their chemical and colloidal properties from one soil horizon to the other are being measured and co-related to mechanical composition of the soil which too changes with depth. It has been found and reported that size of the humus colloid decreases rapidly from surface downward.

The results would provide precious information on profile development in soils.

(b) *Behaviour of surface Active Organic Substances in Solution and at interface* : This is a continuing programme of work in this unit. Adsorption and desorption of organic amphifiles on the surface of clays, primary minerals, metal oxides and sparingly soluble salts have been studied. Adsorption of the surface active substances from solution was shown to be influenced by their state of aggregation in solution and hence a relatively simple method for calculating the critical micelle concentration has been suggested.

Effectiveness of the surfactants to cause selective floatation and floccutation of clay-minerals from binary and ternary mixtures have been studied. The investigation continues.

a. *Digital Systems Research*

Research on Computer Science : Theoretical research works were under progress in the following areas.

1. *Fault tolerant computing* : Methods for generating test sets for fault detection in combinational and sequential circuits were derived. Detection of multiple faults for such circuits was also under study. Development of suitable diagnosis schemes for modular digital systems and microprocessor was under investigation. Sophisticated graphical models were developed which could take care of short circuit and bridging faults as well.

2. *Design for testability in LSI/VLSI* : Testability considerations in LSI/ VLSI were examined from a completely new angle. Research papers reflecting new design rules for inducing testability in LSI/VLSI circuits for detection of stuck-at and bridging faults were published. Methods like random testing, syndrom testing were developed so that these can be used more efficiently for testing large digital logic circuits. The study of inadmissible class of faulty functions in logic circuits were undertaken, the knowledge of which aids the design for testability. Testable design of CMOS/VLSI for detection of hard faults like 'stuck-open faults' had been proposed.

3. *System Diagnosis* : Some studies were made in the area of system diagnosability e.g., techniques for designing optimal self-diagnosable systems etc.

4. *Graph Theory and Combinatorics* : Several theoretical works on different problems of graph theory and combinatorics were undertaken. In particular, the graph isomorphism problem, the forbidden clique problem, Pascal graph, combinational problems involving Stirlings number of the 2nd kind, Fibonacci numbers and their engineering applications were worked out.

5. *Heuristic Search* : The recent techinques of heuristic search algorithms were successfully implemented for solving some difficult problems of message routing in a distributed computing network environment. Many interesting properties of Mobius graphs, De-Brujin graphs were explored regarding their suitability as computer networks. Admissible heuristic estimates can then be assigned to each processor node, which settle the optimal message routing problem in polynomial time complexity. Fault tolerance of these networks is currently under investigation.

6. *Parallel Architecture and Parallel Algorithms* : Parallel realization of numeric, non-numeric and graph theoretic algorithms were under study. In particular, the numeric power evaluation problem, the sorting problem, and the diameter evaluation problem in a symmetric graph, were implemented. Parallel architecture for improving the speed of a FFT processor had also been proposed.

7. *Network Architecture* : Design methods for realizing suitable interconnection structure for computer networks were under study. Properties such as extensibility, fault tolerance, routing under faulty and fault-free conditions were being investigated. A number of interesting structure had already been obtained and reported. A new cost-performance measure for evaluating network architectures were also obtained.

8. *Testing and Fault Tolerance of Multistage Interconnection Networks* : The versatility of MINS and the simplicity of their control have led to wide spread acceptance and use of these networks in multiple processor and communication systems. As a result, testing of the MIN is becoming a topic of increasing interest and research. The fault detection and location techniques and fault tolerant design schemes for a class of MINs, implemented with 2×2 switching elements, connecting a set of processing elements to a set of memory modules were under study. Some interesting results have been obtained for baseline network.

b. *Theoretical Physics*

During the period, the main areas of research undertaken were as follows :

1. *Particle Physics* : The role of conformal group and conformal reflection in the generation of the internal symmetry had been studied. The study of discrete symmetry and disconnected gauge group in various interactions were undertaken. The mathematical formalism of twister geometry and complex manifold were applied to study the internal symmetry of hadrons.

2. *Supersymmetry and Stochastic Field Theory* : The relevance of stochastic field theory in supersymmetric field theory was investigated. The Witten index was derived using the formalism of stochastic field theory at high temperature. Supersymmetry at high temperature was also studied using this formalism. The equivalence of Wess-Zumino supersymmetry and Parisi-Soulas supersymmetry was also investigated using the formalism of stochastic field theory.

3. *Quantum Gravity and Supergravity* : The role of complex manifold and twister geometry was studied to formulate the dynamics of $N = 1$ supergravity. It was shown that this leads to the $SL(2, c)$ gauge theory of Einstein-Cartan action. The relevance of stochastic geometry in supergravity and quantum gravity has also been explored.

4. *String Model and Lionville Field Theory* : The geometry of Polyakov string was investigated and it was shown that Lionville field theory could be realised from a complex manifold using twister geometrical approach. The topological aspects of nonlinear σ-model and Wess-Zumino term were investigated. It was also shown

that Polyakov fermionic string corresponds to 3-dimensional Ising model. Super-string at finite temperature had been investigated.

5. *Skyrmions* : Stochastic quantization of a Fermi field was studied and it has been shown that the skyrme term in the non-linear σ-model appears as a mani-festation of quantum condition. In this formalism fermions appear as solitons.

6. *Stochastic Field Theory and Quantum Statistical Mechanics* : A formulation of equilibrium condition in quantum statistical mechanics and finite temperature quantum field theory was developed in terms of stochastic field theory. In this formalism finite temperature quantum field theory appears as an extension of the $T = 0$ case. The finite temperature renormalization group equation has been developed.

7. *Nuclear Physics* : The static properties of nucleons were investigated on the basis of the skyrme picture of a baryon where the skyrme term has its origin in the anisotropic feature of the internal space.

8. *Quantum Fluid and Superfluidity* : The equivalence of hydrodynamical and stochastic quantization was studied. It was shown that the vortex line in a liquid drop corresponds to the classical fermionic picture. This is then studied to explore the dynamics of superfluidity.

9. *Plasma Physics* : Study of temperature effects on ion acoustic solitary waves in one ion and two ion plasma (both analytically and numerically) and study of relativistic effects on ion acoustic solitary waves using pseudo potential approach were carried out. Using the same approach the effect of non-isothermality on warm ion and multiple electrons in plasma was being studied both analytically and numerically.

10. *Supersymmetry and Field Theory* : Some application of theory of singu-larity in quantum field theory, SUSY phenomenology in high energy physics and cos-mic rays. Study of the energy levels of various potentials using supersymmetric methods, determination of the exact solutions of a number of potentials using supersymmetry.

11. *Dynamical Symmetry and Quantum Mechanics* : Application of symmetry principles, Lie groups, Lie algebras in quantum mechanics, study of solitons, study of nonlinear systems using Kac-Moody algebra, Lie algebra and the dressing operator approach, application of the $1/N$ expansion method using SUSY.

12. *High Energy Physics* : The research activities pertain, in the main, to various problematic aspects of the high energy collisions in space and in the laboratory experiments. Some very important problems in the field of cosmic ray physics and high energy nuclear physics have been dealt with. All this might help understand and/or unravel the mysteries about the ultimate constituents of matter and their properties.

13. *Space-time Metric Fluctuations and the Quantum Fluctuations* : The construction of the model of vacuum considering the probabilistic nature of the metric tensor in the micro domain was under investigation. This helps to understand the recent experimental results of neutron interferometry on wave-particle dualism by Rauch *et al.* Then the non-dissipative nature of quantum fluctuations had been studied with respect to the fluctuations of the metric. It raises new possibility of constructing the framework for quantization of Gravitational field.

To explain the recent results of Neutron Interferometry on wave-particle dualism in Quantum Mechanics it is necessary to consider the role of Quantum Potential in Stochastic Interpretation of Quantum Mechanics. In fact this quantum potential baffled the physicists for long time since the very formulation of De Broglie-Bohm-Vigier hidden variable theory. In 1986 the origin of this quantum potential has been traced back to the fluctuation of the metric of the space-time. The results have been published in *Physics Lett* A (1986).

14. *Vacuum Fluctuation and the Cosmological Problems* : The acceleration mechanism of ultrahigh energy cosmic-ray particles and their origin can be related to the fluctuating vacuum. The cosmological redshift can also be studied by the ether-drag produced by the propagating photon through the random Dirac ether. It encourages to reinvestigate the fired-photon hypothesis as proposed by several cosmologists.

O. Fluid Mechanics

1. *Study of Flow Field in a Hydrocyclone* : The laminar boundary layer on the conical surface of a hydrocyclone was studied when fine suspended solid particle are present in the liquid flowing through the cyclone. The equations of motion for the fluid as well as those for the suspended particles were treated by the method of Kurman-Polhansen. Different methods were tried to solve numerically the resulting simultaneous differential equations.

2. *Effect of a strong vertical vortex on the sandy bed in a river* : Vertical vortices are of common occurrence in rivers and are associated with destructive scouring behind bridge piers, behind diversion structures etc. Experiments were carried out in our laboratory by creating a vertical vortex by rotating a hollow and perforated circular cylinder in a water reservoir with bed of sand. Interesting results were obtained which would help in building up a mathematical model for the two phase flow analysis.

3. *Hydrodynamic Stability* : The Unit has studied the buoyancy and surface tension driven instabilities of a fluid layer which is heated from below and is subject to random vibrations of small amplitude. In particular, the vibrations are characterized by a white noise process and their effects on the onset of convection are investigated. This work is likely addressed to the crystal growth on a low orbitary space-

craft which experiences random vibrations due to spacecraft maneuvers, crew motions and mechanical vibrations etc. Apart from its practical significance, the problem has some methodological interest since the stability analysis is reduced to the study of a certain class of stochastic (or random differential equations. A preliminary result shows that the effect of random vibration is to destabilize the fluid layer heated from below. This work has been done under the project 'Thermocapilary flow phenomena and formation of surface waves'.

4. *Flow of Blood in the Cardiovascular System* : Blood flows in the lumen of arteries under normal conditions. But sometimes the abnormal and unnatural growth is formed in the lumen of blood vessel and disturbs the normal flow field resulting in arterial diseases. It develops at various locations of the cardiovascular system under unfavourable conditions. From the physiological point of view it is absolutely necessary to study the effect of this abnormal and unnatural growth on the flow characteristics of blood.

<center>ELECTRONICS AND COMMUNICATION SCIENCES</center>

Research Work

The unit continued to work in both theoretical investigation of methodology development and applications of the existing methods to the solution of practical real life problems in the fields of PR, Image processing, Artificial Intelligence and Signal Processing. During the period under review research was conducted in various areas as described below.

1. *Development of Methodologies for Pattern Recognition, Image Analysis, Shape Analysis, Image Understanding System and Computer Vision Technology* :

(a) *Studies in Statistical Feature Selection Methodologies* : As a part of the project on investigation of (i) indirect feature evaluation techniques and (ii) mathematical mapping criteria of feature extraction, studies have been made of some Mahalanobis distance-based feature evaluation criteria developed in 1984. They have been successfully applied for the selection of features in Speech Recognition.

(b) *Fuzzy techniques in Pattern Recognition and Image Processing* : Algorithms for feature ordering, clustering, Image Segmentation and Image quantitative measures have been developed using the concept of fuzzy measures. These measures are optimised in order to take decision when the patterns are ill-defined, unreliable and incomplete. Fuzzy transforms are also defined for colour image enhancement and segmentation.

(c) *Human Visual System for Image Analysis and Vision* : Characteristics for Human Visual Responses was found to provide suitable algorithms for discarding insignificant edge points for robot vision and for segmenting image for enhancement.

(d) *Machine Learning* : A generalised guard zone algorithm is developed for self-supervised learning when it is necessary to discard unreliable (doubtful) samples

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from the estimating procedue. Optimum dimension of the guard zone was being studied and the improvement of performance over the existing techniques was established. Convergence of the algorithm under different conditions was also proved.

(e) *Skeletal Maturity from X-rays* : A method for automatic identification of skeletal maturity (age of bone) from X-rays of hand and wrist was developed based on fuzzy set theoretic approach. Merits of fuzzy grammar over the conventional approach were also established.

(f) *Fuzzy Operators* : New fuzzy operators for union, intersection and inclusion have been defined with its possible extension for any kind of membership functions. Unlike the existing ones, these operators take the sense of membership function into consideration. These operators are also found to be generalised in the sense that the existing operators can be formulated from the proposed framework.

(g) *Topology Preserving Approximate Coding, Noise Cleaning and Smoothing for Two Tone Graphics* : In this project a new approximate coding technique was developed which is more efficient than conventional sub optimum block coding. A new controllable spatial noise filtering algorithm, whose characteristics could be set in one of the various forms depending on the type of input document was developed as a part of this project.

(h) *Gray Level Thinning Techniques Based on Distance Measure* : A new gray level thinning technique based on a weighted distance of the pixels from the background was developed. The result of this thinning was found to be satisfactory.

(i) *Symmetry* : Region symmetry had been detected using Cantor's pairing function. The technique finds the axis of symmetry on the basis of a measure which takes help of Cantor's pairing function. An arbitrary line is swept across the region and at each stage the measure is calculated. The line for which the minimum value is attained is taken as the axis of symmetry.

(j) *Coding* : A new coding scheme has been developed for two-tone image contours. The basic idea behind this is to extract some knots on the contour. The arcs between the knots are then coded using variable length code words. The decoding is based on the computer-graphics techniques. It has been shown that the compresibility is high and the visual difference between the original image and the decoded image is not objectionally sensitive.

(k) *Error-Correcting Templates* : Error-correcting templates lead to decrease of human legibility when the number of sensors used is small. Large number of sensors improves human legibility while maintaining an adequate distance among the various prototypes. But large dimension increases the classifier complexity. A dimensionality reduction technique has been developed so that classifier complexity is not increased and human legibility is also not sacrificed.

(l) *Character Recognition* : Some new methods for character recognition have been experimented with. Encouraging results have been obtained. Further development work on this is continuing.

(m) *Development and Formalization of Digital Planimetry* : The properties of Digital lines have been enumerated and uncertainty limits for predicting the analytic line from the digital lines have been defined. Affine Transformations on Digital lines and plane have been studied. Axiomatic foundation of Digital Planimetry has been investigated.

2. *Studies on Automatic Speech Recognition and Speech Processing* :

(a) *Development of Expert System for Isolated Word Recognition* : A basic model of Expert System for Isolated Word Recognition, using the concept of Association of Experts, has been developed and tested through computer simulation using Telugu Speech data. Very satisfactory results have been obtained.

(b) *Development of Lexical Data Base on Bengali Language* : About 20,000 strong Bengali Lexicon has been developed. Properties of the Lexicon is being investigated now using 12 different Alphabetic configurations. A tree structure is being developed for compact data-base organisation at the first stage for verbal forms.

(c) *Spectrographic Analysis of Bengali Vowel* : Spectrographic analysis of the Bengali words recorded for 3 Male and 3 Female speakers is in an advanced stage. The structural model of vowel sounds is almost complete. The analysis of speech data for other speakers is in a preliminary stage.

(d) *Development of Auditory Model for Speech* : An auditory model, namely Hierarchical Perception Linked Model (HPLM) has been developed for perception/recognition of formant based speech sounds.

(e) *Modelling of neural responses in auditory pathway* : A tentative model for neurophysiological signal processing in the subcortical region of auditory pathway has been studied. The simulation results show qualitative conformity with the psychoacoustical phenomena regarding perception of loudness and pitch, tone discrimination and the centre of gravity effect in perception of formants. The model also is in good agreement with the psychoacoustical FTC (frequency Tuning Curves) and threshold of hearing.

(f) *Investigation on Application of PR and Signal Processing Techniques in the Analysis of Hindusthani Music (in collaboration with SRA)* : Investigations are being carried out jointly with SRA into the analysis of Shruti in Hindusthani Music. The existence and significance of singing formants in classical singers are being investigated. Preliminary work has been started to study the feasibility of finding acoustic correlates of the various terms used in classical music. The work on analysis of sounds of Tanpura and Tabla are continuing. A signal processing equipment based on

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a general purpose HP microcomputer organisation has been procured at SRA. The software for pitch extraction is being developed for elaborate studies on Shrutis.

3. *Digital Communication, Signal Processing and Biomedical Engineering* :

(a) *Studies of the Fading characteristics of UHF/VHF signal* : Continuous recording of Bangladesh T. V. Signal at 189 MHz has been going on since 1985. Seasonal characteristics of these propagation studies have been reported. Some especial characteristics such as diffraction phenomena due to passage of some moving object have also been reported. The investigation of the role of thunderstorms/ Norwester in the propagation path have been undertaken. For these studies highly directive antenna systems have been designed and installed.

(b) *Some Studies on the Communication Properties of Computer Network* : Interfacing of μ-computer for online data acquisition work is going on for VHF atmospheric boundary layer data. The main idea of this work is to process the real data straight to a large computer which will be taken up at a later stage.

(c) *Indepth study of the Atmospheric Behaviour within 1 Km Range* : For the investigation of atmospheric boundary layer a sound radar system at the top floor of the Geology building has been installed and the back scattered signal are being recorded continuously. A design report of this system has been brought out and the occurrences of inversions and plume behaviour have been reported. The presence/ occurrences of elevated layer and atmospheric turbulence characteristics of the lower atmosphere within 500 mts range have been undertaken.

(d) *Studies of the Processing of Biomedical Signal* : Acquisition and processing of ECG signals were completed. Some classification studies of cardiac signal have been made and algorithms for certain classes of cardiac diseases have been developed. Work on the development of some advanced algorithms had been undertaken.

4. *Studies on Cybernetics and System Theory* : Research on application of fuzzy set theoretic approach in Management Science and other socio-economic systems was continued. A work on Fuzzy linguistic approach for decoupling of a large multivariate system in the reference of power plant operation had been under consideration. The Department of Electronics, Govt. of India appointed a task-force to study the feasibility of Artificial Intelligence for Thermal Power Plant under the Chairmanship of Prof. D. Dutta Majumder.

Theoretical investigation on Non-Von Newmann Computer Architecture in the light of next generation of computing systems was in progress and several papers on diverse aspects of such as Pattern Recognition, Computer Vision, Image Understanding System and Artificial Intelligence were communicated/ presented in conferences.

5. *Data Base Managements, Software Engineering and Computer Architecture:*

(a) *Computer Algebra:* Techniques have been developed for array manipulation overhead reduction for multiplication of dense polynomials. The results can be easily utilized to implement a fact polynomial multiplication algorithm in a high level language like PASCAL, FORTRAN or PL/T.

(b) *Perfect Hash Functions:* Conventional perfect hash function techniques are based on number theoretical techniques or string oriented techniques. Number theoretical techniques lead to problems of arithmetic overflow and multiprecision arithmetic. String oriented methods fail when there are several keys with same length. Linear maps have been proposed as perfect hash functions. Bounds on the size of the ordered difference sets and a characterization of incompressible keysets have been obtained. It has been shown how the existence of perfect hash function can be decided with the help of principle of inclusion and exclusion.

(c) *New Computer Architecture for Signal Understanding:* Research is in progress in the area of Rule-Based Systems (RBSs) which constitute the best currently available means for codifying the problem-solving know-how of human experts. In this context the proposed computer architecture was assumed to have the four essential elements, viz., rules, interpreters, translations and explanations.

6. *External Collaborative Projects*

(a) The collaborative research project between ISI and Sangeet Research Academy (SRA) on Hindusthani Raga Sangeet and on Indian stringed instruments was continued during the year under review.

(b) The joint project entitled 'Statistical studies on the tropospheric propagation for VHF/UHF and microwave link', sanctioned by the Department of Science and Technology (DST) for 3 years, is going on.

(c) Project of Electronics Commission entitled 'Application for pattern recognition and image processing techniques to geological mapping and mineral detection' is in progress.

(d) Research project under Defence Grant in Aid Scheme, entitled 'System and algorithm development for pattern recognition and shape analysis of objects of defence interest' has been undertaken.

(e) Fifth Generation Computer System/Knowledge Based Computer Systems (FGCS/KBCS) Research—Electronics and Communication Science Unit is a nodal agency (National Nodal Centre) with Prof. D. Dutta Majumder as Co-ordinator oum Project Director in the fields of pattern recognition, artificial intelligence, image processing and computer vision for Fifth Generation Computer Systems Programme of the Govt. of India.

INDIAN STATISTICAL INSTITUTE

Teaching and Training Activities

In addition to participation in the M.Tech. (Computer Science) and the M.Stat. (ASDA) teaching programmes of the Institute, the Unit imparted practical training to 2 students from the Benaras Hindu University, 4 students from the Shibpur B.E. College, 1 student from the Motilal Nehru Regional Engineering College, Allahabad and 3 students from the Jadavpur University.

GEOLOGICAL STUDIES

The following projects have been undertaken during the year under consideration : Study of Delhi metasediments of Central Rajasthan ; Proterozoic tectonics of the Somanpalli area, Pranhita-Godavari Valley ; Stratigraphy and sedimentation of the deformed as well as undeformed sequences of the Pakhal and Sullavai Groups ; Stratigraphy and sedimentology of the Albaka sequence and its comparison with the Pakhal sequence ; Geological controls of arkose formation in marine and continental environments ; Gondwana geology and palaeontology of the North-Western Pranhita-Godavari Valley ; Studies on a Late Cretaceous teleost fish, *Eoserranus* from Central India ; Examination of pelomedusid turtle remains from Late Cretaceous rocks ; Dinosaur remains (including egg-shells) from Lametas in Chandrapur District, Maharashtra ; Studies on Cretaceous micro-vertebrates ; Study of Triassic reptile from Tiki beds of Son-Mahanadi Valley ; Fossil amphibians from the Denwa Formation of the Satpura Gondwana basin and their bearing on stratigraphic correlation ; An empirical statistical study of the preferred orientation of lines in 3-dimensional space—applications in geology.

The above programme of geological research produced the following results which are of special interest :

1. *Tectonics and Stratigraphy* : (a) New ideas about stratigraphy and structure of the Delhi Supergroup of Central Rajasthan are in the manuscript stage of publication. (b) Recent findings relating to the geology of the eastern Proterozoic belt of Godavari Valley establish a group of deformed sediments including greywackes volcaniclastics and volcanics (Somanpalli Group) which is in striking contrast to the generally undeformed and mildly deformed platform sediments in a fold-thrust belt with syn-tectonic volcanics, mainly products of explosive evolution, indicate a convergent margin setting for the Somanpalli Group. Further research in this line is likely to make significant contribution to the understanding of the long term tectonic evolution of the Godavari Valley.

2. *Sedimentation and Stratigraphy* : (a) Aeolian and fluvial components of Proterozoic Sullavai Group (Godavari Valley) are being investigated. So far, there is no record of well documented aeolian deposits in the Proterozoic rocks of India. (b) Some enigmatic geological structures observed in the Proterozoic sedimentary rocks of Godavari Valley have been partially simulated in the laboratory with the

help of stationary vortex. Interaction of stationary vortex with substrate sediment is being investigated. (c) The origin, sedimentological and palaeoecological implications of the peloidal calcirudite/calcarenite associations of the Triassic Maleri Formation (Godavari Valley) have been investigated. (d) The geological mapping of the north-western part of the Gondwana outcrops of the Pranhita-Godavari Valley is now almost complete. The results are now being compiled. The work has led to the discovery of a number of new fossils of considerable interest.

3. *Special Project in Quantitative Geology* : (a) Quantitative analysis of 3-dimensional orientation data of crystallographic axes in naturally deformed quartzites indicate that available p.d.f. relating to directional data (e.g., Fisher, Dimroth-Watson or Bingham distribution) are inadequate for describing many axial data in geology (especially in the realm of petrofabrics). Investigations on the construction of a new family of p.d.f. compatible with monoclinic point group symmetry, which are under way, are likely to offer new tools for efficient handling of orientation data on a quantitative basis.

PHYSICS

Research activities

During the year 1986-87, the Unit carried out research activities mainly on the following topics.

(a) Determination of skin surface pH in normal population of various age groups—prepubertal, young adult, adult and people beyond 50 years of age—using a specialised gel-filled, flat surface micro-electrode and the effect of alkaline, acidic and non-ionic cleansers on the skin surface pH and the multivariate analysis of data obtained.

(b) Studies on the response of thermal stresses of patients suffering from plaque type common psoriasis of hand by cold and heat challenges at temperatures $0°C$ and $45°C$ respectively. Preliminary analysis of data indicates defects in vasomotor tone in psoriatic patients.

(c) The detection of the quantum of thermal sensory loss in cases of Hanseniasis and the quantum of restoration on medication by follow-ups is being continued. Pathological cases such as vitiligo and those involving hypopigmented patches are being studied to detect sensory anomaly for differential diagnosis of very early cases of Hanseniasis. A new model of 'Thermosense' has been developed where the least count is $0.1°C$ as against $1.0°C$ of the earlier model.

Novelty, significance and utility of the activities : Development of 'Thermosense' has led to detection of thermal sensory anomaly in early cases of Hanseniasis where the usual touch and prick method does not work. Further, the method is quantitative and the amount of sensory loss restored may also be quantitatively followed in appropriately treated cases. The detector is giving service to the Leprologists for

confirming the sensory loss. Practising dermatologists, Calcutta Skin Institute, Military Base Hospital, Barrackpore receive free service in this matter regularly.

The simplest experiment of 'Heat and Cold Challenge' in hand psoriasis has been instrumental to detection of defects in vasomotor tone, an information of importance to dermatologists in the light of unknown etiology of psoriasis.

(d) *Project Work*

On-going projects : The title of the on-going project is : Physical properties of Skin—Thermal and Electrical, being logical extension of the previous project : Mechanical properties of skin, on its successful completion. The project aims at, among others, quantitative measurements of cutaneous thermal sensory thresholds, loss and recovery ; studying the phenomenon of heat transport in skin and subcutaneous tissue ; determining the skin surface pH—normal and pathological and evaluation of skin surface hydration *in vivo* by electrical measurements.

Progress of the Project : An electronic device called 'thermosense' has been developed to measure quantitatively the cutaneous thermal sensory thresholds (TST) and is being usefully utilized in early detection of leprosy, particularly the facial lesions, by the amount of sensory loss inflicted already and the restoration of the loss on medication by follow-up.

The skin surface pH in normal population has been measured with SMT pH-90 using specialised electrode and the data so far obtained has been analysed statistically. The preliminary findings show that the mean value of skin surface pH (forehead) is 5.6 with male skin slightly more acidic than the female one. The dependence of skin pH on age is not significant. The exposed skin has lower pH than the unexposed one. Mapping of the skin pH at 20 nodal points is under way. Buffering action of the skin is also being studied by using commercial soaps and detergents.

Photometric measurements of sebum level of skin (casual level) both normal and pathological has also been made, and the correlation of the pH-values with sebum secretion rate is under study. Casual level of sebum in acne patients has been found to be much higher than the normal and it correlates well with the severity of the disease.

Another project work that has recently been taken up is : Methods of Control Theory and its Applications to Electrical Machines and Power Systems. The electrodynamic equations of power system have been transformed into linear multivariable state-space form and controllers, which stabilise and decouple the system, have been designed.

Teaching activities

During the year 1986-87, the Physics Unit gave one full semester course to the Second Year B.Stat. (Honours) students and the course contents included : Thermo-

dynamics, Statistical Mechanics, Special Relativity and selected topics of Atomic and Nuclear Physics.

FLUME PROJECT

The experiments conducted during the last few years are concerned with deposition from suspension under decreasing flow conditions. Flume experiments have shown that in heterogeneous suspension loads, *all* the grain sizes are involved in the process of formation of a bed when the flow velocity is decreased (Ghosh, Mazumder, Saha and Sengupta, 1986, *Jour. Sedim. Petrology*). The experiments in this series were conducted by step-wise reduction of flow velocity.

A new set of experiments carried out during 1986-87 indicates that the results are the same in case of *continuous* reduction of flow velocity also. Preliminary analysis of these experimental results show that the mean grain sizes deposited initial stage of sedimentation are coarser than those deposited later, although at each stage of sedimentation *all* the grain sizes were deposited from suspension. Clearly therefore, it is expected that the settling of the coarser grains was hindered while those of the finer grains were accentuated during deposition. The results of experiments under *continuous* flow deceleration, conducted during 1986-87 are being analysed.

Biological Sciences

ANTHROPOMETRY AND HUMAN GENETICS

1. *Study of Physical Growth of Bengali Children* : The children of Bengali parentage were not included within the purview of national survey on growth and physical development of Indian infants and children. The survey was conducted by the Indian Council of Medical Research (ICMR, 1972). Under the circumstances the importance of the study (cross-sectional in nature) which commences from 1980, may be well appreciated. For the purpose of this growth study the Bengali boys aged 7.0 to 16.0 years were measured at their true and verified ages following the recommendations of International Biological Programme (IBP). Age-specific growth patterns in twentyfive different physical characters related to total body size, trunk, upper limb, lower limb, cephalofacial and subcutaneous fat of the urban Bengali boys of Calcutta are obtained *for the first time* to indicate their growth status and norms. Some of the salient findings of the study deserve to be highlighted in the very interest of those who are concerned with the over-all problems of growth and development of the Indian children in the context of national planning and activities aimed towards health, nutrition and general well-being of the people at large. Important findings are as follows :

(i) Mean heights and weights obtained for Indian boys with verified ages in general, or for urban Indian boys with stated ages in general (ICMR, 1972) are lower

than those offered by the urban Bengali boys within 7.0 to 16.0 years. But heights and weights for Indian boys with stated sages belonging to the socioeconomic class I (upper well-off) agree well with those of the Bengali boys. The urban Bengali boys are thus in general taller and heavier than the national averages of India.

(ii) In heights and weights the urban Bengali girls (aged 5 to 18 years) are on average taller and heavier than their urban coevals in India at large (ICMR 1972). In height the Bengali girls of middle class families do not vary much from the Indian girls of socioeconomic class II (upper middle) but in weight the Bengali middle class girls conform well to the national averages shown for class III (lower middle) Indian girls of the same ages.

(iii) Maximum annual increment in height occurs between 12.0 and 13.0 years among the urban Bengali boys. Peak rise in height appears thus one year earlier among them than what is found among the well-off Indian boys (Raghavan et al, 1971). Peak weight increment in the Bengali boys comes, of course, one year later (14-15 years) than the well-off Indian boys (13-14 years).

(iv) The urban Bengali girls enjoy peak annual increment in height two years later (12-13 years) than what is shown by the well-off girls of India (Raghavan et al. 1971). On the other hand, the Bengali girls attain maximum annual increment in weight one year later than the well-off Indian girls (11-12 years).

(v) The age norms (medians) for both height and weight of the urban Bengali boys are noticeably lower than those obtained for the well-off Indian boys. In the context of national standards for height and weight the Bengali boys present, of course, higher median values (50th percentiles) than those shown for Indian boys at large. In fact, the typical Indian boys are shorter by about 4 to 5 cm, and again, higher by about 2 to 4 kg than the urban Bengali boys.

(vi) The urban Bengali boys present in lower ages (7-9 years) lesser arm fat than the well-to-do Indian boys, but they maintain higher values at the ages 10 and 11, the peak growth increment in arm fat being at 11 years.

(vii) The 50th percentile values for fatfold at triceps of the urban Bengali boys are a little higher than the 25th percentiles but slightly lower than the 50th percentile values of the well-to-do Indian boys.

(viii) Socioeconomic condition of urban families as influenced by per capita income and expenditure capacity, is observed to maintain significant effects on different physical characters of the Bengali growing boys and such effects are especially pronounced on height, weight, upper arm and calf widths and triceps and biceps fatfolds.

(ix) Effects of birth rank and sibship size are also significant on growth in weight, triceps fatfold and biceps fatfold.

(x) Effect of castes on physical growth is found to be of minimal order and only height (including sitting and spine heights) is significantly affected.

2. *Study of Health status and labour productivity* : The study on the relationship between tea labourers' health status and work output (amount of tea leaves plucked per day) does not seem to show any relation of work out put with any health measures studied, except being function.

3. *Sociocultural characteristics and community health status of the Lepchas of Darjeeling district, West Bengal* : The study on effect of religion, rural/urban habitat and socioeconomic developmental status among the Lepchas show that the Buddhist Lepcha children have lower physical growth curves than Christian ones, and the rural developed groups, both Buddhists and Christians, have lower growth curves than both urban and rural less-developed one.

4. *Impact of Altitude on human population* : A comprehensive review of biomedical data collected by us and other scholars on Himalayan populations as well as data on other mountain-dwelling population, show that high altitude *per se* may not have any exclusive effect on these traits.

5. *Survey of Avenue trees in Calcutta* : The main findings of this study are : of the 400 trees stretched along the 5 km—long avenue on B. T. Road, 142 were used for 205 different activities—economic, social and religious. Some 54 trees were used as parking places for rickshaw, hand-carts and tempos and also as bus shelters. Another 54 trees (neem and banyan) were used and venerated as places of worship. And the rest provided shade for diverse people like vegetable sellers, cobblers, motor—vehicle mechanics and barbers. The tree cover was totally inadequate and another 400 could easily been planted. Calcutta has insufficient area under tree cover. The trees play a vital role in the lives of people, especially those belonging to the weaker sections. While we have been concentrating our efforts on afforesting rural areas, there is an urgent need to have a national policy on urban tree planting.

6. *Cultural Ecology of Domesticated Elephants* : The study was conducted at Sonepur fair in Bihar in November 1986. The study reveals that if the present policies of the Government regarding conservation of Elephants is not changed, the cultural tradition of elephant keeping will disappear from the country. The study concludes that the policy needs to be modified keeping in view the societal, social and cultural needs.

Project Work

A. *On going Projects* :

1. *Study of physical growth of Bengali Children* : (a) Age-specific anthropometric data on 25 different physical characters related to over-all body size, trunk, limbs, head, face, and subcutaneous fat of about 1000 urban Bengali boys of North

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Calcutta were further examined in terms of some biosocial factors like parity, sibship size, standard of family living, caste, parental education and occupation to assess how these factors influence their growth. Report writing is in progress.

(b) First-hand analysis and statistical evaluation of growth data related to height, weight, and fatfolds of about 500 urban Bengali girls were completed and a report was brought out. Further data collection is in progress.

(c) About 250 rural Bengali boys aged 5-20 years and belonging to several castes in Kulpi block, Diamond Harbour, Sub-Division, South 24-Parganas district, West Bengal, were measured for 28 different physical characters to obtain family-based growth data. Data collection is in progress.

2. *Pattern of Fertility and Reproductive Wastages by parity and social-class* : Hospital data on 8500 parturient women and their pregnancy—outcomes over 5 years (1980-1984) were examined with respect to some biosocial factors like sex of newborn, maternal age, mother's religion, parity (birth order) and season of birth to highlight the problems of low birth weight in rural families of West Bengal. Report writing is in progress.

3. *Health status and labour productivity* : Field work and analysis are in progress.

4. *Effects of micro environmental factors on health in rural populations* : Analyses and writing up are in progress.

5. *Psychological stress and health of mother and child* : Field work is in progress.

6. *Sociocultural characteristics and community health status of the Lepchas of Darjeeling district, West Bengal* : Analyses and writing up are in progress.

7. *Impact of altitude on human population Phase II* : Writing up of a comprehensive report on data collected earlier is in progress.

8. *Biology of fluctuating and absolute dermal asymmetry in man and its relationship with longevity* : Scoring of the prints of 16 populations from South India and 5 from Orissa has been completed. Analysis of the data is in progress and by the end of 1987 a few papers will be written on the material.

9. *Genetics and diversity in dermatoglyphics of Chimpanzee* : A visit was undertaken to Tucson, and the scoring of the available prints has been completed. The report is being written.

10. *Indo-Soviet collaborative anthropogenetic survey* : Data collected in the survey in 1983 on South Indian populations have been extensively analysed and 6 papers have been published so far. Write-up of the remaining materials will be taken up in 1987-88.

11. *Genetic Survey of Some Endogamous Groups of Eastern India* : Laboratory analysis of blood samples from Assam and Manipur for about 18 serological and biochemical markers has been completed. Statistical analysis of the results have been completed. Writing up of reports have been completed.

12. *Genetic Epidemiology of Blood Pressure* : 10 big multigenerational families of agricultural communities comprising about 500 individual in the rural coastal area of Midnapur district has been surveyed for blood pressure, anthropometric measurement, social and cultural information etc. The statistical analyses of the data is in progress. A similar family survey is now being conducted amongst the Marwari community in the Barabazar area in Calcutta. 10 families covering about 89 individual have already been surveyed.

BIOCHEMISTRY

1. *Distribution of intestinal parasites in West Bengal* : Collection of intestinal parasitic data in relation to regional, ecological, ethnic, socio-economic groups, diet, etc., is needed in order to evaluate the physical, biological and cultural causes and consequences of this major health problem and changes in the prevalence over time, if any.

The area of West Bengal has been divided into six ecological zones, considering, temperature, humidity, rainfall, altitude, soil type, etc., and out of these the "Sandy Coastal" zone has been completed in this period covering six villages. About 450 faeces samples were examined for the investigation of intestinal parasites. Also socio-economic and health oriented informations collected from the subjects. The data of coastal zone is under process.

2. *Genetic epidemiology of blood pressure* : Genetics has some important role in determining hypertension as also the environment and many other factors. To study the relative influences of the determinants of hypertension this study is being carried out.

Blood pressure reading were collected in a village population considering pedigrees of ten families and about 500 subjects on coastal area of West Bengal. Anthropometric measurements (skin fold thickness), pulse rate and interview data on demography, occupation, education, use of tobacco and alcohol were also collected. Similar study has also been started in an urban population in Calcutta. Different biochemical markers in blood will also be estimated in this area. The work is in progress. The study is being conducted in collaboration with Prof. B. N. Mukharjee (AHGU) and Dr. P. P. Majumdar (CSU).

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BOTANY*

1. *Crop Improvement* : Multilocational trials were conducted with '*Subarna*' variety, and indigenous *aman* paddy Selection by Botany Research. (ii) Fertilizer trials were conducted in Baruipur farm indicating importance of compost in rice cultivation. (iii) Performance trial of different rice cultivars in Giridih are suggestive of better selection when Biological yield i.e. total dry matter production is taken as an important criterion rather than Harvest Index alone.

2. *Studies on Intercropping* : (1) Varietal mixture trials on paddy were conducted in the Kharif season and (ii) Interspecies trials with different cereal legume combinations were studied in the rabi season of the year under review in Giridih Farm. The results suggest Wheat-gram, wheat-lentil and oat-lentil as the promising intercropping combinations in that agroclimatic region.

3. *Studies on Underutilized Crops* : This project so far conducted in Leaf Protein Research Unit has been included in Botany Unit as the project leader has been transferred to the said unit. During the last year studies on winged bean were undertaken to evaluate the performance of different selections in Giridih using maize as an intercrop to use it as a natural support. The results suggest winged bean as a very potential vegetable pod yielding crop with outstanding nodulation capacity and a good intercrop combination for maize. Grain amaranth another underutilized crop of C_4 type, studied last year, indicated that this high yielding grain type nutritious pseudocereal is suitable for introduction in this region.

CROP SCIENCE**

Research activities were carried out for the following projects :

1. *Exploratory work on the family palmae (Arecaceae)* : Anatomical and morphological studies of leaves, stems and roots of certain palms were carried out during the period. The growth habit of certain palms after their germination were also studied. *Nypa fruticans* flourishes in the swampy regions, in english it is termed 'water palm' or 'water coconut and is known thus because of its very close association with water. Unlike most mangrove species that inhabit similar tidal swamps and where viviparous germination is the unique mode of propagation, Nipa has no such special adaptation for germination. Fruitlets of nipa start germinating as they float on tidal water along the estuaries and settle on the banks of rivers during lowtide. They develop into plants often in close proximity to already established clumps. The fruitlets are able to float in brackish water and get tossed by the ebb

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and low tides. They sprout and eventually are drifted to the sea-shore or banks of rivers and canals where they strike roots on the wet silt and establish into young plants. During the study it is found that nipa could be grown even far away from the sea coast and with sweet water. The study has revealed that nipa seeds can germinate outside swampy conditions as well. The fact that even without brackish water the seedlings can be made to survive and thus would facilitate transporting of seeds and seedlings to far off places. Every year considerable land area is being swallowed by the sea water. The banks of main rivers often erode due to lack of strong embankment. To provide cement or granite lining over the affected stretches of coastline and banks of estuaries and rivers is extremely expensive. With the aim of providing an alternative, a live-protective barrier of nipa along the coastlines and banks of estuaries and rivers can be introduced.

2. *General problems of levo and dextro-rotatory situations in plants and animals* : Data have been collected with reference to frequency of stomata per unit area, their length on the abaxial and adaxial epidermis, width of individual epidermal cells, and stomatal index between the left and right halves of juvenile leaves of left handed and right handed seedlings of arecanut and coconut.

3. *Introduction of oil palm (Elaeis guineensis) and improvement of coconut (Cocos nucifera) production through introduction and selection of high yielding cultivars in the Sundarbans area of West Bengal* : Seedlings of coconut and oil palm have been raised in nursery beds at Manmathanagar, 24 Parganas, West Bengal from the respective high yielding varieties obtained from Central Plantation Crop Research Institute, Kasaragod and Palode. If these two palms can be grown profitably in the Sundarbans area, it will go a long way to meet the requirement of the edible oil in this region.

4. *Histopathological study on the mango (Magnifera indica) malformation and their correlation with insects and mites* : Some more samples of leaf and stem galls of mango were collected and the anatomical studies were continued.

EMBRYOLOGY

Research activities during the period of report were on the following :

1. *Mathematical and Stochastic Modelling of Development, Differentiation and Morphogenesis during Embryonic Growth* : Mathematical and stochastic models of cellular development, differentiation and morphogenesis were further investigated. Studies of nonlinear multiple-loop biochemical control networks with respect to stability, bifurcation and limit cycle oscillations were continued. The mechanism of differentiation and morphogenesis was mathematically investigated. The importance of negative cross-diffusion in the process of morphogenesis and pattern formation was established. Stochastic models of transcription and translation were further

developed and modified. New methodology and procedures were explored to investigate the mathematical and stochastic models.

2. *Loligo Embryology* : The collaborative work with Laboratorie Arago, France on Loligo embryology was continued. By microinjecting radioactive amino acids in the yolk, light was shed on the problem of embryonic nutrition in cephalopods.

3. *Pheromones of tigers* : This project in collaboration with Bose Institute and funded by DOEN was based on rearing a tiger cub and collecting marking fluid of adult tigers at Nandan Kanan, Orissa. During the year many samples were analysed and molecules like free fatty acids and hydrocarbons were pinpointed with the help of various biochemical techniques. The possible role of bacteria in the production of pheromones is being investigated.

ENTOMOLOGY

Seasonal distribution and relative abundance of the Yellow Fever Mosquito (Aedes aegyptii L.) in two suburban localities—Baranagar and Dum Dum : One hour collection was made in a day. Observations were made in summer only. Collection of larvae of mosquitoes (and sometimes the adults also) were made from already known spots. Larvae of *Aedes aegyptii* were never found during this summer although one or two adults could be collected with difficulty. This is also the case with *Armigeres*. *Anopheles* larvae were rare. More than ninety per cent of the collections (both larvae and adults) showed the presence of *Culex pipiens fatigans* which seems to be the dominating species of mosquitoes during summer.

LEAF PROTEIN

1. *Screening and agronomic studies of various plant species including fodder crops, weeds (water and terresterial weeds) and tree leaves* : (i) The results of the screening work done on 16 local aquatic plants have already been reported. As the N extractability percentage is an important criterion for primary selection of promising species, nine plants with a total N extractability above 25% were taken up for their proximate analysis. Work done in laboratory showed that leaf protein prepared from azolla had the highest N content of 9.4%. Ipomea, Pistia, Limnanthenum and Mikania had N in the 7-9% range, while the rest had N values below 7%. The ash content of leaf proteins prepared from Commclina, Lemna, Enhydra and Hydrilla was very high and it was observed that the N content was found to be proportionately lower in plants with higher ash level. The in-vitro digestibility of leaf proteins prepared from Ipomea, Pistia, Limnanthenum and Mikania were the best and the general range observed for the nine aquatic plants were between 43.6 to 57.7%.

Analytical work on the fat, polyphenol and β-carotene content of these species is under progress.

The water weeds samples collected on 28th October 1986 (Botanic Gardens) and 10 March 1987 (Joka area) were brought to the laboratory and washed thoroughly. A known amount of all the plant samples were dried, ground and kept for analytical work. Samples of weeds which were procured in large quantities were also tried for leaf protein extractions. Those samples were Salvinia, Ceratophyllum, Nymphaea, Nelumbium, Ottelia and Lippia. The proximate analysis of leaf proteins prepared from these plants are in progress.

Side by side, samples of four aquatic weeds, namely, Allmania nodiflora, Marsilea Quadrifolia, Enhydra fluctuans and Ipomea reptans are being collected from the same pond (for each weed) at monthly intervals to assess their seasonal variations in proximate and mineral compositions.

Standardization of procedures for mineral estimates by the flamephotometric method is also being carried out.

(ii) Four plant species (Mangrove) from Sundarbans have been brought—they are being identified and then subjected to standard LP extraction methodology for assessment.

(iii) Eight terrestrial weeds after standard LP extraction practices, their LPC were analysed for CP which varied between 36.58% to 54.36%. NO_3 and oxlate content of these weeds have been also analysed. These weeds are : Urena lobata L, Heliotropium indicum, Mikania scandens wild, Nicotina plumbaginia folia, Solanum torrum, Euphorbia hirta, Leonurus sibiriens and Croton bonplandianum.

(iv) Twelve tree leaves were collected from ISI campus and analyzed for LP extraction. Except 2-3 species where total N extractability was around 25%, others did not give good results. This may be due to their age and character. However with the help of forest department a few more species will be analysed to select promising tree leaves for detailed studies.

(v) In 1985-86, effect of N level with herbicide trial on cauliflower cv. snowball 16 demonstrated enormous effect of on-growth and yield of cauliflower. Extracted LP yield from tops varied between 73-452 kg/ha. The highest level of nitrogen (240 kg/ha) with herbicide oxyfluorofan E.C 0.240 kg a.i./ha had produced 253.89 quintals of curd, 416.9 q of fresh tops and 452.12 kg of LP per hectare. There was no significant variation between oxyfluorofan E.C. 0.120 kg and 0.24 a.i. kg/ha.

2. *Microbiological aspects of Leaf Protein Research* : (i) Chemical composition of fungal biomass obtained during fermentation studies : In our recent study COD and BOD determinations were carried out in numerous leaf protein by-product (whey) before and after the growth of various filamentous fungi without adding extra nutrients to the substrate. A number of fungi such as *Curvularia lunata, Cladosporium herbarum, Rhizopus nigricans, R. arrhizus, Trichoderma viride, Fusarium moniliforme, Aspergillus japonicus, A. niger, A. terreus, A. flavus, Penicillium chrysogenum* were

employed in different fermentation studies. Biomass obtained from different media were analysed for their chemical composition. Harvested mycelia were analysed for ash, nitrogen, crude protein, total carbohydrate and lipid content. Maximum protein (28%) was produced by *Aspergillus flavus* and *A. terreus* in turnip whey. Whey nutrients were properly utilized by two fungi. Protein production was minimum (19%) in winged bean whey by *Curvularia lunata*.

(ii) Soil screening programme : Soil screening programme was initiated in this laboratory to obtain some promising, native microbial strains. Soil samples obtained from different localities were dried and diluted samples (10^{-3}, 10^{-4}) were plated in Potato-Dextrose-Agar (for fungi), Nutrient Agar (for bacteria), Glucose-Asparagine M_{18} for streptomycete). Ten soil samples are at present under study and twelve fungi, ten bacteria, and five streptomycete have been isolated. These strains will be utilized for suitable microbial utilization of fibre and whey.

A large number of microorganisms, especially fungi are reported to have cellulolytic activity including such fungi as *Trichoderma viride* (Reese *et al*, 1950) *Chaetomium cellulolyticum* (Chahal and Hawksworth, 1976) and *Sporotrichum chermophilia* (Coutts and Smith, 1976). The search of new cellulolytic organism is in progress.

(iii) Microbial utilization of whey (Deproteinized leaf juice as a medium for growth of *Rhizobium*) : The growth of *Rhizobium leguminosarum*, *R. phaseoli*, *R. meliloti*, *R. lupine*, *R. japonicum* was studied in two leguminous whey samples. The deproteinized juice was further fortified with $CaCO_3$, K_2HPO_4 and sugar (mannitol/ sucrose/molasses/malt extract) to get better cell yield. Rhizobial strains were maintained in yeast extract-mannitol slants and cell concentration of all the inoculum was adjusted to 5×10^8 cells/ml. Rhizobia thrive well and multiply in deproteinized juices of leguminous plants. Most of the Rhizobia are capable of utilizing mono or disaccharides. If standard yeast extract-mannitol medium is compared with that of winged bean whey supplemented with 0.01% K_2HPO_4, 0.2% $CaCO_3$ and 0.75% molasses, it is evident that growth is same in both the case of *R. legumino sarum* where as in case of *R. phaseoli*, *R. meliloti* and *R. japonicum*, the cell count was even higher in supplemented winged bean than that in *YE-M* medium.

3. *Effect of some oils, fats and bile salts on growth and lipase production by streptomyces sp.* L_t. : The lipase production by *streptomyces* sp L_t was found to increase when triobin, rapeseed oil, cholesterol and lard were added to the culture medium Olive oil, coconut oil and tween-80 were effective in stimulating growth of the *strepto myces*. The lipase was extracted from the broth and purified step by step, firstly by ammonium sulphate precipitation, (60% saturation, which was determined by trial and error) followed by dialysis and concentrating the dialysed product using polyethylene glycol and lastly by column chromatography on DEAE cellulose. The lipolytic activity of the broth was measured by titrimetric method using olive oil as

the substrate. The control medium for lipase production contained 7.5 peptone, 10.0 soluble starch, 3.0 $NaCl$ and $MgSO_4$, H_2O 1.0 g/L. 5 ml enzyme extract was made from 50 ml broth after growth for 4 days. Total lipase activity of the extract varied with different fortifications from 1000 units/ml to 1460 units/ml. One unit of activity of the enzyme was defined as μ-moles of fatty acids/ml/hr.

4. *Influence of different C-sources and N-sources on enzyme and biomass production by a soil streptomycete* : Different C-sources (glucose, lactose, inositol, starch, xylose, galactose, maltose, fructose and sucrose) and N-sources (potassium nitrate, ammonium sulphate, ammonium nitrate, sodium nitrate, alanine, phenyl alanine, lysine, threonine, methionine, asparagine, tryptophan), were studied for their effect on enzyme and biomass production by *Streptomyces* sp. L_1. Glucose and fructose as carbon source and asparagine and lysine as N-sources increased enzyme yield. For biomass production, glucose and fructose as C-sources and lysine, phenyl alanine, methionine, threonine and asparagine as N-sources were found to be promising.

5. *Effect of inoculation of growth and nodulation of winged bean* : A rhizobial strain was isolated from effective pink nodules of winged bean (cv Lucknow-1). The seeds of the cultivar were inoculated with this strain. Inoculated and not inoculated seeds were sown separately in experimental plots. Harvests were made at one month interval. It was found that inoculation had always increasing effects of plant characteristics like dry weight of plant and nodules as also nitrogen and starch contents in shoots and roots respectively.

6. *Effect of rhizobial inoculation of seeds and addition of nitrogen, potassium and phosphate in factorial combination on growth and nodule parameters of winged bean (P. tetragonolobus)* : Winged bean (cv UPS 31) seeds were inoculated with a strain of Rhizobium isolated form nodules of winged bean (cv-Lucknow 1). Seeds were sown in the experimental pots. Urea, potash and superphosphate were added to the pots. Control and maintained with uninoculated seeds. Harvests were made at interval of one month. Dry matter content of root and shoot, number of leaves and nodule, nitrogen contents of plant parts, leaf area per plant were recorded for each treatment. Further studies are in progress.

7. *Biochemical and Nutritional studies of different Leaf Protein Concentrates and other fractions from water weeds, byproducts leaves-tree leaves, etc.* : For biochemical studies following has been achieved so far :

(i) Polar and nonpolar lipids in the 3 different LPS namely unfractionated, chloroplastic and crytoplasmic to understand the storage and shelf life problem. The studies were made in three water weeds namely Eichhornia—Crassipes, Limnanthemum cristatum and Ipomea reptans.

(ii) The three LP fractions from root crops viz. turnip, radish, beet and cauliflower were analysed for their protein, carbohydrate, lipid and ash, protein

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extractability and biochemical parameters like total and available lysine and digestibility.

(iii) Then these three fractions of LP from crops like Allmania nodiflora, mustard, hybrid napier and cabbage were studied for their P extractability, protein, lipid, starch, ash and free polyphenols. Also pepsin pancreatin digestibility, available lysine and methionine.

Work is under progress to evaluate different LP fractions from 16 water weeds for their chemical, biochemical and nutritional parameters. Five of those water weeds are being thoroughly analysed for mineral and β-carotenes besides the other factors. Steps are underway to assess these five by rat feeding trials to compare in vitro and in-vitro results. Similar studies will be carried out in LPC's from tree leaves and byproduct leaves.

A through study especially in weeds for anti-nutritional parameters like nitrate, oxalate, saponins, phenolics/tennins, lactins, trypsin inhibitors, plant oestrogens, phytic acid etc. has been taken up. Already oxalate and nitrate contents have been analysed in eight weeds.

8. *To evaluate and to demonstrate technical and economic feasibility of LP production and to circumvent other practical problems like shelf life, recipes etc. to bring LP to marketable level.* : After about 3 years and many meetings with the personnel of the DST and IIT, the project has been sent to IIT on 9.3.87 for onward transmission to the DST. Favourable comments of the DST are already recorded in the preamble.

(ii) Preliminary work and 'thought process' and correspondence is underway to select manually operated machinery suitable for rural sites where electric power is not available.

(iii) Keeping the cost and essential amino acids along with LP composition in mind many recipes are being worked out to get recipes which will be cheaper, containing more protein and better quality than dal protein.

(iv) The main body of the project was divided into two parts and presented in SGVR Seminar held in 1985 at ISI and in 1986 in the B.H.U. respectively. Wide acceptance and appreciation of the project has been very encurging.

9. *Conditions to achieve maximum yields of tops and roots in sugarbeet crop and complete utilization of all the parts and working of economic aspects in comparison to the conventional practice* : The analytical data on the LP extraction from the tops were partitially available. Therefore for presentation of results on this aspect of the experiment further work is in progress to retrieve the data.

However, other results indicate that effect of four nitrogen doses—60, 120, 180 and 240 kg per hectare and cultivation practice like earthening up and

non-earthening up on the yield of roots, tops, gross sugar and sugar percentage were observed. Maximum top yield of 51.33 t/ha at 90 days with 180 kg N/ha and earthing up was noted. Root yield and gross sugar yield of 49.44 t/ha and 5.54 t/ha respectively were recorded with N_{150} E treatment. Sugar concentration increased till 120 days of the crop and then decreased rather sharply. Highest sugar per cent was recorded with N_{90} NE at 120 days. Statistical analysis of the data to work economic optimum condition for the sugar and LP yields are underway.

Meanwhile, *a pilot plant to produce ethanol, pectic, leaf protein and animal feed* in the from of another experiment was laid in the winter months of 1986-87. Nitrogen doses, this time, have been kept at 60, 90, 120 and 150. Though the crop could be sown very late (26 December) due to non-availability of seed and failure with germination in first effort we expect reasonable results.

Social Sciences

DEMOGRAPHY*

Research activities during the period of report were on the following :

Plan Projects :

1. *Reconstruction of Indian life tables* : The object is to fill in the gap in the series of Actuarial Life Tables for the decades 1911-21 and 1931-41, originally constructed by Kingsley Davis. Considering also, that a uniform methodology was not adopted for the construction of Actuarial Life Tables, a study had been completed for reconstruction of life tables for all the eight decades (1901-11 to 1971-81) and for projection for the decades 1981-91 and 1991-2001. A logit linear model suitably tuned to Indian mortality pattern was used. The estimations of probability of dying in the infant and childhood ranges were dealt with separately.

2. *Socio-economic and demographic trends since* 1951 *with specific reference to disparities across social groups* : The project had been taken up jointly with the Economic Research Unit of the Institute. The object is to study demographic imbalance which has resulted in social tension, economic hardship and ecological mismanagement in selected regions of Eastern India (e.g., Manipur, Tripura). Further, the study aims at evolving a general framework for analysing the underlying factors responsible for discontent and social tension in several regions of India. The analysis of Tripura part of the study has been completed.

3. *A Study of Educational Wastage (Stagnation and Drop-out) at Primary and Middle School Levels* : The objective of the study is (a) to estimate the expected

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student life—a problem of methodological interest, (b) to find out educational wastage differential by various demographic, socio-economic and other related factors, and (c) to identify and evaluate various factors as determinants of educational wastage. In respect of rural areas of the district of 24-Parganas in West Bengal, three cohorts of students—two for those enrolled in class I in 1978 and 1982 and one for those enrolled in class V in 1977— were selected through sample schools for follow-up studies through school record and household interviews. The sample survey employed for the study consist of three schedules—one for school, one for teachers and another for students household. The field work is complete except for possible revisits that might be necessary during scrutiny.

4. *Some Determinants of Infant Mortality and the Latter's Impact on Fertility* : The study undertaken in the district of Hooghly, West Bengal, aims at understanding the phenomenon of high infant mortality and its effect on fertility.

The base line survey among 3,000 active couples in both rural and urban areas was completed during the year 1985-86. The data entry to computer preparatory to final tabulation is in progress. An effort would be made to prepare a preliminary report on the basis of the findings.

Non-Plan Project :

1. *Demography of ageing* : *Indian experience* : The study focuses on the phenomenon of ageing in India, using data from the national census series. It considers several indicators of population ageing and examines the dynamics of changes in the population age structure over a period of hundred years. The ageing of the population of India occurred mainly from the apex rather than from the base because of the decrease in mortality in the older age range and almost unchanging fertility. The prospect for the ageing process is that India will enter 21st Century with more than 75 million old people.

2. *Estimation of demographic parameters for India* : The study consists of an attempt to improve the estimation of basic demographic parameters for India by the application of recently developed demographic techniques to the same data sets. It provides alternative estimates of fertility, mortality and nuptiality and also of the population in sex-age categories.

3. *Family welfare performance statistics* : *problems and issues* : The object of the study is to monitor and evaluate family welfare performance statistics in India. The study identifies various sources of error in programme statistics and suggests methods of improvement. For example, an approach to evaluating the reliability of service statistics prevalence levels is to correlate them with fertility levels in the respective states with suitable time lag. Several methods of evaluation (such as quasi-experimental design, couple-years of protection, regression analysis including path analytic model, etc.) of the family welfare programme are also discussed.

4. *Child Mortality and Environmental Differentials in a Newly Industrialised Indian City—Durgapur in West Bengal* : (A collaborative project with the School of Oriental and African Studies, London). The object is to obtain information on child and infant mortality differentials and other basic socio-economic data among working class families living in two contrasting settlement areas.

It is intended to examine the hypothesis that there is a need for public sector interventions in the field of health planning and health related infrastructure to ensure that the whole population is adequately serviced in these new town localities.

The pilot study for the project has been completed.

5. *Estimation of Adult Mortality in India* 1971-81 : Adult mortality level for India has been estimated by using two different methods—one based on information on widowhood in the census of India 1981 and the other based on census age distributions in 1971 and 1981. Life table functions for both the methods have been presented. The results based on two successive censuses are highly plausible and consistent. The widowhood method gives reasonable estimates of male adult mortality whereas the female adult mortality is severely underestimated. It appears remarriage among Indian males may not be negligible as is normally assumed.

ECONOMIC RESEARCH

The Economic Research Unit continued to be engaged in research work covering different fields of theoretical and applied economics and in teaching and training at various levels. A brief account of these activities is given below.

Research Activities

The research activities of the Unit during the period under review covered fields like economic theory, national and regional economic planning, level of living and poverty in India, besides methodological studies in theoretical and applied econometrics.

1. *Economic Theory* : Research work has been going on over the past several years on the history of economic thought. This has now been widened out of its earlier preoccupation with classical and post-classical economic theory. The two other major themes of research pursued are social accounting and price formation mechanism. Investigations were also continued (i) on the analytical foundations of Keynes' 'General Theory' (ii) on social choice theory and game theory, covering topics like ethical indices of income mobility, migration and welfare, aggregation problems in welfare economics, measurement of inequality, horizontal inequity, social mobility etc., (iii) on different models of international trade, and (iv) on dual economy and other kinds of aggregative models.

2. *Economic Planning* : Studies were continued on different aspects of planning models, in connection with the projects sponsored by the Planning Commission. Analytical studies in the area of regional planning were continued partly in connection with Ph.D. dissertations. Special mention may be made of two studies, one of optimal programming for spatial movements of foodgrains, and the other on VLS versus OLS regression techniques with applications to regional analysis. Further, attempts had also been made to obtain a generalised formation of multivariate spatial indices for formal regional analysis—both Kendal's optimal index formulation and Pal's equity index formulation can be shown to be just special cases of this generalised formulation. In fact, the scope of this generalised formulation lies in the flexibility of choice of the representativeness multiplier vector m and the simultaneous consideration of both this vector and the extended weight vector w^* that is to be determined to know the aggregate representation ρ and the aggregating weight vector w of the constituent variables.

3. *Poverty and Level of Living* : A number of studies had been completed or had continued on various aspects of poverty and level of living in rural India. One study was concerned with examining the impact of changes in food prices on rural poverty. In another study, partly based on NSS data, an attempt was made to compare the time trends in level of living in rural India revealed by large-scale sample surveys and the corresponding findings of the micro-studies conducted by anthropologists. A survey project had been initiated in rural areas of three districts of West Bengal with a view to assessing the changes in level of living, if any, since the early 70's.

4. *Methodological Studies in Econometrics* : A considerable amount of research was carried out on various topics in econometrics, e.g., (a) formulation of new systems of demand equations and their performances vis-a-vis other wellknown systems in the analysis of the Indian data, (b) use of Box-Cox transformation in acreage reallocation among competing crops in agriculture, (c) analysis of multicollinearity and Ridge regression, (d) development of an information theoretic approach to measure causality, (e) formulation of a new index for measuring business concentration and (f) study of biased estimators in presence of misspecification in single equation regression models.

Project Work :

The members of the Unit had undertaken quite a number of projects. Some of the projects were completed and final reports submitted during the year, while others were on-going. These projects are described below in brief.

(a) "Relative price of food and the rural poor : the case of India"—a project sponsored by the ILO (final report submitted). This study, largely based on the NSS data, made a comprehensive analysis of trends in level of living and in the incidence of absolute poverty in rural India since the 50's.

(b) "Studies on multisectoral planning models"—a project sponsored by the Planning Commission, Govt. of India ; final report was submitted.

(c) A project entitled "regional model for agriculture", had also been sponsored by the Planning Commission, Govt. of India with the primary objective of building up more realistic national plan on agriculture from regional models on yield functions, cropping pattern and optimal distribution of irrigation and fertilizer within different states. The work in respect of Karnataka had been completed and the analysis of the data on Haryana had started.

(d) The survey work connected with the project entitled "measurement of changes in rural level of living" was completed. The objective was to *revisit* sample villages and households in rural areas of three districts of West Bengal which were covered in the 27/28th rounds of the NSS and to collect data on different aspects of level of living. The main idea was to assess whether there had occured any appreciable change in the level of living of given households over this period.

(e) The Institute had undertaken a project in collaboration with the Oil and Natural Gas Commission (ONGC) with the purposes of developing (i) a model for the estimation of discovery cost and (ii) an optimisation model for the allocation of resources between exploration and exploitation of hydrocarbon with a view to achieving some specified targets. The project would continue also in the following year and scientists from ERU and other Divisions of the Institute had been participating in the project. A theoretical model on the estimation of discovery cost had already been developed and the empirical testing of the model was in progress. The preliminary work on the development of the optimisation model had also been taken up.

(f) Work on a large-scale project for "statistical-linguistic analysis of Tagore's works" was taken up in collaboration with the Institute for Study of Languages and Cultures of Asia and Africa (ILCAA), Tokyo and with Dr. B. P. Mallik, who became associated in an honorary capacity. ILCAA began to transcribe Tagore's works on magnetic tapes and to supply word counts and the other results to the ISI groups for further linguistic and statistical analysis. Three poetical works were taken up during 1986-87—Gitanjali, Sandhya Sangeet and Prabhat Sangeet—and aspects like compounds used with grammatical categories, compound verbs used, relative shares of tatsama words, tadbhava words etc. began to be studied.

Teaching and Training Activities :

Members of the scientific staff shouldered the responsibilities of teaching economics, economic statistics and econometrics in the degree and other courses conducted at ISI, Calcutta. There were in addition a number of Junior/Senior Research Fellows working for the Ph.D. degree. Several members of the faculty participated in the teaching programmes of other universities and institutions, e.g., the M.A. Course in Economics, Calcutta University ; B.Tech. Course in Applied Chemistry, Calcutta University, etc.

INDIAN STATISTICAL INSTITUTE

PLANNING (DELHI)

During the year, the Unit's research activities covered both economic theory as well as applied economics. Much of the work even in economic theory was connected to problems or issues related to the Indian Economy in particular and more generally to economics of Third World Countries.

A group of researchers formulated macroeconomic model for analysing the implications of a wide variety of policy instruments such as dual pricing and quantity rationing. Another popular topic was in the area of agrarian markets and institutional developments. In particular, the institution of "interlinkage" in markets was studied in depth. The general conclusion of such studies seem to imply that "interlinkage" is a rational response when markets are not perfectly developed. Other areas of work in pure theory included game theory and its applications to economics, the economics of multinational enterprises, dual economy model. Studies in regional planning were also conducted during this period, with the aim of understanding and evaluating the spatial structure and processes of developmdnt at the state and intrea-state levels.

Empirical work in the Unit was carried on vigorously in several different fields. These include work on the data base of the Indian Economy, construction of state-wise consumer price index numbers, estimation of poverty in India, problems relating to casual labour and unemployment in India and women's studies.

Interactions with other academic institutions were carried out in several forms. Members of the Unit participated in many conferences both within and outside India and the second I.S.I. Conference on Economic Theory and Related Mathematical Methods was organised in February, 1987. Over 60 participants attended the conference. The Unit also benefitted from the presence of many visitors at different times in the year.

ECONOMIC ANALYSIS (BANGALORE)

The Unit's main interest of research work during the period under report was in the following broad areas :

1. Poverty and levels of living ;
2. Consumption Inequalities ;
3. Measurement of Extreme Disparities ;
4. Agricultural Modelling.

NATIONAL INCOME

The National Income Research Unit (NIRU) continued to be engaged in researches on different aspects of national income and related aggregates with special

reference to the Indian economy at national and regional levels. The faculty members also participated in the teaching of economics and economic statistics in different courses conducted by ISI at Calcutta.

The following is a brief account of the research activities of the Unit during the period under review.

The report on the sample survey of wage earnings of workers in small-scale manufacturing enterprises in Calcutta is nearing completion. The material collected in the household survey of unaccounted components of human capital formation conducted in the previous year has also been analysed and the report is being finalized.

A study has been undertaken with a view to evolving an overall index of development which takes account of different economic and non-economic indicators and then utilizing it to study the development of different countries over the past three decades. The report is completed.

The most accepted measure of economic development—GNP per capita—suffers from the problem of representativeness. It does not indicate to what extent the needs of the people have been met through continuous employment, adequate protein and calorie intake, better schooling for children, adequate medical care, supply of safe drinking water, arrangements for recreation etc. An indicator of level of development of a country must take into account many economic and non-economic variables. In one study, composite indices were built using 13 variables for 70 countries in 1960 and 95 countries in 1982. It appeared that inequality in terms of such a composite index declined over time while that in terms of GNP per capita increased over the same period.

The theories regarding distributive shares of income tends to reflect the situations of the developed economies and the conclusions may not apply fully to the developing economies. In one study an examination was made of changes in the share of labour in such an economy like India's by sectoral breakdowns and also in the aggregate over the period from 1960-61 to 1982-83

One study examined consumer price indices (CPI's) for three groups of population—agricultural labourers, industrial workers and urban non-manual employees—for sixteen states and for all-India during 1960-61 and 1980-81. Inter-state variation in the CPI's was examined. Attempt was made, using principal component analysis, to construct an overall index for each state and to study the trend of this overall index.

Project Work :

Progress of the on-going project : Study on the estimation of capital formation and national income in India : 1857 to 1900 : This project has been completed and a paper drafted on the basis of the estimated series has been accepted for the 20th

Conference of the International Association for Research in Income and Wealth to be held in Rome, Italy, 23-29 August 1987.

One of the major causes and effects of economic development of a country is the gradual increase in aggregate and per capita stock of reproducible tangible assets like construction, machinery and equipment, inventories and net soil improvement. The growing stocks of these reproducible assets are essential pre-conditions for raising the level of economic productivity and for reaching the desired rate and level of growth of domestic or national product.

The objectives of this study have been to find out the changes in the structural relations of different economic aggregates on the basis of these two of the core series and also to find out their impact on economic growth, both total and per capita.

It cannot be gainsaid that there is a vast body of literature dealing with per capita income at that period but few scholars tried to resolve this controversy producing direct estimates. Attempt has been made to undertake this marathon task of probing the existing statistical materials and prepare direct estimates of national income and capital formation in India.

The estimated series of national income and capital formation in India have been analysed along with other comparable aggregates to judge the objectivity of the estimated series. Attempts have been made to find out how the two series are functionally related.

LINGUISTICS

The programme of research in the areas of Fundamental and Applied Linguistics was continued in the Linguistic Research Unit, during the period April 1986 to March 1987. The research projects in the Unit may be grouped under three main headings, namely :

 I. Studies on the phonetic structures of major Indian languages and application of the results in the areas of : (a) Speech Pathology ; (b) Second Language Acquisition ; (c) Cultivation of Mother-tongue.

 II. Studies on acquisition of language and bi-lingualism., and

 III. Application of statistics in linguistic problems.

 I. *Fundamental Research* : A survey of the articulatory and acoustic structure of the Oriya language is in progress. Sound-spectrographic recordings of Oriya speech sounds have been analysed and final analyses of quantitative data, with the help of the sound-spectrograph, will be carried out. Fundamental research on the suprasegmentals of Bengali, Hindi 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) Measurement of the threshold of Bilingualism.

In continuation of its pioneering efforts to study the acoustic phonetic structure and suprasegmentals of major Indian languages, a number of comparative studies are planned, based on spectrographic data on Indo-Aryan and Dravidian language as well as Serbo-Croat and English. Studies on pitch and intensity are being carried out, utilising the Visi-Pitch, recently installed in the Unit.

PRE-CENSUS POPULATION STUDIES*

The Pre-Census Population Studies Unit conducts quantitative historical studies on India and works on the project on population of India prior to 1872 in collaboration with the Office of the Registrar General, India. Two Volumes have been published, one Volume entitled Report on the Population Estimates of India, Vol. 3, 1811-1820, Part-B, India, is in the Press and another Volume for the period 1801-1910 has been submitted to the Registrar General, India.

The following are the plan projects :-

(i) Economic changes in rural India :

    (a) A study of 200 villages in Bengal, 1850-1981 ;

    (b) Trends of Socio-Economic changes in 4 districts, Burdwan, Broach, Gorakhpur and Bellary, in India, 1801-1981.

(ii) Pre-census atlas.

Progress of the plan projects :

Data were collected from Central Record Room of Directorate of Land Records of Survey for more than 3000 villages of the districts of 24 Parganas, Nadia, Murshidabad, Malda, Birbhum. Bankura. Purulia, West Dinajpur, Darjeeling for 1846-1850 on a ten percent sample basis. There is a map for each village and statistical data on population by religion and by division into agricultural and non-agricultural, area, house type (Kuchha and Pucca), plough and other implements are inserted. Among these 1080 villages have been identified on a current list contained in the respective District Census Handbook. Supplementary data at mauza level have also been collected from settlement Halka Office, Collectorate Record Room, Tauzi Assessment Office and settlement Circle Office of the respective districts.

On a thorough scrutiny it has become possible to find out the Jurisdiction List number of 645 villages only varying in between districts from 8 to 199 villages. A systematic sample with random start of 200 villages has been drawn with due weight

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* Pre-Census Population Studies Unit and Demography Research Unit merged to form Population Studies Unit with effect from 1 June 1987.

to proportion of villages in each district. All relevant data published, up to 1985 available from official sources will be collected for a follow-up study.

There was progress of work in all the 4 districts. Burdwan and Gorakhpur-Data on population with various classifications, such as age, sex, caste, religious breakdown, occupation and land distribution showing area under cultivation, irrigated land, area under different crops, and materials on other aspects have already been collected and tables have been prepared. The final report will be prepared shortly.

Broach and Bellary : Similar data are being collected for these districts also. Archival materials on population and agriculture available for Broach district from the Maharashtra Archives and those for Bellary district from Madras State Archives are being processed to prepare final tables. Tables have been prepared for Broach district to show urban population for 1820 to 1875. A comparative wage table is prepared to show the wages of labourer, carpenter and bricklayer for 1774, 1844, 1864 and 1875.

12 maps on Pre-Census atlas are being published in the Report on the Population Estimates of India, Vol. III Part-B, India.

PSYCHOMETRY

Research activities :

    1. *Development of a forced-choice scale to measure certain managerial skills* : The scale is ready and the report has been published.

    2. *Development of a non-verbal intelligence test for hearing imparired children* : The test is ready; only data are being collected from different parts of India for development of norms. Data from Calcutta, Delhi, have been collected. Collection of data from Madras and Bombay is in progress.

    3. *Consequences of socio-economic deprivation on academic achievement* : Survey of the relevant literature is over. A report on the pilot study is available. Data are being collected for the final study, and intermediate report is being written. So far, data from 250 subjects are being collected for the final study.

    4. *Predictive validity of the forced-choice scale of managerial skill* : Literature review has been carried out. Data collection has also been started.

    5. *Popular views on mental health* : Part of data was computerised and analysis has been completed. A report in this connection is awaiting publication.

    6. *Assessment of minimum learning in primary education* : Data have been collected from 1700 Class IV students reading in 57 primary schools (Rural—30, Urban—16, Municipal—8 and Govt. School—3) selected by systematic sampling methods in the Hooghly district. Besides the three achievement tests (Bengali,

Mathematics and Environmental study) data have also been collected on the socio-economic status of the guardians (guardian/parent schedule) and the relevant information on the concerned schools (school schedule).

Some special tests were administered to the pupils (260 in number) of a selected group of 26 schools to assess their general intelligence (Raven's Progressive Matrices), span of memory (digits forward) etc. Their reading ability was also recorded.

At present scrutiny and scoring of the data collected are in progress on the basis of recommendations made in the workshop "on problems of evaluation and analysis of educational data", organised by the Unit on 10-12 March 1987.

7. *Measurement of aptitude and interest for Class VIII students* : Differential aptitude and interest for Class VIII students of Loreto School, Entally, was conducted for screening of pupils into different streams at the request of school authorities. On the basis of their scores on aptitude and interest and also on the basis of their performance records (examination marks) students were categorised into different streams. A paper in this connection is being prepared.

SOCIOLOGY

Research and Project Activities :

1. *Potentialities and Constraints of Development : A Social-Ecological Approach* : The primary objective of this study is to explore the scopes and barriers to development of symbiotic relationship between societal groups and their natural resources in a specific ecological zone. The area under study is Simlipal forest range in the district of Mayurbhanj, Orissa. The field survey is just completed.

2. *Social Ecology of Sundarban* : The objective of the study is to explore the possibilities and potentialities of a symbiotic relationship between the societal groups and their natural resources.

Relevant available materials from the existing sources have been collected and the first phase of the field work has been completed.

A preliminary report on some aspects of the study is available in the Unit. Final report writing stage is in progress.

3. *Ageing of population in India* : The project was started in 1985-86 and is likely to continue upto 1989-90. Two field surveys in the district of Giridih (rural), (i) Health care of the elderly, and (ii) Perception of the young and adult persons about the old, were completed in early 1986. Since then data cleaning, coding, code posting and transcription of data were in progress. In the meantime a technical paper was prepared for presentation in a national conference on ageing, at Hyderabad.

4. *Demographic, Social and Economic Aspects of Population Ageing* : This was a collaborative study with the CICRED (Committee for International Cooperation in National Research in Demography), Paris. Data collection from secondary sources for the preparation of a country monograph began.

5. *Problems of Afforestation* : This was undertaken jointly with the Economic Research Unit of the Institute. Surveys in West Bengal and Bihar villages were completed earlier. Data processing and transcription continued· and a draft report was prepared.

6. *Factors disintegrating non-formal networks of help and cooperation in rural society* : *An exploration into villagers' perception* : Report is under preparation.

7. *The peasant movements during the early phase of colonial rule in Bengal* : Objective of this project is to study the variations in the context of peasant risings which challenged the colonial rule from the middle of the 18th century onwards with special reference to the Hindu-Muslim relations, which have played an important role in Indian society.

Collection of data from the State Archive and records preserved in the district collectorates of West Bengal is continuing. Two research papers have been prepared and published on the basis of the collected data so far.

8. *Value systems and social change* : The study seeks to identify socio-cultural and political value patterns among various societal groups in two sample villages in Purulia to find out how and to what extent these affect the programmes of rural development.

A report based on first phase work has been prepared and circulated among the interested scholars and experts for their valued comments as a preparatory to publication process. A research paper based on the study has been presented at the Anthropological conference in Calcutta. Detailed analysis of the entire data is in progress for preparing the final report.

9. *Child Labour* : *An exploratory enquiry in Giridih, Bihar* : Usually young workers below 14 years of age are known as child labour in India. Percentage of such workers (vide Census 1971) to total workers is nearly 6%, which covers nearly 5% of total children population. In Bihar percentage of child workers to total workers, and to total children are 6% and 4% respectively.

Various industrial/commercial establishments had been covered to gather data from employees including child labours.

10. *New pattern of leadership and social action* : *An exploratory enquiry* : The objective of the enquiry is to study the process and background of the new generation of leaders emerging in the villages along with the recent socio-political changes in the State. Field-work has been completed and a report is under preparation. The framework of analysis is graph-theoretic, along with the collaboration of a scientist of Statistics-Mathematics Division of ISI.

11. *The study of registry marriage and the impact of legislation in West Bengal* : The objective is to study the role played by the marriage legislation in changing the character of marriage institution in West Bengal. The study attempts to identify the groups involved and explore the social, economic, cultural and psychological forces behind their social action with an emphasis on their pre and post-marital adjustment.

Detailed information have been collected through field survey in and around Calcutta. These are being processed and tabulated for detailed analyses. One paper has been revised and submitted for publication.

12. *A study of educational wastage (stagnation and drop-out) at primary and middle school levels (in collaboration with Demography Research Unit)* : The objective of the study is to (a) attempt an estimation of expected 'life' of a student—a problem of methodological interest ; (b) find out educational wastage differential by various demographic, socio-economic and other related factors, and (c) try to identify and evaluate various factors as determinants of educational wastage. The study will be confined in the 24-Parganas district of West Bengal.

The sampling of schools has been completed and field work is going on.

13. *Perception of political movements in contemporary Bengali literature* : Source materials are being collected from the State Archive and different libraries and secondary source materials.

Statistical Quality Control and Operations Research

1. *General*

Statistical Quality Control and Operations Research Division was set up by the Government of India in 1952 under the technical guidance of the Indian Statistical Institute. The Division continued with its objectives of promoting applications of Statistical Quality Control (SQC) and Operations Research (OR) methods, training and education of executives, inspectors, trainees, operators, consultative services to industrial establishments and research in SQC and OR and allied methods. The activities of the Division are organised through comprehensive programme under the broad classification of (i) promotion, (ii) training, (iii) plant services, and (iv) research.

1.2 Promotional activities were continued in public and private sectors. Inplant training of technologists, trainers, inspectors and operatives etc. including the training programme in local language and services continued to have support from a number of public and private sector organisations. The units of Bharat Heavy Electricals Ltd.,—Hyderabad, Hardwar, Bhopal and Jahansi etc. and Hyderabad and Calcutta units of Hindustan Cables Ltd. continued as servicing plants of the Division besides a number of other plants both in public and private

sectors. Several organisations were added to the list of servicing plants during the period.

1.3 The Division undertook new project assignments during the period apart from rendering consultative services to factories already on its roll. The Division has so far produced about 950 specialists and over 800 research papers, technical literatures, manuals etc.

1.4 The Division continued liaison with various academic and technical institutions, productivity councils, societies and several other national and international bodies by way of its academic, technical and promotional activities.

2. *Service*

2.1 During the period under review 11 plants joined the SQC service scheme. 68 technical reports were sent to factories and 3 factories discontinued. A total of 71 factories are taking consultative services as in March 1987.

2.2 Special studies involving applications of SQC and OR methods were taken up in the selected areas : optimisation of process parameters in the manufacture of pesticides ; yarn quality improvement through better performance at blow room ; improving quality of winding holders ; statistical control of varnishing process of magnets ; control of rework at—welding in circuit breaker and rotor assembly ; comparison of performance of pumps for different impellars and diffusers ; evolving receiving material acceptance inspection procedures ; rejection analysis of electrical parts ; control of variation in the dimension of catch holders ; limit switches and wall thickness of rotors ; control of hunting problem of governors ; study of mould wear problem ; HFP compressor prewelding rejection due to wrong gaskets ; control of rejection of water coolers due to less drop ; RAC compressor due to auxiliary terminal clip drop ; investigating causes of motor burn cut ; control of post-dehydration breakage of rubber stoppers in the compressor assembly ; evaluation of variation in the copper wire ; acceptance sampling procedure for PIJF cables for electrical parameters ; wooden drums circum battens ; test procedure for polythen granules ; accelarated water penetration life test for PIJF cables ; acceptance sampling procedure for water proof cotton tape ; control of rejection due to lead segregation ; evolving optimum raw material mix ; process capability of machines and statistically establishing optimal measuring internal and optimal calibration for bottom and wall thickness of 37 mm shells ; control of variation at annealing of aluminium coils ; performance of clutch assembly in 100 cc scooters ; reduction in casting rejection ; kinetics of reduction of iron ores simultaneously by carbon and hydrogen ; random assembly of inner and outer rings of bearing ; forecasting the tea production etc.

3. *Education and training*

3.1 Inplant training programme at various factories continued. A series of training programmes for senior executives of Bharat Heavy Electricals Ltd. conti-

nued on regular basis besides regular inplant programme for executives etc. at various level. One-year special programme for executives at fairly advanced level blended with practical applications continued for Seventh and Eighth batches of trainees at Madras. Several short term specially designed training programmes were also conducted at different units of the Division for select group of executives etc. from organisations in India and abroad.

3.2 Faculty members of the Division participated in the teaching of academic courses of the Institute such as M.Stat. degree courses at Calcutta and Delhi, SQC-OR Diploma course at Calcutta, Part-time SQC-OR courses at Bangalore, Bombay, Hyderabad and Madras and ISEC course at Calcutta.

3.3 During the period under review 3403 managers and technologists were trained in various inplant, general and other courses, 107 trainees underwent professional training in SQC and OR at a Post-graduate level and in part-time courses in Calcutta, Bombay, Delhi, Madras, Bangalore and Hyderabad.

3.4 A Staff Development Programme on Computers Programming and its applications was conducted at New Delhi during July-August 1986 for the staff members of the Division. Twenty five participants including the staff members of the SQC Unit, Delhi attended the programme.

4. *Research*

4.1 During the period under review 18 papers were published, 27 submitted for publication, and presented at conferences, seminars etc., 22 manuals and technical reports, etc. prepared by the specialists of the Division.

Some of the areas in which applied and theoretical research work is carried out include optimum allocation of boreholes in geological prospecting, preemptive single sampling plan of given strength ; goal programming approach to design fixed sample size plans ; weight variation test using ratio statistics ; designing three-decision inflection average outgoing quality (IAOQ) plans ; determination of three-decision plans by Thyregod's method ; asymptotic solution to three-decision acceptance sampling plans ; matroidal games ; non-negativity of principal minors of Z-matrices ; cutting stock problems ; shock models ; linear complementarity problem etc.

5. *Promotional activities*

5.1 The specialists from the Division delivered 149 lectures, talks etc. to various institutions and organisations. The Division also arranged 33 seminars and the specialists from various units attended 65 seminars.

5.2 Introductory visits were paid to 51 factories. 27 surveys and pilot projects were carried out and 24 reports sent.

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Library, Documentation and Information Sciences

CENTRAL LIBRARY

With the addition of 1,588 books and 800 bound volumes of journals to the stock, the total collection of the library rose to 1,85,458 volumes. The total membership of the library was 3867 which includes 558 new members. The total memberships includes ISI staff, general member, research scholars, Project assistants, B.Stat. & M.Stat. students, ISEC trainees etc. as well as outside students and institute members. The total number of membership withdrawn was 256. 474 readers were given special permission to use the library for a short period.

Acquisition : The Unit accessioned 1,639 books during the period under report, out of which 1046 were purchased and 585 were received as gift. 9 titles were received on exchange basis. It also acquired 327 titles for the Circulating Library.

Periodicals : The Unit received 2,289 periodicals out of which 770 were received against subscription, 900 on complimentary basis and 619 on exchange arrangement with national and international organizations. The Library also acquired 60 back volumes of journals. It accessioned 1689 journals and completed the technical processing of 800 bound journals.

Circulation : The Unit issued 42,771 books and journals to the users on loan and on reference. 37 books and journals were borrowed from other libraries and 7 books and journals were loaned to other libraries under the inter-library loan arrangement.

Reports and Records : The Unit accessioned 523 titles and processed 762 titles. 1420 titles were issued to borrowers during the period.

Translation : The Unit translated the following : (i) From English to French— The resume of a paper by Dr. S. Bandyopadhyay, (ii) From German to English—First four chapters of the book : Daniel Bernoulli als physiologe und Statistiker ; Research publication of the University of Basel published in the year 1958—work done for Dr. B. P. Adhikari, (iii) From Japanese to English : Research Memoir on Multivariate Analysis ed by Prof. T. Kitawaga, University of Tokyo. One French document was translated to English by Shri Sunit Bose. Shri Bose is giving regular Russian lectures to the B.Stat. students.

Special Materials : The Unit accessioned 8 micro-documents and 130 Russian books. It also checked and processed 200 microfilms.

Technical Processing : The Unit classified 999 and catalogued 1588 new books.

Reprography and Photography Services : The Unit provided 3,41,191 xerox prints for the users during the period under report.

440 frames of photographs of different natures, 4434 prints of photographic enlargements, 1399 prints of photo copies of documents, 3085 frames of microfilming from drawing books, charts, journals etc., 455 frames of lecture slides and 202880 offset prints were made during the period under report.

Circulating Library : The Workers' Circulating Library acquired 331 new titles bringing the total collection to 33,535. It issued 28,357 books to the members.

BANGALORE CENTRAL LIBRARY

1. *Additions* :

During April 1986 to March 1987, 635 books were added to the library. During this period 56 books were received on gratis. The library received 82 books from the British Council ODM scheme through DRTC. During the year, a total of 320 volumes of journals were bound. All the titles subscribed for 1986 were continued for the 1987 subscriptions. 55 back volumes of journals were received in the library as donations.

2. *Stock position* :

The total stock position as on 31st March 1987 : books 9,656 ; books on gratis 354 ; bound volumes of periodicals 2,896 ; number of current periodicals titles 210 ; number of current periodicals titles (gratis) 28.

3. *Technical Work*

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

4. *Circulation* :

Along with the increase in Faculty and student in the Centre, the circulation of books and periodicals also was increased. A total of about 6300 books and 2500 periodicals (including bound volumes) were circulated by the library during this period. The in-house use of books and periodicals was around 12,000. About 200 inter-library loan transactions were registered.

5. *Services* :

During April 1986 to March 1987 the ISI Bangalore Centre Library provided the following services : (i) Circulation service, (ii) Inter-library loan service, (iii) Reference service, (iv) Monthly addition list of books, (v) Fortnightly list of current periodicals, (vi) On-demand bibliography compilation, and (vii) Reprographic service.

DELHI CENTRE LIBRARY

During the period 1st April 1986 to 31st March 1987, Delhi Centre Library was busy performing the following activities :

1. *Acquisition* : 400 new books, 309 bound volumes of journals, 95 publication on gift have been added to the existing collection bringing the total stock to

26,208. 100 reprints in printed form and 100 in microfilms were added to the existing collection of reprints.

2. *Periodicals* : 274 current journals, both Indian and foreign have been received in the library during the period. Out of it 266 have been received against subscription and 8 on exchange and complimentary basis. All the subscribed titles have been renewed for the next year also. 7 new titles of current journals have been subscribed during the year under report.

3. *Membership Circulation* : Total members during the period under report were 187, 40 as temporary members availed reading room facilities only. 125 permanent members availed the lending facilities. 22 visiting professors were also given the lending facilities. Approximately 11,198 publications were circulated during the period among the members.

123 publications were lent out on Inter Library Loan to other Institutes and 162 publications were borrowed from other Institutes by ISI, Delhi Centre Library under the said programme.

4. *Reprographic Services* : Xerox copies of about 36,390 pages have been provided to Research Scholars and Scientists of the Institute during the period under report.

5. *Documentation Services* : An annual issue of the bimonthly list of additions, listing the new books added to the library stock during the period January to December 1986 is under preparation.

6. *Other Activities* : Like every year this year too, library trainees were appointed on a monthly remuneration. Each trainee was appointed for a maximum period of six months and after the expiry of the training period, each trainee was given an experience certificate.

DOCUMENTATION RESEARCH AND TRAINING CENTRE (DRTC) BANGALORE

1. *Objectives and programmes of DRTC* : The objectives of DRTC are as follows : (a) To contribute to the development of different branches of information sciences including documentation and library science by doing, guiding, and supporting research and development in the concerned fields. The aim is to develop expertise and excellence in different areas of information science. (b) To help development of information centres including libraries, documentation centres, data centres, and information analysis and consolidation centres by offering advisory services in designing specific development plans, tools, and techniques required for this purpose. (c) To disseminate results of research, information analysis and consolidation and of advisory services in different areas of information sciences including documentation and library science. (d) To develop man-power with appropriate professional skills and

understanding that is capable of participating efficiently and effectively in the management (that is, design, development, organization, implementation, operation, control, and evaluation) of information service systems, centres, and programmes, and in the advanced teaching and research programmes in information sciences ; and help this manpower in finding appropriate job opportunities. (e) To ensure the development of the man-power engaged in professional activities. (f) To ensure the development of the members of the DRTC Faculty.

To achieve these objectives, the activities of DRTC have been organized into the following programmes :

(1) Research Programme ; (2) Advisory Service Programme ; (3) Extension Programme ; (4) Publication Programme ; (5) Training Programme ; (6) Employment Information Programme ; (7) Continuing Education Programme ; and (8) Faculty Development Programme.

2. *Training in Documentation and Information Science* :

2.1 *ADIS Course* : Under the training programme, DRTC conducts a Course of 24 months duration leading to the award "Associateship in Documentation and Information Science". The award is recognised by the Government of India as equivalent to a Master's degree in Information Science. Not more than 10 students are admitted in each academic session. The admission is based on merit as determined by an admission test and interview. In July 1986, a batch of 5 students completed their formal residential part of the course. They are now engaged in their respective research projects. On 1-9-1986, the course for 1986-88 was started. In all, 8 candidates were selected for admission to the course. All the 8 candidates have joined the course.

2.2 *Short Term Course on Library Automation* : Under the sponsorship of the National Information System for Science and Technology (NISSAT), Department of Scientific and Industrial Research, Government of India, New Delhi, DRTC is conducting a 6-week short-term course on Library Automation. The first course was held during 15 October to 25 November 1986. A batch of 7 students were selected for the first course. All of them have completed the course. The second 6-week course on Library Automation was started on 9 February 1987. A batch of 7 students were selected for the second course. The course continued upto 20 March 1987. All the 8 students have completed the course.

2.3 *Special Training* : Under its special training programme, DRTC offers specific project oriented training in library science, documentation and information science to persons with professional degrees or experience. Professor Madhav Gadgil wanted to develop an Environmental Information System for the Centre for Ecological Studies of the Indian Institute of Science, Bangalore. He contacted Professor G. Bhattacharyya of DRTC for Advisory Service in October 1986. As the Centre

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did not have any professionally trained person, Prof. G. Bhattacharyya advised to select one Scientist for special training in DRTC. Shri K. Venkata Rao (M.Sc. Botany) was selected and sent for special training in DRTC in December 1986. He was undergoing training in DRTC upto the end of April 1987 under Dr. S. Seetharama. Dr. Seetharama trained him in all information handling techniques. Under his guidance, as a part of the training programme, he has designed a vocabulary control device for subjects in the field of "Biological Diversity" with special emphasis on Western Ghat. In addition, Dr. Seetharama guided him in developing a perspective plan for the development of the Information Centre at the Centre for Ecological Studies.

2.4 *Study Tour of ADIS Students* : For the first time, an Educational Tour of the students of the ADIS Course (1986-88 batch) was arranged. The primary objective of the educational tour is to provide an opportunity to the DRTC students to make a thorough observational study of Information Work and Service in-action.

The Programme for the educational tour was fixed up for the period 20th to 31st March 1987. The places chosen for this purpose were the Cities of Bombay and Goa. The tour was conducted under the guidance of Prof. M. A. Gopinath. For the purpose of observational studies, the students visited (1) The Indian Institute of Technology, Bombay, (2) The Tata Institute of Fundamental Research, Bombay, (3) The National Institute for Training in Industrial Engineering, Bombay, (4) The SNDT Women's University, Marine Larine Lines Campus, Bombay, (5) EXIM Bank Bombay, (6) The British Library, Industrial Information Division, Bombay, (7) The American Centre Library, Specialised Information Cell, Bombay, (8) Larsen and Toubro Ltd. Library, Bombay, (9) The Goa University Library, Goa, (10) The National Institute of Oceanography, Goa, and (11) The State Central Library, Goa.

(a) In all these Institutions, the Students witnessed the use of microcomputers. Demonstrations were arranged in the EXIM Bank, Bombay, NITIE, Bombay and NIO, Goa.

(b) At the TIFR and IIT, the students observed the layout and arrangement of shelves and reading facilities in their respective annexures. At the Goa University, the library operational research aspect of shifting a library collection from one place to another was demonstrated.

(c) The International Libraries such as British Library and American Centre Library indicated the international aspects of the information transactions. The requirements analysis as well as the Demand/Supply aspects of information from Indian users in these libraries were discussed and case studies were analysed.

(d) The Larsen and Toubro Information Centre was a model for in-house information system, based on Trade Catalogues, Standards, Patents, Reports and other specialised materials.

After the completion of the study tour, each student submitted a report of their observational studies.

3. *Research Activities* : The members of the DRTC Faculty carry out research mostly in the areas of their specialisation falling within the purview of Library Science, Documentation and Information Science. The main topics of research in which the different members of the DRTC Faculty have been engaged in during the period of report are furnished below :

(a) Designing classauri based on general theory of subject indexing language for indexing documents in the fields of agricultural sciences and technology ; (b) Linguistics ; (c) Labour Economics ; (d) Revision of the schedules of basic subjects and common isolates of the colon classification of Dr. S. R. Ranganathan ; (e) Characteristic features of the different varieties of sources of information and communication media ; (f) Application of Facet Analytic techniques to knowledge representation in the Knowledge-Base Management Systems (KBMS) ; (g) Computer-communication technology : inputs to education for Library and Information Science ; (h) Design and development of depth classification schedule in the field of Health Sciences ; (i) Planning and Management of Information Systems and Services ; (j) Information Analysis and Consolidation ; (k) Designing an environmental information system including the development of a vocabulary control system for Biological Diversity in the West Coast of India ; (l) Bibliometrics : designing a suitable model to describe various bibliometric processes ; (m) Application of computer to library and information work and development of software packages as well as application of packages using a well established software packages such as CDS/ISIS, SPDOC etc. ; (n) Computerisation of Postulate Based Permuted Subject Indexing (POPSI) ; (c) Conversion of the software development of POPSI to run on microcomputers ; (p) Application of Facet Analysis Techniques in Computer-based information systems.

3. SYMPOSIA, SEMINARS, LECTURES AND CONFERENCES

Among different conferences, symposia, seminars, workshops and lectures organised by the Institute mention may be made of the following :

3.1. *Symposia, Conferences, Workshops, etc.*

The Theoretical Statistics and Mathematics Division held a Summer School in Analysis and Probability from May 26 to June 21, 1986 at Indian Statistical Institute, Calcutta. Apart from students and Junior Research Fellows of the Institute there were 26 participants (37 were selected out of 156 applicants but some could not join the course.) The participants were fresh MA/MSc.'s, Research Scholars and Lecturers from Universities.) There were four topics of Lectures with 23 lectures on each topic. The topics were : Fourier Analysis, Functional Analysis, Discrete parameter Martingales and Wiener process. Six of the participants gave lectures on their research interests.

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A summer school on sample survey, 'Sample Survey : Unified Approach and Applications' was conducted by the Applied Statistics, Surveys and Computing Division at Shimla during 26th May to 9th June, 1986. The objective of the course was to acquaint the participants with the recent developments in the area of survey sampling, different approaches to making inference on the basis of surveys, their controversies and unification, various techniques of a sampling, estimation and their applications. Seventeen researchers selected from different universities throughout the country and two officials from the Goverment of India participated in the training programme.

A Winter School on Computation Intensive Methodologies in Statistics was organised jointly by the divisions of Theoretical Statistics and Mathematics and Applied Statistics, Surveys and Computing during 3—7 February 1987. This was funded by the UGC. The following topics were taught : Jack-knife, Boot-strap, Projection-pursuit, Clustering Methods, Classification techniques, Use of computer packages, and Survival Analysis. Nineteen external students, three local and six internal students participated in the school.

The ISI accepted a proposal by the USEFI to host their annual Economic Institute Workshop for college teachers from different parts of India. The Workshop spanned over a period of 3 weeks (5 May, 1986—22 May 1986) and consisted of about 64 lectures on Mathematical Economics, Statistics and Econometrics as well as on the American and Indian Economics. The teaching was done mainly by faculity members of the Economic Research Unit. Guest Lecturers included Professor Dhires Bhattacharjee from Calcutta University, Mr Bruce Duncombe from the Economic Division of the American Embassy, Dr. K. L. Krishna of the Delhi School of Economics and Dr. J. S. Uppal from the Economics Department of the State University of New York at Albany. In all there were 25 participants from all-India.

A short term training programme in statistical application for officers of Central Staff Training Research Institute, Calcutta was organised by Computer Science Unit during 21 July—1 August, 1986. 13 officers of the Central Staff Training and Research Institute participated in the programme. The main object of the course was to make the participants familiar with the method of data collection and their appropriate analysis. This is felt important because they have to conduct surveys frequently as a part of their regular activities.

A two-week course on 'Systems and Operation of PDP 11/24 Minicomputer' was organized by *Electronics and Communication Sciences Unit* during August 18-29, 1986 for the acquaintance of the members of the Unit with the newly installed minicomputer system. The course was given by M/s. Hinditron Computers Private Limited and it was attended by twelve members of the Unit. This new computer system was procured under a project financed by the Department of Electronics, Government of India. Various peripheral devices including image processing equip-

ments like video camera, graphics display system have been interfaced with the computer.

Statistical Quality Control and Operational Research Division organised a Summer Institute on Reliability at New Delhi during June-July 1986. About 20 participants from various academic organisations, etc. attend the programme.

The International Seminar on Handling and Retrieval of Chemical Information was held at the Indian Statistical Institute, Bangalore Centre, from 23 June to 27 June 1986. The seminar was organised under the sponsorship of the General Information Programme of UNESCO, Paris. In all there were 18 participants and 10 resource persons from different parts of the world.

Post-XI World Congress of Sociology Symposium on 'Ideology, Social Formation and Transformation' was held during 26-28 August 1986 at ISI, Calcutta. The Symposium was jointly organised by the Sociological Research Unit of ISI, and socil scientists of other universities and institutes of Calcutta. The participants included leading social scientists from India and the third world countries, like Colombia, England, Finland, Bangladesh, The Netherlands, West Germany, Brasil. Professor Ashoke Maitra, the then Director, ISI, welcomed the participants and Shri Jyoti Basu, Chief Minister of West Bengal delivered the inaugural address. Professor Bhabatosh Datta gave the presidential address. The proceedings of the symposium is under preparation for publication as a book.

The All India Workshop on Information Management Technology sponsored by the Department of Science and Technology, IASLIC, and Micrographic Congress of India was held at the Institute at Calcutta from 6 to 16 August 1986.

A discussion meeting with Teachers/Researchers/Prospective employers/Distinguished educationists/individuals/institutions for suggestions to improve the curriculum in Economics was held in Bangalore on 8 November 1986. The meeting was jointly organised by the Economic Analysis Unit of the Institute and the University Grants Commission, Curriculum Development Centre in Economics, University of Bombay. About 30 participants discussed various problems of teaching Economics.

A Seminar on New Trends in Information Management was held at ISI, Bangalore Centre on 21 November 1986. About 50 participants attended the seminar.

Public lecture by Professor Kenneth J. Arrow, Nobel Laureate in Economics (and President of the Eighth World Economic Congress, New Delhi) was jointly organised by the Economic Analysis Unit of ISI and the Bangalore University, Bangalore on 22 November 1986.

The second I.S.I. Conference on Economic Theory and Related Mathematical Methods was held at Delhi on 11-14 February 1987. The Conference was attended

by over 60 participants from India and abroad. The conference was organised by the Planning Unit, ISI, Delhi Centre.

The International Symposium on "Social Movement and Social Change : Theory and Practice" was organised under the auspices of the ISI, Delhi Centre, at the Jawaharlal Nehru Memorial Museum and Library on 23 August 1986.

Two day Symposium on "Strategic Behaviour and its Application" was organised by the Planning Unit, ISI, Delhi Centre, at the National Institute of Public Finance and Policy on February 26 and 27, 1987.

Teacher's Workshop was organised by the Psychometry Unit on 22-24 May 1986 at the Government Sponsored Junior Basic Training Institute, Hooghly, for construction of question banks from which to draw items for the study. The workshop was collaborated by S.C.E.R.T., District School Board, Hooghly, the office of the District Inspector of Schools (Primary), Hooghly. Altogether 25 trained primary school teachers participated. The participants split up into five groups for construction of questions in the five areas : language (Bengali), Mathematics, History, Geography and Science. They worked in five sessions spread over three days and wrote questions under the guidance for resource persons from S.C.E.R.T. and Psychometry Unit of ISI, about 1300 questions covering the five subject matters, were generated.

Teachers' Workshop on 'Problems of evaluation and analysis of educational data' was organised by the Psychometry Unit from 10-12 March 1987 at the Ramkrishna Mission Balakashram, Brahmananda P.G.B.T. College, Rahara. The Workshop was collaborated by R. K. Mission P.G.B.T. College and S.C.E.R.T., West Bengal. The workshop was inaugurated by Shrimat Ramanda Maharaj, Secretary, R. K. Mission Balakashram, Rahara. Prof. K. K. Chatterjee, Head, Division of Curriculum Development, S.C.E.R.T., presided over the meeting. Altogether 20 trained school teachers both from Primary and Secondary, participated in the evaluation of data in four technical sessions. In other two sessions they discussed with different subject experts. The aim was to evolve a standard scoring procedure of the data collected in connection with the project on assessment of minimum learning in primary education.

3.2 *Lectures and Seminars* :

The following seminars/lectures were arranged during the period :

Stat-Math, Delhi

Professor Nguyen Van Thu, Institute of Mathematics, Hanoi (8.4.86): "Prediction problems for strictly stationary processes in L^p spaces".

Dr. B. L. S. P. Rao, ISI, Delhi (30.4.86) : "Position Emission Topography (PET : a statistical approach)".

Professor P. K. Mitter, University of Paris (12.5.86) : "Non linear stochastic differential equations and quantum field theory".

Professor G. A. Swarup, ISI, Delhi (15.5.86) : "Poincare's conjecture".

Dr. R. Chandrasekaran, University of Texas (25.6.86) : "Pseudo Matoids".

Dr. K. G. Murthy, University of Michigan (26.6.86) : "Gravitational methods for linear programming".

Dr. K. G. Murthy, University of Michigan (15.7.86) : "How difficult is it to compute a local minimum in simple nonconvex program—Realistic goals for algorithm".

Professor P. S. R. S. Rao, University of Rochester (16.7.86) : "Variance Components".

Dr. Siddharthia Sahi, Princeton University (22.7.86) : "The endogenous emergence of markets under strategic behaviour".

Dr. K. C. Das, Jadavpur University (22.7.86) : "Antieigenvalues and antieigenvectors of matrices".

Dr. K. G. Ramamurthy, ISI, Delhi (24.8.86) : "An optimization problem in statistics and its many facets".

Professor J. A. R. Halbrook, University of Guelph (30.10.86) : "Quaternionic fractals".

Dr. R. Bhatia, ISI, Delhi (11.11.86) : "The absolute value of an operator".

Dr. R. Bapat, ISI, Delhi (18.11.86) : "Multinomial distribution and permanents".

Professor D. Basu (17.11.86) : "Optimal stopping rule".

Dr. K. Varadarajan, University of Calgary (24.11.86, 26.11.86 28.11.86) : "Pseudo-mitotic groups".

Dr. V. Ptak, Academician, Czechoslovak Academy of Sciences (8.12.86 & 10.12.86) : "An abstract model for contraction operators".

Dr. G. Misra, ISI, Calcutta (9.12.86) : "Finite dimensional modules".

Professor Stef H. Tijs, University of Nijmegen (23.12.86 & 24.12.86) : "Bankruptcy games and the—value" ; "Combinatorial games".

Professor T. E. S. Raghavan, University of Illionis (31.12.86) : "Scalings of non-negative matrices and some applications".

Professor J. M. Deshouillers, Universite de Bordeaux I, Mathematiques et Informatique (12.1.87) : "Waring's Problem".

Dr. R. L. Karandikar, ISI, Delhi (3.2.87) : "Filtering theory, recent developments"

Dr. T. Parthasarathy, ISI, Delhi (17.2.87) : "P-N Jacobian matrices and global univalence".

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Mr. G. Ravindran, ISI, Delhi (24.2.87) : "Schur complements".

Professor R. L. Hudson, Nottingham University, UK (18.2.87 & 20.2.87) : "Quantum Diffusions".

Professor Ajit Iqbal Singh, University of Delhi (3.3.87) : "Completely positive maps on matrix algebras (The theorems of Stinespring and Choi)"

Professor K. R. Parthasarathy (10.3.87) : "Martingale characterisations of CCR and CAR".

Ms. Neelam Mittal, Indraprastha College (17.3.87) : "Arveson's Hahn—Banach Theorem".

Dr. K. R. Parthasarathy, ISI, Delhi (24.3.87) : "The Lindblad generator of a one parameter semigroup of c.p. operators".

Dr. S. Nag, ISI, Calcutta (31.3.87) : "String Theory and Teichmuller spaces".

Applied Statistics, Surveys and Computing

Professor V. N. Reddy, Indian Institute (2.4.86) : "Estimating the population totals of bottom (top) P-percentiles of a finite population".

Dr. Y. P. Chaubey, Concordia University, Montreal, Canada (30.4.86) : "Some investigations on the properties of product estimator".

Dr. Sangit Chatterjee, Northeastern University, Boston (20.3.87) : "Computer Intensive Methods in Statistics".

Professor Arijit Chaudhuri, ISI, Calcutta (6.8.86) : "Calcutta School Survey 1985".

Dr. Arun Kumar Adhikary, ISI, Calcutta (24.9.86) : "Domain estimation in equal probability sampling".

Dr. Parimal Mukhopadhyay, ISI, Calcutta (26.11.86) : "Asymptotic properties of a generalised predictor of a finite population variance under probability sampling".

Electronics and Communication Sciences Unit

Dr. Subrata Das, IBM Thomas J. Watson Research Centre, Yorktown Heights, New York (22.7.86) : "Automatic speech recognition and acoustic processing".

Dr. Pradip Bose, IBM Thomas J. Watson Research Centre, Yorktown Heights, New York (27.3.87) : "Expert system for computer engineering problems".

Dr. Swapan Kumar Parui, Formerly of Leicester Polytechnic, England (25.3.86 to 2.4.86) : "Syntactic pattern recognition".

Economic Research

Dr. Sanjay Bandyopadhyay, University of Buffalo (4.7.86) : "Adjustment costs, Rational Expectations and Neoclassical Macroeconomics".