Annual Report

Platinum Jubilee Year
2006-2007

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Indian Statistical Institute

INDIAN STATISTICAL INSTITUTE

Annual Report
April 2006 – March 2007

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INDIAN STATISTICAL INSTITUTE
SEVENTY FIFTH ANNUAL REPORT
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Director's Report

It is my proud privilege and pleasure to present the annual report of the Indian Statistical Institute for the year 2006-07, which happens to be the second one after I assumed charge as the Director of the Institute on August 1, 2005. The Institute has its headquarters in Kolkata and two other centres at Delhi and Bangalore besides a branch at Giridih and a network of service units under the Statistical Quality Control and Operations Research Division across some other major cities in the country like Mumbai, Chennai, Hyderabad, Pune, Vadodara and Coimbatore.

True to the tradition of the Institute, a number of prestigious awards and honours have been received by some of our scientists in the last year for significant contributions in their respective fields. I mention a few of them: Prof. Bikas K. Sinha of the Stat-Math Unit, Kolkata, has been selected as a member of the National Statistical Commission of the Government of India. Prof. Rajendra Bhatia of the Stat-Math Unit of the Delhi Centre has been awarded the prestigious J.C. Bose Fellowship of the Government of India administered by its Department of Science & Technology. Prof. Bidyut Baran Chaudhuri of the Computer Vision and Pattern Recognition Unit and Prof. Arup Bose of Stat-Math Unit, Kolkata, have been elected Fellows of the Indian National Science Academy (FNA) in Engineering Sciences and Mathematical Sciences respectively. Prof. Bhargab B. Bhattacharya of the Advanced Computing and Microelectronics Unit has been elected a Fellow of the Institute of Electrical and Electronics Engineering (IEEE), USA, while Prof. Sushmita Mitra of Machine Intelligence Unit has been elected a Fellow of the Indian National Academy of Engineering (FNAE). Prof. Ayanendranath Basu of the Bayesian and Interdisciplinary Research Unit has received the C.R. Rao National Award in Statistics from the Ministry of Statistics and Programme Implementation, Government of India. Prof. Palash Sarkar of the Applied Statistics Unit and Dr. Arup Pal of the Stat-Math Unit of the Delhi Centre are the recipients of the B.M. Birla award while Prof. Bharat Ramaswamy of the Planning Unit of the Delhi Centre has received the Mahalanobis Memorial Medal of the Indian Econometric Society. Among the young faculty, Prof. Abhay G. Bhatt of the Stat-Math Unit of the Delhi Centre has received the Scopus Young India Scientist Award in Mathematics from Elsevier, while Dr. Utpal Garain of the Computer Vision and Pattern Recognition Unit was awarded the Young Engineers Award from the Indian National Academy of Engineering. The Institute is proud of their achievements.

The Institute has a long and glorious tradition of conducting fundamental research in several areas that is being carried on with vigour by its distinguished faculty. The Institute continues to conduct, again with the help of its able faculty, prestigious courses, and to produce successive generations of students well-trained for research and other professions. The courses are updated from time to time to cater to the needs of the students and the nation. These widen the opportunities available to the graduating students for joining industry and other job markets, as well as for pursuing higher studies.

Apart from the DST-sponsored "Center for Soft Computing Research: A National Facility", there are about 100 externally (both national and international, Government and Private) funded projects in the Institute. Funding agencies mainly include the DST, DBT, CSIR, DIT, ISRO, DRDO, DAE, ICMR, UNDP, Ministry of Environment and Forests, Ministry of Statistics and Programme Implementation, Intel Corporation (USA), NSF (USA), NIH (USA), INSEAD (France), Indo-French Centre for Promotion of Advanced Research, NHF (Netherlands), India-Trento Programme on Advanced Research (Italy), Hewlett Packard, e-global, Iran Khodro Company (Iran), L&T, Macmillan, WIPRO, and Reliance. These projects are of various natures, for example, many of them have strong research components, some are mostly of a consulting and income-generating nature and some involve a major amount of sample survey. Notable among the new projects in terms of grant amount is the one funded by MIT titled "Research and development of some cryptographic primitives".

While the number of small projects is going up yearly, emphasis is being given to increase the number of big interdisciplinary projects of national importance, which cut across the different divisions of the Institute and exploit their respective expertise. This is particularly appropriate in view of the fact that the Institute has a unique multi-disciplinary character that is aptly described by its motto of "Unity in Diversity". Similarly, more inter-institutional projects are encouraged with the same synergistic objective where scientists should have, deeper involvement in fewer projects rather than shallow

involvement in several projects. Although applied research relating to *official statistics* is being encouraged, and requests from different ministries of both central and state governments are being entertained by executing projects of national importance on problems and issues related to minorities, unemployment, unorganized labor, poverty, and socio-economic development, efforts should be made by the investigators, wherever possible, to embed strong research components in such activities. This is also true for many internally funded plan projects involving sample surveys, where motivation should be to publish the research output in journals of high impact factor.

The celebration of the one-year Platinum Jubilee functions of the Institute has begun with a glorious inauguration on December 24, 2006 in the presence of Dr. Monmohan Singh, the Hon'ble Prime Minister of India; Shri Pranab Mukherjee, Minister of External Affairs, Government of India; His Excellency Shri Gopal Krishna Gandhi, Governor of West Bengal; Shri Buddhadeb Bhattacharya, Chief Minister of West Bengal, Shri Priya Ranjan Das Munsi, Minister of Information and Broadcasting, Government of India; Shri G.K. Vasan, Minister in Charge of Statistics & Programme Implementation, Government of India; Prof. M.G.K. Menon, President of the Indian Statistical Institute; Dr. A.P. Mitra, Chairman, Section 8(i) Committee of the Indian Statistical Institute and some of the esteemed former Directors. The Institute took this occasion as an opportunity to confer the honorary D.Sc. degree to our Hon'ble Prime Minister, Dr. Monmohan Singh who is a Distinguished Economist, for his outstanding contributions as a leader in economics and national planning. In this context, I am happy to mention that the Government of India has declared 29th June as the "Statistics Day" to commemorate the birth anniversary of Prof. P. C. Mahalanobis. For the purpose of celebrating the Platinum Jubilee of the Institute in a befitting manner, the Government of India has also approved about 12 crores of rupees as a special grant.

There have been several academic programs like conferences, workshops, seminars, lecture series in the Institute, highlighting the emerging areas of ongoing frontline research in its various scientific divisions, centres, branches and outlying units. A series of comprehensive volumes in different subjects under the title "Statistical Science and Interdisciplinary Research" will be brought out by the World Scientific Press, Singapore. Institution of Platinum Jubilee Chairs and Platinum Jubilee Fellowships together with infrastructural development is also an important part of the programme. The infrastructural development includes, among other things, the construction of a separate ISEC building of international standards, a motorable subway between the north cottage and the main campus at Kolkata, a hostel building at Delhi centre and an auditorium at the Bangalore centre.

The construction works for the "Platinum Jubilee Academic Building" (whose foundation stone had been unveiled by the Hon'ble Prime Minister) and the D type quarters in Deluxe Garden, and an extensive face lifting work of the Kolkata campus are going on in full swing. Major renovation work of the "Amrapali" building and ISEC hostel is almost complete. This will enhance the longevity of the former, the residence of Prof. P. C. Mahalanobis, now called the Mahalanobis Memorial Museum and Archives, which embodies our proud heritage from the illustrious founder of the Institute, and will upgrade the facilities for international students in the latter.

Recruitment of Schedule Caste and Schedule Tribe personnel in different categories for filling up the required quotas in line with national policy has started. The policy is also being incorporated in case of our student admission. Enhancement of stipend and contingency grant of our M. Tech students is made with the approval of the government in order to keep them at par with other premier Institutes like the Indian Institute of Science and the Indian Institutes of Technology.

At the advice of the Section 8(i) Committee, attempts have been made to revise the existing pay scales and promotional policies for the faculty in order to attract bright young researchers at an early stage of their career. The issue is currently under consideration of our administrative Ministry after it was recommended by the Governing Council of the Institute. Similar is the case with the issue of enhancement of the age of superannuation from 62 to 65 of our workers at the rank of Lecturer or equivalent and above, keeping the recent national policy for Institutes of higher education and learning in mind, in order to compensate for the phenomenon of unavailability of qualified faculty appropriate for the Institute.

The Major strides, being taken again at the advice of the Section 8(i) Committee to revitalize the research and academic activities in Giridih office through a 2-year "verification period with 3 tier administrative system", are worthy of mention. Following the perspective plan, the Institute is considering the upgradation of its Chennai unit and the Giridih branch to centre status with new additional training and research programs. Also, efforts are being made in the same spirit to revive the Institute's campus at Takdah, Darjeeling, with a possibility of its scientific utilization, in conjunction with other research centres and universities around, in the greater interest of the nation.

The 15 year vision document of the Institute has been approved by the council. The 10 year perspective plan, in line with this, is in the process of finalization. The basic philosophy of the vision document is based on the unique perception of Mahalanobis of nurturing statistics as a unifying discipline, enriched suitably with time, with the strategy for interlacing and encompassing newly emerging areas of research in all its scientific disciplines. One of the objectives is to project the Institute as an international repository of knowledge in Statistical Science and other related disciplines with various emerging applications, and to render services to the community by providing access to such knowledge-base consisting of theory, data, tools and methodologies, analytics, and technical expertise. In addition to interdisciplinary research, the document further envisages giving additional focus on applied research in the area of *official statistics* with a strong scientific component in order to serve the needs of the Government. It also proposes, among others, to open new units in Delhi and Bangalore centres in the area of Computer Science under the Computer and Communication Sciences Division (CCSD) to strengthen the research activities in the centres.

As the humble inheritors of this great legacy of Mahalanobis, we all shoulder an immense responsibility. To make this mission successful, I earnestly request cooperation from all workers, scientific and non-scientific, of our different campuses to contribute their utmost in their own domains of activity. If we work in unity I am sure we will succeed. In this context, we must keep in mind the fact that in this high-tech age of globalization, the technology and work culture are changing at a dramatic pace. If we do not adapt ourselves to these changes, we are bound to fall behind.

The Institute is internationally recognized as a "Centre of Excellence" both for its theoretical contributions to Statistics as well as applications of Statistics. Keeping the famous saying, "Work is worship" in mind, we must uphold this unique standard in years to come in order to keep the banner of the recognition high, and cherishing our immortal motto, "Unity in Diversity".

I am extremely grateful to Prof. M. G. K. Menon, FRS, President of the Institute, and to Shri Pranab Mukherjee, Chairman of the Institute and Hon'ble Minister of External Affairs, Government of India for their valuable advice at various stages for the smooth functioning of the Institute. I also thank the officials of the Ministry of Statistics & Programme Implementation, Government of India, and the members of the Section 8(i) Committee for their support, and last, but not the least, all the workers of the Institute for their cooperation in the respective sectors.

March 31, 2007   Sankar K. Pal

A Brief History of the Institute

Research in the theory and applications of statistics as a new scientific discipline began in India in the early 1920s through the pioneering efforts of Prasanta Chandra Mahalanobis. After completing his Tripos in mathematics and natural sciences at Cambridge University by 1915, Mahalanobis was drawn to statistics through reading the volumes of Biometrika, edited by Professor Karl Pearson. After returning to Calcutta (currently renamed Kolkata), one of his first statistical works came out of an assignment on the examination system of University of Calcutta, entrusted to him by Professor Brajendra Nath Seal in 1917. Mahalanobis started functioning, from 1922, as a Professor of Physics at Presidency College, Calcutta, where he soon set up a Statistical Laboratory, paving the way for the eventual foundation of the Indian Statistical Institute (henceforth the Institute or ISI) on 17th December 1931. Mahalanobis became the founder Secretary and the first Director of the Institute which was registered as a learned society on 28 April 1932, having its headquarters at Calcutta.

Professor Mahalanobis perceived statistics to be "a key technology", and encouraged the interaction of statistics with various other sciences – natural, social, biological, earth, and computer & communication. He also emphasized that in a developing country like India, it was essential to make statistics purposive "to help in solving scientific or practical problems" of the society.

Much of the early history of the Institute was reflected in Professor Mahalanobis's personal achievements. In the 1930s and '40s, Professor Mahalanobis successfully applied statistics to solve some important problems of the country. These included innovative projects on sample surveys for the estimation of yield and land utilization of crops, assessment of the socio-economic after-effects of the Bengal famine, study of the anthropometric similarities among ethnic groups, and problems of flood control. Through these studies, he made significant contributions to statistical theory and methods. Particular mention should be made of his D^2 statistic known as the Mahalanobis generalized distance, pilot surveys, interpenetrating network of sub-samples and optimal designs of sample surveys. He also successfully inspired a large number of bright Indian students to take up statistics as a career.

The symbiotic relationship between statistics and other sciences began to be reflected in Sankhyā, the Indian Journal of Statistics, which has been regularly published by the Institute since 1933. Sankhyā carried much of the significant research work of Professor Mahalanobis and his close associates, such as Professor R. C. Bose, Professor S. N. Roy and Professor C. R. Rao. Sankhyā continues to be one of the leading statistics journals of the world even today.

Subsequent to India's independence in 1947, Professor Mahalanobis was appointed the Honorary Statistical Adviser to the Central Cabinet, Government of India, in 1949. In 1950, the National Sample Survey (NSS) was initiated in ISI for conducting socio-economic surveys covering the whole of India. Soon after, he helped create the Central Statistical Organization (CSO) to implement a sound national statistical system, along with a chain of State Statistical Bureaus. The setting up of the NSS and CSO are among the most important landmarks in the development of India's official statistics system; considering that it happened in the 1950s, these were tremendous achievements for a developing nation and are tributes to the vision of Professor Mahalanobis.

In 1954 Jawaharlal Nehru, the then Prime Minister of India entrusted Professor Mahalanobis and ISI with the responsibility of preparing the draft Second Five-Year Plan for the country. The draft submitted by Mahalanobis and the planning models formulated by him and his colleagues have since been regarded as major contributions to economic planning in India. The Second Five-Year plan primarily focused on the need for industrialisation in India. That this very important task was entrusted to ISI reflects the confidence of Pandit Nehru on Mahalanobis personally and on ISI as a whole.

Although the empowerment to grant degrees came much later, the teaching programme of the Institute started taking shape from 1939 in order to create a national statistical cadre. It was organized more systematically during 1950s under the active guidance of Professor P. C. Mahalanobis, Sir Ronald A. Fisher and Professor J. B. S. Haldane. The Institute's teaching programme also received encouragement and support from Professor Satyendra Nath Bose and Dr. C. D. Deshmukh. Degree

courses in the Institute started in 1960. In the long run, the Institute played a very important role in promoting the culture of statistical training in India.

Adhering to the course of inter-disciplinary research, the Institute made major strides in the area of computer science as far back as in the early 1950s. The Electronic Computer Laboratory was established in ISI in 1950. The first electronic computer in India, an HEC-2M, was installed in the Institute in 1956. In 1961, ISI, in collaboration with Jadavpur University, undertook the design, development and fabrication of a fully transistorized digital computer, called ISIJU-1, which was commissioned in 1966. The foremost formal course in computer science in the country was introduced in the Institute in 1963.

In the early 1950s, ISI initiated the use of Statistical Quality Control and Operations Research (SQC & OR) in India. Once again the Institute was far ahead of its time in this remarkable initiative. The SQC promotional work gradually began to spread all over the industrial centres in India under a comprehensive programme covering education and training, applied research and consultancy services. Late in 1948 at the recommendation of a team of experts from the United Nations Technical assistance administration (UNTTA) and subsequently by the committee of the Government Of India headed by the then Finance minister, Dr. C. D. Deshmukh, ISI was entrusted with the mission of setting up SQC units to assist Indian Industries in introducing quality management practices.The visit of Dr. W. A. Shewhart in 1948, and of other notable experts such as Dr. W. E. Deming and Dr. Genichi Taguchi significantly helped the ISI initiative. The first SQC unit was set up in Bombay (now Mumbai) in 1953 followed by units in Bangalore and Kolkata. Eight more SQC units at different cities came into being by 1959.

In 1950, the International Statistical Education Centre (ISEC) was established in ISI in order to impart training in statistical sciences to participants coming from developing countries of Asia and Africa. For many years ISEC has been run by ISI in collaboration with the International Statistical Institute under the auspices of UNESCO and Government of India.

On 17th December 1956, Dr. C. D. Deshmukh, the then President of the Institute, inaugurated the Silver Jubilee celebration of ISI in Calcutta. In his address Professor Mahalanobis stressed the need for autonomy in internal management of the Institute in order to encourage the initiative for a united endeavour towards solving 'scientific problems or problems of national development'. Sir Ronald A. Fisher and Professor F. Yates, along with other dignitaries, participated in the Silver Jubilee celebration. A series of lectures and symposia were organized in two groups: 56 lectures were held under the auspices of the Institute, while two international symposia were organized at the initiative of ISEC.

In 1959, the Government of India recognized ISI as an 'Institution of National Importance' by the enactment of the ISI Act in the Parliament, which was steered by Pandit Jawaharlal Nehru himself. Thereafter the Government of India began to extend almost total financial assistance to the Plan and non-Plan activities of ISI along with the concomitant reciprocity of accountability on the part of the Institute. In the process, it was ensured that the basic autonomous character of ISI as a learned society, registered under the West Bengal Societies' Registration Act, would remain undisturbed.

Following the enactment of the ISI Act (1959), the Institute was empowered to award degrees and diplomas. The already existing teaching programmes were consolidated and expanded. The courses leading to the degrees of Bachelor of Statistics [B.Stat. (Honours)] and Master of Statistics (M.Stat), post graduate Diplomas in Computer Science and in SQC & OR, and Ph.D programmes were introduced in June 1963. Later, courses leading to Master of Technology degree in Computer Science [M.Tech (CS)] and in Quality, Reliability and Operations Research [M.Tech (QR & OR)] were initiated. All these programmes have been eminently successful in turning out well-trained students, many of whom have subsequently attained international reputation. The ISI Act of 1959 was amended by the Parliament in September 1995 to empower the Institute to award degrees/diplomas – in addition to statistics – in mathematics, quantitative economics, computer science and in such other subjects related to statistics as may be determined by the Institute from time to time. Following this amendment,

certain new courses have been introduced in ISI such as Master of Science degree in Quantitative Economics [M.S. (QE)] in 1996, followed by the Bachelor of Mathematics [B.Math (Honours)] and Master of Mathematics (M. Math) degree courses.

Professor Mahalanobis passed away in Calcutta on 28th June 1972. Around the same time, two decisions of the Government of India led to a major shift in the activities and functioning of ISI. One was the delinking of the Institute from the Perspective Planning Division of the Planning Commission; the other was the separation of National Sample Survey from ISI in 1972. As a result there was a drop in the systematic involvement of the Institute with the wider problems of national development. However, the academic activities of the Institute continued to flourish under the able guidance of Professor C. R. Rao, who had already emerged as the academic leader of the Institute and inheritor of much of Mahalanobis's legacy by the 1960s.

In 1974, the ISI Council, led by its Chairman Shri P. N. Haksar, amended the Memorandum of Association and the Regulations of the Institute, which were implemented with the concurrence of Government of India in 1976. One more clause was added to the existing objectives of the Memorandum of Association, which henceforward read as follows:

   (a) to promote the study and dissemination of knowledge of statistics, to develop statistical theory and methods, and their use in research and practical applications generally, with special reference to the problems of planning for national development and social welfare;
   (b) to undertake research in various fields of natural and social science, with a view to the mutual development of statistics and these sciences;
   (c) to provide for, and undertake, the collection of information, investigations, projects and operational research for purposes of planning and the improvement of efficiency of management and production,
   (d) to undertake any other ancillary activities in fulfilment of the above objectives.

Around this time, the structure of the Institute went through a major reshuffle. Various scientific and administrative service units, earlier located within the Research & Training School (RTS) and in the Common Services Division of the Institute, were reorganized. Subsequently there have been several other minor reorganizations. Currently, the Institute has seven academic divisions: (i) Theoretical Statistics & Mathematics, (ii) Applied Statistics (iii) Social Sciences, (iv) Biological Sciences, (v) Physics and Earth Sciences, (vi) Computer and Communication Sciences, and (vii) Statistical Quality Control & Operations Research. The Institute has four other divisions (viii) Teaching and Training, (ix) Library, Documentation and Information Sciences, (x) Computer and Statistical Services Centre (CSSC), and (xi) Administrative Services, which look after the administration and teaching programmes of the Institute as well as provide other supporting services to the scientific staff of the Institute. Although not directly under one of the seven scientific divisions, many scientific workers of the Institute are placed in the Library and CSSC, and carry on basic independent scientific research of their own. At present, the Institute continues to have its headquarters at Kolkata, two other centres at Delhi and Bangalore, a Branch in Giridih, a network of units of SQC & OR at Baroda, Mumbai, Pune, Coimbatore, Chennai and Hyderabad, and a station at Takdah in Darjeeling.

The Golden Jubilee celebration of the Institute was inaugurated by Shrimati Indira Gandhi, the then Prime Minister of India, in Calcutta on 29th December 1981 at a meeting presided over by Shri Subimal Dutt, President of the Institute. Besides the Prime Minister, Shri P. N. Haksar (the then Chairman of the ISI Council), Shri S. B. Chavan, (the then Union Minister for Planning), Shri Pranab Mukherjee, (the then Union Cabinet Minister of Commerce and Steel & Mines), Professor C. R. Rao, Profesor G. Kallianpur, and Professor B. P. Adhikari, the then Director of ISI, gave speeches on the occasion. Six conferences and three symposia were held during the Golden Jubilee celebration. The first Asian Quality Congress was held by the SQC & OR Division during this period.

The Birth Centenary celebration of Professor P. C. Mahalanobis was inaugurated in Calcutta by Shri P. V. Narasimha Rao, the then Prime Minister of India, in a special function on 29th June 1993. It was

presided over by Professor M. G. K. Menon, President of the Institute, and was also attended by Shri P. N. Haksar (the then Chairman of the ISI Council), Shri Jyoti Basu (the then Chief Minister of West Bengal), Shri Pranab Mukherjee (the then Union Minister of Commerce), and Professor B. L. S. Prakasa Rao, the then Director of ISI. Two international conferences, three national conferences and symposia and three special lectures were organized during the Birth Centenary celebration of Professor Mahalanobis. The Indian Postal Service released a commemorative postage stamp on Professor Mahalanobis on this occasion.

The Prime Minister inaugurated the P. C. Mahalanobis Memorial Museum and Archives at 'Amrapali', the residence of Professor Prasanta Chandra and Mrs. Nirmal Kumari Mahalanobis, situated in the Institute campus during Professor Mahalanobis's birth centenary celebration. The Institute has carefully nurtured the museum and archives since then. At present they represent major display items and original resource materials on the growth of the Institute and draw keen attention of outside visitors. Full computerization of the total holdings of the archives, including lectures and audiovisual recordings, and development of archival record management systems are envisaged for the future.

The Platinum Jubilee celebration of ISI, which is going on at the present time, was inaugurated on 24th December, 2006 in Kolkata by Dr. Manmohan Singh, Prime Minister of India, in a solemn function presided over by Professor M. G. K. Menon, President of the Institute. All those who spoke on the occasion – which also included Shri Pranab Mukherjee (Union Minister of External Affairs and Chairman of the ISI Council), Shri Buddhadeb Bhattacharjee (Chief Minister of West Bengal), Shri G. K. Vasan (Union Minister of Statistics & Programme Implementation) and Professor Sankar K. Pal, Director, ISI – recounted the contributions of Professor Mahalanobis and applauded the interdisciplinary character of the Institute and the high standard of research being done by the scientists of the Institute. In his speech, the Prime Minister declared that henceforth 29th June, the birthday of Professor Prasanta Chandra Mahalanobis, would be nationally honoured as 'Statistics Day'. Professor Sankar K. Pal, Director, announced that a comprehensive academic programme under the banner of "Statistical Science and Interdisciplinary Research" was envisaged for the Platinum Jubilee celebration. The Prime Minister was felicitated by the President of the Institute with a Doctor of Science (honoris causa) degree of ISI. Two other Prime Ministers of India – Pandit Jawaharlal Nehru and Shri Morarji Desai – had earlier received honorary D.Sc. degrees from the Institute.

No account of the Institute can be complete without some reference to the stream of eminent scientists and statesmen who visited and/or have been associated with the activities of the Institute from its formative period. Since 1939, Sir Ronald A. Fisher was a frequent visitor to ISI and, at the request of Professor Mahalanobis, helped shape some of the emerging scientific activities of the Institute. In 1957 Professor J. B. S. Haldane joined the Institute, helped Mahalanobis initiate the B. Stat (Honours) programme, and provided direction to quantitative biological research in the Institute. Other eminent visitors who visited the Institute during the Mahalanobis period include Harold Hotelling, Walter A. Shewhart, Frederic and Irene Juliot Curie, Norbert Wiener, Genichi Taguchi, Jan Tinbergen, F. Yates, A. N. Kolmogorov, J. L. Doob, Neils Bohr, Pamela Robinson, P. M. S. Blackett, Jerzy Neyman, J. D. Bernal, Oscar Lange, Joan Robinson, Charles Bettelheim, D. Blackwell, R. L. M. Synge, Nicholas Kaldor, Simon Kuznets, Ragnar Frisch and William Q. Meeker. Among the front-ranking statesmen who visited the Institute during 1950s and 1960s, special mention should be made of Chou-en-Lai, Ho Chi Minh, Che Guevara, Alexei Kosygin, Lyndon Johnson, and J. K. Galbraith. Pandit Jawaharlal Nehru, the first Prime Minister of India, visited the Institute on several occasions, particularly in the context of the formulation of the draft Second Five-Year Plan of the country. Shri Lalbahadur Shastri also visited the Institute, although that was prior to his becoming the Prime Minister of India.

Other important scientific personalities who have been prominent visitors to the Institute include Martin Shubik, Llyod S. Shapley, James Harrington, K. Ito, E. B. Dynkin, P. A. Meyer, D. J. Desmond, Rene Thom, J. Thomspon, Alain Connes, L. Kantorovich, Ellis R. Ott, Werner Hildenbrand, L. Hurwicz, J. R. Hicks, Amartya Sen, Paul Erdos, Claude Berge, Harish-Chandra, A. R. Haralick, A. Rosenfeld, Sir W. F. Bodmer, David Gale, Juan Enrique Martinez Legaz, S. S. Abhayankar, J. F. Mertens, L. A. Zadeh, M. F. Atiyah, Robert J. Aumann, Sir Michael Brady and Sir Roger Penrose. Many of them left lasting

Brief History

Impressions on the research programmes of the Institute. For example, research on Graph Theory in ISI was profoundly influenced by Paul Erdos and Claude Berge, both of whom were regular visitors to the Institute.

During the last three decades leading statisticians and probabilists of the world who have visited the Institute, some of them to deliver the prestigious Mahalanobis lectures, include Harald Cramer, Sir D. R. Cox, S. Karlin, Peter Bickel, Persi Diaconis, T. W. Anderson, Peter Hall, James Berger, C. F. Jeff Wu, Frank R. Hampel, Keith Worsley, Shun Ichi Amari, Ulf Grenander, Michael Keane and D. M. Titterington.

If there is one scientist apart from Mahalanobis who deserves special mention in any history of the Institute, it is Professor C. R. Rao. Professor Rao was a part of the Institute for a very long time. Together with Professor Mahalanobis, he has been the Institute's best known face. His academic leadership and guidance have been major factors in the continued growth of the Institute during the late Mahalanobis years, as well as in the post Mahalanobis era. His contribution to different areas of statistics including estimation theory, multivariate analysis and biometry has influenced the future research of several generations. He is one statistician who is likely to feature in everybody's list of ten best Indian scientists.

Apart from Professor C. R. Rao, many other front ranking statisticians and scientists of India – of different generations – have been closely associated with the Institute and its activities during its 75 year history. C. V. Raman was the Vice Chairman of the Institute for several terms. S. N. Bose had served as the President of the Institute. Meghnad Saha also had a close relationship with ISI. Among the scientists of the Institute, R. C. Bose and S. N. Roy were among the early associates of P. C. Mahalanobis. The ascent of C. R. Rao, whose contributions have been already discussed, was the most important landmark of the 1940s and 1950s in the chronology of the Institute's scientific personnel. In the 1950s the faculty of ISI included, apart from Mahalanobis and Rao, many other distinguished scientists such as R. R. Bahadur, Debabrata Basu, G. Kallianpur and D. B. Lahiri. Some of them studied abroad and subsequently joined ISI as a faculty. Bahadur's contribution to decision theory and large deviations are well known. Debabrata Basu joined the Institute as a student and later went on to become a Professor of the Institute as well as the first Dean of Studies. He made outstanding contributions to foundations of inference; in particular, he provided a critical assessment of inference from sample surveys. Kallianpur made lasting contributions to filtering theory including white noise theory and to infinite dimensional stochastic differential equations. D. B. Lahiri was a self-taught mathematician who contributed significantly to sample survey methods. In the early 1960s a younger group of talented mathematicians emerged in the Institute. Their pioneering work on theoretical probability and related areas became famous all over the world; this group included V. S. Varadarajan, R. Ranga Rao, K. R. Parthasarathy and S. R. S. Varadhan. M. N. Murthy was a key person in sampling theory, while B. Ramachandran deserves mention for his work in the area of characteristic functions. Moving along to more recent times, G. Kallianpur provided vision and direction to the Institute in the role of the Director during the late 1970s. B. P. Adhikari greatly influenced the research in the biological sciences division of the Institute. Stalwarts like Debabrata Basu, Ashok Maitra, Jayanta K. Ghosh and Sujit K. Mitra helped shape the scientific course of the Institute during the later years. Some of them were also directly and indirectly responsible for the revival of mathematics group and mathematical research in ISI – at the Kolkata and the Delhi centres of the Institute initially and, later, at the Bangalore centre. Ashok Maitra, K. R. Parthasarathy, M. G. Nadkarni and others played a similar role in the area of probability. Ashok Maitra's initiative led to the growth of the area of descriptive set theory and logic in the Institute. Rigorous statistical inference flourished under the leadership of Debabrata Basu, Jayanta K. Ghosh and Somesh Dasgupta; Jayanta K. Ghosh made fundamental contributions to asymptotic theory, and was the primary figure in developing the area of Bayesian analysis in ISI; he also initiated or participated in many interdisciplinary studies at the Institute. Somesh Dasgupta was a key person in multivariate analysis. T. Parthasarathy, B. L. S. Prakasa Rao and E. M. Paul were some of the other notable scientists in the statistics-mathematics area in the later periods. Paul was also a very colourful teacher, remembered fondly by his students. Samarendra Kumar Mitra, the Head of the Computing Machines and Electronics Laboratory (CMEL) at ISI was instrumental in the 1950s in building indigenous analogue computers. He developed a

collaborative association with Soviet Scientists in the area of computer hardwares. He was honoured in Soviet Russia when a street in Penza, a town north east of Moscow, was named after him. Dwijesh Dutta Majumdar was a pioneer of research activities in pattern recognition, image processing, computer vision and artificial intelligence in the Institute. Jogabrata Roy was instrumental in the Institute's drive towards computerisation and took active part in many issues and problems related to India's official statistics. Nikhilesh Bhattacharya also played a leading role in continuing with the tradition of empirical applications initiated by Mahalanobis, and made significant contributions to the area of applied econometrics. Deb Kumar Bose had an important part in the growth of the economics and planning group of the Institute. Moni Mukherjee was another outstanding economist of the Institute, particularly in the area of India's national income, with great proficiency in both theoretical and empirical work. B. S. Minhas played a major role in setting up the National Sample Survey Organisation (NSSO) in the 1970s. Ramakrishna Mukherjee was the leading figure in developing the research programmes for social sciences. K. C. Malhotra had a major role in conducting studies on social forestry and ethno-ecobiology. Amitabha Basu was an important intellectual role model for ISI anthropologists and provided health studies as a new research direction. Ratan lal Brahmachari was another outstanding ecologist and embryologist and had a major influence on the other researchers in his area. S. B. Rao, Kalyan B. Sinha and Sankar K. Pal, the most recent Directors of the Institute, have all done their part in providing strong leadership to the Institute. Professor Sankar K. Pal, the present Director of the Institute, is an internationally acclaimed computer scientist. The current generation of scientists in the Institute are worthy successors of their predecessors, and are carrying on their scientific work with vigour.

Top Indian statesmen have continued to visit the Institute even after Professor Mahalanobis had passed away, particularly on special occasions. In 1978, Shri Morarji Desai, the then Prime Minister of India, visited the Institute to deliver the Convocation Address. In 1981, Mrs. Indira Gandhi, the then Prime Minister of India, inaugurated the Golden Jubilee celebration of the Institute. In 1993, Shri P. V. Narasimha Rao, the then Prime Minister of India, took part in the birth centenary celebration of Professor P. C. Mahalanobis at the Institute headquarters in Calcutta. A. P. J. Abdul Kalam, the then President of the Republic of India, delivered the Convocation Address in 2004. In 2006, Dr. Manmohan Singh, the Prime Minister of India, visited the Institute to flag off the Platinum Jubilee celebration.

At the present time, the Institute is recognized as one of the world's leading organizations in many areas of scientific research. The passing away of Professor P. C. Mahalanobis did represent the end of an era in the history of the Institute. However, even after his demise, the Institute adhered to the basic objectives as envisaged by the late Professor and continued to grow and diversify in many areas in both theoretical and applied research. The quest for excellence is continually pursued by the Institute which is reflected in the quality of outcome in research and project related activities carried out by the scientists of the Institute. In addition to its traditional areas of strength in probability and stochastic processes, asymptotic theory of inference, sample surveys, design of experiments and multivariate analysis, research in statistics in the Institute has diversified into several other areas of theoretical and applied statistics. In recent times the Institute faculty have made notable contributions in resampling methods, Bayesian inference, nonparametric and robust inference, bio- and medical statistics, statistical genetics, survival analysis and reliability among others. In the 1980's the Institute was the birth place of the new subject of quantum probability. As part of more recent history, research in the interdisciplinary applications of statistics shows a significant growth in areas like geological mapping, social network analysis and applications of graph theory, clinical epidemiology, modelling the growth of HIV infection, statistical image and signal processing and pattern recognition, analysis of fMRI data and brain mapping, analysis of microarray data, fossil shape analysis and applications to environment and ecology.

In mathematics, the Institute scientists have made significant contribution in the areas of harmonic analysis, functional analysis, theory of matrices operator algebras, non-commutative geometry, commutative algebra, differential and algebraic topology, and descriptive set theory and logic.

Brief History

The economics group of the Institute have contributed substantially in the areas of game theory, growth and development, measurement of inequality, poverty, international trade, Industrial organization, social choice and applied econometrics.

In the discipline of computer science, the Indian Statistical Institute is now regarded by many as the leading institute in the country. This has been corroborated by detailed independent studies. The areas in which the computer scientists of the Institute have a strong presence include soft computing, VLSI design, mobile computing, computational geometry, pattern recognition, image and signal processing, machine intelligence, digital document processing, information retrieval, cryptography and cryptanalysis. The "Center for Soft Computing Research (CSCR): A National Facility" was set up in the Institute in 2005 with the support of DST under the IRHPA (Intensification of Research in High Priority Areas) scheme. The centre aims at conducting research, both theoretical and applied, of international standard, and providing training in the field of soft computing.

The SQC & OR group of the Institute is now recognized nationwide as a leading scientific group providing statistical consulting to the industrial community of India. In recent times its activities have spread beyond India, as many foreign organizations have sought the assistance of this group. Major areas in which this group has distinguished itself include Six Sigma initiatives, statistical process control, software and system reliability, acceptance sampling, statistical modeling of engineering and marketing processes, complementarily theory, generalized convexity, integer programming and cooperative, noncooperative & stochastic games.

The geological studies group is doing significant work on tectonosedimentary evolution of the Precambrian and Gondwana basins of peninsular India, structure, petrology, and geochemistry of deep crustal rocks, morphometric analysis of fossil skulls and river dynamics in sub-Himalayan foothills. *Barapasaurus tagorei*, a fully mounted skeleton of a Jurassic herbivorous dinosaur housed in the Geology Museum, continues to attract the general public as well as researchers from all over the world.

The physics and applied mathematics group is well known for its work in fluid mechanics, quantum information theory and quantum mechanics and field theory.

The main thrust of research of the biological science group are in the areas of mathematical modelling of ecological systems, ecophysiology of mangrove ecosystems, water pollution in pond ecosystems, natural resource inventory and agricultural technology transfer, biopesticidal efficacy, plant medicines and microbiology, health and disease in contrasting environments, variation and inheritance of morphological traits, population structure and peopling in India, genetic epidemiology of complex diseases and evolutionary and disease genomics.

The sociology group is involved in doing research on, among other areas, social network analysis, industrial and urban development, impact of economic reforms on production and human development, labour employment and labour problems, gender issues, issues on literacy and education, and the problem of Dalits.

The Psychology group is working in the area of psychometry and various fields of application such as educational, developmental, cognitive and organizational psychology as well as in modern psychometric methods such as item response theory.

The Linguistic Research Unit has been working on the acoustic aspects of Bengali phonetics and articulatory norms of Bengali speech sounds, quantitative macrolinguistics with special reference to Bengali and other Indian languages, the formal syntax and morphology of Bengali and other Indian languages, and different aspects of cognitive linguistics.

The Delhi Centre is the older of the two outlying centres of ISI and houses a strong, research oriented scientific community. Apart from the Statistics and Mathematics Unit and SQC & OR unit, it also includes the Planning Unit, which is internationally recognized for its outstanding research quality in

areas like game theory, Industrial organization, environmental economics, trade, macroeconomics, social choice and development economics. Historically, the planning unit was set up with the objective of providing input to the Indian planning process; in fact it was initially housed within the Planning Commission premises before being shifted to the present ISI Delhi campus in the mid 1970s. The unit continues to contribute to the planning process even today, with the faculty working on various issues of policy importance, most of which are carried out in the Planning and Policy Research Unit (PPRU).

The Bangalore Centre of the Indian Statistical Institute was conceived during 1960s. Since that time scientific activities have been going on in Bangalore, although it gained a centre status only in 1996. Both Professor Mahalanobis and Professor G. Kallianpur played crucial roles in the development of the Bangalore Centre. Apart from the Stat-Math Unit, the SQC & OR Unit and the Economic analysis uint, one of the special features of the Bangalore campus is the Documentation, Research and Training Centre which came into being in 1962. Dr. S. R. Ranganathan had a major part in the development of this group in Bangalore. At present, the Bangalore Centre represents a vibrant scientific community of active researchers.

The Institute continues to be one of the leading centres of teaching and training in the world in different areas of science. The recent conferring of the Abel Prize – considered the equivalent of a Nobel Prize for mathematics and given away by the King of Norway himself – on Prof. S. R. S. Varadhan in 2007 is one of the latest success stories of the Institute alumni. Professor Varadhan was among the earliest recipients of a Ph. D degree from the Institute. It is a happy coincidence that he received his award when the Platinum Jubilee celebration of the Institute is going on. Many other alumni and scientists of the Institute have won the Bhatnagar and other prestigious national awards and have also received similar recognitions at the international level, and/or are fellows of national and international scientific bodies. Many Institute alumni are currently placed in important and responsible positions throughout India and abroad.

At present the Institute is fully funded by the Ministry of Statistics and Programme Implementation, Government of India. The support and encouragement of the Ministry are among the major factors which have helped the Institute to sustain its excellence.

In conclusion, a list of the distinguished scientists and statesmen who have served the Institute during the 75 years of its existence in the capacities of President, Chairman or Director is presented. A list of recipients of the honorary D.Sc. degree given by the Institute is also provided.

Presidents of the Institute

1	Shri Rajendra Nath Mookerjee	1932-35
2	Shri E. C. Benthall	1936-37
3	Shri James Reid-Kay	1938
4	Shri Badridas Goenka	1939-41
5	Dr. Nalini Ranjan Sarkar	1942-43
6	Dr. Chintaman D. Deshmukh	1944-1963
7	Shri Y. B. Chavan	1964-66
8	Prof. Satyendra Nath Bose	1967-75
9	Shri Subimal Dutt	1976-89
10	Prof. M.G.K. Menon	1990-till date

Chairmen of the Institute

1	Shri B. Rama Rao	1954
2	Shri D. N. Mitra	1955-63
3	Shri K. P. S. Menon	1964-70
4	Shri S. C. Roy	1971
5	Dr. Atma Ram	1972
6	Shri. P. N. Haksar	1973-97
7	Dr. Bimal Jalan	1998-2001
8	Dr. N. R. Madhava Menon	2002-03
9	Shri Pranab Mukherjee	2004-till date

Directors of the Institute

1	Prof. P. C. Mahalanobis	Dec	1931	- June	1972
2	Prof. C. R. Rao	July	1972	- June	1976
3	Prof. G. Kallianpur	July	1976	- Sept	1978
4	Prof. B. P. Adhikari	Aug	1979	- Oct	1983
5	Prof. Ashok Maitra	April	1984	- Jan	1987
6	Prof. J. K. Ghosh	Jan	1987	- Jan	1992
7	Prof. B. L. S. Prakasa Rao	Jun	1992	- Feb	1995
8	Prof. S. B. Rao	July	1995	- July	2000
9	Prof. K. B. Sinha	Aug	2000	- July	2005
10	Prof. S. K. Pal	Aug	2005	- Till date	

List of persons awarded the D.Sc. (Honoris Causa) by the Institute

February 1962	Prof. Satyendra Nath Bose, Prof. Ronald A. Fisher, Pandit Jawaharlal Nehru, Dr. Walter A. Shewhart
April 1962	Prof. A. N. Kolmogorov
May 1965	Dr. Chintaman Dwarkanath Deshmukh
December 1974	Prof. Raj Chandra Bose, Dr. M. V. Keldysh, Prof. Jerzy Neyman
February 1977	Prof. Harald Cramer
February 1978	Shri Morarji Desai, Prof. L. V. Kantorovich
December 1989	Prof. C. R. Rao
January 2001	Prof. Gopinath Kallianpur
February 2004	Prof. S. R. Srinivasa Varadhan
March 2006	Prof. L. A. Zadeh
December 2006	Dr. Manmohan Singh

P C Mahalanobis with Harold Hotelling at Gupta Nivas in 1939

W A Shewhart delivering a lecture at ISI in 1948. P C Mahalanobis is present along with other scientists

J D Bernal, Rani Mahalanobis, Frederic Joliot-Curie, Madame Irene Joliot-Curie and P C Mahalanobis at ISI in January 1950

P C Mahalanobis with Haris and Meghnad Saha at Amrapali in 1953

Norbert Wiener and Mrs. Wiener at the Institute in January 1954

Pandit Jawaharlal Nehru, Prime Minister of India, inaugurating Studies on National Planning at ISI, Calcutta, on November 3, 1954

Pandit Jawaharlal Nehru shaking hands with G Taguchi at Amrapali on November 3, 1954. P C Mahalanobis and W A Shewhart are also present
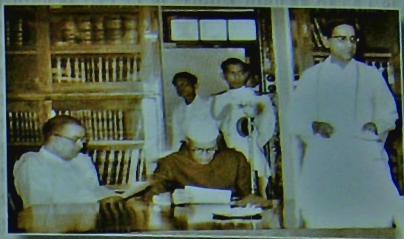
Jawaharlal Nehru, Prime Minister of India, in Amrapali with B C Roy, Chief Minister of West Bengal, and P C Mahalanobis on November 3, 1954

Farewell party for G Taguchi at ISI in 1955. P C Mahalanobis (second from right) is present

P C Mahalanobis and P N Bannerjee at the farewell for Jan Tinbergen, Nobel Laureate in Economics, at ISI, on February 13, 1956

Oscar Lange, celebrated Polish Economist and Mrs.Lange with P C Mahalanobis at their farewell in ISI, on March 10, 1956

P C Mahalanobis and C D Deshmukh having a discussion at Amrapali in 1956

P C Mahalanobis (second from left) at the installation ceremony of a Russian Computer at the Institute, on April 2, 1956

P C Mahalanobis speaking at the Silver Jubilee Celebration of the Indian Statistical Institute on December 17, 1956. R A Fisher is on the dais, along with other dignitaries

P C Mahalanobis and Chou-en-Lai, Prime Minister of China, during the latter's visit to ISI in December 1956

J B S Haldane and P C Mahalanobis at the Amrapali on the former's birthday, on November 5, 1957
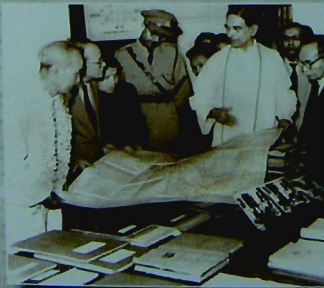
P C Mahalanobis with Ho Chi Minh, President of the People's Republic of Vietnam, in ISI, on February 13, 1958

Che Guevara, leader of a Cuban delegation, visiting ISI on July 10, 1959

Niels Bohr, Nobel Laureate, Director, Institute of Theoretical Physics, Copenhagen, with P C Mahalanobis at the ISI, on January 16, 1960

J B S Haldane speaking at the inauguration of ISI degree programs on August 16, 1960 in the presence of P C Mahalanobis, S N Bose and C R Rao

(From left to right) - P C Mahalanobis, Pamela L Robinson, R A Fisher (showing picture of a dinosaur) and Alec Smith standing in front of fossil bones of dinosaurs excavated by the ISI team, on February 11, 1961

P C Mahalanobis addressing the first Convocation of ISI, on February 12, 1962

(From right) S N Bose, A N Kolmogorov and P C Mahalanobis at a special Convocation of ISI on April 28, 1962 to confer an Honorary D Sc on Kolmogorov

M C Chagla, Union Minister of Education, at the Inaugural ceremony of ISIJU-1 Computer, on April 2, 1966
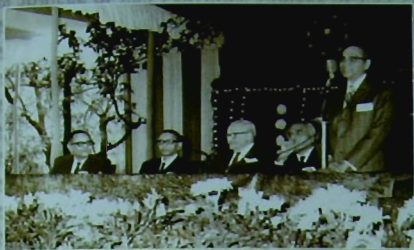
Special Convocation to confer the Honorary D Sc Degree on Academician M V Keldysh, J Neyman and R C Bose (speaking) held on December 18, 1974. (Academician Keldysh was awarded the degree in absentia). Other dignitaries sitting on the dais are P N Haksar, C R Rao and Moni Mukherjee

C R Rao, L Kantorovich and Mrs. Kantorovich at Amrapali, ISI in 1975

Harald Cramer with G Kallianpur and C R Rao at ISI in 1977

(From right) Shri Morarji Desai, Prime Minister of India, Subimal Dutt, ICS, President of ISI, G Kallianpur and others at ISI Convocation on February 7, 1978

Smt. Indira Gandhi, Prime Minister of India, with B P Adhikari, Director, during the inaugural function of the Golden Jubilee Celebration of ISI, on January 29, 1982

Inaugural function of the Golden Jubilee Celebration of ISI, on January 29, 1982. G Kallianpur and C R Rao are on the right, Indira Gandhi and Subimal Dutt are in the centre and P N Haksar and B P Adhikari are on the left

Ashok Maitra, Director of ISI, speaking at the P C Mahalanobis Memorial Lecture on December 9, 1985. Sitting on the dais are P N Haksar and T N Anduras

(From left) A B Gupta, Nikhilesh Bhattacharya, T Krishnan, J Roy and Ajoy Adhikari at the closing ceremony of Intensive Course in Computer Applications on December 6, 1991

J B S Haldane Birth Centenary Celebration at ISI, during December 16-19, 1992
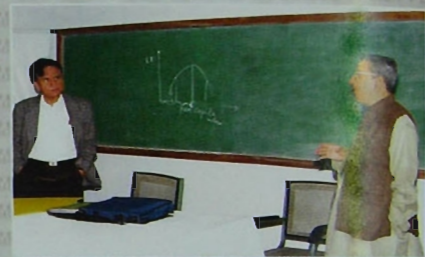
Jayanta K Ghosh and Robin Mukherjee at the Training Programme on Environmental Economics for Government Officials held during January 18-23, 1999

Dr. Bimal Jalan, Chairman, ISI, (right) at the 36th Convocation with M G K Menon (centre), President, ISI and K B Sinha, Director on January 15, 2002
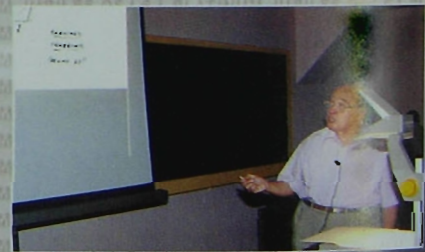
Michael Atiyah, FRS, delivering a special lecture at ISI on November 20, 2003

Dr. A P J Abdul Kalam, President of India, at the 38th Convocation of ISI, on February 27, 2004

S R S Varadhan being conferred the Honorary D Sc by Dr. A P J Abdul Kalam, President of India at the 38th Convocation of ISI on February 27, 2004

Madhav Menon, Chairman, ISI (left) and K B Sinha, Director (centre) at the Council meeting on September 15, 2004

S B Rao (left) presents a bouquet to C R Rao (right) at ISI, in 2005 as A R Rao (centre) applauds

Shri Pranab Mukherjee, Chairman, ISI Council inaugurating the ISI playground on August 28, 2005. Eminent players are present

L A Zadeh, Pioneer in Fuzzy set theory, delivering an address at the 40th Convocation of ISI on February 16, 2006

○ Roger Penrose, FRS, with Sankar K. Pal, Director on November 7, 2006 at ISI

○ Ian Witten at the Tutorial on Building Digital Library using Greenstone Digital Library Software and Dspace convened by the Library on December 11, 2006 at ISI

○ Winter school on Teaching of Statistics at undergraduate level held during January 8-10, 2007 at ISI

○ Tapan Roychowdhury, eminent historian being presented with the Pictorial Album by Sankar K. Pal, Director on January 09, 2007

○ Spring School on Soft Computing : Advances and Applications (SSSCAA) held during March 13 - 16, 2007 organised by Center for Soft Computing Research, ISI

○ Inauguration of the Workshop on Consortia Based Subscription of Online Resources convened by the Library on March 30, 2007

C R Rao receiving the honoured guests, academician Pyotr Kapitsa and his wife, in the new campus of Indian Statistical Institute, Delhi on February 8, 1974

Smt. Indira Gandhi, Prime Minister of India, inaugurating the Delhi Campus of the Institute on December 30, 1974
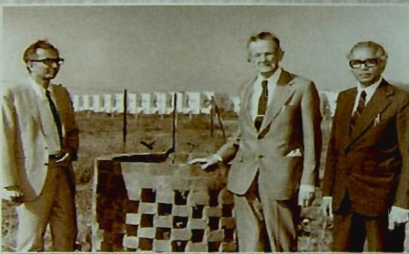
G Kallianpur, Harald Cramer and C R Rao at ISI, Delhi

Jerzy Neyman, P N Haksar and Smt. Indira Gandhi, Prime Minister of India at the inaugural function of Delhi campus, ISI on December 30, 1974

(From right to left,) Djordje Kostic, Director, Institute of Experimental Phonetics and Speech Pathology, Belgrade, C R Rao, Alokananda Mitter and others at the ISI Delhi Campus

Robert J Aumann, Nobel Laureate at Delhi ISI on January 10, 2007

L to R : A Neelameghan (giving Welcome Address), Nagabhushana, Justice Nittur Srinivasa Rao, Shri C D Deshmukh, S R Ranganathan at the inauguration of DRTC on April 16, 1962

1st Building of DRTC at Malleswaram, Bangalore, 1962

Prof. C R Rao planting a sapling at the Bangalore centre in 2006

M A Gopinath, T Krishnan and B K Chandrasekhar on 114th Birth Anniversary of P C Mahalanobis at ISI Bangalore on 29th June 2007

Prof. IG. Godefroy, University of Paris VI, giving Choquet memorial lecture at ISI, Bangalore on June 2007

P C Mahalanobis in a field visit at Giridih Branch of ISI in 1953

Prime Minister's visit to ISI, Kolkata : December 24, 2006

Dr. Manmohan Singh, Prime Minister of India, releasing the 'Platinum Jubilee Commemorative Album 1931-2006'

Dr. Manmohan Singh, Prime Minister of India, after planting a mango sapling at ISI

Dr. Manmohan Singh, Prime Minister of India laying the foundation stone of the Platinum Jubilee Academic Building

Dr. Manmohan Singh, Prime Minister of India being conferred the Honorary D Sc by M G K Menon, President. Pranab Mukherjee, Chairman, ISI and Defence Minister, G K Vasan, Minister of Statistics & P I, C R Rao, Sankar K Pal are on the dias

Dr. Manmohan Singh, Prime Minister of India delivering the inaugural address at the Platinum Jubilee Celebration of ISI
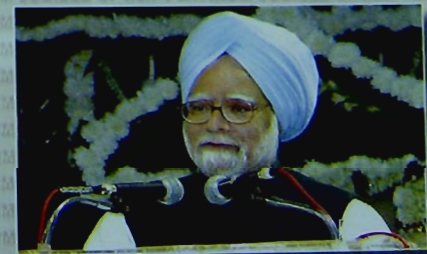
A close up of Dr. Manmohan Singh, Prime Minister of India delivering the inaugural address at the Platinum Jubilee Celebration of ISI

The Five Most Recent Mahalanobis Memorial Lectures at ISI

Peter McCullagh, Department of Statistics, University of Chicago on March 15, 2001

Keith J Worsley, Department of Mathematics and Statistics, McGill University, Montreal, Canada during March 17-21, 2003

Ulf Grenander, Brown University, USA, during January 27-28, 2004

Michael S Keane, Department of Mathematics and Computer Science, Wesleyan University on January 9, 2006
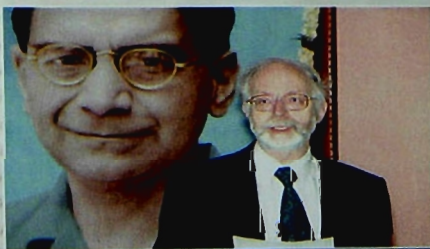
Donald M Titterington, University of Glasgow, U K on January 24, 2007

1. TEACHING AND TRAINING

Degree and Other Courses

The regular full-time programmes of study of the Institute are:

1. B. Stat. (Hons.) : Bachelor of Statistics (Honours)

2. B. Math. (Hons.) : Bachelor of Mathematics (Honours)

3. M. Stat. : Master of Statistics

4. M. Math : Master of Mathematics

5. M.S. (QE) : Master of Science in Quantitative Economics

6. M.Tech. (CS) : Master of Technology in Computer Science

7. M.Tech. (QROR) : Master of Technology in Quality, Reliability and Operations Research

8. ADIS : Associateship in Documentation & Information Science

9. Research Fellowships in Statistics; Mathematics; Economics; Computer and Communication Sciences; Physics and Applied Mathematics; Sociology; Demography; Geology; Psychology; Biological Anthropology; Agriculture and Ecological Sciences; Human Genetics and Library and Information Science.

The Institute also runs a six-month part-time programme at the SQC & OR Units at Hyderabad and Bangalore called Part-time Certificate Course in SQC & OR.

A total of 10,638 candidates applied for admission to the 2006-07 session of the above programmes for which Admission tests were conducted at 22 different centres all over the country. In all 8382 candidates finally appeared for admission tests out of whom 567candidates qualified in the written tests, and were called for interviews and finally 209 candidates were offered admission.

The number of students admitted to the different degree, associateship courses and in Junior Research Fellowship during 2006-07 and the number of students passed in the annual examinations in 2006 held during May, 2006 are given in Table 1. The 2006-07 academic session commenced on 10 July 2006.

Convocation

The 41st Convocation of the Indian Statistical Institute was held on 7th March 2007 at 3.30 P.M. It was started with Vedic Hymns presented by the ISI Club, followed by a welcome address by Prof. M. G. K. Menon, President, ISI, and the presentation of the annual review by Prof. Sankar K. Pal, Director, ISI. The degrees and associateships were awarded to students by Prof. M. G. K. Menon, President, ISI. This was followed by a Convocation Address by Sir Michael Brady, University of Oxford, UK. The Convocation was closed by Prof. M. G. K. Menon, President, ISI, after a vote of thanks by Prof. Bimal Kr. Roy, Dean of Studies, ISI.

The ISI Alumni Association *Mrs. M.R. Iyer Memorial Medals* for outstanding performances were given to:

B. Stat. (Hons.) :	Gourab Mukherjee	M. Stat.:	Partha Sarathi Dey
M. S. (QE):	Anil Kumar Somani	M. Tech. (QROR) :	Subhasis Chaudhury

ISI Alumni Association *Rashi Ray Memorial Medal* for outstanding performance was given to:

M. Tech. (CS):   Shibdas Bandyopadhyay

1

Teaching and Training

ISI Alumni Association *P. C. Panesar Medal* for outstanding performance was given to:

M. Math. :   Somnath Jha

Sunity Kumar Pal Gold Medal for best dissertation was given to :

M. Tech. (CS) :   Abhay Kumar

S. H. Arvind Gold Medal for outstanding performance was given to:

B.Math. (Hons.) :   Tanmoy Neelesh Deshpande

Table - 1
Number of students who passed the different courses during 2006 and number of
existing students/fellows during 2006-2007.

Sl. No.	Courses	Number of Students Passed the Annual Exam. in 2006	Existing Number of Students/ Fellows in 2006-07
01.	B.Stat.(Hons.)		
	1st year	34	26
	2nd year	28	34
	3rd year	33	29*
02.	B.Math.(Hons.)		
	1st year	9	11
	2nd year	12	9
	3rd year	8	13*
03.	M.Math.		
	1st year	9	7
	2nd year	1	10*
04.	M.Stat.		
	1st year	16 (11+5)	53 (32+21)
	2nd year	40 (36+4)	16
05.	M.S.(QE)		
	1st year	19	27 (19+8)
	2nd year	17	21
06.	M.Tech. in Computer Science		
	1st year	21	18
	2nd year	17	21
07.	M.Tech. in Quality, Reliability & Operations Research		
	1st year	10	20
	2nd year	10	10
08.	Junior & Senior Research fellows and Research Associates in different disciplines	12**	87
ASSOCIATESHIP			
09.	Associateship in Documentation and Information Science (Bangalore)		
	1st year	9	7
	2nd year	4	9
	Grand Total	309	428

Total number, including Kolkata and Delhi. ** Two students repeating the final year. * A student repeating the final year. ** Ph. D. Degree awardees.

Table 2

Ph.D. Degrees awarded by the Institute in the 41st Convocation held on March 07, 2007

Sl. No.	Name of the Fellow	Title of the Thesis	University/ Institute	Name of the Supervisor(s)
1.	Anup Majumdar, B. E. (Mech. Engg.), (University of Burdwan) Diploma in SQC&OR, (ISI)	Multiattribute Acceptance Sampling Plans.	ISI	Prof. A. C. Mukhopadhyay, ASU (Retired), ISI, Kolkata
2.	Gyan Prakash, M. Stat. (ISI)	On Some Problems in Additive Number Theory.	ISI	Prof. R. Balasubramanian, Institute of Mathematical Sciences,Chennai.
3.	Madhur Malik, M. Sc., Appl. Math. (University of Roorkee)	Some Geometrical Aspects of the Cone Linear Complementarity Problem.	ISI	Prof. S. R. Mohan and Prof. S. K. Neogy, SQC & OR Unit, ISI, Delhi Centre
4.	Ratna Dutta, M. Sc., Appl. Math. (University of Calcutta)	Studies on Pairing-Based and Constant Round Dynamic Group Key Protocols.	ISI	Prof. Rana Barua, Stat-Math Unit, ISI, Kolkata
5.	Yumnam Kirani Singh, M. Sc., Electronics (Gauhati University)	On Some Generalized Transforms for Signal Decomposition and Reconstruction.	ISI	Prof. Swapan Kumar Parui, CVPRU, ISI, Kolkata
6.	Soumen Chowdhury, M. Sc., Physics (University of Calcutta)	Concatenative Text-to-Speech Synthesis: A Study on Standard Colloquial Bengali.	ISI	Prof. A. K. Dutta, ECSU (Retired), ISI, Kolkata and Prof. C. A. Murthy, MIU, ISI, Kolkata
7.	Deepak Kumar Dalai, M. Tech. (CS) (ISI)	On Some Necessary Conditions of Boolean Functions to Resist Algebraic Attacks.	ISI	Prof. Subhamoy Maitra, ASU, ISI, Kolkata
8.	Sarif Kumar Naik, M. Phil., Mathematics (Sambalpur University)	On Edge Detection and Object Recognition in Color Images.	ISI	Prof. C. A. Murthy, MIU, ISI, Kolkata
9.	Soumyananda Dinda, M. Sc., Economics (Burdwan University)	Environmental Kuznets Curve: Some Econometric Analyses.	ISI	Prof. Dipankar Coondoo, ERU, ISI, Kolkata
10.	Anupam Kumar Singh, M. Sc., Mathematics IIT, Kanpur	Reality Properties of Conjugacy Classes in Algebraic Groups.	ISI	Prof. Manesh Thakur, SMU, ISI, Bangalore
11.	Sanjit Chatterjee, M. E., B. E. College (Deemed University)	Construction of (Hierarchical)Identity-Based Encryption Protocols Using Bilinear Pairing.	ISI	Prof. Palash Sarkar, ASU, ISI, Kolkata

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12.	Arijit Laha, M. Tech. (CS) (ISI)	On Some New Methodologies for Pattern Recognition Aided By Self-Organizing Maps.	ISI	Prof. Nikhil R. Pal, ECSU, ISI, Kolkata

Table 3

Research Fellows of ISI who have been awarded Ph.D. degrees by Academic Bodies other than ISI during 2006-07 for work done in the ISI.

SI. No	Name of the Fellow	Title of the Thesis	University	Name of the Supervisor
1.	Susmita Mukhopadhyay	A Study of Organizational Health and Job Satisfaction in Rural Banks from Psychological Perspective.	University of Calcutta	Dr. Debdulal Dutta Roy, PRU, ISI.
2.	Manjishtha Maitra	A Study of Short-term Memory Assessment With Successive Decrease in Stimulus Presentation Time Using Computeraided Digit Span Test.	University of Calcutta	Dr. Debdulal Dutta Roy, PRU, ISI.
3.	Hema Joshi	A Study of Community Structure,Species Distribution and Above Ground Biomass With Special Reference to Soil Characteristics of Mangrove Forest in Lothian Island of Sundarbans, West Bengal.	University of Calcutta	Prof. M. Ghose, AERU, ISI.
4.	Partha Sarathi Mandal	Checkpointing and Self-Stabilization for Fault-tolerance in Distributed Systems.	Jadavpur University	Dr. Krishnendu Mukhopadhyaya. ACMU, ISI.
5.	Partha Pratim Goswami	New Variations of Proximity and Clustering Problems in Two Dimensional Point Set.	University of Calcutta	Dr. Subhas C. Nandy, ACMU, ISI.
6.	Arupendra Mazumder	Health of Urban Disabled: A Biosocial Study in Calcutta and Suburbs.	University of Calcutta	Dr. Subrata K. Roy, BAU, ISI.
7.	Mahuya Sengupta	Quantitative Inheritance of Dermatoglyphic and Anthropometric Traits With Special Reference to Asymmetry in Vaidyas of West Bengal, India.	University of Calcutta	Dr. Bibha Karmakar, BAU, ISI.
8.	Sobhanjan Sarkar	Risk of Cardiovascular Disease in Relation to Contrasting Lifestyles among the Bhutias of Sikkim.	University of Calcutta	Dr. Barun Mukhopadhyay, BAU, ISI
9.	Suhhasis Bandyopadhyay	On Contaminant Dispersion in Laminar and Turbulent Flows.	Jadavpur University	Prof. B. S.Mazumder, PAMU, ISI.

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10.	Kajal Kumar Mondal	Mass Transport Phenomena in Steady and Unsteady Flows.	Jadavpur University	Prof. B. S.Mazumder, PAMU, ISI.
11.	Tanmoy Kanti Das	Analysis and Design of Digital Watermarking Schemes.	Jadavpur University	Dr. Subhamoy Maitra, ASU, ISI (Jointly with Dr. Debesh Das, J.U.)

During 2006-2007, 207 trainees of Engineering and Technology courses from various Universities/Institutions received two weeks/six weeks/two months/three months/four months and six months Project training in different units of the Institute, viz., ACMU, AERU, ASU, BIRU, CSSC, CVPRU, ECSU, ERU, GSU, MIU, SMU and SQC & OR Unit under the guidance of different faculty members of the Institute.

The number of candidates awarded degrees/associateships in the 41st Convocation of the Institute, held on 7th March, 2007.

	Degree/Associateship	Number of candidates
1.	Doctor of Philosophy (Ph.D.)	12
2.	Master of Technology (M.Tech.) in Computer Science	17
3.	Master of Technology (M.Tech.) in Quality, Reliability and Operations Research	10
4.	Master of Statistics (M.Stat.)	40
5.	Master of Mathematics (M.Math.)	01
6.	Master of Science (M.S.) in Quantitative Economics	17
7.	Bachelor of Statistics (Honours) (B.Stat. (Hons.))	33
8.	Bachelor of Mathematics (Honours) (B.Math. (Hons.))	08
9.	Associateship in Documentation and Information Science	04
	Total	142

International Statistical Education Centre (ISEC)

The announcement of the 60th term Regular course was issued from the Centre at Kolkata. Prospectus and application forms were distributed from Kolkata. A number of prospectus and application forms were also distributed through Government of India. The Government of different countries were invited to nominate suitable candidates for training at the Centre. The applications for admission were forwarded to the Centre through the respective Indian Missions. On behalf of the Board of Directors, the Member-Secretary shouldered the responsibility of selecting the candidates for the 60th term ISEC regular course. This year 16 trainees from 8 countries, namely Oman (1), Myanmar (5), Sri Lanka (3), Georgia (1), Grenada (1), Senegal (1), Ghana (2) and Gambia (2) joined the course. Of the 16 trainees, 5 trainees were supported by fellowship awarded by the Government of India under the Technical Co-operation Scheme of the Colombo Plan (TCS of Colombo Plan), 7 trainees received

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grant from India Technical and Economic Cooperation (ITEC) and 4 trainees were supported by the Special Commonwealth African Assistance Plan (SCAAP).

The course was conducted in four phases. The first part of the first phase consisted of compulsory subjects on statistics and related fields at the introductory level. In the second part of the first phase, the trainees continued some of the subjects of the first phase and took up some more compulsory and optional subjects. After completing the first phase the trainees went to Delhi to attend the six-week course on official statistics conducted by Central Statistical Organisation (CSO), Dept. of Statistics, Govt. of India. After coming back from Delhi, the trainees underwent the third phase, which consists of mainly optional subjects. In the final phase each trainee chose one of the five special topics offered to them.

The trainees were provided with computer facilities and internet connections in the ISEC PC room and in the ISEC hostel. They had access to the books of the ISI library. The trainees participated in different programmes in ISI and outside. They were invited by the Rotary Club of North Calcutta. The aim of this interaction is to promote international understanding.

A remarkable change in the infrastructural facility has been made in the ISEC. Prof. S.K. Pal, the Director of ISI, took special interest in the development of the ISEC, formed a committee for upgrading the infrastructural facilities of the ISEC and sanctioned huge funds for this purpose. All the rooms have been renovated. One sports' room has been constructed on the roof of the ISEC mess. All the rooms have been furnished the new sets of cots, mattresses, almirahs, chairs, tables and linens. Also, the ISEC classrooms have been reorganized and renovated and new PCs and softwares have been installed. The construction of a new international building which will include the ISEC hostels, class rooms and offices has been planned and is expected to be complete by 2008. Prof. C. R. Rao was very keen to see the ISEC trainees enjoy a comfortable stay in the hostel and get state-of-the-art training here. He came to Kolkata, spent a few days with the trainees and initiated the process of upgrading the infrastructural facilities for the trainees.

Teachers of the head quarters at Kolkata and officers of the Government of India participated in teaching the regular course during the year. All the trainees in the regular course have successfully completed the course and have been recommended for the award of Statistical Training Diploma.

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2. RESEARCH AND OTHER ACTIVITIES

The major thrust of the Institute is on research in various disciplines including theoretical and applied statistics, mathematics, computer and communication sciences, biological sciences, economics and other social sciences, physics and earth sciences, statistical quality control and operations research and library and information sciences. Scientists of the Institute carry out independent research in their own basic discipline and also undertake interdisciplinary research in collaboration with other units within the Institute and outside organizations. The Institute also takes up various internally and externally funded projects in diverse fields on challenging live problems of national and international importance. As part of their research activities, scientists of the Institute are involved in consultancy work as well. This section gives a brief account of the principal areas of work over the past year of the seven scientific divisions of the Institute and the LDIS division. These divisions are listed below :

Theoretical Statistics and Mathematics Division

Applied Statistics Division

Computer and Communication Sciences Division

Physics and Earth Sciences Division

Biological Sciences Division

Social Sciences Division

Statistical Quality Control and Operations Research Division

Library, Documentation and information Sciences Division

In addition, there is a report each from the 'Center for Soft Computing Research: A National Facility' and the 'Computer and Statistical Services Centre'.

Theoretical Statistics and Mathematics Division

This Division, with a unit each in Kolkata, Delhi and Bangalore, is engaged in research in statistics, probability theory and mathematics, with a small group in Kolkata pursuing theoretical computer science. Beside their research, members play a major role in the teaching of statistics, probability, mathematics and theoretical computer science in the B.Stat. (Hons.), B.Math. (Hons.), M.Stat. and M.Tech. (Computer Science) programmes of the Institute. Courses are also run for research fellows and there are seminar activities all round the year. The administration of Sankhya is also done from this division and a number of faculty members of this division are also engaged in its editorial functions. Some of the faculties are also associated with the administration of the Mathematics Olympiad Project of NBHM at the regional and national levels.

Stat-Math Unit, Kolkata

Mathematics:

Commutative Algebra

The general structure of codimension-one A1-fibration over a locally factorial Krull domain was discovered.

Amartya K. Dutta and *Nobuharu Onoda*

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The structure of codimension-one A1-fibration over normal domains is currently being investigated.

S. M. Bhatwadekar, Amartya K. Dutta and Nobuharu Onoda

Over a complete discrete valuation ring R with algebraically closed residue field, it has been proved that any Noetherian R-subalgebra of R[X] is finitely generated. The result has been illustrated with Examples of Noetherian but non-finitely generated sub algebras of polynomial algebras in one variable over general discrete valuation rings.

Amartya K. Dutta and Nobuharu Onoda

Algebraic Deformation Theory

Algebraic Deformation Theory for Leibniz algebras over commutative local algebra base has been developed. The notion of formal deformations of Leibniz algebras have been studied. Versal deformations of Leibniz algebras have been constructed.

Alice Fialowski, Ashis Mandal and G. Mukherjee

Probability

Maximum of exchangeable random variables in a dependent setup was studied. Multinomial random variables were considered as examples. Gumbel distribution has been obtained as the limiting distribution of the centered and scaled variables when the number of trials increases fast enough. When the number of trials increases slowly, a conjecture has been made and would be worked upon. The result has extended the known results in independent setup successfully.

Arup Bose, Amites Dasgupta and Krishanu Maulik

Maximum of a triangular array of gamma random variables with changing shape parameters was studied and the limiting distributions have been characterized. A simpler proof has been provided for the known case and the method has been extended to prove all the cases. Some non-trivial limits have been obtained. When the shape parameters decrease fast enough, linear scaling had to be replaced by log transformation. The results about the maximum of Dirichlet were obtained as a corollary.

Arup Bose, Amites Dasgupta and Krishanu Maulik

The rate of decay of the tail of the convergent sum of records was studied and the limit distributions were obtained. A couple of interesting new results on the non-decreasing Π varying and regularly varying functions, which are of independent interest, were obtained as well.

Arup Bose, Sreela Gangopadhyay, Krishanu Maulik and Anish Sarkar

The limiting behaviour of the divergent sum of records was studied and the limiting distributions were identified. Some progress was made towards applying the results to a problem of random graph.

Arup Bose, Krishanu Maulik and Anish Sarkar

A general framework for dealing with the limiting spectral distribution (LSD) of large dimensional random matrices has been developed. This uses the moment method and the approach is relatively easy compared to other approaches available in the literature. As a consequence, new insight is obtained into the existing LSDs. At the same time, new LSDs have been obtained, specially for matrices with dependent entries.

Arup Bose and Arnab Sen

Consider the random matrix with independent and identically distributed fair Bernoulli entries. It is known that as the dimension increases, its rank is full with a very high probability. We show that in contrast, the rank of a random adjacency matrix with suitable dependent Bernoulli entries is approximately half the dimension, as the dimension increases. We also show that the limit distribution of the rank is normal.

Arup Bose and Arnab Sen

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ıl noncentral Toeplitz and Hankel matrices

Arup Bose and *Arnab Sen*

Generalized Increase Multiplicative Decrease (GIMD) models were proposed for modeling modern internet protocols like fast TCP and analyzed. These models include the classical AIMD models for the usual TCP, as well as MIMD models for the fast TCP. The classical square root law for TCP was extended to this new setup as well. The results would help in understanding and developing better alternatives to the current TCP.

Krishanu Maulik and *Bert Zwart*

We model stock price behaviour as the standard geometric Brownian motion and the stock market as characterized by the presence of a few large traders and a fringe of marginal "noise traders". We use the Nash equilibrium concept to compute the optimal value functions for the large traders. We show that the stability of the state process under equilibrium strategies of the large traders. We also provide numerical examples for each variation of our model to illustrate the general results.

Gopal K. Basak, Mrinal K. Ghosh and Diganta Mukherjee

Statistics

Statistical study of agreement, statistical inference, statistical study of surveillance, statistical study of apportionment index, statistical modeling of dyadic interactions, optimality studies in mixture designs and some areas in statistical ecology have been carried out.

B. K. Sinha

Suppose a risk neutral principal hires a risk averse production agent and the underlying production uncertainty is characterized by a gamma density. We establish that an optimal linear compensation schedule performs remarkably well relative to the optimal non-linear compensation schedule. In most situations, the percentage loss to the principal arising from such a linear contract is less than 2%.

Arup Bose, *Debashis Pal* and *David Sappington*

Properties of generalised confidence intervals have been obtained using Edgeworth expansions. This work brings out the reason for the good performance of generalised confidence intervals that has been observed by practitioners. It also helps to show to what extent generalised confidence intervals may or may not improve upon the performance of some other confidence interval techniques.

Arup Bose and *Anindya Roy*

Classification problems based on paired training samples have usually assumed that the training sample consists of fully paired observations. In practice often there will be some marginal observations available along with paired observations. We consider the general form of such unbalanced training samples. Taking a nonparametric approach we develop a likelihood based nonparametric classification technique. We study some of its theoretical properties and also demonstrate that it performs quite well in real and simulated data.

Subhadip Bandyapadhyay, Arup Bose and Debasis Sengupta

A novel gene prediction algorithm based on statistical learning techniques has been developed and implemented on several bacterial genomes producing promising results. The algorithm is based on unsupervised learning. A closely related algorithm has been developed to predict horizontally acquired genomic islands in bacterial genomes. Both algorithms make predictions along with a statistical measure of prediction confidence.

Probal Chaudhuri

We develop three new tests for testing parameters and mean of a gamma distribution. We numerically investigate the performances of these tests and that all of these tests control Type I error rates for small samples when the true shape parameter is not too small. We numerically compare power curves of two newly developed tests that we propose for the scale parameter and find that Test II has an edge

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over the other one. The results are illustrated with two examples; one from ground water monitoring system and the other one from engineering applications.

Dulal K. Bhaumik, Kush Kapur, Joydeep Bhanja and Gopal K. Basak

We model a coding channel by, $X_i = (Y_i + Z_i) \pmod 2$, where $Y_0, Y_1, \cdots$. is a Markov chain on state space $\{0, 1\}$ with stationary transition probability and $Z_1, Z_2, \cdots$, be i.i.d. Bernoulli (d) and Z_i's are independent of all Yj's. To estimate the parameters of the Markov chain from the output data X and to predict input data Y, one needs a computation in the order of 2^n through the existing set of algorithms. We are working on an algorithm to reduce the computational complexity of the problem and we have made some limited progress.

Gopal K. Basak and Joydeep Bhanja

Speech Recognition and Image Processing

Here we study a new application of image comparison, automated speaker identification in a closed set of speakers by scrutinizing datasets of spectrograms of the speakers to find the spectral pattern "perceptually closest to the spectrogram of the unknown speaker". This paper, mainly, revolves around trapping the complex patterns of variation in frequency and amplitude with time while an individual utters a given word through spectrogram segmentation. These segmented spectrograms are used as a database to successfully identify the unknown individual from his/her voice. This is a notable drift from the usual Gaussian Mixture Models (GMM) and the Vector Quantization (VQ) techniques for text-dependent speaker identification/verification. The features used for identifying, rely on the Kolmogorov-Smirnov test for image comparison. Performance of this novel approach on a sample collected from 30 speakers show that this methodology can be effectively used to produce a 100% success rate.

Tridibesh Dutta and Gopal K. Basak

We address the problem of identifying speakers using spectrograms in the text dependent problem. The spectrogram of a speech signal is segmented in an `optimal' number of bands. Using spectrogram segmentation, this paper, mainly, revolves around understanding the complex patterns of variation in frequency and amplitude with time in an utterance of a given word by an individual. The features used for identifying a speaker based on an observed variable extracted from the spectrograms, rely on the distinct speaker effect, his/her interaction effect with the particular word and interaction with the frequency bands of the spectrogram. Performance of this novel approach on a sample collected from 40 speakers show that this novel methodology can be effectively used to produce a 100\% text-dependent speaker identification success rate in a closed set of speakers.

Gopal K. Basak and Tridibesh Dutta

Cryptography

Using the Cramer-Shoup paradigm, a new public-key encryption scheme has been obtained using a bilinear map.

Rana Barua and Mahabir Jhanwar

Simple Voting Games

For the first time, characterizations of Coleman Indices of voting power have been obtained by two sets of independent axioms.

Rana Barua, Satya R. Chakravarty and Palash Sarkar

Quantum Groups and Processes

Given a classical or noncommutative Riemannian manifold, it is proved that the category of all compact quantum groups acting `smoothly' and `isometrically' (i.e. the action preserves the algebra of smooth functions and also commutes with the Laplacian) admits a universal object. This universal object is defined to be the quantum isometry group of the underlying manifold.

Debashish Goswami

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Quantum Isometry Groups : Examples and Computations

The quantum isometry groups of a number of classical and noncommutative manifolds (e.g. commutative and noncommutative tori, sphere etc.) are computed and their properties are studied.

Debashish Goswami and Jyotishman Bhowmick

A nice connection between the second Hochschild cohomology and the theory of quantum stochastic dilation has been observed. It is proved that given a conditionally completely positive map L on a unital *-algebra A, a sufficient condition for constructing a quantum random walk in a suitable algebraic sense is the vanishing of second Hochschild cohomology of A with coefficients in the GNS bimodule associated with L.

Debashish Goswami and Lingaraj Sahu

Some more results on the Evans-Hudson type quantum stochastic dilation of a semigroup with unbounded generator are obtained.

Debashish Goswami and J. M. Lindsay

Graph Theory and Applications

Almost Ramsey type theorems for directed graphs, energy of graphs and matrices (bounds), NP-completeness of various graph labelings with specified properties have been studied.

S. B. Rao

Stat-Math Unit, Delhi

Probability

The work on three projects namely, (1) Hard-Core model on random graphs, (2) On the cluster size distribution for percolation on some general graphs and (3) Free energy computation and Counting without sampling was continued.\

Antar Bandyopadhyay

Broad area of Markov processes and martingale problems with special emphasis on stochastic filtering theory and stochastic control theory was continued. The study of a new statistical algorithm to predict genes in the P. Falciparum genome was continued.

A. G. Bhatt

Some aspects of random graphs and mathematical biology have been studied.

R. Roy

Some aspects of random graphs and extreme value theory have been studied.

A. Sarkar

Linear Algebra

The work on resistance matrix of a graph was continued. Formulas were obtained for the determinant and the inverse of the resistance matrix of a unicyclic graph. The relation between the q-Laplacian matrix and the Ihara zeta function was explored.

R. B. Bapat

Some striking theorems in the theory of positive definiteness preserving maps, that were hitherto known as consequences of deep theorems of Schoenberg, Rudin and Herz, were proved by direct and elementary means. Results in the same spirit were found for nonlinear completely positive maps.

R. Bhatia

Design of Experiments

Through improved lower bounds to $E(s^2)$, new optimal supersaturated fractional factorial designs have been obtained. Optimal and efficient diallel cross designs have been obtained.

A. Das

Research was carried out in Design of experiments, with special reference to fractional factorial plans. Improved bounds for the $E(s^2)$ criterion for supersaturated designs were obtained and designs attaining the improved bound were constructed. A method of allocating factors to the columns of an orthogonal array was devised to estimate some 2-factor interactions.

A. Dey

Inference

Research on competing risks model was continued and research on load sharing models have been initiated. Nonparametric tests for testing whether failure of first component stochastically reduces the life of the second component in a two component system have been developed.

I. Dewan

Sinusoidal frequency and some related models was continued. Estimation of parameters, asymptotic properties of the estimators, computational aspect of the problem, model selection criteria in this set-up were studied. Chirp signal model and a recently proposed burst signal model are two important models and work was carried out on them. Started working on a review paper on sinusoidal frequency model. Surrogate data method, a resampling technique, is mainly used by physicist. At present we are working on a particular problem of the phase-randomized surrogate data method and amplitude adjusted Fourier transform method.

S. Nandi

Noncommutative Geometry and Quantum Processes

The work on noncommutative geometry was continued, in particular on the geometry of odd dimensional quantum spheres. Connections between certain families of equivariant spectral triples and C^*-extensions were established. This has been written up as a paper and has been accepted for publication in the Letters in Mathematical Physics. In another article which is under preparation, Poincare duality was proved for the odd dimensional quantum spheres, which in particular yields Poincare duality for the quantum $SU(2)$ group.

A. Pal

Research on non-commutative geometry, quantum stochastic processes and spectral theory of Schrodinger operators was continued.

K. B. Sinha

Stat-Math Unit, Bangalore

Design of Experiments

Attention has been focussed on main effect plans (MEP) for asymmetrical experiments. Inter-class orthogonal MEP requiring considerably fewer runs than fully orthogonal plans have been constructed. In these plans, each factor is orthogonal to all except possibly the factors in its own class. Further, the concept of "partial orthogonality" is introduced and has been attained by some pair of factors in the same class. The concept of orthogonality through blocking factor has been introduced and has been utilised to obtain orthogonal MEPs on smaller nember of small-sized blocks.

Sunanda Bagchi

Analysis

Obtained sufficient and necessary conditions for the Choquet-Deny theorem to hold in the class of compactly generated totally disconnected locally compact groups of polynomial growth, and in a larger class of totally disconnected generalized $\overline{FC}$.

C. R. E. Raja and W. Jaworski

Considered the action of a group G on a compact metrizable group K. First it was shown that each b in G is distal on K implies G itself is distal on K, a local to global correspondence provided G is a finitely generated group of polynomial growth or K is a connected finite-dimensional group. We have also shown that G contains an ergodic automorphism of K when K is a finite-dimensional compact connected abelian group and G is ergodic on K.

C. R. E. Raja

Geometry of Banach Spaces

Work continued on several aspects of the geometry of Banach spaces. A uniform notion of proximinality was investigated. In a joint work with D. Narayana, it was shown that M-ideals are ball proximinal. Factor reflexive proximinal subspaces of certain c_0-direct sum of Banach spaces were proved to be both U-proximinal and ball proximinal.

T. S. S. R. K. Rao

Extremal structures in Banach spaces have been studied. It was shown that the group of surjective isometries of the space of continuous functions on a countable compact set, is algebraically reflexive.

T. S. S. R. K. Rao

Algebra and Number Theory

Given positive integers a, b and coprime integers c and d, the density of the set of prime numbers in the residue class c modulo d which divide a member of the sequence a^n+b^n was completely determined. In particular, three claims of Fermat were refuted in a very refined sense.

B. Sury and P. Moree

The number of conjugacy classes of the wreath product of two finite abelian groups was determined. In particular, new families of groups were produced whose commutativity degrees tend to $1/n^2$ for arbitrary n thereby answering a question of Lescot in a strong sense.

B. Sury and Igor Erovenko

By a new method, completely determined over a field K of any characteristic, all the polynomials f(x), g(y) for which f(x) - g(y) has a quadratic factor in K[x,y]. This contains as a special case the analogue in characteristic 0 by Yuri Bilu; an earlier proof of a more special result obtained by us was not published.

B. Sury, Manisha Kulkarni and Peter Mueller.

The wreath products of finite groups by an infinite group was shown to possess a dichotomy - that is, have Bass's FAb property or are not boundedly generated.

B. Sury and Igor Erovenko

The unitary Whitehead group of a division algebra with an involution of the second kind was determined in some special cases.

B. Sury and Yoav Segev

The problem of Kronecker conjugacy of polynomials over number fields is being studied.

B. Sury and Manisha Kulkarni

Applied Statistics Division

The Applied Statistics Division came into being in September 1996 in place of Applied Statistics, Surveys and Computing Division. The Computer Science Unit was renamed as the Applied Statistics Unit and the Biometry Unit was transferred to the Biological Sciences Division. Till 2005-2006, the

Applied Statistics Division consisted solely of the Applied Statistics Unit. During the year 2006-2007, a new unit viz. Bayesian and Interdisciplinary Research Unit was created in this Division. Scientists of this division are involved in different kinds of research, training and development activities.

Applied Statistics Unit

Sample Surveys

An empirical study funded by ILO is launched on applying a combination of (i) network sampling to capture child labourers through their links to household and establishment in rural and urban areas and (ii) adaptive sampling to enhance selection of units with increased information contents and also constraining the sample sizes retaining unbiasedness in estimation.

For Rao-Hartley-Cochran sampling the efficacy in employing Horvitz-Thompson estimator is demonstrated through simulation on applying various standard error formulae.

Use of Hartley-Ross's ratio-type unbiased estimation of epileptic and other patients in Kolkata Municipal Corporation area on supplementing model-based techniques is demonstrated on implementing an empirical study supported by ICMR.

To estimate population size bearing stigmatizing characteristics allowing respondent options for direct or randomized responses without revealing the option exercised, relevant theories are developed.

For direct response surveys it is well-known that better estimator for population means are provided by means of the distinct units rather than all units sampled in simple random sampling with replacement. Consequences on the extension of this to randomized responses to cover sensitive characteristics are under active consideration.

Arijit Chaudhuri, Mausumi Bose and Kajal Dihidar

Application of GIS in small area estimation was investigated.
Shibdas Bandyopadhyay, Rama Chaudhury Sahu and Kasturi Basu

Design of Experiments, Combinatorial Methods and their Applications

Optimal main effect plans in designs with small blocks were obtained. Crossover designs which remain optimal when experiment is terminated at any stage after the 3rd period are obtained when carryover effects have a special structure.

Various types of response-adaptive designs were investigated.
Mausumi Bose

Reliability and Survival Analysis

A framework for estimating the distribution of quality adjusted lifetime under some illness-death models was provided through parametric and non-parametric approaches. An improved calibration procedure for graphical comparison of two life distributions was proposed. The problem of estimating regression parameters and baseline cause specific hazards in competing risks framework with general missing pattern has been investigated.

In the context of a space vehicle reliability project sponsored by ISRO, a method for predicting the pressure-time curve of a solid rocket motor was developed.
Anup Dewanji and Debasis Sengupta

New parametric models and tests for Accelerated Life Testing have been proposed based on conditional specifications. Change-point problems with multivariate observations on cancer patients were studied.
Ashis SenGupta

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Signal Processing

Strategies for predicting the extent of wear of a cutting tool using electrical, force and acoustic emission signals from a face milling machine were studied, using experimental data from IIT Kharagpur. The methods were studied theoretically as well as through simulations. In the case of real industrial data, the proposed methods outperform existing methods in terms of empirical mean squared error.

Debasis Sengupta

An integrated approach based on Bayesian hypotheses testing has been enhanced for tracking and recognition of dynamical events in a video.

Ashis SenGupta

Multivariate Analysis

The problems of classification and clustering of high-dimensional data was considered. The problem of dimension reduction in clustering was studied theoretically as well as empirically in the context of the on-going project on tiger pugmark analysis. The problem of determining the optimal number of dimensions was also addressed.

Debasis Sengupta

New non-parametric tests for multidimensional scatter have been proposed. Generalized canonical variables have been constructed for some large dimensional real-life data sets.

Ashis SenGupta

Statistical Inference

Union-intersection tests and their relations to P^3 tests in mixture models have been studied. Bayesian methods for Growth curve analysis and for Change-point problems are enhanced.

Ashis SenGupta

Categorical and Directional Data:

A general model was obtained for longitudinal categorical data set up. Some related inference was carried out. Some works on the measures of association for nominal categorical data was also carried out. Time series of categorical data (both nominal and ordinal) was also done. Some non-stationary processes have been developed.

Atanu Biswas

Constructions of and inference for axial distributions, asymmetric circular distributions and multivariate directional distributions have been given. Models for directional regression analysis have been enhanced. Exploratory data analytic tools for change-point problems and parametric resampling based classification rules for circular data have been studied. Bayesian inference for multivariate circular distributions with unknown normalizing constants have been presented.

Ashis SenGupta

Cryptology

Research on several areas on cryptology has been carried out by faculty members of ASU. Among these are pairing based protocols, time/memory trade-off cryptanalysis, design of secure modes of operations, Boolean functions, coding theory, key pre-distribution in sensor networks.

A 40-year old open problem on covering radius of Reed-Muller codes has been solved.

Three meaningful criteria for comparing Visual Cryptographic Schemes (VCS) were introduced and methods of constructing VCS from several classes of combinatorial designs satisfying the above

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criteria were obtained. Optimality criteria along the lines of optimal designs are developed and optimal VC schemes obtained.

Bimal K. Roy, Palash Sarkar and Subhamoy Maitra

Environmental Statistics

Statistical methods have been employed to study severity of arsenic contamination in water in different parts of West Bengal. Also effectiveness of arsenic removal plants have been studied. The effect of noise pollution on school children with respect to different adverse health issues has been studied.

Anup Dewanji and Atanu Biswas

Bayesian and Interdisciplinary Research Unit

Robust Estimation

The properties of a new class of minimum distance estimators have been investigated in detail. This family is observed to generate estimators and tests which provide excellent alternavties to the methods based on the Hellinger distance.

The method of minimum density power divergence estimation has been appropriately extended to handle the case of parameter estimation for the case of right censored survival data. The proposed method achieves reasonable efficiency at the model, but performs substantially better than traditional estimators under data contamination. The method requires no noparametric density estimation.

Ayanendranath Basu

Goodness-of-fit tests for Growth Curve Models

A natural goodness of fit test for the exponential growth curve model based on the relative growth rate has been developed.

Ayanendranath Basu

Incubation Distribution from HIV to AIDS

Estimating the incubation distribution from HIV to AIDS is a problem of great practical implication. A method is developed for estimating the same in the Indian context.

Ayanendranath Basu

The Unlinking Conjecture

Some new results on the unlinking conjecture of independent polynomial functions have been developed.

Subir K. Bhandari and Ayanendranath Basu

Block and Factorial Design

Constructions, analyses, studies of properties and uses of various kinds of block designs and factorial designs in a variety of application areas have been considered.

G. M. Saha

Model Selection, Nonparametric Function Estimation

Bayesian Model Selection for prediction purposes have been studied. In particular, cross-validatory predictive density as a model selection criterion has been studied and optimality results have been found on the fraction of sample to be kept for validation and fraction to be kept for estimation. Related

'Oracle' properties of such rules have also been studied. Adaptive rate optimal estimation of regression function using the Akaike Information Criterion (AIC) has also been studied.

Arijit Chakrabarti

Application of Mixture Models in Signal Segmentation

Finite mixture models are often used to study whether the data is generated from a homogeneous population. Problems of detection of discontinuity of signals and segmentation of speech signals at the pre-processing stage for speech analysis or speaker identification have been studied using local mixture likelihoods. In this context a notion of Projected Likelihood Contrasts (PLC) have been developed which can be easily adapted to situations where nuisance parameters are allowed in local likelihoods. Theoretical results have been obtained establishing large sample properties of such statistics and power properties have been studied through simulations.

Debapriya Sengupta

Laws of Large Numbers

The utilities of "Uniform Integrability" type conditions as one of the ingredients of a set of sufficient conditions for the validity of various laws of large numbers have been studied. Extensions of the second Borel-Cantelli Lemma for dependent variables have been obtained. Relaxation of the sufficient conditions of the celebrated Kolmogorov-Etemadi SLLN are being attempted.

Tapas K. Chandra

Crossover Designs

Crossover designs with p periods, t treatments and n units under the model allowing two types of carry over effects (simple carry over and mixed carry over) have been studied. Universal optimal designs with $p > 2$, $t > 2$ for the estimation of contrasts in mixed carry over effects have been identified.

Rita SahaRay

Optimal Design for Screening Experiments

Study of optimal designs for screening experiments, when the primary goal is to identify main effects of factors and the secondary goal is to detect potential two factor interactions have been undertaken. For 16 run designs, performance of several designs obtained via foldover technique, Placket–Burman designs, Margolin designs and Li-Natcheim designs have been compared.

Rita SahaRay

Study of Minimum Critical Set in the Context of Latin Square

The structural form of the minimum critical set which consists of minimum information to retrieve uniquely the combinatorial structure of a Latin square L representing the elementary abelian 2-group of order 8 has been identified.

Rita SahaRay

Clustering and Classification

Various aspects of the clustering problem have been taken up. Clustering based on statistical learning has been used to study the geometry of Shear Stress Conditional Statistics in turbulent flow over a trough region. The problem of determining the number of clusters using cross-validation and co-membership has also been considered. Multivariate process control using wavelets has been used to detect engine failures in a real life situation. The problem of classification for high-dimensional data with large number of classes has also been considered. Combinations of classifiers have been tested in the context of the ongoing speaker identification project. An useful speaker database in Bengali language is being developed as part of the project.

Smarajit Bose

Adaptive Sequential Testing Problem

Adaptive sequential testing problem in connection to clinical trial has been studied. Bandit Problem in connection to optimising values of two functions has been considered instead of considering the usual one function optimisation problem.

Subir K. Bhandari

Directional Majorization and Multivariate Majorization

Using computer simulation, a counter example has been constructed numerically to show that directional majorization and multivariate majorization are not equivalent.

Subir K. Bhandari

Numerical Analysis

Newton's forward interpolation formula has been shown to be exactly identical with Newton's backward interpolation formula. When the values of the argument are equidistant , it has also been shown that Lagrange's interpolation formula coincides with Newton's forward interpolation formula.

Arun Kumar Adhikary

Sample Surveys

An attempt has been made to improve upon the Hansen-Hurwitz (1943) estimator based on PPSWR sampling scheme through Rao-Blackwellisation. In order to derive the sampling variance of the improved estimator obtained by Rao-Blackwellisation it is of interest to derive the probability distribution of the number of distinct units in the sample drawn according to PPSWR sampling scheme as the improved estimator is based solely on the distinct units in the sample . It has been possible to write down the exact distribution of the number of distinct units in the sample drawn by PPSWR sampling scheme in a closed form.

Arun Kumar Adhikary

Bayesian Inference for Directional Data/Bayesian Clustering

Research has been going on in Bayesian inference for directional data and Bayesian clustering with applications to vegetation data obtained from the Western Ghats. New methodologies have emerged, with very useful applications.

Sourabh Bhattacharya

Complex Computer Models/Regenerative Simulation

Bayesian emulation of complex dynamic computer models, applications of regenerative simulation to Bayesian computation are being studied. New theories and applications have made appearances in these areas as well and have been well-received.

Sourabh Bhattacharya

Stochastic Models for Study of Fertility

In connection with couple fertility, stochastic models have been developed incorporating socio-cultural factors to explain and analyze observed data on various types of birth intervals and number of births to couples in a specified period of time and to outline new procedure for obtaining the estimates of the parameters involved in these models.

Shankar Dihidar

Analysis of fMRI Data

Existing literature on analysis of fMRI data does not seem to say much about the relevant inferential procedures when *multiple* activation effects are of interest (e.g., response for four different types of working memory). In particular, the *within subject* dependence of one effect on another is an important issue with a multivariate repeated measures model. Most standard statistical methods regard such

correlation as a nuisance, to be adjusted for and then ignored. Two simple and intuitive tests to make inference on the existence of such correlation have been developed. The solution consists in formulating a suitable hypothesis involving the dispersion matrix of the last stage of a mixed linear model. The hypothesis is non-standard and standard tool like likelihood ratio test is not tractable. Use of these tests has been investigated by application on an fMRI study of attention switching.

Sumitra Purkayastha

Computer and Communication Sciences Division

The faculty members of the Computer and Communication Sciences Division are engaged in research in theoretical and applied areas of Computer Science and Technology. They always participate actively in teaching and training in B. Stat., M. Stat., M. Tech. (Computer Science) and M. Tech. (QR & OR) courses of ISI. They also supervise M. Stat. and M. Tech. projects/dissertations besides the supervision of Ph. D. theses of both ISI and non-ISI students. Many undergraduate and postgraduate students of Computer Science, Information Technology, Electronics and Telecommunication, Electrical Engineering, MCA and students of Bio-informatics courses from different universities and institutes undergo their training under the supervision of the faculty members of this Division.

Advanced Computing and Microelectronics Unit

Communication Issues in Mobile Networks

The number of mobile users in cellular networks is currently increasing at almost an exponential rate. On the other hand, the available bandwidth for communication is very much limited. Design of real-time algorithms for channel allocation among the requesting mobile users in an optimal way and at the same time with minimum call blocking is a challenging issue in the true sense. A set of such allocation algorithms has already been developed. However, there is a lot of scope for further improvement on these algorithms with a view to designing a set of hierarchical algorithms with varying degrees of complexity and execution time. We have been working on this problem to integrate all these algorithms for short-term, long-term and intermediate-term allocation of channels.

Moreover, for multimedia traffic, there are different Quality of Service (QoS) requirements for message communication of different types of signals. For example, delay jitter may be a primary concern in voice or video communication, while a loss of a few packets may be tolerated. But for data communication, packet loss is the most important issue and has to be avoided. Design of routing algorithms for such multimedia traffic on ad hoc networks through appropriate nodes, so as not to route too much through nodes with low battery life and high load, will be investigated in this project. Some lower bounds on bandwidth requirement for multimedia signals have already been derived. Design of an appropriate channel allocation algorithm is in progress.

Bhabani P. Sinha

At present, in cellular networks, base stations are placed in quite an ad hoc fashion, without any careful analysis of the effects of such base station placements and their transmission powers. To avoid interference with limited bandwidth, need to be reduced the cell area (with lesser transmitting power of the base stations. On the other hand, this may tend to increase the frequency of hand-off situations, thus leading to packet loss or dropping calls in the worst case. Hence, a trade-off is necessary to meet both these ends. A new technique for using directional antennas with an efficient distribution of channels across the cells has been proposed to improve the quality of hand-off.

Nabanita Das

Moreover, more base stations would mean more capital investment and maintenance cost. Also, improper placement of base stations may also produce some uncovered regions (holes) in the network. Proper placement algorithms considering all these issues are being developed in the proposed project. An algorithm for placement of base stations has already been developed using the concept of Voronoi diagram which outperforms all the existing algorithms in this area.

Bhabani P. Sinha, Subhas C. Nandy and Sandip Das

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Recently, with the proliferation of small computerized devices including intelligent cellular phones, palmtops, laptops, demands for greater mobility with computing power has popularized the notion of infrastructure-less networks namely the ad hoc networks. In ad hoc networks, since all the communications take place through the same media using a single channel, in general, simultaneous transmissions often interfere and contention resolution becomes a major issue. We have been working on developing distributed algorithms for efficient contention resolution to improve throughput. Also, energy efficient routing algorithms are developed for improving the life-time of ad hoc networks, especially for sensor networks.

Nabanita Das and Jayasree Duttagupta

Power-aware Placement

Scaling of transistor feature size has allowed performance and density gains in geometric proportions. This has directly contributed to sharp increase in semiconductor power density. Today, power density for microprocessors stands at about 75 watts/cm^2, and is expected to rise to about 200 watts/cm^2 by 2010 as we approach 45nm technology. This has several unintended consequences including reduction of electron mobility due to very high temperatures and hence timing faults at GHz operating frequencies. The issues that have received most attention in the recent past are the battery life problem for the mobile parts and thermal dissipation in packaging. This mandates proper geometric modeling of hot spots for placement of optimal number of heat sinks.

Some preliminary models have been proposed for heat dissipation, which need to be validated against actual data and also to be extended for time-varying situation. These models are being utilized in the design of power-aware placement algorithms to prevent thermal congestion in both ASICs and state-of-the-art FPGAs such as Virtex-II. This may be tackled as either post-processing of layout by topological expansion, or as definition of a cost metric in the iterative placement method to include power density along with area and net-length. A thermal resistive-capacitive network model has been developed and is being studied extensively for analysis of thermal profile of a chip.

Susmita Sur-Kolay

Physical Layout of Nonlinear Scan-Path Architecture

Recently, a nonlinear scan-path architecture called *double-tree scan (DTS)* has been developed by us, which that reduces power consumption drastically in the scan-path and clocking circuit for built-in self-testing of VLSI systems. This design has manifold applications to both random and deterministic testing of low-power embedded systems, and systems-on-a-chip. However, the problems of *Clock tree design, Power consumption, Physical layout* are yet to be solved in this context. We are investigating the above issues in order to design an algorithm for finding a good layout of a DTS. Work is in progress in all these areas.

Bhargab B. Bhattacharya

Sensor Network Management: A Geometric Approach

Studies on the problem of sensor placement have been made using graph-theoretic and statistical formulation. Almost no result is available which considers the geometry of the field of interest and the obstacles. Our study mainly focuses on this aspect. We have studied the range assignment problems for the base-stations for mobile communications, assuming that the base-stations are already positioned. Optimal algorithms are proposed where the base-stations are arranged on a line. As the problem is NP-hard for more than one dimension, efficient heuristics for the 2D version of the problem is proposed. Both 1D and 2D versions are of importance in several applications. We have also studied the problem of locating the base-stations for the power-optimal management using geometric approach.

Sandip Das and Subhas C. Nandy

Parallel Algorithms related to Fragment Assembly in DNA Sequencing

The key steps for genome decoding are blasting multiple copies (clones) of the whole genome into several fragments, sequencing the fragments and performing fragment assembly to discover long stretches of genome. The overlapping fragments of the genome should ideally form an interval graph. However, experimental inaccuracies may creep in with missing fragments. Non-contiguous fragments may also attach to form a chimera.

A linear time sequential algorithm for recognition and determining the canonical interval representation of interval graphs has been implemented and validated. A lexicographic breadth first search based sequential algorithm to determine the interval number has been implemented and the number of passes required for correctness has been studied carefully. For a few special classes of graphs, an efficient algorithm to produce an interval representation with minimal number of intervals and to convert a given noisy near-interval graph to an interval graph with minimum perturbations have been addressed. Parallel algorithms for both of these problems are also being devised and implemented on a Linux cluster.

Susmita Sur-Kolay

Application of Computational Geometry to Terrain Analysis

Geometric properties of a terrain surface are important for many applications related to environmental modeling, land use management and geographical information system. We have currently concentrated on the shortest path problems on weighted polyhedral surfaces in a triangulated terrain, and monotone descent path problems in a terrain. We are also planning to study the properties of a terrain in terms of mobile communication, where the objective is to deploy sensor nodes to collect information. This type of problem is of national importance in the defense issue of the country and disaster management.

We are also analyzing the terrain with an objective to identify the shortest path with specific visibility characteristic (e.g. avoiding guards, radar, etc.). The multiple watch-tower installation problem for guarding a terrain is also being considered.

Sandip Das and Subhas C. Nandy

Computer Vision and Pattern Recognition Unit

Document Analysis

A modified system has been developed for the recognition of printed English artistic document. We have modified the existing word-wise script identification system to get higher accuracy, and a system has been developed for the identification of word-wise English and Thai scripts from a single document. A modified scheme for word-wise handwritten script identification is developed. A part of system towards generalized OCR for Indian multi-lingual and multi-script document is developed. Some work on pin-code and city-name recognition has been done towards Indian postal automation.

Umapada Pal, Utpal Garain and Bidyut B. Chaudhuri

Handwritten Character Recognition

Some progress has been made for recognition of handwritten numerals and basic characters of Bangla when the input mode is online. A database of online handwritten Bangla numerals and basic characters, has been developed. A new feature vector (based on direction code representation of the pen trajectory) has been proposed for recognition of online handwritten characters. Preliminary recognition results on a database of Bangla basic characters are encouraging. Also, an HMM-based recognition approach has been developed for online handwritten Bangla numerals using a new method for extraction of sub-strokes based on shape and size features.

The following studies are done on off-line recognition of handwritten characters/numerals. (i) Recognition of handwritten Oriya numerals: An HMM based scheme has been developed; (ii) Recognition of handwritten Devanagari numerals and characters: A neural combination of an HMM, an

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MLP and a quadratic classifier has been developed; (iii) Recognition of handwritten Bangla basic characters: A hybrid scheme based on an HMM and an MLP is proposed. Also, a two-stage recognition approach has been proposed; (iv) Recognition of handwritten Bangla vowel modifiers: A tree classifier using Gaussian and Dirichlet distributions has been proposed; (v) Recognition of handwritten Tamil characters: A two-stage recognition approach has been developed. Additionally, we made an in-depth analysis of error sources towards improved form processing ISIFORM. (vi) Recognition systems for Kannada, Tamil and Telugu off-line handwritten characters have been developed. (vii) Databases of handwritten characters of Devnagari, Telugu, Kannada and Tamil scripts have been developed.

Ujjwal Bhattacharya, Swapan K. Parui and Umapada Pal

Natural Language Processing

This year a study has been made on sense identification of Multi-word construct in Bangla. Bangla language is replete with MWEs especially different forms of reduplicative words, echo words, hyphenated words, compound verbs, composite verbs and idioms. A detailed study has been made on the Bangla verb especially in respect of the automatic identification of compound and composite verbs. We have worked on sense identification of 'ki' like interrogative sentence in Bangla. For this purpose we have analyzed interrogative sentences in Bangla and made a list of all interrogative words in Bangla. Also developed a program to identify the interrogative sentences and translate Bangla interrogative word with the appropriate English interrogative words. We have made a study on "Named Entity Detection in the domain of News Documents in Bangla". In this respect we have taken 20,000 most frequent words from news paper corpus and manually tagged those words as per their type and probability to be a Name. A system was developed that would tag names in any document using that 20,000-word database, used as the knowledge base of our system.

Bidyut B. Chaudhuri, Shamita Ghosh and Subhankar Bhattacharya

Document Image Compression and Security

Novel algorithms for lossless symbolic compression of document images, processing of documents in compressed domain, and watermarking of compressed images have been designed. The lossless compression algorithm is tested to outperform many of the existing algorithms commonly used for the same purpose. Methods for spotting of stop words, word stemming in text images, and summarization of short (e.g. sport news) document images in the compressed domain facilitate efficient retrieval of document images. Watermarking of images makes copyright protection and authentication of document images easy. This research is additionally motivated by the current needs of digital libraries where such methods often find their utility.

Utpal Garain and Sarbani Palit

Information Retrieval

Work on cross-lingual information retrieval from Indian language documents continues. This work currently focuses on building an evaluation framework for Indian language Information Retrieval, and is being carried out under a DIT-funded project on Cross-Language Information Access. Our group participated at CLEF 2006 (Cross Language Evaluation Forum): a retrieval system incorporating a statistical stemming approach proposed earlier was successfully tested on a mono-lingual French retrieval task. Preliminary experiments on cross-lingual document alignment (English-Hindi) using out-of-vocabulary (OOV) words have also been carried out. Work on XML retrieval is also in progress. Our group participated at INEX 2006 (Initiative for the Evaluation of XML Retrieval): elementary modifications were made to an existing retrieval system to adapt it to work on XML data. Further refinements are being implemented.

Mandar Mitra

Speech Analysis and Synthesis

Some recent recorded speech data has been collected from various sources. Refining of modification of Bangla Grapheme to Phoneme dictionary has been made. The information regarding the intonation

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pattern of more than 2000 most frequently uttered Bangla words has also been added in the Bangla Grapheme to Phoneme Dictionary.

Bidyut B. Chaudhuri and Chittranjan Das

Electronics & Communication Sciences Unit

Mathematical Morphology

In order to improve the effective depth-of-field of the camera, two different morphology based fusion algorithms have been developed utilizing multi-focused images. The results have been compared with other existing techniques and are found superior. Morphological tools are also used to extract and recognize geographic legends present in paper maps.

Bhabatosh Chanda

Image Compression

A novel algorithm for color image compression is developed using BTC-PF method that has initially been proposed by us for grayscale image. A method of progressive image transmission based on the same concept is also completed.

Bhabatosh Chanda

Content Based Image Retrieval

Work on variants of the CBIR system using low-level visual features like shape, texture and color, such as multi-scalar texture co-occurrence matrix are in progress. A Mann-Whitney test based relevance feedback system is developed to improve the performance of the retrieval system.

Bhabatosh Chanda

Document Image Processing

A novel algorithm for detection of Tables from document page image is developed, implemented and evaluated over a large database. A binary document image compression method is also developed.

Bhabatosh Chanda

Image Segmentation

Segmentation of images of oil sand ore is investigated in order to estimate oil sand ore size. This information is useful for extracting crude oil from the oil sand ore. This work also includes assessment of image quality to judge whether an oil sand ore image is a good candidate for image segmentation or not.

Dipti P. Mukherjee

Fuzzy Logic Approach to Forecasting of Radiation Fog

A fuzzy logic based approach to approximate reasoning for prediction of radiation fog has already been developed. The method has been tested with the parameters: dew point, dew point spread, rate of change of dew point spread, wing speed and sky coverage. Primary results on prediction of radiation fog are quite satisfactory. Ultimately this method of prediction using approximate reasoning will be used as a complement of model based prediction of radiation fog in real life problems.

Arun K. De, Kumar S. Ray and Narayan C. Deb

Bio-Informatics

A novel scheme for finding biomarkers for cancer discrimination has been developed. Unlike, several existing gene ranking methods, the proposed method can deal with multi-class problems. The method has been tested on several groups of cancers. Neural network based methodologies for predicting

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tertiary structures of proteins have been developed. In this context some new features based on sequence information as well as properties of amino acids are introduced. The proposed schemes are tested on benchmark datasets and the recognition accuracy obtained is better than that available in the literature. Structural properties of short fragments of residues are also analyzed and used to develop representative building blocks which are then, in turn, used for reconstruction of three dimensional structure of proteins.

Nikhil R. Pal

Fuzzy Logic

Although there are numerous successful applications of fuzzy logic, designing of fuzzy systems from data, it is still a major problem for high dimensional data. There have been some attempts to address this issue using hierarchical approaches, but for such an approach interpretability of the derived features becomes difficult and thereby we loose the most important properties, readability, of fuzzy systems. A new scheme that integrates dimensionality reduction and rule extraction into a single framework has been proposed. This system can pick up the important features while learning the rules and thereby can account for the subtle nonlinear interactions between features, features and the tool, and features and the problem at hand. The modeling has been done for all three types of fuzzy systems, viz., Mamdani-Assilian type, Takagi-Sugeno type and classifier type systems.

Nikhil R. Pal

Sodar Structure Representation and Boundary Layer Characteristics Observation

A system for on line Sodar structure representation and Boundary Layer characteristics Observation based on the concepts of pattern recognition and artificial neural networks is being developed.

Narayan C. Deb

Machine Intelligence Unit

Soft Computing

A novel clustering architecture has been introduced, whereby several subsets of patterns can be processed together with an objective of finding a common structure. The structure revealed at the global level is determined by exchanging prototypes of the subsets of data and by moving prototypes of the corresponding clusters towards each other. Thereby the required communication links are established at the level of cluster prototypes and partition matrices, without hampering the security concerns. A detailed clustering algorithm is developed by integrating the advantages of both fuzzy sets and rough sets, and a measure of quantitative analysis of the experimental results is provided for synthetic and real-world data.

Sushmita Mitra

A new model of multi-objective simulated annealing algorithm has been proposed that incorporates the novel concepts of amount of domination and situation specific acceptance probabilities. It is demonstrated that the proposed method outperforms other well-known multi-objective optimization methods especially for many objective cases. A new multi-objective clustering method has been developed and its effectiveness in distinguishing the different landcover types from satellite images has been demonstrated.

Sanghamitra Bandyopadhyay

A multi-objective genetic algorithm with relative distance measure and constraint handling capability has been proposed. New performance measures for evaluating the performance of a multi-objective strategy have been developed. New models of particle swarm optimization and their application to feature selection problems are currently being studied.

Sanghamitra Bandyopadhyay and Sankar K. Pal

A novel method of Particle Swarm Optimization (PSO) incorporating obstruction avoidance has been developed. It has been shown theoretically that the proposed method converges to global optimal solution as the number of iterations goes to infinity. Experimentally, its superior performance over the existing PSO methods and the real coded genetic algorithm has been demonstrated.

C. A. Murthy and Sankar K. Pal

Multi-layer perceptrons (MLPs) have long been in use for pattern classification. The technique has recently been modified to speed up the underlying algorithm. Its convergence has also been tested. The results are found to be encouraging.

Sambhunath Biswas

Bio-Informatics

Biclustering or simultaneous clustering of both genes and conditions have generated considerable interest over the past few decades, particularly related to the analysis of high-dimensional gene expression data. The objective is to find sub-matrices, *i.e.,* maximal subgroups of genes and subgroups of conditions where the genes exhibit highly correlated activities over a range of conditions. Since these two objectives are mutually conflicting, they become suitable candidates for multi-objective modeling. A novel multi-objective evolutionary biclustering framework is developed by incorporating local search strategies. A new quantitative measure to evaluate the goodness of the biclusters is designed. The experimental results on benchmark datasets demonstrate better performance as compared to existing algorithms available in literature.

Sushmita Mitra

Evolutionary algorithms and local search techniques are combined to design a protein-ligand docking algorithm. Distance based classifiers are used for protein secondary structure analysis. Combination of classifiers is being used for protein secondary structure predictions.

Ashish Ghosh

A literature survey of the use of computational intelligence techniques for gene identification has been conducted. A parallel sequence alignment algorithm is being developed which is currently being tested on a cluster of workstations. A variable string length GA based technique for ligand design with improved encoding strategy has been developed which hybridizes local search heuristics.

Sanghamitra Bandyopadhyay

The problem of gene ordering has been tackled using new operators of genetic algorithms and a heuristic search technique. Results show significant improvement over other methods. A new dynamic range based distance measure for microarray expressions has been proposed and it is used to develop a fast gene ordering algorithm.

Sanghamitra Bandyopadhyay and Sankar K. Pal

In most pattern recognition algorithms, amino acids cannot be used directly as inputs since they are non-numerical variables. They, therefore, need encoding prior to input. In this regard, bio-basis function, using an amino acid mutation matrix, maps a non-numerical sequence space to a numerical feature space. One of the important issues for the bio-basis function is how to select the minimum set of bio-bases with maximum information. In this regard, an algorithm, termed as rough-fuzzy c-medoids (RFCMdd) algorithm, has been developed for selecting the most informative bio-bases. It is comprised of a judicious integration of the principles of rough sets, fuzzy sets, the c-medoids algorithm, and the amino acid mutation matrix. Some new indices are introduced for evaluating quantitatively the quality of selected bio-bases. The effectiveness of the proposed algorithm, along with a comparison with other algorithms, has been demonstrated on different types of protein data sets.

Pradipta Maji

A set of reaction databases in the context of metabolic pathway analysis has been compared. A method for identification of optimal metabolic pathways from a given substrate to a target metabolite under flux balance approach is being developed. The method, first of all, generates data on reaction

fluxes in a pathway based on biomass conservation constraint. A set of constraints is formulated incorporating weighting coefficients corresponding to concentration of enzymes catalyzing reactions in the pathway. Finally, the rate of yield of the target metabolite, starting with a given substrate, is maximized in order to identify an optimal pathway through these weighting coefficients.

Rajat K. De

Image Processing and Computer Vision

A multi-classifier system is developed for land cover classification of remotely sensed images. Wavelet based feature extraction techniques are developed for improved classification of land covers. A new fuzzy aggregation based reasoning technique is developed for pattern classification with a demonstration to remotely sensed image classification. A few neural network based techniques are developed for detecting changes in remotely sensed images.

Ashish Ghosh

A new algorithm has been developed to segment a color image into approximately similar (fuzzy) regions based on coefficients of multiscale wavelet packet transform. The wavelet based features are clustered using fuzzy C-means algorithm. The final cluster centroids, which are the representative points, signify the color and texture properties of the pre-assigned number of classes. Fuzzy topological relationships are computed from the final fuzzy partition matrix. The color and texture properties as indicated by centroids and spatial relations between the segmented regions are used together to provide overall characterization of an image. It is observed that the closeness (visual) between any two images can be estimated with an acceptable accuracy using these properties. This technique is designed mainly for application like content based retrieval of color image from a large image database. The effectiveness of this method was tested on large databases like a) SIMPLIcity image database and (b) Corel 10000 miscellaneous database. The results obtained are found to be very effective if the recall and precision rates are considered as performance measures.

Malay K. Kundu

Robustness is a key attribute of spread spectrum (SS) watermarking scheme. It is significantly deteriorated if one tries to achieve high embedding rate keeping other parameters unaltered. In literatures, typically various transformations like DFT, DCT, Fourier–Mellin and wavelet are used for SS multimedia watermarking but almost no studies have been made so far to investigate what are the possible factors which can improve robustness. Considering this fact, an investigation has been made to critically analyze effect of various factors, namely, effect of code pattern design, selection of appropriate signal decomposition scheme for data embedding, direction of decomposition, selection of regions for data embedding, signaling scheme, choice of modulation functions and embedding strength. Based on this investigation, a wavelet based SS watermarking scheme has been developed. It is found that the proposed scheme could be able to achieve a marked improvement in robustness performance which is also verified by extensive simulation experiments.

Malay K. Kundu

Two methods for object recognition for color image database are developed. One method utilizes cluster information of pixels locally whereas the other one utilizes the edge information of pixels locally. These developed methods have been found to provide significantly better results than the existing one on standard datasets such as COIL, SOIL and ALOI.

C. A. Murthy

Pattern Recognition

A new distance measure is proposed which takes into account the point symmetry property of the data. A fixed length genetic algorithm based technique has been developed using this measure while assigning the points to the different clusters. Approaches for automatic determination of certain threshold values and genetic parameters have been incorporated in this regard. The proposed method is found to yield good performance for both convex and non-convex clusters. New validity measures are being formulated, and they are utilized for developing automatic crisp and fuzzy genetic clustering

techniques. A two level clustering algorithm is proposed which first exploits the concept of multi-class membership of the points to detect points on the class boundaries, and then performs the clustering. An efficient algorithm for outlier detection using genetic algorithms has been developed. A new data structure is proposed in this regard.

<div align="right">Sanghamitra Bandyopadhyay</div>

A generalized hybrid unsupervised learning algorithm, termed as rough-fuzzy-possibilistic c-means algorithm, is proposed. It comprises a judicious integration of the principles of rough sets and fuzzy sets. The algorithm is generalized in the sense that all the existing variants of c-means algorithms can be derived from the proposed algorithm as a special case. Several quantitative indices are introduced based on rough sets for evaluating the performance of the proposed c-means algorithm. The effectiveness of the algorithm, along with a comparison with other algorithms, has been demonstrated on a set of real life data sets.

<div align="right">Pradipta Maji</div>

A new rough set based ensemble classifier has been developed. Its performance is mathematically shown to be at least as good as the performance of each of the individual classifiers in the ensemble. Additionally, it has been shown to achieve the performance of Bayes classifier as the number of training sampled points goes to infinity, if one of the base level classifiers goes to Bayes classifier. The superior performance of the proposed classifier has been successfully demonstrated on several data sets in UCI archive as well as on several web page data sets.

<div align="right">C. A. Murthy and Sankar K. Pal</div>

Physics and Earth Sciences Division

Geological Studies Unit

Proterozoic Basin Analysis with Special Reference to the Evolution of Chattisgarh and Pranhita-Godavari Basins

Detail facies analysis of the Lohardi Sandstone Formation at the lower most part of the Chattisgarh succession exhibited episodic uplift of the basement, and transfer of vast amount of coarse quartzo-feldspathic detritus forming fandelta sequence in a transgressive setting (Patranabis Deb and Chaudhuri, 2007). The cyclicity was attributed to episodic rifting of the basement and uplift of fault blocks. The thick wedge of conglomerate, arkose, quartzarenite and shale deposited in fan-delta–pro-delta environments at the base of the succession attested to a fault controlled sedimentation marking the rifting stage of the basin. The Chattisgarh basin comprises a very minor amount of coastal alluvial deposit at its base, and in contrast to major continental rifts, the basin was inundated by shallow tide and storm dominated sea at the on set of extension, and rapidly evolved into a large epicontinental sea.

Near absence of coarse siliciclastics and predominance of shale and carbonate in the upper part of the Chattisgarh succession speak for a passive margin setting. The open oceanic connection was attested by multiple cycles of transgression and regression, and tide and storm dominated deposition in almost all the major stratigraphic units. Chattisgarh carbonates developed as a shallow water platform, though the lower platform includes an extensive sheet of black limestone attesting to an event of rapid sea-level rise.

<div align="right">Sarbani Patranabis Deb and A. K. Chaudhuri</div>

Precambrian Geodynamics in the East Indian Shield

Homblende-dehydration melting in mafic protoliths producing charnockitic melt of tonalitic to granodioritic composition, was documented from the Sunki suite in the EGB. Additionally, this thermal event was dated approx. 1.8 Ga, by whole rock Rb-Sr and Sm-Nd studies. U-Pb zircon data in the Koraput alkaline complex indicated 773 Ma as the age of alkaline magmatism. Granite-gneiss of the Bastar Craton in the Jaypore sector was dated approx. 2459 Ma by U-Pb zircon data.

<div align="right">Samarendra Bhattacharya</div>

Mafic Crustal Xenoliths in the Eastern Ghats Belt

Rb-Sr and Sm-Nd isotopic studies from mafic granulite-charnockite in the EGB, revealed three ages of granulite facies metamorphism and attendant crustal melting, at approx. 3.0, 1.9 and 1.7 Ga in different sectors of the EGB. Also, significant age-difference between crustal accretion and high-grade metamorphism in the corresponding sectors, was found to be consistent with the lower crustal process of a collisional orogen.

Samarendra Bhattacharya

Evolution of the Nallamalai Fold Belt (NFB) – Fault Reactivation and Kinematics

Progressive deformation history frozen in fabric of calcite mylonites associated with thrust zone rocks beneath the Palnad klippe (nappe) in northeastern NFB and along the Rudravaram line in western NFB was interpreted from quantitative measurements on SEM images. Limited variation in recrystallized calcite grain size has been shown to be influenced by relative abundance and size of phyllosilicate/quartz impurity under low temperature deformation. Attainment of steady state fabric in Palnad calcite mylonites has been indicated by similar asymmetric c-axis fabric pattern, marked by strong point maximum (or paired maxima) at a high angle to mylonitic foliation and stretching lineation, and limited variation in dynamically recrystallized grain size (16-22 μm) in spite of increase in strain ($2.2 < R_s < 3.0$) read from grain shape change.

Dilip Saha and Sukanya Chakraborty

Proterozoic Crustal Convergence and Paleostress

A distinct difference in deformation regime between the Vellikonda thrust front and the Rudravaram line has been shown from preferential development of quartz and calcite mylonites from the eastern margin of the Nallamalai fold belt and lack of quartz mylonites around Rudravaram line in the west. Normal-sinistral slip on a steep north dipping fault affecting the Kurnool Group and older strata has been interpreted from analysis of structures including fault slip data from large transverse faults and associated minor fault arrays (e.g. Gani-Kalva-Ramallakota line), common in the western part of the Cuddapah basin. Slickenside and other brittle fault plane features in the Kurnool subbasin have been utilized to segregate multiple episodes of brittle fault slip activity in response to Proterozoic/early Paleozoic crustal convergence.

Dilip Saha and Vikash Tripathy

Trace Fossils in the Paleoproterozoic to Mesoproterozoic Quartzites, South India

First report of Rhysonetron and other probable trace fossils in the form feeding burrows from the Paleoproterozoic Gulcheru Quartzite and in the form of sinuous trails from the Mesoproterozoic Nagari Quartzite from the Cuddapah basin, south India has been made. These finds of trace fossil like markings raise a fresh debate on the metazoan antiquity.

Dilip Saha

Sedimentology and Palaeoclimatology of the Upper Gondwana Succession in Satpura Basin

The existing knowledge base on basin tectonics, stratigraphy, and sedimentologic characters of the Satpura succession as well as inferred changes in palaeoclimate during Satpura sedimentation provided a platform for initiating a provenance analysis of the sediments.

Analysis of new data on petrographic, mineralogic and geochemical characteristics of the Permo-Triassic strata (mainly Motur, Bijori, Pachmarhi and Denwa Formations) corroborate earlier contention that the basin fill sediments were derived from Precambrian rocks bordering southern and southeastern margin of the basin.

Soumendra Nath Sarkar, Partha Ghosh, Tapan Chakraborty and Pradip K. Maulik

Triassic – Jurassic Faunal Transition

Vertebrate faunal turnover during the Triassic Jurassic (T-J) transitional period has been critically analyzed from the fossil records of the Pranhita-Godavari basin of India and the Indian scenario was compared with the other Triassic-Jurassic terrestrial vertebrate bearing horizons of the world.

Saswati Bandyopadhyay and Dhurjati P. Sengupta

Analysis of the New Elements of the Denwa Fauna

Archosaur material collected from the western part of the Satpura Gondwana basins (Denwa Formation) are being prepared and studied and compared with other coeval archosaur fauna of the world.

Saswati Bandyopadhyay and Pralay Mukherjee

Detailed study on the taxonomy and functional morphology of a rare temnospondyl amphibian collected from the Denwa Formation has been communicated for publication.

Dhurjati P. Sengupta

Osteological Study of Barapasaurus Tagorei

In the light of new discoveries of basal dinosaurs mainly from the South-East Asian countries, new theories on basal dinosaurs and their phylogeny, a detailed osteological study of *Barapasaurus tagorei* has been undertaken. This study included the description of several undescribed materials of the axial skeleton as well as the already described bones. The present study gave new information especially on the cervico-dorsal region and also on the foot bones of the eusauropods which is not yet described from the early Jurassic horizons.

Saswati Bandyopadhyay and Dhurjati P. Sengupta

Detailed Mapping of the Area South of Sohagpur (Hoshangabad District)

High resolution mapping, plotting of the fossil occurrences and the study of the depositional aspects of the middle Triassic sedimentary rock units around Sohagpur have been carried out. It proves the presence of Lower and Upper Denwa rocks (with vertebrate fossils) around Sohagpur. The Lower and Upper Denwa being derived from the similar mapping already done by the sedimentologists of GSU at the Eastern part of the basin. Now it is possible to provide a detailed map of the Denwa Formation stretched from east to west of the Satpura Basin.

Dhurjati P. Sengupta, Saswati Bandyopadhyay and Pralay Mukherjee

Morphometric Studies on Temnospondyls

The growth pattern of temnospondyl skulls, from juvenile to adult, whose fossilised remains are common in Indian Gondwanas, has currently been under study. All the internal sutures of the skull roof bones of few benthosuchids and watsonisuchids taxa have been studied and their changes through ontogeny have been digitally mapped. The differential growth along the bone boundary is estimated by assuming maximized uniform growth of the individual bones. Considering each bone as a polygon, some aspects of polygonal containment problem where all free polygonal placements of one polygon inside another were considered. With the application of grid search technique over the domain of free placements of one bone inside another, the optimization problem has been solved and henceforth the differential growths have been estimated along the bone boundaries.

Dhurjati P. Sengupta and Partha Ghosh

Surface, Colloid and Environmental Sciences (Micellar and Microemulsion systems)

Phase diagrams have been constructed and interfacial composition has been estimated of microemulsion systems derived of mixed surfactant CTAB and Brij-58 with 1-butanol or 1-pentanol as cosurfactant and n-heptane or n-decane as oil at four different temperatures (293, 303, 313 and 323 K) and six different compositions ($X_{Brij-58}$ = 0, 0.2, 0.4, 0.6, 0.8 and 1.0) using the dilution method. The related thermodynamic parameters (free energy, entropy and enthalpy) of transfer of alkanol from oil

phase to the interface has also been estimated and has been found that at equimolar composition of Brij-58 and CTAB, the transfer process was athermal.

Physicochemical studies on microemulsions stabilized in nonaqueous polar solvents (NPS) are rarely reported. The phase behavior of the pseudo-quaternary systems, polyoxyethylene (10) stearyl ether (Brij-76)/ 1-butanol/ isooctane/ water [with equal amount of oil and water, in absence and presence of NPSs, formamide (FA), N, N-dimethyl formamide (DMF), ethylene glycol (EG) and tetraethylene glycol (TEG)], have been constructed at 303 K using fish-tail model, and the appearance of three-phase body confirmed the establishment of hydrophile-lipophile balance (HLB) of the mixture. The maximum solubilization capacity (S_{max}) is decreased with increase in ψ (weight fraction of NPS in the mixture of polar solvents) for FA and DMF systems at 303 K. The effect has been found to be more pronounced for DMF than FA. On the other hand, S_{max} initially increased and passed through a minimum at $\psi = 0.2$ and again decreased with increase in ψ for EG and TEG systems at 303 K. The effect has been found to be more pronounced for TEG than EG. The HLB temperature (T_{HLB}) has been found to be increased for FA and DMF systems and decreased for EG and TEG systems with increasing ψ at a fixed $W_1 = 0.6$. A correlation between T_{HLB} and HLB number (N_{HLB}) has been established for all NPS systems.

Bidyut Kumar Paul and Debdurlav Nandy

River Dynamics of the Sub-Himalayan Alluvial Plain, NE India

This project concerned itself with the dynamics of Sub-Himalayan rivers and related flood inundations in parts of Sikkim, West Bengal, Assam and Arunachal Pradesh. Interpretation of the satellite imageries and surveyed maps of this region have helped to differentiate the river plan-form changes that were induced due to neo-tectonic movements from those reflecting climatic changes. In order to characterize the tectonic movements and climatic changes that had effected the rivers of this alluvial plain, the deposits of these rivers preserved as terraces were studied. It has been recognized that at least four apparently climate driven depositional events took place in this region during the Quaternary period. During these events, a number of alluvial fans and megafans prograded ba inward forming extensive low relief gravelly/sandy units. The measurements of terrace morphologies as well as the characterization of the river catchments could identify some of the zones of tectonic movements and it was possible to understand the temporal relationship between the events of formation and climate change. Based on these observations a preliminary stratigraphic succession of the Quaternary deposits of the eastern Himalayas has been prepared. The representative sediments have been sampled for absolute age determination for future refinement of the stratigraphy of this region.

Partha Ghosh and Tapan Chakrabarty

Physics and Applied Mathematics Unit

Condensed Matter Physics

Recently non-commutative spaces have been linked with problems related to Berry Phase in Condensed Matter Physics. The motion of a particle in generalized forms of non-commutative phase space has been studied. It simulates monopole and other forms of Berry curvature, that can be identified as effective internal magnetic fields, in coordinate and momentum space. The Aharonov-Bohm effect, Aharonov-Casher effect and also their duals have been considered in this form of phase space, with operatorial structures of noncommutativity. Physical significance of our results was also discussed. The phase shift in a gravitational field on the non-commutative space in the light of gravito-electromagnetism was also studied.

An explicit connection has been provided between the semi-classical dynamics of anyon excitations in Ga-As alloys and the motion of 2 + 1-dimensional spinning particles (or anyons) in electromagnetic field in the Non-Commutative geometry framework. The Berry curvature plays a major role in this analysis.

It has been shown that the concurrence of two-site entanglement is related to the geometric phase accumulated due to a complete rotation of the entangled state. The geometric phase and hence the concurrence was evaluated for some particular space system.

Banasri Basu and Subir Ghosh

Quantum Information Theory

Quantum mechanics by its very nature of being non-local, has found its application in various quantum information processing. The most recent area where entanglement (non-local correlation) in quantum mechanics has started playing a big role is communication complexity problem. It has been shown that though quantum correlation does not replace communication, it can reduce the communication necessary for solving some distributed problem. This area has been taken up for study and some work have been performed in this direction.

Guruprasad Kar

The principle of superposition is one of the novel features present only in the quantum world. A general class of qubits, which satisfies the transformation of equal superposition, has been obtained by different methods. Further, the spatial probability distribution of the associated quantum random walk was studied.

Preeti Parashar

Quantum Field Theory

Aspects of Non-Commutative (NC) geometry, in particular of Lie algebraic forms, in contexts of Higher Energy and Condensed Matter Physics have been studied. These structures are directly connected to Doubly Special Relativity (DSR) where modified forms of mass-energy relations for free relativistic particles are introduced. Explicit geometric Lagrangians for point particles with κ-Minkowski NC phase space that obeys a modified dispersion relation have been constructed. The corresponding non-linear Lorentz transformations were also constructed and their implications investigated. These models have been analyzed from twisted symmetry point of view. Also new structures of NC phase space have been constructed that can have relevance in real condensed matter systems. Some of these issues have been studied with Dr. Probir Pal, Uluberia College, West Bengal.

Subir Ghosh

Quantum Computation and Ion Trapping

Several attempts have been made to realize the quantum computation using ion trapping. We have studying the trapping of Ca and K ions in relation to quantum computation. The Ca and K ions play significant roles in understanding the information processing in the biological systems.

Sisir Roy

Quantum Mechanics

Explicit realization of a second order-intertwining operator linking a non-Hermitian Hamiltonions to the adjoint of its nonlinear pseudo-supersymmetric partner Hamintonion has been found which gives rise to a new pair of isospectral Hamiltonians. Also Coherent states of non-Hamiltonian quantum systems have been constructed using Klauder's minimal prescription higher order intertwining operators and time dependent quantum systems are currently under study.

Supersymmetric techniques have been used to study relativistic systems. Non-Hermitian models within the same framework have also been studied. Some important results have been obtained in this area. PT symmetry and position dependent mass problem is another area of study where a significant relation has been found.

Pinaki Roy, Barnana Roy and Rajkumar Roychoudhury

Theoretical Plasma Physics

Solitary wave solutions in quantum plasma in non-planar geometry using a hydrodynamic model was actively pursued and extended to four-component dusty plasma.

Rajkumar Roychoudhury

High and Ultrahigh Energy Physics

Understanding the latest data from FERMILAB experiments involving hadron-nucleus interactions at high energies with an altogether different; 'non-standard', non-QCD approach, attempts have been made to interpret a large part of the experimental data on RHIC experiments with the help of non-extensive thermodynamics. Probing the physical problems in the light of this same approach paves a way to the unification of physics fields with some other disciplines of scientific studies.

Subrata Bhattacharyya

Interacting Fock Space

Influence of cavity decay on phase distribution and Rabi flopping in cavity QED has been studied. Also the state equation of the optical cavity in interacting Fock space as well as boson Fock space was derived. Closed-loop feedback control system of a composite cavity QED in boson Fock space using beam splitter device has been designed and it was proved that the system is stable.

Pradip K. Das

Classical Optics

Analytic construction of phase function for small sized Mie particles was carried out, with a view to applications in the areas of Astrophysics & Bio-medical optics. The work has been done in collaboration with Professor S. K. Sharma of S. N. Bose National Centre for Basic Sciences (SNBCBS), Kolkata.

Inversion of interstellar extinction spectrum by semi-analytic method has been developed by us recently. The work is being continued in collaboration with Professor S. K. Sharma, SNBCBS and Professor R. Gupta, IUCAA.

Asim K. Roy

Cosmology

The action principle for generalized Chaplygin gas has been studied in both non-relativistic and relativistic Born-Infeld form. New results related to the Poincare invariance of the generalized model have been obtained. This work was done in collaboration with Dr. Robin Banerjee of SNBCBS.

Subir Ghosh

Astrophysics

We have used the non-parametric test for analyzing the quasar data from Veron-Cetty catalogues (2006) as well as from Sloan Digital Survey (SDSS) so as find the validity of Hubble law at high redshift. This will shed new light on the discordant redshift and cosmological debates.

Sisir Roy

Planck Scale Physics and Cellular Network Theory

Cellular Network Theory has been proposed to understand the space-time at Plank Scale. Kind of self-similar processes were supposed to be involved in the emergence of space-time around Planck Scale. Recently, Agent based simulations (using Net Logo Software) has been done successfully along with Professor Ralph Abraham of University of California, to validate our above hypothesis, both in spatial and tempered dynamics

Sisir Roy

Basic Fluid Flows

Development of thin film over a stretching surface has been studied. It has been found that the final thickness of the film neither depends on the initial distribution of the fluid blob over the sheet nor the stretching force at which the sheet is stretched. It has also been shown that thermal variation of viscosity has strong effect over the final product.

Bhabani Sankar Dandapat

Hydrodynamic Stability and Waves

Liquid was allowed to flow out of a nozzle over the center of an uneven rotating disk and then the discharged liquid flows outward forming a thin liquid film over the disk. Assuming general form of the surface of the disk a linear stability analysis has been performed and finally disturbance growth rate was predicted. Considering different forms of the surface it was observed that different types of waves may develop over the film surface.

Bhabani Sankar Dandapat

Laminar and Turbulent Flows

In recent times much interest has been taken on applied problems of laminar and turbulent flows. The nonlinear dynamical equations involved in these problems were solved by the similarity and group-theoretic methods. Problems of both Newtonian and non-Newtonian fluid flows, as applied to industry and in many practical situations were tackled. In case of turbulent flows, importance was given to the construction of an improved model for turbulent boundary layer, employing the data from sophisticated laboratory measurements.

Himadri Pai Mazumdar

Convective and Diffusive Transport

Transport of dissolved/non-dissolved substances due to the shear effect of current has been studied numerically in oscillatory laminar/turbulent boundary layer flows. This study provides the basic mechanism of dispersion of contaminants in open-channel flows relevant to river geometry, estuaries or tidal basins. Dispersion of contaminant is important not only to the physical process of matter transport, but also to the biological processes of birth and growth of plank-tonic larvae in the sea.

B. S. Mazumder and Suvadip Paul

Sediment-fluid Interactions

To understand the development of roughness boundary layer thickness associated with turbulence and shear stress characteristics over a series of 2D asymmetric waveform structures, a series of experiments have been carried out using 3-D Micro-Acoustic Doppler Velocimeter (Micro-ADV) at the Indian Statistical Institute's (ISI) flume, Kolkata. The variations of turbulence statistics along the flow effected by wavy structures have been studied.

B. S. Mazumder and Satya Prakash Ojha

To gain the better understanding of nature of sediment movement in bed layer and suspension, detailed measurements of all three components of velocity with fluctuations have been carried out, using 3-D Micro-Acoustic Doppler Velocimeter (Micro-ADV), to determine the contributions of burst-sweep cycles to the total Reynolds shear stress. The mean time intervals of occurrence of burst-sweep cycles were determined by adopting a threshold hole size.

B. S. Mazumder, Chandan Chakrabortyand Satya Prakash Ojha

The High-Speed Motion Scope System (500fps) available at the Fluvial Mechanics Laboratory of Physics and Applied Mathematics Unit, Indian Statistical Institute (ISI), Calcutta, was used to record the motion-picture photography of the granular particle movement of different sizes at near-bed turbulence under the controlled flow conditions. The Image Pro-Plus (IPP) was used to characterize

the nature of particle motion, such as, speed and mode of transportation of the granular particles during displacement, trajectories, particle rotation and their interactions with the boundary layer. The main challenge in this project was to address the statistical distributions of physical parameters of turbulence and its consequences to the particle motions.

B. S. Mazumder and Anindita Bhattacharya

Statistical characteristics of circulation patterns and direction of turbulent flow over the waveform structures in an open-channel have been studied using the velocity data collected by 3-D Acoustic Doppler Velocimeter (ADV). The velocity fluctuations have been modeled using multivariate normal distribution and its effectiveness was studied in the light of explaining turbulent bursting events, like sweeping and ejection. The principles of Statistical Clustering have been used to classify the flow into the different regions based on the circulation patterns. The directional data analysis has been adopted to visualize the flow pattern.

B. S. Mazumder, Rahul Mazumder and Smarajit Bose

Dynamic Geometry and Brain Function Modelling

The idea pf Dynamic Geometry has been proposed and developed jointly with Professor Rodolfo Llinas of New York University School of Medicine, to understand the functioning of brain activities. The Bayesian approach to decision theory for brain is under investigation within the framework of dynamic geometry

Sisir Roy

Multivariable System and Control Theory

A number of numerical algorithms have been developed in recent times for identification, realization and stabilization of systems. Computational methods were also developed for the design of non-interacting controller for the system.

Subrata Gangopadhyay

Biological Sciences Division

Agricultural and Ecological Research Unit

Land Use Pattern, Natural Resource Inventorying Using Satellite Imagery and Technology Intervention at Eastern Plateau and Coastal Areas of West Bengal

Satellite imageries of Birbhum and South 24 parganas districts of West Bengal have been acquired for which digital analysis has to be done for getting the natural resource status and land use pattern as well. The Geometica software for remote sensing has been updated to its current version for doing the above-mentioned work. Digital analyses of the imageries are in progress.

Two experiments have been conducted at Sekhampur, Birbhum. One is on baby corn –legume-intercropping system where the objective was to assess the advantage/disadvantage of cereal legume intercropping system. The effect of cereal on biological nitrogen fixation by the legumes is another aspect of the study. The other experiment is on integrated nutrient management on baby corn based cropping system. In this experiment the direct and residual effect of vermicompost is being studied. Both the experiments had been carried out for one year and the data is under process.

P. Banik

Adaptability and Yield Performance of Sugar Beet (Beta Vulgaris L.) Varieties in Lower Gangetic Plains of West Bengal

Sugar beet (Beta vulgaris L.) has already been established in different states of our country as a short duration, water efficient sugar producing crop and now this crop is replacing sugar cane crop in many sugar cane growing areas. This crop has recently been identified as a rich source of ethanol. The recent findings showed that a good quality and quantity of leaf protein can be extracted from its leaves

without sacrificing sugar yield. Role of fertilizers indicated that 150 kg N, 100 kg P and 120 kg K per hectare would be the best doses for getting the maximum yield. Now we are trying to establish this crop in different places of north 24-parganas with the help of the Department of Agriculture. To meet the acute shortage of ethanol particularly in Eastern India the sugar beet crop can be a good and cheaper source of ethanol production.

S. Barik and S. Chanda

Innovative Biopesticidal Efficacy of Some Indigenous Plants on Insect Pests

Insect cuticle is covered with single layer lipid molecules which protects the water barrier. Using inert surface functionalized lipophilic nanoparticles, we have been able to generate several physically active biopesticides, which can break water barrier. We have studied the mechanism of action of the nanoparticles at the molecular physiology level. Natural nanoparticle biodiversity and their formation in vivo have been mapped in several organisms and we have demonstrated that actinomycin treatment abolishes the formation of nanoparticles in vivo indicating the involvement of RNA mediated mechanism. Detail studies on the processing of naturally occurring nanoparticles are in progress. Apart from them, eight plant lipid based biopesticides have been generated which are potentially active against coleopteran insect pests. Value addition studies on poultry birds for these active plant products are currently undergoing.

A.Goswami

Ecology and Physiological Studies on the Mangroves of Sundarbans

Five species of mangroves (*Bruguiera gymnorrhiza*, *Excoecaria agallocha*, *Heritiera fomes*, *Phoenix paludosa* and *Xylocarpus granatum*) were investigated in view of their photosynthesis rate, chlorophyll content, mesophyll conductance, specific leaf area, stomatal conductance and photosynthetic nitrogen use efficiency under saline (15 - 27 PPT) and non-saline (1.8 - 2 PPT) conditions. Some inorganic elements were estimated from the leaf samples to compare the concentrations with change in salinity. Certain physiological, biochemical and ecological investigations for their adaptive status against salt stress, nutrition, and the Mycorrhizal status of rhizospheres of mangroves of some islands of the Sundarbans have been studied.

M. Ghose, S. Das and K. Bhattacharya

Studies on the Ecology, Conservation, Propagation and Utilization of Palms with Special Reference to Rattans

Extensive survey conducted in Cachar district of the Barak Valley region of Assam, has revealed the existence of nine species of rattans (canes). These include some 'rare' and 'very rare' species, which need to be conserved immediately through both in-situ and ex-situ methods. Soil samples collected from different areas of cane brakes have been analyzed to find out their ecological preferences. Mature seeds of *Calamus tenuis* and suckers of *Calamus erectus* and other rattans were collected and their mode of germination and propagation is being studied. Seedlings raised in the nursery are being transplanted in the adjacent campus of Assam University.

M. Ghose, S. Das, K. Bhattacharya and A.Gupta (Assam University)

Ponds, Aquatic Weeds and Water Quality: An Investigative Study

Monthly sampling of six ponds with phytoplankton blooms continued during the year. The algal communities present in the water were noted and water samples were analyzed in the laboratory. The different algal communities, on the basis of their dominance, were: green algal types, euglenoids, blue-green algal types. It was found that the total algal diversity decreased with the occurrence of blue green algal blooms when an appreciable decrease in the soluble form of phosphorus (SRP) was also noted showing a high level of consumption. Incase of other water quality variables, dissolved oxygen (DO) showed a uniform trend indicating constant photosynthesis for all bloom types. pH values were in

the alkaline range. Secchi depth visibility, a measure of water clarity, was inversely proportional to the algal load which was clearly by the high chlorophyll-a values.

A. Dewanji

Study of the Microbial Succession and Changing Microbial Molecular Diversity of a Bio-Organic Composting System

The composting process at the microbial level involves several interrelated factors such as metabolic heat generation, temperature, ventilation (oxygen input), moisture content and availability of nutrients. Attempts have been made to use microbial innoculants to enhance the rate of biodegradation and improve the quality of compost. From compost sample, chromosomal DNA was isolated, 16S rDNA was cloned and sequenced with the help of Polymerase Chain Reaction (PCR) to identify microorganisms which have good ability to assimilate carbohydrates and degrade biopolymers i.e. starch, cellulose and proteins, at high temperatures. This study aims to provide an insight into the relationship between the structure and function within microbial communities. Two strains 22a and 23a showed much higher activities as compared to others. Strain 23a, a high amylase producing strain which showed very good activity even at 75 degree Celsius was identified as a member of the genus geobacillus. The Fasta formatted sequence was analyzed with the aid of BLAST tool to reveal its identity. Strains 23a, 22a and three other cellulolytic strains were cultured in large scale in liquid LB medium for field trails.

S. Chanda, S. Barik and S. Pal

Mathematical Models on Ecology and Epidemiology

Analyzing the plankton data and several mathematical and stochastic models, we have observed the role of toxin-producing phytoplankton (TPP) on the dynamics of other phytoplankton and zooplankton. The main findings are (1) Toxin producing phytoplankton has two distinct roles: the inhibitory role on predator zooplankton, and compensation of competition coefficients among different phytoplankton species. (2) Toxin-allelopathy due to the toxin producing phytoplankton ensures the stable coexistence of competing phytoplankton species. (3) The so-called 'planktonic non-equilibria' is due to switching of plankton dynamics through self-sustained oscillations and fragile-stable state, and the toxin inhibition on zooplankton is responsible for such switching. These results provide a novel solution to the plankton paradox.

J. Chattopadhyay

Allelopathy In Natural and Manipulated Ecosystems – with Reference to Root Exudates, Leaf Leachates and Fruit Pulp

Active allelochemical with 472 mol. wt. have been isolated, purified and crystallized from teak leaf. This allelochemical at concentration of 500 ppm, 1000 ppm, 1500 ppm and 2000 ppm shows antifungal activity on four species namely, Aspergillus japonicus, Aspergillus fumigatus, Aspergillus flavus and Penicillium sp. and exhibits antibacterial activity against several Gram positive and Gram negative bacteria at a concentration of 250 ppm, 500 ppm, 750 ppm and 1000 ppm. The whole leaf dust of teak at different conc. i.e. 5gm, 10gm, 15gm, 20gm in leaf debris soil bioassay shows stimulatory result on both shoot length and root length. But when the major active allelochemical was isolated and purified, showed concentration dependent stimulatory and inhibitory activity on rice seeds. This active teak allelochemicals is an antifungal and antibacterial agent without having any adverse effect on germination and growth of rice.

S. Mandal and S. Chanda

Biological Anthropology Unit

Health and Disease Among Populations Inhabiting Contrasting Ecological Niches

The project aims at a comprehensive evaluation of health status of different ethnic communities inhabiting contrasting ecological settings and experiencing life style variations. Populations from

Sikkim Himalayas (Bhutia and Rai), Coastal Midnapore (Jelia Kaibarta) and Orissa plains (Shabar) are chosen as study populations from whom a large variety of data pertaining to different domains of health are being collected. The analyses of data so far reveal the following : (a) Significant difference exists in respect of fertility and infant mortality between Rai and Bhutia populations; (b) Significant difference in immunization coverage exists between the Rais and the Bhutias; (c) Rais and Bhutias experience significant differences in respect of prevalence of obesity and hypertension among the adults; lipid profiles of adults, however do not show significant difference; (d) Low prevalence of hyperglycemia is evident in both these ethnic groups; (e) Rural Shabars showed significantly higher infant and child mortalities compared to their urban counterparts; (f) Prevalence of chronic energy deficiency is higher among urban males, while the trend is reversed in case of Shabar females.

B. Mukhopadhyay, R. Gupta, P. Bharati, S. K. Roy and S. Mukhopadhyay

Status of Austro-Asiatic Tribes in the Peopling of India

Through extensive analyses of the mitochondrial and Y-chromosomal DNA among most of the Austro-Asiatic populations of India, compelling evidence has been obtained to infer that the ancestors of the present day Austro-Asiatic tribes of India, particularly of the Mundari speakers from Chotanagpur plateau, are the parental source populations of all the present day Austro-Asiatic populations of the world, distributed predominantly in the South and Southeast Asia. Evidence was also found for Khasi tribes of Meghalaya to provide genetic link between Indian and Southeast Asian populations reinforcing the earlier hypothesis of Northeast Indian corridor for early human migrations.

The study has examined the universality of the hypothesized greater Y-chromosomal compared to mtDNA variability in patrilocal populations and found that given the unique population structure with rigid endogamy rules governing the marriages, this hypothesis does not fit the Indian situation.

B. M. Reddy

A Molecular Genetic Study of Couples with Recurrent Spontaneous Abortions

The HLA based work on the couples with recurrent spontaneous abortions has considerable social relevance and the findings which are underway are expected to help in genetic counseling of these couples and in designing appropriate therapeutic measures.

B. M. Reddy

Genomic Diversity of Adi Tribal Cluster of Arunachal Pradesh

The main objective of the study is to investigate the genomic diversity and affinity of the Adi sub tribes. Based on blood samples, (collected from the sub tribes of Adi from their remote villages), and typing for 15 autosomal STR loci, mtDNA and Y chromosome markers will be undertaken for tracing the maternal and paternal past genetic history of the tribes and their affinity and diversity with other tribes, castes of Dravidian, Austro-Asiatic and Indo-European speaking populations and with other Mongoloid tribes of eastern and southeastern countries, to understand the structural diversity.

T. S. Vasulu

Adolescents Reproductive Health: Bio-Cultural Dimensions

In India, more behavioral research is needed to explore the levels, patterns and socio-cultural factors underlying adolescent reproductive health, their vulnerability caused by young age, their ignorance on matters related to sexuality and reproductive health their lack of factual knowledge on contraception and inability or unwillingness to use health services put the adolescents at the risk of serious consequences. With an objective (i) to obtain information on knowledge and attitude on reproductive health, (ii) to assess the effects of socio-cultural dimensions on reproductive health and (iii) to assess the constrains they face in acquiring health services, the present study can help explore adolescent reproductive health needs and ways in which health and information services can be structured to respond to these needs in tune with the social, cultural and economic constraints they face.

Susmita Mukhopadhyay

Health and Disease: Comparison between two Ecological Settings

The objectives of the project are (i) to assess the health status of the Meiteis and Bengali speaking Assamese group who are inhabiting closely for several years, (ii) to evaluate the relative effectiveness and limitations of their traditional health management systems regarding health and disease, (iii) to determine the micro-environmental risk factors including socioeconomic and cultural factors affecting health. Data on mortality, morbidity, anthropometric indices, haemoglobin level data of about 300 individuals have been collected to satisfy the objectives (i) Some qualitative data including the health and hygienic practices, traditional belief and real-life practices in times of crises have been collected from about 350 individuals of both sexes. The data on micro-environmental risk factors including the nutritional status, work pattern have also been collected on about 300 individuals of both sexes. The same work has been extended on Demasa Cachari and Bishnupriya Manipuri during 2006 – 2007.

S. K. Roy

Human Genetics Unit

Genetic Epidemiological Studies on Common Diseases in Indian Populations

Various diseases with significant genetic and environmental contributions are increasing in frequency in India. Of particular importance is the increasing prevalence of metabolic syndrome. In order to assess the impact of modernization with concomitant changes in dietary and other life-style factors, we have completed a genetic epidemiological study on metabolic syndrome in two Indian ethnic groups. The relevance and the primary findings of this study were:

(a) *Background & objectives*: Metabolic syndrome is one of the major causes of morbidity and mortality in the world. The prevalence of this syndrome is high among Asians, including Indians, and is rising, particularly with the adoption of a modernized life style. Whether traditional societies in India have a low prevalence and the extent to which a transition to a modern life style contributes to the increase in prevalence are unknown. To examine the role of environmental and genetic factors in metabolic syndrome we conducted a study in two sub-Himalayan tribal populations with shared ancestry (Toto and Bhutia). The Toto live exclusively in a rural area, whereas a section of the Bhutia has adopted a modern life style. (b) *Methods*: Fasting (12 h) blood samples of Toto (n=258); rural Bhutia (n=75) and urban Bhutia (n=230) were collected, with written informed consent. Lipid profile, blood pressures, body fat and other anthropometric parameters were assessed. Criteria suggested by National Cholesterol Education Programme (NCEP) Adult Treatment Panel III (2001) were used for assessment of metabolic syndrome. (c) *Results*: The prevalence of metabolic syndrome was high (about 30-50%) among the Bhutia, with no significant rural-urban difference. Among the Toto, though the prevalence of metabolic syndrome was low (about 4-9%), their lipid levels were alarmingly adverse (about 37-67% had low HDL cholesterol or high triglyceride levels). There was an additional adverse impact of adoption of urban ife-styles (perhaps primarily mediated through dietary changes) on cardiovascular risk factors. (d) *Conclusions*: Our study suggested that metabolic syndrome and its correlates could be a major health problem even in traditional societies, indicating that this syndrome was not necessarily a result of modernization. Further, our study indicates that genetic factors that adversely affect the levels of such variables have long antiquities in Indian ethnic groups.

We have also carried out a case-control study on genetics of Gilbert's syndrome. Patients suffering from this syndrome have high levels of unconjugate bilirubin. The background and findings of this study were: (a) *Aim*: To identify the variants in UDP-glucuronosyltransferase 1 (UGT1A1) gene in Gilbert's syndrome (GS) and to estimate the association between homozygosity for TA insertion and GS in India, as well as the frequency of TA insertion and its impact among normal controls in India. (b) *Methods*: Ninety-five GS cases and 95 normal controls were selected. Liver function and other tests were done. The promoter and all 5 exons of UGT1A1 gene were re-sequenced. Functional assessment of a novel trinucleotide insertion was done by in silico analysis and by estimating UGT1A1 promoter activity carried out by luciferase reporter assay of appropriate constructs in Hep G2 cell line. (c) *Results*: Among the GS patients, 80% were homozygous for the TA insertion, which was several-fold higher than reports from other ethnic groups. The mean UCB level was elevated among

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individuals with only one copy of this insertion, which was not significantly different from those with two copies. Many new DNA variants in UGT1A1 gene were discovered, including a trinucleotide (CAT) insertion in the promoter found in a subset (10%) of GS patients, but not among normal controls. In-silico analysis showed marked changes in the DNA-folding of the promoter and functional analysis showed a 20-fold reduction in transcription efficiency of UGT1A1 gene resulting from this insertion, thereby significantly elevating the UCB level. (d) *Conclusion*: The genetic epidemiology of GS is variable across ethnic groups and the epistatic interactions among UGT1A1 promoter variants modulate bilirubin glucuronidation.

<div align="right">P. P. Majumder</div>

Genomics of Oral Cancer

Polymorphisms at N-acetyl transferase 2 locus have been studied in genomic DNA of oral precancer and cancer patients to know the risk of the diseases. Acetylation polymorphism did not modulate the risk of the diseases but XRCC1 variant genotype at codon 399 increased the risk of precancer among the slow acetylators. XRCC1 variant haplotypes, in combination with slow acetylation, also increased the risk of cancer among mixed tobacco users. On mitochondrial genome, major allele at A12308G polymorphism increased the risk cancer compared to controls. Major allele at A12308G polymorphism in combination with risk-genotype at GSTP1 also increased the risk of cancer compared to controls. So, it is proposed that polymorphisms at two or more loci may be involved in diseases.and cancer among mixed tobacco users. So, it is proposed that multiple risk genotypes on two loci increase the risk of cancer and precancer.

<div align="right">B. Roy</div>

Genomic Studies on Cervical Cancer

We carried out detailed molecular epidemiological studies to dissect the HPV16 epigenetic modifications (CpG methylation) that modulate cervical cancer (CaCx) risk. Analysis of the methylation status of the E2 binding site (E2BS-I), proximal to the P97 promoter in CaCx cases and controls revealed an overrepresentation of E2BS-I methylation in cases compared to controls. Sequencing of methylated case samples revealed absence /rare presence, of methylation at a few CpGs within transcription factor binding sites. Methylation was found to be more at CpGs within E2 binding sites proximal to the P97 promoter. These results indicate the involvement of E2 binding site methylation in presence of intact E2, leading to loss of E2 repressor activity in CaCx. Analysis of host genetic factors, HLA class I alleles (A, B, C) revealed that B*1301, and B*1801 alleles were predominant, while B*4006 occurred in decreased proportion among the HPV16/18 positive cases, compared to the HPV16/18 positive control women. This suggests that such HLA class I alleles may contribute towards risk of, or act as protective for HPV related disease development.

<div align="right">S. Sengupta</div>

Statistical Genomics

Some novel statistical methods have been developed for linkage and association analyses of complex genetic traits. These include: developing a multivariate phenotype approach to dissect an end-point binary trait based on a linear regression strategy using i.b.d. scores as the response variable and phenotypic observations as the explanatory variables.

extending a non-parametric regression-based linkage method to incorporate squared sib-pair trait sums in addition to squared differences. Examining for any possible bias in using the same families for TDT analysis as those used in the affected-sib-pair linkage analysis.

evaluating ANOVA as a method for QTL association mapping.

Analyses were performed on:

Quantitative endophenotypes in the ongoing COGA study.

Type 2 diabetes and related quantitative precursors.

Major psychoses phenotypes including bipolar disorder and schizophrenia.
Autism.

In connection with our ongoing studies on population genetics and bioinformatics, we are mining public domain databases. One of the most useful and popular population genetic databases is the HapMap. In the course of our work on mining HapMap data, we discovered some major discrepancies. We then designed some wet laboratory experiments to identify the causes of these discrepancies. The relevant details and findings were: The HapMap data are being widely used in human genetic studies. We show by direct resequencing of a B6-kb region of chromosome 1 that the HapMap data are unreliable for this region. This region contains a recent mitochondrial (mt) DNA insertion. The HapMap data report the corresponding mtDNA variation and not the nuclear DNA variation. In view of mtDNA insertions of varying lengths throughout the human genome and considerable segmental duplications, it is necessary to use the HapMap data cautiously.

S. Ghosh

Social Sciences Division

Economic Research Unit

During the period under consideration, the scientists in the Unit have undertaken research, both theoretical and empirical, in diverse areas. The `Discussion Papers' posted at http://www.isical.ac.in/~eru/ provides an overall view of the Unit's current research activities. The important topics are the following.

Agriculture Economics

Information Marketing and Credit Constraints

The main objective of this study, a collaborative work with Boston University, USA, is to examine the role of information dissemination policies in raising agricultural incomes, and promoting human development among poor farmers in developing countries. Specifically, it is planned to study the impact of a randomized intervention providing market price information to small farmers in two potato-growing districts in West Bengal, India and to examine the price and income impact of this intervention for poor farmers. The importance of information constraints will be assessed relative to credit constraints for small farmers, as well as possible complementarities between information and credit policies. In the process of assessing credit constraints, evaluation of an innovative randomized credit intervention aimed at enhancing the access of the poor to credit will be done. Econometric analysis will allow testing predictions of theories that will be developed about the impact of these interventions on marketing margins, cropping patterns, farmer incomes as well as intra-household behavior.

Sandip Mitra , Dilip Mookherjee and Sujata Visaria

Labour Efficiency and Indian Agriculture

Individual farm-level data for 478 Indian farms have been used to analyse (a) separability of the labour inputs, (b) elasticity of substitution between family labour and hired labour and (c) effective labour functions. The analysis is based on an ordinary least square (OLS) estimation of the translog production function with family and hired labour as two distinct inputs. Results of analysis have shown that family and hired labour in Indian agriculture are weakly separable from other inputs such as land and material inputs. These two labour inputs are, however, very close substitutes and they are equivalent in terms of efficiency. Thus family and hired labour in Indian agriculture should be considered as homogeneous inputs.

Manabendu Chattopadhyay and *Manjari Bhattacharya*

Monsoon and Economic Activity

This short essay tries to answer why a positive relationship between a good monsoon and the level of industrial production is observed in a country like India. A standard explanation, provided in terms of a good monsoon increasing agricultural income and thereby boosting up industrial demand, does not

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stand up to reason because agricultural goods have inelastic demand and so a rise in supply should reduce suppliers' income. An alternative answer is provided in terms of procurement and support prices of agricultural goods by the government.

Abhirup Sarkar

Tenancy Contracts in Indian Agriculture

The question of existence of share tenancy and fixed rent tenancy in Indian agriculture has been addressed in this study. It is well known that fixed rent tenancy contract was very uncommon before the mid-sixties. The system, however, has been on the increase during the current decades. A number of explanatory factors have been considered to explain this phenomenon. The findings, primarily based on the NSS data, suggest that among the factors considered, intensity of irrigation and land productivity are the most important ones to explain the changes in the extent and forms of tenancy in Indian agriculture during the current decades.

Manabendu Chattopadhyay and Chiranjib Neogi

Analysis of Height, Weight and Nutritional Status

Earning / wage differentials by height among coal mine workers in India has been analyzed in this study. It has been suggested that workers of above average height earn 9–17% more than their shorter counterparts and 6–13% more than average reference height. Also, long-term investments in health human capital might ensure increase of labour productivity and thereby earnings, particularly in underdeveloped economies.

S. Dinda, P. K. Gangopadhyay, B. P. Chattopadhyay, H. N. Saiyed, M. Pal and P. Bharati

In order to assess the nutritional status of 42 communities belonging to four major social groups (scheduled caste, scheduled tribe, general & other caste group and Muslims) of Orissa and Bihar States in Eastern India, for 9075 adult males aged 18-62 years height, sitting height and weight were taken for the analysis. Cormic Index (CI) and Body Mass Index (BMI) have been computed. With few exceptions, there are significant differences in BMI and CI between scheduled tribal groups of states (Orissa and Bihar) and other rest of the groups. The present study reported prevalence of chronic energy deficiency (<18.5 kg/m^2) among scheduled caste group of Bihar to be the highest followed by scheduled tribe of Bihar and Orissa. But over all prevalence of CED of Orissa is lower than that of Bihar. BMI and CI are highly correlated for each of the social groups in Bihar and Orissa.

D. K. Adak, R. K. Gautam, A. K. Gharami, S. Bharati, M. Pal and P. Bharati.

Malnutrition among children is prevalent in almost all states in India. The extent and causes of malnutrition in two eastern Indian states with similar climates, namely West Bengal and Assam, were assessed using data from the National Family Health Survey 1998–99 (NFHS-2). The three indices of malnutrition taken for analysis were weight-for-height (WHZ), height-for-age (HAZ) and weight-for-age (WAZ). These were assumed to depend on birth order, preceding birth interval, parent's educational status, working status of the mother, mother's age at delivery of the children, source of drinking water, toilet facilities and standard of living of the household. Logistic regression was carried out separately for each of the three indices on the explanatory variables for both the states. Different sets of variables were obtained for two states and for three indicators to explain the levels of malnutrition. The importance of variables has been found to be different in the two states.

S. Som, M. Pal, B. N. Bhattacharya, S. Bharati and P. Bharati

Child Labour and Minimum Wage

It has been shown in this paper how minimum wage law can be useful in reducing the incidence of child labour. The study has been done in an overlapping generation set –up.

Chandana Das and Ambar Ghosh

Deprivation, Inequality and Welfare

Several properties of the Bonferroni inequality indices, including their welfare theoretic interpretation have been investigated. The absolute Bonferroni index has been characterized as the average of

subgroup average depression indices, where to each income a subgroup containing all persons whose incomes are not higher than this income is associated. An aggregate depression index for a subgroup has been derived axiomatically as the sum of gaps between the subgroup highest income and all incomes not higher than that.

Satya R.Chakravarty

Welfare ranking of income distributions often involves a trade off between equity and efficiency. In the income scale a person's feeling of deprivation about higher incomes may be of relative or absolute type, that is, it may depend on income ratios or on income differentials. An intermediate notion of deprivation, which is defined as a convex mix of relative and absolute deprivations, is considered. The problem of ranking income distributions using a social welfare function whose value increases under a globally equitable redistribution and which shows efficiency preference if income increases take place without altering intermediate deprivation is then investigated. The ranking relation developed is implemented by a simple graphical device . It is shown that all deprivation indices can be regarded as inequality indices but the converse is not true. Finally, a numerical illustration of the results developed in the paper is also provided.

Satya R. Chakravarty

Econometrics : Theory and Application

Cointegration

Cointegration tests under univariate framework are known to have little power. A method for cointegration tests in panel data framework has been developed incorporating cross sectional dependence. It is shown that this new test has standard normal distribution with good power property. This work is in progress.

Samarjit Das, Gouranga Sinha and T. K. Mitra

Mean and Volatility Dynamics

This study is concerned with time series modelling of foreign exchange rate of an important emerging economy, viz., India, with due consideration to possible sources of misspecification of the conditional mean like serial correlation, parameter instability, omitted time series variables and non-linear dependences. Since structural change is pervasive in economic time series relationships, the paper first has studied this aspect of exchange rate series in detail and found the existence of four structural breaks. The estimated GARCH and EGARCH models have suggested that return on Indian exchange rate series is marked by instabilities and that the appropriate volatility model is EGARCH. Further, out-of-sample forecasting performance of the model has been studied by standard forecasting criteria, and then compared with that of an AR model only to find that the findings are quite favourable for the former.

Rituparna Kar and Nityananda Sarkar

Panel Unit Root Test

Dealing with fixed effects (intercept, time trend) in unit root tests is a major problem. Panel unit root tests also have the same problem. However this issue has not been focused in panel unit root literature. A few methodologies have been proposed to deal with such factors. This work is in progress.

Joerg Breitung and Samarjit Das

Singular Linear Models with Multicollinearity

Several estimators are available for estimating parameters of standard linear regression models with multicollinearity. Of late, some suggestions have been made for similar estimators for singular linear regression models. In this work, an attempt is being made to combine these estimators into one and study its properties from decision theoretic point of view.

Nityananda Sarkar

Studying Predictability and Nonlinearity of Indian Stock Returns

India is now considered to be one of the most important emerging market economies. Consequently, its integration with the developed economics is now occurring to a great extent. In such an economic scenario, the present study is concerned with predictability and nonlinearity of two most important time series viz., India's stock index and foreign exchange rate. Apart from short-run prediction, predictability aspect in this study also includes long-run consideration. The choice of these variables has been made from consideration of the fact that roles of capital market and foreign exchange market are extremely important for any major economy. Several nonlinear models like SETAR, STAR, SETAR-GARCH, Markov switching regime model etc., have been considered for this study. Best predictive equations for these two variables have been obtained under different specifications and their forecasting performances studied using appropriate criteria.

Nityananda Sarkar

Study on Regional Disparities

An empirical study has been done to test whether regional disparities in India across states are diverging over time. It has been found that rural sector is diverging from urban sector. Furthermore there is a stark difference in rural sectors across states.

T. K. Mitra, Gouranga Sinha and Samarjit Das

Temporal Analysis of Income Elasticities

The limited objective of this study is to examine the change in income elasticities of household consumption during the 90's across different expenditure groups of population of 15 major states in India.

Saswati Das and Amita Majumder

Economic Growth, Human Capital and Infrastructure

Human Capital, Economic Growth and Dual Economy

This study analyzes the transitional dynamic properties of a growth model of a dual economy in which dualism lies in the mechanism of human capital accumulation of two types of individuals. The conditions under which the saddle path converging to the steady-state growth equilibrium point is unique and the conditions under which equilibrium growth path may be indeterminate are derived.

Manash Ranjan Gupta and *Bidisha Chakraborty*

Human Capital, Endogenous Growth and Dual Economy

This study develops an endogenous growth model of a dual economy where human capital accumulation is the source of economic growth. The dualism between the rich sector and the poor sector exists in the mechanism of human capital accumulation. Individuals in the rich sector (region) allocate labour time not only for their own production and knowledge accumulation but also to train the individuals in the poor sector (region). External effects of human capital are considered not only in the production technology in the rich sector but also in the production technology and in the human capital accumulation in the poor sector. The model helps us to derive some important properties of the steady state growth path of a competitive household economy as well as that of a command economy. Steady-state growth equilibrium in the competitive economy may not be socially inefficient.

Manash Ranjan Gupta and *Bidisha Chakraborty*

Public Infrastructure, Employment and Sustainable Growth

A theoretical model of endogenous growth motivated by the recent Indian paradox of an improving GDP growth rate in the face of unsatisfactory 'employment' growth rate is built. The source of the problem is believed to be inadequate growth of 'manufacture' for the absorption of unskilled or semi-

skilled labour in rural sectors. The paper studies the impact of free trade on 'employment' and GDP growth in a small, developing economy in the absence as well as presence of 'foreign direct investment'. The model also recognizes the importance of 'public infrastructure' accumulation to support the growth process. The results indicate that free trade with or without a corresponding free inflow of foreign capital into the manufacturing sector has a positive impact on 'employment' and GDP growth. However, the beneficial effect is stronger in the presence of foreign capital. Foreign and domestic capital grow at equal rates in equilibrium.

Dipankar Dasgupta and *Koji Shimomura*

A model of endogenous growth where public infrastructure acts as the engine of growth is considered. The service of infrastructure in production is assumed to be a pure public good. The analytical implication of this assumption is that even with identical firms in any given sector of production, the number of firms in the different sectors appear as explicit parameters in the model. This allows for the possibility of comparative statics exercises with respect to the number of firms. The paper explains the manner in which changes in the number of firms can improve or worsen the balanced rate of growth for the system both under autarky and free trade.

Subrata Guha, Dipankar Dasgupta and *Koji Shimomura*

Economics of Public Finance

An attempt has been made to prepare a book to deal with the theories of Government expenditure and its financing. To give some idea a few sample chapters like "Fiscal federalism" "Tax equity", "Public goods, private goods and mixed goods" can be named.

Chandana Ghosh and *Ambar Ghosh*

Employment Segregation

A Generalized Index of Employment Segregation

An axiomatic derivation of a class of numerical indices of integration (equality) in the distribution of male-female workers across occupations has been developed. The associated segregation (inequality) indices parallel the multidimensional Atkinson inequality indices. Two members of the class of segregation indices are monotonically related to the Hutchens square root index and the Theil-Finizza index. A numerical illustration of the family of indices is provided using U.S. occupational data.

Satya R. Chakravarty and *Jacques Silber*

Occupational Segregation in Rural India

There exists a vast economic literature on the issue of inequality in the distribution of income and wealth across different socio-economic groups. Very few attempts have, however, been made to examine empirically the inequality in the distribution of people across occupations, particularly in the less developed economy. The purpose of this work is to examine the level of employment segregation in the rural labour force of India for the period 1981 – 2001, using the existing tools of analysis of segregation.

Manabendu Chattopadhyay

Environmental Economics

Environmental Valuation

Deepor Beel is one of the important natural wetlands of Assam having great biological and environmental importance besides being the only major storm water storage basin of the Guwahati City and the only Ramsar Site in the state. The basic objectives of this study were (a) to identify economic activities, (b) to estimate income and employment and (c) to ascertain people's perception about the wetland and their willingness to pay for preserving the resource. The interesting observations are (a) around 75 % of households in that area depend on the Beel in some way. The fishing community, mostly belonging to the middle-income group, absolutely depends on the Beel. (b) Most of

the households showed their concern about the maintenance of the Beel to get rid of prospective threat of hazards caused by developmental activities. (c) Level of education as well as income from Beel have significant positive role in explaining the willingness to pay (WTP) for maintaining the Beel. (d) Also, as expected, the expenditure of the household has significant negative effect on WTP.

Kunal Chattopadhyay, Chiranjib Neogi and Pulakesh Maiti

Urban Waste Management

In an urbanized area a possible method of management of huge amount of wastes may be the reduction in volume for ultimate disposal by a scientific methods due to shortage of space for dumping. People's participation in the form of physical and financial support may provide incentives to the municipalities to take up scientific waste management methods and to operate the system efficiently. An attempt has been made to find out how the authority may be able to involve people in its management programme, both physically and financially.

Snigdha Chakrabarti, Amita Majumder and Subhendu Chakrabarti

Group Strategyproofness and Queueing Problem

This study examines the tradeoffs between group strategyproofness, efficiency and budget balance in queueing models. In general, group strategyproofness is incompatible with efficiency and budget balance. It is shown that strong group strategyproofness is incompatible even with efficiency and feasibility. The study identifies a necessary condition for weak group strategyproofness and efficiency and uses it to show that these two requirements are incompatible with budget balance if the set of agents is not equal to three. With three agents, weak group strategyproofness, efficiency and budget balance are compatible. Next, the paper identifies a sufficient class of efficient mechanisms that satisfy weak group strategyproofness. Finally, we identify the complete subclass of these mechanisms that are feasible.

Manipushpak Mitra and *Suresh Mutuswami*

Health Economics Study In North-East

The study has attempted to show the various stages of treatment so far followed in a part of Meghalaya. It has been found that a large unorganized private sector is active in the North East. Due to lack of Public Medical facilities people increasingly have become dependent on the private sector. Hospitalisation cases may not reflect the exact scenario unless dealt together with all the facilities available in the area. It is well known that in an underdeveloped area a vast unorganized sector coexists with the organized sector. Under a process of development the organized sector is expected to grow at a faster pace. However, in areas, which are too backward, the process of transformation is rather slow. The role of NGO's is felt at this crucial juncture. It is felt that the so-called 'barefooted doctors' may influence the health scenario significantly. In the N.E states it may be more relevant as the area is dominated by tribal communities.

Sandip Mitra, Chaiti Sharma Biswas, *D.C Nath*, Manoranjan Pal and Biswanath Bhattacharya

Human Well Being

Human Development and Economic Performance

The broader relationship between technological capability index (TCI), human development index (HDI) and economic performance index (EPI) has been investigated in the BIMST-EC countries, Japan and the rest of the world. Special emphasis has been given on the countries of 'Bay of Bengal Initiatives' and Japan. Thereafter the nature of the relationship between these three concepts of technological development have been tested over the last 10 years considering the period pre-globalization programme (that is, early 1990s) and the post-reform period (say, 2000). Some cautious conclusions regarding the future course of actions for strengthening the economic cooperation of the countries under 'Bay of Bengal Initiatives' (Bangladesh, Bhutan, India, Myanmar, Nepal, Sri Lanka and Thailand), have been tried to be drawn, keeping in mind a broader regional economic cooperation in the long run with Japan.

Buddhadeb Ghosh and *Yaowapa Maneechai.*

Measuring Human Well Being

An attempt has been made to measure human well being across different sections of the society in rural and urban India over time where sections have been made in terms of ten decile groups of income.

Saswati Das

Incentives for Cooperative and Non-cooperative R&D

In this study incentives for cooperative research vis-à-vis non-cooperative research have been studied when there are two conceivable product innovations. It has been shown that, contrary to the literature, there are situations where non-cooperative R&D generates a larger payoff even when the success probability in R&D is high. Given that there are different forms of cooperation, if research cooperation has access to all these forms, cooperative R&D will dominate at least for high probability of success. The paper has also studied the effect of patent protection on the choice of R&D institution. It is shown that patent protection reduces the scope of cooperation in R&D.

Tarun Kabiraj

Incentives for cooperative research for firms competing in the product market have been analyzed here. Contrary to the literature, situations are portrayed to show that non-cooperative R&D can occur even if the probability of success in R&D is large. Then the paper has modeled synergy in cooperative R&D. It has been shown that when the innovation size is large, cooperative research is likely to occur.

Tarun Kabiraj

Information Extraction and Scheduling Problems

This study deals with the problem of scheduling a set of jobs through a set of machines where the processing speed of the machines can differ. It is assumed that the waiting cost of each job is private information and that all jobs take identical processing time in any given machine. After allowing for monetary transfer, the study identifies the complete class of multiple non-identical machine scheduling problems for which it is possible to find information revelation mechanisms that lead to (a) minimization of aggregate cost (or efficiency) and (b) costless information extraction.

Manipushpak Mitra

International Economics

Brain Drain Theorization

This study proposes an alternative way of looking at the issue of brain drain. It tries to bring into focus the crucial role of repatriated earnings of emigrants that can potentially help higher absorption of skill and sustain a higher level of skill differentiation in the domestic economy. A situation might also arise where insufficient demand for the skill-using sector gives way to an outcome in which the economy produces and exports a higher level of skilled workforce but is unable to absorb the same domestically, and this might be potentially welfare immiserizing.

Brati Sankar Chakrabarti

Innovation, Imitation and Intellectual Property Rights

This note analyses the effect of the policy of tightening Intellectual Property Rights (IPR) on the rate of innovation in the North and on the welfare in both North and South in a model which is otherwise identical to the Helpman model except in the concept of knowledge capital. We assume that the South based imitated products do not contribute to the knowledge capital in the North. It is shown that the tightening of IPR raises the rate of innovation in the North and may improve the welfare of both North and South. These results are significantly different from those in Helpman's study.

Debasis Mondal and Manash Ranjan Gupta

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Product Development, Imitation and Economic Growth

A dynamic North-South general equilibrium model of International product cycle is presented in this study. The qualitative effects of strengthening intellectual property rights (IPR) on the balanced growth rate of the world economy is studied in two alternative cases: (i) imitation is direct from North to South (ii) multinationalisation is the channel of product transfer.

Debasis Mondal and *Manash Ranjan Gupta*

Liberalization and Domestic Product Quality

This paper has provided a model of vertical product differentiation to study the impact of liberalization on the choice of the product quality of a local monopolist. It has been shown that under liberalization as one foreign firm enters with a superior quality, the local firm reduces its quality level unless the foreign firm's product quality is sufficiently higher. As the efficiency of the local firm goes up, its quality choice responds more under liberalization than under protection. However, its market size in the protective regime is independent of its efficiency level.

Tarun Kabiraj and S. Roy

Literacy

Two population principles for intersociety literacy comparisons have been suggested and their relationships with literacy axioms proposed earlier in the literature have been established. The results have been illustrated numerically using Indian data. Some policy implications have also been discussed.

Satya R. Chakravarty and Amita Majumder

Millennium Development Goals

The Millennium Development Goals (MDGs) are time-bound quantified targets for improving the human condition from different perspectives. Within each Goal several targets have been set and to each target there corresponds one or more indicators. For each indicator an index of perceived progress towards reaching the Goals has been characterized such that it can be used for monitoring the progress. A composite index of progress, which allows the calculation of percentage contributions of progress made in different dimensions is also characterized. This, in turn, enables one to identify the dimensions for which desired progresses are more. This is important from policy perspective. An empirical illustration of the characterized indices using cross-country data for different indicators is also provided.

Satya R.Chakravarty and Amita Majumder

Polarization

Absolute polarization indices remain unchanged under equal absolute augmentation in all incomes. The class of absolute polarization indices whose orderings of alternative income distributions agree with the rankings generated by nonintersecting absolute polarization curves has been characterized. The possibility of using an ethical absolute inequality index in polarization measurement is explored. It is established that although inequality and polarization are dissimilar concepts, different absolute inequality indices can be employed to design alternative absolute polarization indices. A numerical illustration is provided using Indian data and it is shown that inequality and polarization are different issues in income distribution analysis.

Satya R. Chakravarty , Amita Majumder and Sonali Roy

Political Economy

Local Democracy and Patterns of Political Participation

In this study some preliminary findings have been reported from a survey that was carried out (in 2002-04), involving 2400 households in a sample of 85 villages from all districts of West Bengal (excluding Kolkata and Darjeeling). The information regarding political participation reported by

interviewed heads of households, as well as votes they cast (across different political parties active in their relevant areas) were collected through a secret ballot, which was administered separately. Some of the important observations obtained from the analysis of data are as follows. (a) On an average, West Bengal villages are characterized by high levels of political participation; (b) With the exception of education, gender and immigrant status, participation rates vary little with socio-economic status; (c) 95% households reported absence of disturbances or irregularities in local elections. 99% of those registered turned out to vote, and almost no voters reported failure to cast their vote owing to disturbances and (d) There is a significant fraction of swing voters: more than half do not vote like their father, and one-third have switched support in the past 25 years.

Pranab Bardhan, Sandip Mitra, *Dilip Mookherjee* and Abhirup Sarkar

Poverty and Social Exclusion

The Measurement of Poverty and Social Exclusion

The problem of replacing the traditional crisp view of poverty with a fuzzy structure, which allows membership of poverty set or the possibility of poverty in different dimensions of life to take any value in the interval $[0,1]$ is explored. An attempt has been made to establish how standard multidimensional poverty indices might be translated into the fuzzy framework. Suggestions have also been made for suitable fuzzy analogues to axioms for a multidimensional poverty index. A characterization of a membership function has also been developed.

Satya R.Chakravarty

If the absolute number of poor people goes up, but the fraction of people in poverty comes down, has poverty gone up or gone down? The economist's instinct, framed by population replication axioms that undergird standard measures of poverty, is to say that in this case poverty has gone down. But this goes against the instinct of those who work directly with the poor, for whom the absolute numbers notion makes more sense as they cope with more poor on the streets or in the soup kitchens. A family of poverty measures combining the two conceptions of poverty into a common framework (without a population replication axiom) is presented. This family has an intuitive link to standard measures, but it also allows one or other of "the absolute numbers" or the "fraction in poverty" conception to be given greater weight by the choice of relevant parameters. This family is expected to prove useful in empirical and policy work where it is important to give both views of poverty—the economist's and the practitioner's—their due.

Satya R. Chakravarty, *Ravi Kanbur* and Diganta Mukherjee

The multidimensional extension of the Watts poverty index may be expressed as a function of five determinants measuring respectively the impacts of what are defined in the paper as the Watts poverty gap ratio, the Theil-Bourguignon index of inequality among the poor, the overall headcount ratio, the weights of the various dimensions and some measure of correlation between the various dimensions. Using the Shapley decomposition, this index has been applied to world data on the per capita GDP, life expectancy and literacy rates and the contributions of the five determinants defined above to the variation of this index between 1993 and 2002 are derived. A characterization of the Watts index has also been developed using subgroup decomposability.

Satya R.Chakravarty, *Joseph Deutsch* and *Jacques Silber*

An axiomatic approach the measurement of social exclusion has been developed. At the individual level social exclusion is viewed in terms of deprivation of the person concerned with respect to different functionings in the society. At the aggregate level social exclusion is regarded as a function of individual exclusions. The class of subgroup decomposable social exclusion measures is identified. The problem of ranking exclusion profiles using exclusion dominance criterion is investigated and some policy applications are also discussed. Applications of the suggested measures using European Union data have also been made.

Satya R. Chakravarty and *Conchita D'Ambrosio*

Poverty Measurement: An Empirical Study

Most empirical studies of poverty assume an equitable sharing of resources among all household members, although the assumption is unrealistic. Along the line suggested in Findlay and Wright (1996), this paper explores the impact of unequal sharing of resources on poverty measurement in the Indian context. Simulations based on household level National Sample Survey data for the 50th round for the states of Andhra Pradesh, Kerala, Punjab and West Bengal are carried out under the assumption that women 'lose' and men and children 'gain' because of unequal sharing in the household. The results show that the conventional poverty measures overestimate the overall poverty when compared with cases where intra household allocations or adjustment of poverty lines according to nutritional requirements of men, women and children is taken into account. The poverty measures are highly sensitive to the choice of the sharing parameter as well as to the adjustment of the poverty lines.

Amita Majumder and *Saugata Basu*

Poverty and Environment

This study examines the relation between poverty and the environment. A number of macro-level studies have been reported. Why does poverty harm environment is a moot question. This is examined at a micro-level in a remote village using primary data and observations. Failure of institution of local commons and the neglect at the hands of implementing agencies of public policies- particularly population control, matter more in environmental damages. Gender bias and the neglect of education at the grass-root level increase environmental degradation. The need of the day is to arouse a sense of awareness among the poor people to protect environment as an asset on the one hand, and to check the harming living-style of rural-rich, on the other. Education to all at the grass-root level and the women association would work to protect environment.

Shyam Sunder Pd. Sharma and Chaiti Sharma Biswas

Regulating an Open-access Essential Facility

A vertically integrated firm owns an essential input and operates on the downstream market. There is a potential entrant in the downstream market. Both firms use the same essential input to provide the final services. The regulator's objectives are (a) to ensure financing of the essential input and (b) to generate competition in the downstream market. The regulatory mechanism grants non-discriminatory access of the essential facility to the entrant provided it pays a two-part tariff to the incumbent. The optimal regulatory mechanism generates inefficient entry, that is, it is possible that a cost efficient entrant stays out of the market and it is also possible that a cost inefficient entrant enters the market. The inefficient entry captures the trade off between market efficiency and infrastructure financing that results due to incomplete information and due to the provision of non-discriminatory access of the essential facility to the entrant.

Manipushpak Mitra and *Axel Gautier*

Women Studies

Determinants of Women's Health Care Decision

In explaining the low levels of maternal health care used by the women, mainly provision and geographic accessibility of services have been focused. But attention has not been given how socio-economic and cultural factors, inequitable gender rates influence the decision to use the services. In this context, an attempt has been made to investigate the role played by the socio-economic status of women on the use of maternal health care system available to them.

Snigdha Chakrabarti and *Pranab Banerjee*

Role of Women in Schooling and Child Labour Decision

The role of women's education has been explored in exploring and improving the child's human capital scenario in the face of a changing social pattern and economic opportunities.

Saswati Das and Diganta Mukherjee

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Economic Analysis Unit

The unit is engaged in research in quantitative methods in economics and social sciences. Application of these methods to different problems in agriculture, industry and monetary economics is being actively pursued. Topics in agricultural economics, growth and inflation and estimating the effects of economic reforms are of current interest. Research in inventory models under production smoothing hypotheses and variance-bound tests, intervention analysis, transfer function analysis, VAR and VECM models is being pursued by the research scholars of the unit.

Linguistic Research Unit

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

A: Sociolinguistics;
B: Corpus Linguistics and Language Technology,
C: Cognitive Linguistics, and
D: Clinical Linguistics.

A: Sociolinguistics

The unit has taken up the study of linguistic (lexical and syntactic) difficulty. The sociolinguistic dimension of linguistic difficulty has been studied within single languages, in relation to the mapping between the full conceptualization system and its basic level kernel, and across languages in the Indian context. Here the important target of study has been the place of English in the sociolinguistic fabric of India.

Probal Dasgupta

B: Language Technology

The current study on language technology involves (a) analyzing a large lexical database for defining linguistic rules for automatic processing of nouns, pronouns, adjectives, adverbs, postpositions, and other types of word found in Bengali corpus; (b) developing an English-Bengali dictionary of idiomatic expressions, set phrases, and lexical collocations to be used as translation equivalents in Machine Translation; (c) analysing various types of suffix parts used with Bengali adjectives to generate a suffix database to be used in automatic POS tagging of adjectives in corpus; (d) accessing relevant websites and literature to design a model for generating speech corpora in Indian languages, (e) designing a model for using information lexical items from Bengali corpora to develop electronic lexicon for Bengali, (f) designing a model for using information derived from language corpora to be used in both first and second language education in Indian languages, (g) working on a model for using information obtained from language corpora to develop a usage-based online electronic dictionary in Bengali, (h) working on a model for using information collected from language corpora to develop a usage-based general grammar in Bengali.

Niladri Shekhar Dash

C: Cognitive Linguistics

The unit has initiated the substantivist study of conceptual networks on the basis of Whole Word Morphology. Earlier work has demonstrated a connection between this inquiry and the linguistics of lexico-phrasal difficulty. The unit now proposes to initiate research in conceptualization kernel studies.

Probal Dasgupta

Clinical Linguistics

The unit continues its rehabilitation program and speech therapy as well as research on speech pathology with a view to enable a systemic approach to language habilitation in children with speech and neuro-linguistic disorders. The developmental status of various speech sounds for language development is being studied as a foundation for understanding delayed milestones in language and

related disorders, including the impact of hearing loss, psycho-social variables affecting language acquisition, disorders related to congenital and acquired cognitive disabilities, etc.

Shubhasree Ganguly

Planning Unit, Delhi

Economic Theory

A major research area has been the limit properties of large markets. The objective of this research is to see if the markets become more efficient as the number of firms increase. Another important area is the design of voting mechanisms with ambiguity and Choquet-rational players. The goal of this work is to characterize incentive-compatible random voting and allocation mechanisms. Other works analyse multi-unit and assignment auctions, as well as the role of incentives in organizations, in particular in determining hierarchy and control structures.

Macroeconomics

In macroeconomics, the literature on growth and distribution is being extended to an open economy framework. Also on the research agenda is the issue of talent allocation and economic growth, and the impact of trade liberalization on product quality. The issue of terrorism is another area of active research. In financial development, dynamic aspects of micro-finance have received attention. Schemes have been proposed (potentially applicable to India) that can solve the informational problems intrinsic in micro-finance.

Empirical Analyses of the Indian Economy

This has encompassed a wide range of issues. In environmental economics, a study of groundwater sales found high prices averaging 60 paise per cubic meter and a one-for-one responsiveness of water use to price suggesting that marginal cost pricing of electricity would substantially diminish groundwater over-extraction. Research in commodity markets showed that open economy policies and imports were critical in facilitating the evolution of a futures market in soya oil. A policy study on energy subsidies concluded that while the case for abolishing LPG subsidies was strong, eliminating kerosene subsidies would cause large welfare losses unless it is accompanied by rural electrification. Ongoing research has developed a theoretical model to be used to measure the long term impact on families affected by HIV/AIDS. Other current research projects include examination of non-linear relationship between child labour and land wealth of households, benefits of road connectivity in rural India, measures of multidimensional inequality, and the costs of plant biotechnology regulation.

Priyodorshi Banerjee, Sanghamitra Das, Satya P. Das, Chetan Ghate, Debasis Mishra, Abhiroop Mukhopadhyay, Bharat Ramaswami, Tridip Ray, Prabal Roy Chowdhury, Arunava Sen and E. Somanathan.

Specific Areas of Work:

The Economics of Terrorism

Satya P. Das and Prabal Roy Chowdhury

HIV/Aids Epidemic In India

Sanghamitra Das, Debasis Misra, and Abhiroop Mukhopadhyay

Economics of Food Labeling, Information and Technology Choice in Agriculture

Bharat Ramaswami

Auction theory, the role of asymmetry in the formation of NATO like organizations, the theory of joint ventures, industrial organization, on the SHG-linkage program, the dominant mode of micro-finance in India now, on multi-person bargaining with holdout.

Prabal Roy Chowdhury

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Population Studies Unit

Living Arrangements of Older Adults in India: Reduced Forms for Co-residence Model

This study is aimed at investigating the factors that are associated with the living arrangements of the older adults. It extracts information on Indian socio-cultural system vis-à-vis the older population from the 42nd round data of the National Sample Survey (NSS). The conceptual framework consists of availability factor, feasibility factor and cultural factor. It is asserted that the state of economic independence, the marital status, the place of residence, the sex and the age are potential factors determining the living arrangements at older ages. The analysis points to the need of formulating long term policies for caring older adults, given the heterogeneity of the population and their living arrangements.

Sanjeev Bakshi and Prasanta Pathak

An Analysis of the State of Empowerment of Females vis-à-vis Males at Old Ages in India

The state of well being of older adults is understood partially by their level of empowerment. The present study addresses these issues using the 42nd Round data of the National Sample Survey (NSS). This study defines certain empowerment indicators and investigates their variation and interrelationships across the provinces. A three tier conceptual framework consisting of individual, household and social characteristics has been proposed to find out the factors that are associated with empowerment. The gender dimension of the state of empowerment has also been investigated. The findings establish that suffering from certain diseases is negatively associated with the state of empowerment. Currently married older females are found more empowered than other older females. Economic dependence is negatively associated with empowerment.

Sanjeev Bakshi and Prasanta Pathak

Estimation of Actual Prevalence of Sexually Transmitted Infections Based on Available State Level Data on India

The study differentiates between reported prevalence and actual prevalence of sexually transmitted infections and attempts at finding out through statistical modelling the severity of actual prevalence of

the infections in different states. The states are categorised based on the severity and their performances under the on-going health programmes over time have been assessed.

Prasanta Pathak and Sudipto Pal

Grabbling the Justification of Fertility Estimates Based on Traditional Methodologies under Demographic Cauldron

This study was carried out for a North-Eastern State of India namely, *Mizoram*, because in almost all of the north-eastern states demographic parameters such as fertility, mortality and migration are not known to date. This is the reason why the study started with the estimates of fertility based on available traditional methodologies. Levels of fertility estimates for *Mizoram* that has attained the status of a state in the demographic map of India in 1987 were obtained using Census 2001 data set. The study has made an attempt to grabble the justification of fertility estimates for Mizoram.

Anuj Kumar Saha

Status of Gender Differentials and Trends in India: Population, Health, Education and Employment

This study tried to investigate some of the important socio-economic demographic classifications in regard to the extent and variation of gender differentials in a process of a trend per se. A new index of dissimilarity (ID) has been developed and tested through some data from census and registration system of GOI, New Delhi. The paper was presented at ISI's Platinum Jubilee Celebration.

B. K. Mukhopadhyay and *P. K. Majumdar*

Factors Associated with Population and MCH Policies Around the World

This study attempts to build up a model containing some variables such as Per capita GDP, Poverty level, Education, Mortality statistics etc., responsible for the development of i) official population policy and ii) maternal and child health policy around the world.

P.K.Majumdar and B.K. Mukhopadhyay

Demographic Scenario of Tribal Population in India and Madhya Pradesh

The main objective of this study is to provide an overview of demographic scenario of tribal population in India and Madhya Pradesh. It is concerned with demographic indicators e.g proportion of ST, sex ratio, literacy rate, enrolment ratio, drop out rate and age pyramid to evaluate the status of scheduled tribes in India and Madhya Pradesh.

Pranati Datta

Status of Tribal Women in India

This study is concerned with status of Indian tribal women, their basic features and persisting problems. It has used several indicators e.g sex ratio, female literacy rate, female participation rate, dependency ratio, girls enrolment per boys, gender parity index, parity progression ratio to examine status of tribal women. Lastly some basic issues including high incidence of illiteracy, high drop out rate, need for medium of instruction in tribal dialect, commitment of teachers, provision of incentives and timely supply of books have been taken into account to incorporate with policy recommendation.

Pranati Datta

Immigration to Assam

Assam has a long history of migration The main objective of this study is to examine documented and undocumented immigration to Assam. Census records will be used for documented migration. For undocumented parts existing literature will be used. Cohort study will be made for documented migration. Relevance of IMDT Act for illegal migration, though it is scrapped by Supreme Court, will be assessed.

Pranati Datta

Child Immunisation

An analytical study of Child Immunization and Ante natal care of women in all the states of India from NFHS1 and NFHS2 data and also the longitudinal study of immunizational status among group of states in India have been carried out.

Swati Sadhu

Globalization and Industrial Disparity among Indian States

The purpose of the paper is to investigate the nature, composition and direction of industrial development across the states dividing the period from 1980 to 2003 into two broad parts: 1980-81 to 1990-91 (Period 1, pre-reform) and 1990 to 2003 (Period 2, post-reform). It also tries to find out at the aggregate level whether there was any broad relationship between industrial entry, employment, skill labour, productivity, capital formation, purchasing power and state level income from 1980 to 2003.

More specifically, we first intend to check to what extent globalization has occurred in India in terms of broader macroeconomic features. Then we attempt to study the broader changes in industrial composition, employment intensity, capital intensity and productivity across Indian states over different time spans since 1980-81.

Swagata Gupta

Gender Disparity, Levels of Living and Regional Variance in Indian States

It is natural that the broad research objective of the present project would be to investigate the relationship between levels of living, education and women freedom in India with special emphasis on the disparity across the states, and wherever possible, between rural and urban areas. It would help us to understand the nature of linkage between existing levels of living, women's access to resources including land and non-land sources of income generation, financial and human capital as well as role of existing institutions in rural areas.

Swagata Gupta

Mortality Projection Using the Sample Registration System Data

This is a longitudinal study by age and sex specific mortality rates for India and its states. Aims of this study is to evaluate the trends in age and sex specific mortality rates by residence and to find out the demographic developmental and environmental factors which influence the mortality rates.

Subhash Barman

Schooling Facilities of Children (5-14 Years), Enrolment Rates, Causes of Drop Out and Engagement in Different Occupations

The aim of this study is to find out the determinants of child labour under different household and village characteristics by age, sex, residence and variations under different geographical locations.

Subhash Barman

A Temporal and Spatial Dimensions of Under Five Mortality with Emphasis on Impact of National Health Programme: For the Period 1976-2004

The objective of the study is to find out the levels of components of under-five mortality and changes over time during the period 1976-2004 in major states of India and India as a whole, and a test for a causal relationship between changes and the health interventions. The entire study will help in understanding the factors determining the level of child mortality and what interventions will be required in the area of child health programme and also in other socio-economic developmental programmes at the state level to achieve the targeted goal set by the Government. Now based on the findings, suggestions may be given to improve the coverage of the health services among the deprived groups, improvement in quality of care and life in order to reduce child mortality in India.

Partha De