MEGHNAD SAHA MEMORIAL LECTURE, 1965

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I am grateful to my colleagues of the National Institute of Sciences of India for inviting me to deliver the Meghnad Saha Memorial Lecture. Though not one of his early college friends—a few of whom are still with us—my contact with Meghnad Saha began in 1913, when immediately after my return from England I was appointed an examiner in B.Sc. Practical Physics at the Scottish Churches College centre, Calcutta. Five years later, after I had joined the University College of Science, I was told by my colleague, S. N. Bose, of the brilliant batch of students whom I had examined in Pass Practical Physics in 1913, which included amongst others Meghnad Saha, Satyendranath Bose, Jnan Chandra Ghosh, J. N. Mukherjee and several others.

I joined the Physics Department of the University College of Science in 1919 after my enforced five years' stay in Berlin. Two of my young colleagues in the Physics Department, Meghnad Saha and S. N. Bose, had been starved of information about the advancement in Physics which took place in Germany, specially in Berlin. At that time were congregated in Berlin scientists like Planck, Einstein, Warburg, Max Born, Walter Nernst, promulgators of Quantum and Relativity theories and their further theoretical development and experimental verification.

I remember the characteristics of my two colleagues which illustrated their different approach towards scientific research. I gave S. N. Bose two books written by Planck, *Thermodynamik* and *Warmestrahlung*, to read, as they were not available then in this country. S. N. Bose appreciated very much the logical way in which Planck deduced the whole of Thermodynamics from a limited number of postulates. On the other hand, Planck's deduction of his famous formula on the spectral distribution of energy in black body radiation was based mainly on classical Electromagnetism and Thermodynamics to which a single quantum postulate had been added. S. N. Bose noted the inner inconsistency in Planck's exposition and missed in it the clear logical formulation which characterized Planck's *Thermodynamik*. This intellectual dissatisfaction with Planck's deduction of his radiation formula led, I believe, to Bose's deduction on a combinatorial basis of Planck's formula in 1925.

Meghnad Saha's approach was more direct; he wanted to learn from me the latest advances on the frontiers of research in Physics in relation to Quantum Physics and Thermodynamics. From time to time he discussed with me

the theory of thermal ionization of gases and its application to the interpretation of stellar spectra. Next year in 1920, as an examiner of Griffith Memorial Prize essays, for which the candidates had to give a nom-de-plume, I came across amongst other papers one by Heliophilus on 'Origin of lines in stellar spectra'. As the paper was so outstanding compared to other essays submitted for the prize, there was no hesitation in recommending it for the award of the Griffith Memorial Prize. Saha's paper published in the Proceedings of the Royal Society in 1920 secured immediate recognition. Rosseland, in evaluating the contribution of Saha to Astrophysics, remarked: 'The impetus given to Astrophysics by Saha can scarcely be overestimated, as nearly all the later progress in this field has been influenced by it and much of the subsequent work has been refinement to Saha's theory.' In 1920 Saha went for one year's study to England and Germany; after his return, from 1921 to 1923, Saha was Khaira Professor of Physics in the University College of Science, Calcutta. During this period he discussed with us the possibility of carrying out laboratory experiments for verification of his theory. The resources at our disposal were not adequate enough. Later on, towards the end of his period of stay at Allahabad, Saha received a munificent grant from the Royal Society of London by means of which his students in Allahabad were able to verify some of his predictions. Saha would have been very pleased to follow the results of recent magneto-hydrodynamic experiments in which a gas, raised to a high temperature and seeded with volatile compounds of an alkali metal and made to flow with high velocity across a transverse magnetic field, delivers an electric current between insulated electrodes placed transverse to the magnetic field and the direction of flow of the gas.

The thermal ionization in gas and its application to the elucidation of the stellar spectra, which he published in 1920 when only 27 years of age, is the most outstanding and original work on which Saha's fame as a physicist will rest. Saha with his students published a number of other important theoretical papers in Spectroscopy, on the propagation and reflection of electric waves in the upper atmosphere; but these are not of the same importance as his series of papers on thermal ionization in gases. During his 15 years' stay in Allahabad (1923–38) Saha had built up an important school of theoretical and experimental Physics; Kothari, R. C. Majumdar, Kichlu, Toshniwal, Srivastava, Tandon and many others belonged to this group.

Up to 1930 Saha was entirely engrossed in teaching and research in Science. In 1952, when he entered Parliament, Saha explained how the new phase of his activities which dealt more with organization of research and the application of Science to national development problems began. 'Scientists are often accused of living in an Ivory Tower and not troubling their mind about realities; apart from my association with the political movement of my juvenile years, I lived in the Ivory Tower till 1930.'

These extramural activities, which gradually occupied an increasing share in Saha's activities, I have in a previous article divided into two groups. In the first could be placed those activities which dealt mainly with extending the scope of scientific research in the country and the support of research by establishing new laboratories for special type of research, by reorganization and extension of scientific research in already well-established institutions, by establishing academies of science, and journals for the popularization of science and its application to national problems.

Saha realized in 1930 that for communication of results of scientific research and for their discussions more academies of science and specialist societies were necessary.

In 1931, on his initiative, the U.P. Academy of Sciences was founded whose name was later changed to the National Academy of Science. His expectation that this body would serve as an all-India academy did not materialize when another body, the Indian Academy of Science, was started in Bangalore.

An influential group of Indian scientists felt at this time that these regional bodies could not serve the function of an all-India organization. In his presidential address before the Indian Science Congress held at Poona in 1934, Saha strongly stressed the need for such a body. It led to the formation of an Academy of Science Committee with Saha and S. P. Agharkar as Secretaries. As a result of their deliberations the National Institute of Sciences of India was inaugurated in Calcutta and started functioning from January 1935. In 1945 the headquarters of the Institute were removed to Delhi. Between 1933 and 1935 Saha was responsible for the foundation of two other scientific organizations in Calcutta, the Indian Physical Society in 1933 and the Indian Science News Association in 1935.

During the period 1935–53 Saha used *Science and Culture*, the journal of the Science News Association, as the vehicle for propagating his ideas on the application of Science to national development.

I shall end this part of my address by recalling Saha's achievement in providing Calcutta with two well-equipped institutions for research in physicochemical sciences and in nuclear physics.

The original buildings of the Indian Association for the Cultivation of Science, where Raman and Krishnan with their research students did some very outstanding work—for which Raman was awarded a Nobel Prize and Krishnan elected Fellow of the Royal Society—proved inadequate for further laboratory extension. In 1944, mainly through Saha's efforts, the Association for the Cultivation of Science was provided with about 10 acres of land at Jadavpur on which a well-equipped laboratory for physical and chemical research has been erected. Through Saha's efforts mainly, the Association is receiving substantial grants from the Ministry of Scientific Research. As

usual for a developing institution, the financial needs of the Institute have outstripped its present grants.

Soon after joining the Calcutta University as Palit Professor in 1938, Saha recognized the importance of the recently discovered nuclear fission of uranium by Hahn for research in nuclear physics and for the utilization of nuclear energy for industrial purposes. He introduced nuclear physics as a special subject in the M.Sc. syllabus and attempted to build up a special laboratory for nuclear physics. His single-handed efforts to establish a separate institute for nuclear physics in the grounds of the Science College led to the foundation stone of the Institute being laid by the late Syamaprosad Mookherjee in 1948 and the opening of the Institute by Mme. Joliot Curie in 1951.

During the period when Saha was establishing his Institute, the late H. J. Bhabha, between 1946 and 1948, succeeded in converting the existing Atomic Energy Committee to the Atomic Energy Commission, of which he became the Chairman. There was a tendency for the Commission to restrict the main developments of atomic energy to Bombay. It was an achievement of Saha to have secured recognition from the Commission of the Nuclear Physics Institute, Calcutta, and the sanction of a grant amounting to about Rs.50 lakhs for the Second Five-Year Plan period (1955–60). The grant has since been considerably increased. But for the Saha Institute of Nuclear Physics, Calcutta would have been deprived of all facilities for modern atomic and nuclear physics research. The Institute has still to build a modern atomic accelerator for the eastern region.

THE SECOND GROUP of activities in which Saha was engaged was concerned with the application of Science and scientific methods to solution of problems of economic development of the country. This type of activities requires the co-operation of many types of abilities and experience; giving effect to such constructive proposals could only be possible through State efforts either during periods when a leader enjoying the confidence of the people became the head of Government or when a powerful group controlled the State machinery. Due to the complexity of the problems and our want of experience in dealing with them, at no stage has there been a complete diagnosis of the problems. We find that even now we are still grappling with their solution handicapped by lack of complete data, by wishful thinking and a certain amount of hesitation in decision-making.

Saha's importance lies in his being aware of such problems earlier than others, in his capacity for rapid mastery of the essentials of the problems, his matchless publicity campaign focusing public attention to them, putting forward some concrete solutions, and in severely criticizing Government plans when necessary. It is, however, one thing to put forward a solution of a complex problem based upon available, generally incomplete, data and

another thing to come to close grips with the problem, to realize its complexity and to try and evolve alternate pathways for its solution.

I shall first give an account of some of the problems, attention to which was first drawn by Saha, and his proposed solutions. From the efforts to find solutions to these problems, organizations grew up with which some of the men who were Saha's contemporaries concentrated their life's works. These problems are still with us. I propose in the remaining part of my address to consider some of them and discuss the solutions which have been tried and also the fresh problems which have come up in course of the evolution of our national economy.

I shall select only four of the important contributions of Saha on the organization of resources for the solution of the country's developmental problems. They are given here, not in a chronological order, in which Saha attempted them. These are:

(1) Organization of scientific and industrial research.
(2) Atomic energy and its industrial utilization.
(3) River valley development projects.
(4) Planning.

In view of the present confusion over fixing the target and mobilizing resources for the Fourth Five-Year Plan, I have given some space to Saha's proposals for capital mobilization and how they appear in relation to the present situation.

Scientific and Industrial Research: The Government's responsibility for encouraging such research was recognized in the U.K. during the First World War, resulting in the creation of the D.S.I.R. It took about 22 years and the outbreak of the Second World War for the Government of India to organize a Board of Scientific and Industrial Research. The director appointed, Dr. S. S. Bhatnagar, had his first laboratory in the Government Test House, Alipore. Immediately after Japan's entry into the war, the laboratory was removed to Delhi. Bhatnagar's connexion with the C.S.I.R. continued unbroken till he passed away in January 1954. During this period he served the C.S.I.R., of which later he became the Director-General, with single-minded devotion. He took great pride in working under Pandit Nehru and often repeated to me the Prime Minister's admonition: 'You and I, Bhatnagar, must never spare ourselves in serving our country.' The entire responsibility for the planning of the first few national laboratories and supervising their erection was entirely to Bhatnagar's credit. The first three national laboratories, the Physical, the Chemical and the Metallurgical, were opened during 1950-51. We are now realizing that the primary objectives of these laboratories should be rather to foster industrial productivity of the country, for which purpose the present set-up of national laboratories is not well suited.

Saha took up from 1939 the study of the British prototype, the D.S.I.R., and the need for introducing similar organizations in this country—several articles on this topic appeared in *Science and Culture* during the period 1939–47. At one time Saha advocated the formation of an autonomous organization on the Canadian model, the National Research Council, which would be responsible for organization of all researches in the country. The idea did not materialize.

Saha was an influential member of the C.S.I.R. governing body; his relations with Bhatnagar were always cordial and co-operative. On several occasions his advice was decisive in the establishment of a national laboratory, for research on special technological areas, its location and choice of director.

Atomic Energy: With the enactment of the Atomic Energy Act of 1949, a Department of Atomic Energy (Government of India) under the Prime Minister was established with Dr. H. J. Bhabha as Chairman of the Atomic Energy Commission. The beginnings of teaching and research in nuclear physics, however, was in Calcutta and not in Bombay. As I have described earlier, already in 1939 Saha had introduced a course in nuclear physics in the M.Sc. syllabus of the Calcutta University. Dr. Saha was able through the mediation of Jawaharlal Nehru, the Chairman of the National Planning Committee, to secure a donation of Rs.60,000 from the Dorabji Tata Trust to purchase parts of a cyclotron machine. The Calcutta University gave a matching grant for the construction of a two-storied building to house the cyclotron. Dr. B. D. Nag Choudhuri, the present Director of the Saha Institute of Nuclear Physics, was at that time working in the Radiation Laboratory at Berkeley, California; he was authorized to purchase an early model of the cyclotron from its designer, Prof. E. O. Lawrence. After many vissicitudes, including loss of some essential parts due to enemy action during sea transport, the machine was set up. Dr. Saha was at that time meeting with great difficulty in collecting resources to build up the first nuclear physics laboratory in India. He had probably hoped it would be the nucleus round which the future Indian Atomic Energy Establishment would grow up, but it turned out otherwise.

Dr. Bhabha returned to India in 1940 after a brilliant academic and research career in Cambridge. After taking the Mechanical Science Tripos, Part I, he took the Part II in Physics; this was followed by some advanced research in theoretical Physics partly in collaboration with Heitler. The importance of these researches was recognized by Bhabha being elected in 1941 a Fellow of the Royal Society, London, when only 32 years of age. From 1940–45 Bhabha was acting as Professor of Physics in the Indian Science Institute, Bangalore. In 1943 Bhabha attended the Calcutta session of the Indian Science Congress as president of the Physics section; Bhabha stayed on in Calcutta to give, on the invitation of M. N. Saha, a course of lectures on

collision processes in gaseous media. By 1945 Bhabha was able to interest the Dorabji Tata Trust to sponsor the establishment of the Tata Institute for Fundamental Research. This became the turning-point of his career. Bhabha had an attractive personality; not only was he a first-rate theoretical physicist with the basic training of an engineer, he had also great artistic sensibility with a flair for painting. Our Prime Minister Nehru discovered in Bhabha in many ways a similarity of temperament. This, along with other considerations such as the possible co-operation of the Tata Industries in the building up of a future atomic energy industry in India, must have decided Nehru to locate the Department of Atomic Energy in Bombay. It started with an Atomic Energy Committee formed in 1946. I remember attending some of the early meetings of the Committee which met in a modest hired building in Pedder Road, Bombay, where the Tata Institute was then located. Saha, Bhatnagar, Krishnan were members of the Committee.

The decision of the Prime Minister to locate the Department of Atomic Energy and the Atomic Energy Commission with Bhabha as Secretary of the former and Chairman of the latter must have caused some disappointment to Saha. Since 1935 Nehru and Saha had co-operated in many fields of common interest, including the formation in 1938 by Subhas Chandra Bose of the Planning Committee of the Indian National Congress with Nehru as Chairman and Saha as an important member. A growing estrangement with the Prime Minister on some of his later decisions may have been one of the factors which decided Saha to enter politics in 1952. There can be no doubt, however, as the events shaped subsequently, that Prime Minister Nehru was undoubtedly right in entrusting Bhabha with the development of India's plan for utilization of atomic energy. Bhabha identified himself completely with the development of atomic energy in India. Saha's interests were many and varied.

Hydrology: Bengal, specially the southern region, is deltaic in formation, through which two large river systems—the Ganga and the Brahmaputra—flow to the sea. One branch of the Ganga, known as the Bhagirathi, flows through what is now known as West Bengal and forms the delta on which the most important port in eastern India, Calcutta, is situated. The problems of West Bengal are twofold :

(1) The upper reaches of the Bhagirathi where it branches out from the Ganga are silting up. Only during high monsoon can water flow from the Ganga to the Bhagirathi (Hughli), so necessary for scouring its channels. The approaches to the port of Calcutta are hampered by the formation of shifting shoals and sandbanks through which the main channel of navigation has to be maintained by continuous dredging. As a consequence the Hughli river is getting estuarine in nature with saline water penetrating gradually the upper reaches of the port of Calcutta. Saha in his 1938 presidential address to the National Institute of Sciences of India gave a

remarkable survey of the river problems of India. Based upon historical evidence Saha showed how floods in rivers, apart from causing human misery, have changed the appearance of the countryside and caused the disappearance of several ancient Indian cities under thick layers of mud in deltaic regions. He pleaded for special study of the problems which are active even now. He drew attention to the importance of a Ganga Barrage for diverting a portion of Ganga water along the Hughli branch of the river. Mainly through his efforts a River Research Institute, now located at Haringhata, was established in Bengal for special study of the river problems of deltaic West Bengal.

(2) Saha was very successful in drawing attention to another river problem of Bengal and for general acceptance of the solution proposed by him, known as the River Valley Development project. The river Damodar, which is fed by tributaries rising in the Chotanagpur Hills area and is itself tributary of the Hughli river, is on occasion subject to floods which, besides causing great human suffering, often threaten to break through new channels which are of potential danger to Calcutta. The two present outlets of the Damodar river, the Rupnarayan and the Damodar, to the Hughli carry a large amount of silt which blocks up the mouths of these rivers and goes to form the James and Mary sandbanks, which have considerably complicated the navigational problems of the river Hughli. After one of the severe floods in 1943, Saha in a series of articles in *Science and Culture* made a detailed study of the problems and proposed a scheme for flood control now designated as the multipurpose river valley development scheme. It was based upon the successful operation of the Tennessee Valley River project. Saha's scheme was presented to the Damodar Flood Enquiry Committee of 1943-44, of which Saha was a member. It contained some important proposals on which recommendations of the Committee were based. The Committee recommended some permanent measures to control the flood, viz. (*a*) construction of concrete dams on the Damodar river and its tributaries to hold up 1–5 million acre feet of water at a cost of about 6 crores of rupees; (*b*) irrigation canals and flushing system costing about $3\frac{1}{2}$ crores; (*c*) taking steps for afforestation and other appropriate measures to check soil erosion costing about 30 lakhs of rupees. It also recommended the allotment of definite storage capacity for generation of hydroelectric power and irrigation facilities. On Saha's suggestion, Mr. Voorduin, a T.V.A. expert, was brought by the Government of India to become a temporary member of the Central Technical Power Board. Mr. Voorduin was responsible for drawing up the Damodar Valley Act.

The idea of establishing similar multipurpose river valley schemes caught on; several river valley development projects were subsequently planned and put into operation, like the Bakra Nangal (Sutlej Valley) project and the Hirakud (Mahanadi) project. With increasing shortage in food production, criticisms are being voiced whether these expensive river valley projects, in

which the cost of completion usually substantially exceeds the estimated cost, have served one of the main objectives to provide irrigation facilities.

I have some knowledge of the working of the Damodar Valley project. It now appears that in an area like the Damodar-Barakar Valley, with abundant supply of coal, the proposal to combine irrigation facilities and hydro-electric power generation was a mistake. In this area there are already two steel plants and a fertilizer factory and there are proposals for further industrial development. Much of the water resources of this area have to be diverted for industrial purposes.

In most of the river valley projects it has been found necessary to provide alternate thermal power stations to supplement the falling off of hydel power supply during the off-monsoon seasons. In the D.V. project during summer months, when the need for irrigation water is greatest, the water supply is controlled to maintain a sufficient head of water for the hydel power generation. In spite of some efforts being made for afforestation, soil erosion has not been noticeably controlled; there is a growing accumulation of silt and sand behind each of the dam sites whose removal will entail a considerable amount of money and labour. The time has now arrived when an audit both of expenditure incurred and performance obtained is necessary, specially of the D.V. project.*

In spite of many difficulties which the working out of the project have created, the majority of which are due to defects in planning as well as in execution, all credit must be given to Saha for producing a well-thought-out blueprint of how the T.V.A. Multipurpose River Valley project could be adapted to Indian conditions.

National Planning: The beginnings of National Planning go back to October 1938 when Subhas Chandra Bose as President of the National Congress convened a meeting of the State Ministers of Industries, where it was decided to form a National Planning Committee to thrash out problems of industrialization and national reconstruction. Jawaharlal Nehru was named Chairman, Prof. K. T. Shah Secretary, M. N. Saha a member of the Committee and Chairman of the Power and Fuel Sub-Committee and member of the Sub-Committee on River Transport and Irrigation.

Evidently in course of this work the N.P.C. met with a good deal of opposition from the orthodox group of Congress ministers who were wedded to what became known as the Gandhi plan (1943); its aim was to establish decentralization of economy with self-sufficient villages. The development of cottage industries was one of the main objectives of the plan.

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* A Calcutta University group has tried to evaluate the benefits of irrigation by the Damodar. It has found that seasonably the supply of canal water was very variable. Canal water was available only for the benefit of the *khariff* crop in a limited area; in *rabi* seasons practically no water was available (*Sci. Cult.*, **32**, 1966, p. 165).

Saha was conducting at this period a cold war with the followers of the Gandhi plan which he dubbed 'the spinning-wheel and bullock-cart cult'. Saha had accepted the Marxian doctrine that the social and political structure of the country depended upon the economics of production based upon the prevailing techniques of the country.

In one of the addresses he delivered at that time, Saha said, 'The philosophy of kindness and service to our fellow-men was preached by all founders of great religions. No doubt some of the great kings and ministers of religion in every country and at all ages have tried to give effect to this philosophy. But their efforts were not successful for the simple reason that the methods of production of commodities were too inefficient to yield for all, which is an indispensable condition for practical altruism.

'We can, therefore, hold that so far as individual life is concerned, Science has achieved a target set by the great founders of religion in advanced countries of the world. The effects of maldistribution of wealth due to historic causes are being rapidly cured by the introduction of social laws.'

Saha's interest in planning revived when, after the declaration of India as a republic on January 26, 1950, the Congress Working Committee passed a resolution which strongly urged the Government to appoint a Planning Commission to help action being taken on the fourfold objectives of achieving social order, increasing production, ensuring the best utilization of resources and maximum self-sufficiency. Saha, however, took objection to that part of the Working Committee resolutions where it was said 'that one of the duties of the Planning Commission would be to secure full and all-round progress in the process of planning and the execution of the plan'. According to Saha, 'it would be within the competence of the Planning Commission to study the stages of development of the plan and of the difficulties and failures which are likely to be experienced during the progress of its execution and to make recommendations for future guidance. The Planning Commission should not be given any responsibility in the matter of execution of the plan.'

The next point which Saha stressed, to which sufficient attention had not then been given, was the role of scientists, engineers and other experts in the Planning Commission. The Commission has doubtless to be guided by the over-all political and social philosophy which the Parliament will choose to place before the country, but the success will primarily depend upon the extent of expert and scientific competence. Saha noted with approval that since 1949 the Government had created step by step new organizations which, properly co-ordinated and allowed to function, will materially advance the working of the Planning Commission. These include a Central Statistical Organization under the charge of the Statistical Adviser to the Cabinet, a Central Office for Census and Vital Statistics, a Scientific Advisory Committee of the Cabinet to co-ordinate the scientific activities of the different ministries.

The concept that planning to be effective must be based upon statistical collection of data on which planning alone could be based became clear to Saha after he had studied P. C. Mahalanobis's Presidential Address, 'Why Statistics', delivered at the 1950 Session of the Indian Science Congress as General President.

Saha (*Science and Culture*, **15**, 1950) quoted the following from the Mahalanobis address:

'National planning has several aspects. First, there is the preparation of plans at the technical level requiring the help and co-operation of workers in every branch of Science and Technology. Statistics is indispensable at this stage for the supply of basic information. Secondly, the individual plans have to be built into a general plan. Here statistics is the common denominator and supplies the common binding medium for the whole. Thirdly, the plan has to be implemented.

'At this stage also statistics can help in two ways. First, by establishing scientific control to ensure the programme of action proceeding on efficient lines. Secondly, by conducting continuous assessments of the results by keeping accounts of the input of money effort and resources and measuring what it obtained in return. The process is never-ending. In the actual working of the plan, defects are revealed and new possibilities emerge requiring consequential changes.

'Statistics is again invaluable in diagnosing weaknesses in guiding controlled experiments and in suggesting improvements. Statistics is thus an integral part of the dynamics of national planning.'

Saha quotes with approval the concluding portion of the Mahalanobis address:

'In a national plan, scientists and technologists also have to make their contributions. They can give the labour of their thought and by the skill of their research and experimentation show how to overcome difficulties and open out new possibilities. The statisticians have a humble role but they also can help in reaching vital decisions.'

Saha then refers to Mahalanobis's analysis of the Government drive in attaining self-sufficiency in food by 1951, which showed how official optimism was hardly substantiated by available statistical evidence. When one takes into consideration the increasing pressure of population, increasing food import during the last ten years, inadequacy of food and agricultural statistics, the Government's emphatic declaration of the policy of attaining self-sufficiency in food by 1951, however commendable, represents hardly anything more than a pious wish.

In this connexion Saha quoted the following from Mahalanobis's address:

'It is certainly necessary', he said, 'to attain self-sufficiency in food by 1951. But this is not enough. The production of food must keep pace with

the growth of population. But not only food; it is also necessary to produce houses, clothes and thousands of other things in increasing quantities. Production must keep pace with population. The future trend of population in India is, therefore, a matter for serious concern. Available evidence indicates that at the existing level of production the balance has already become adverse. A further and continual growth of population without commensurate growth in the means of production will be disastrous. The only way is to develop our national resources.'

Prof. Saha passed away in 1956; his criticism of Government plans was consequently confined only to the first one. Before taking up Saha's criticisms of the first plan, I propose to say a few words of how the plan studies were continued by P. C. Mahalanobis. The Indian Statistical Institute which was started by Prof. Mahalanobis in 1932 confined itself during the first few years to purely theoretical studies. From 1938 the Institute began to take up economic enquiries including crop surveys. In 1950 in collaboration with the Central Government the Institute organized the National Sample Surveys. In 1949 Mahalanobis was appointed Honorary Statistical Adviser to the Cabinet. In 1954 he was entrusted with two important studies, one on solving the unemployment problem within ten years, and the second to increase national income at a reasonably rapid rate. On the basis of these two studies a draft plan frame was prepared by him in 1955 which was accepted as basis for the Second Five-Year Plan.

Since then, at the request of the Government the Statistical Institute has taken up study of Perspective Planning which has led to the creation of the Planning Division of the Institute.

It should at the same time be recognized that all the machinery of Perspective Planning has not prevented the Government from committing one mistake after another in the formulation of successive plans and in their implementation.

After the publication of the draft First Five-Year Plan, Meghnad Saha devoted several editorials in *Science and Culture* (**15**, 1950; **18**, 1953) to a critical study of the plan; the first two articles were more or less objective expositions of the plan proposal. In his later editorials and articles entitled 'Re-thinking our Futures', Saha criticized root and branch the plan proposals.

To understand Saha's criticisms it is necessary to say a few words on what the Five-Year Plans proposed to achieve for an underdeveloped country like India. To break through the stagnant economy of such a country it is necessary to inject large capital input into the economy. By such means the machinery of production is considerably enlarged resulting in larger production of capital and consumer goods, food, apparel, dwelling-houses and other amenities of life; these are material evidences of increase in the per capita income of the people. From this newly-acquired wealth a sizeable amount

may again be channellized for further expansion of the machinery of production with resulting increase in the production of consumer goods as well as provision of social amenities.

The two large countries in which attempts at rapid development are taking place under totalitarian control are Russia and China. In these the State participates actively in mobilizing capital resources for planning; the machinery of production is mainly in the hands of the State. Some decisions have to be taken on the priorities to be given to the production of capital goods, like development of mining, irrigation, power production, production of steel and its utilization in the construction of heavy machinery. In the two countries mentioned, Russia and China, the stress has always been given to making the countries industrially self-sufficient and great military powers. Consumer goods based upon agriculture, textiles and production of other amenities of life are given a second place. It is noticeable that both in Russia and in China, where the ownership of the land lies with the State, attempts are always made to change over to large-scale agricultural production, but the results have not come up to expectation. As one writer has remarked, 'There has been a continuous neglect of agriculture throughout the Communist world in order to provide a modern armed force to satisfy their international ambitions.'

India is at present a Welfare State in which production of capital goods is divided between public and private sectors. In the first Indian plan a great portion of capital and consumer goods production was allotted to the private sector. In this country, therefore, controversies have been going on since the publication of the first plan on (*a*) the respective roles of the public and private sectors in implementing the plan and (*b*) the priorities to be given to the production of capital goods or of consumer goods. A characteristic of the Communist countries is that they have tried to raise their capital requirements by methods which impose extreme hardship on the people during the transition period; these powers have striven to depend on the internal resources of the country for their capital formation, to avoid as much as possible foreign loans. In India we have followed so far an easier way—of depending on foreign loans, foreign technical assistance to make up our deficiencies in food supply and in technical resources, both of hardwares and know-how, and also on deficit financing.

Saha's criticisms of the Five-Year Plan draft were mainly directed (*a*) to criticism of the Government timidity in mobilizing a ridiculously small capital resource necessary to implement a reasonable plan project and (*b*) to the inequitable distribution of the plan allocation between agriculture and industry. He has indicated what a bold plan should aim at and how the necessary capital resources may be mobilized first.

In all his criticisms Saha used as yardstick the allocation of resources proposed in the Bombay plan whose data, according to Saha, were taken from those collected by the National Congress Planning Committee:

A. *Allocation (in crores of rupees)*

	Total	Agriculture	Industry
Government Plan	2,069	361 (17·5%)	173 (8·4%)
Bombay Plan	5,600	800 (14%)	3,160 (56·5%)

B. *Financial Resources (in crores of rupees)*

	Total capital to be raised	Central and State Budget	Savings and internal loans	Foreign loan
Government Plan	2,069	738	520	800

It is not clear from Saha's account how the financial resources for the Bombay plan were to be mobilized.

Saha has criticized the financial resources allocated to the plan as grossly inadequate: a total of Rs.2,069 crores for the Government plan as compared to Rs.5,600 crores in the Bombay plan. In the Government plan both the developments of agriculture and industry are starved; also within the given total the amount allocated to industry, Rs.173 crores (8·4 per cent), compared to agriculture, Rs.361 (17·5 per cent) crores, is very unwise. Saha divided the industries in two groups: (A) Industries producing means of production—to this belong iron and steel, aluminium and other non-ferrous metals, heavy chemicals, heavy machinery and machine tools. Under group (B) were consumer goods, industries like cotton textiles, pharmaceuticals, locomotives, wagons, trucks, etc.

It is clear that without industries of group (A), group (B) industries cannot flourish. Iron and steel are the key of key industries.

I shall not enter into details of Saha's critique of the Government agricultural plan and population policy, but pass on to the consideration of his criticism of the Government policy concerning the development of industries. The Government had placed more stress on consumer goods industries rather than on capital goods industries: it is obvious that without the prior development of the latter the consumer goods industry cannot flourish. The main point of criticism is that in consigning the development of industries, consumer as well as capital, mainly to the private sector, the Planning Commission has committed a major blunder. It is a wrong assumption that in a country

like ours development of industries can take place in the same way as in the U.K. and the U.SA., out of private gain motives.

Some of the drawbacks in the first plan have been rectified in the subsequent plans. A number of steel plants and heavy machinery plants have been started in the public sector. This has given rise to some pertinent criticisms on the general inefficiency of the State-managed industries.

The allocation of funds to the development of agriculture, industries, etc., depends upon the total amount mobilized for capital investment, which is Rs.2,069 crores including Rs.800 crores from foreign loan; the latter is a highly controversial method of raising funds. Probably Saha was referring to the Russian experience. Even with foreign loan the annual capital formation was Rs.414 crores which represented a capital accumulation of about 4·5 per cent of the estimated annual national production of Rs.9,000 crores.

Saha points out that even in war-riddled Europe, after the last war, the rate of capital investment in relation to their respective national incomes was in England about 20 per cent and in France from 20 to 25 per cent. This capital formation in these countries could have been achieved only by imposing severe austerities in the mode of living of the people and by tapping all possible sources of income. Comparing the leeway which had to be made up, an annual investment of Rs.1,400 crores representing about 15·5 per cent of our annual production should be the target of our capital investment; out of this Rs.700 crores should be invested in forced and planned industrialization.

The proposed investment according to the plan and the small allocation to industry and power development were too meagre for any sizeable accumulation of capital, as only industrial investment can raise the national income from which future plans could be financed; agricultural investment hardly leaves any surplus.

Having accepted the need for a forced industrialization of the country, Saha turns to what Russia had done to transform the country from a feudal agricultural State to a highly industrialized one which had become strong enough to withstand the most mighty military machine of modern times. Russia was able to raise from the poverty-stricken millions of Russia a huge capital of about Rs.50,000 crores between 1927 and 1940, not by deficit financing, as our Finance Minister proposes to do. No doubt, the Russians tried deficit financing, for it is a very catching idea like perpetual motion—when by the use of the printing press you can create money out of nothing—but it led to disastrous inflation and the Russians had to fall back upon the gold rouble to stabilize their currency. Taxation did not amount to more than 10 per cent, savings of all kinds, whether voluntary or forced, to another 10 to 15 per cent, and tapping of hoarded wealth to about 10 per cent in the early stages. But the major part of the finance amounting at times to 60 to 70 per cent of the capital

investment was obtained from the 'Turnover Tax' and the rest from trade balance which were very strictly controlled.

'In our own plan', according to Saha, 'there is no scheme for the tapping of hoarded wealth—cash, jewellery and gold lying with the Indian Princes and rich magnates—for investment in profitable national enterprises. There is no justification for not tapping this wealth, for it is, after all, people's money and obtained from people's sweatings.'

Saha has given an estimate how, on an annual production of one million tons of steel, a 40 per cent turnover tax could yield an annual return of Rs.20 crores.

Besides steel, other items on which turnover tax could be usefully introduced in this country are salt (tax recently abolished), other articles of consumption like clothing, coal, railway earnings, electrical energy. The Russians had turnover taxes even on food material. Of course this is forcing compulsory austerity on everybody during the next ten years, but it will enable us to raise large blocks of capital for investment.

From the quotation I have given, it will be seen that Saha had considerable sympathy with the autocratic methods by which Soviet Russia achieved self-sufficiency in industrial production and military armaments without depending on foreign loans. In another place Saha has quoted with approval how the Nazis in 1934 when they had taken over the administration of Germany found the food shortage to be 20 per cent but, nothing daunted, they asked the nation to tighten its belt, prohibited food imports and restored the industrial efficiency and national production to a much higher pitch than was ever the case in German history. 'We have no sympathy', remarked Saha, 'for the ultimate Nazi objectives, but we can still learn much from the procedure adopted by them in restoring Germany to her supremacy in production on the European continent.'

The conditions then prevailing in Russia were in many ways not similar to those of India; there was no critical balance to be maintained between population explosion and food supply.*

The experiment which China since 1949 under Mao Tse-tung has been making to create a self-sufficient economy combined with military preparedness is taking place under conditions in many ways similar to that prevailing in India. It makes the Chinese experiment of great significance to India. The Chinese efforts have been greatly hampered from the beginning by four major economic realities of China—the large population estimated at 655·2 millions and increasing by 2 per cent annually; the limited amount of agricultural

* There is no reliable information available of the cost in human sufferings including loss of lives which accompanied the transition of Russia from a capitalistic economy including private ownership of land to a socialistic economy. Russia has been transformed into a great industrial and military power, but she has not been able to attain yet self-sufficiency in agriculture.

land and its low output per manpower; the low rate of capital accumulation and voluntary savings; and the low rate of technical ability and dependence on foreign assistance.*

The Communist revolution in China commencing from about 1950 has gone through several phases. In the first phase the landlords were expropriated and the land distributed among the peasants. Shortly after receiving the land the peasant lost control over it as he was put under pressure first to join a co-operative in 1954 and then a collective in 1956.

During this period there was rapid industrial development due to a Russian loan of about 300 million dollars together with a loan of Russian experts who helped in building industrial plants and in training Chinese technicians. In the first five-year plan (1951–56) almost half the State investment was in industry, of which about 85 per cent was invested in heavy industry and only 3 per cent in agriculture. This is an indication of the Communists' desire to reduce foreign sources of supply, to change China from an agricultural to an industrial nation. All Communist governments at one time or another have believed that, even with limited investment and minor changes in the actual method of production in agriculture, it is possible to increase agricultural output by forming co-operatives or collectives. Such organizations usually give governments greater control over both the peasant and his output, but offer little evidence that they succeed in achieving the required output.

There was a rapid growth of domestic economy of about 11 per cent per annum. The situation changed between 1956 and 1957 when the Soviet loan trickled down and virtually ceased and at the same time the Soviet began to withdraw the Russian technicians. China has since then had from her meagre exports to repay the Russian loan, pay subsidy to some underdeveloped countries whose policy China wanted to influence, as well as to pay for the import of some urgently required machines.

During 1954–59 China tried a new strategy. The country was divided into a number of communes containing between 25,000 and 100,000 people; the government appeared to have great faith in the utility of such organization for agricultural production. Along with this came the Big Leap Forward movement which was an attempt to provide a new strategy of development. It was an attempt to use the surplus in agriculture and native technology in each commune to build up small-scale industrial production throughout the country. The commune movement ended in failure during the severe agricultural crisis of 1959–61. The industrial result of the Big Leap movement which was tied up with the commune was not successful for several causes

* This account of China's present economic situation is based upon an article, 'Economic Realities', by Robert F. Demberger, Assistant Professor of Economics, University of Chicago, and published in the special issue of the *Bulletin of the Atomic Scientists*, entitled 'China Today' (June 1966).

which we cannot discuss in detail here. The failure of the commune movement caused the Chinese to abandon this emphasis on the rapid development of heavy industry and to concentrate on the development of agriculture.

There are, however, difficulties in attempting a rapid rate of increase of agricultural products. Agricultural productivity can be increased by adoption of some of the following methods:

(1) Additional land could be brought under cultivation, but the necessary very large expenditure for these reclamation projects could not be provided.
(2) Agriculture could be mechanized—here again the cost of mechanization would be prohibitive at present. Besides, in the absence of rapid industrialization, there was little chance of agricultural labourers made surplus by mechanization being absorbed.
(3) Adoption of the method which the Japanese have used so successfully—to retain labour intensive methods but to increase the use of fertilizers and to increase the area under irrigation. But increase of fertilizer production and construction of large-scale water conservation require, however, large increase in volume of expenditures. This is not possible under present conditions.
(4) The method of organizing the country into communes, which as I have discussed earlier has not been a success.

By the end of 1963 one-half of the land under cultivation has been irrigated, while the supply of chemical fertilizers and the total number of tractors has doubled what it was in 1958.

At the same time increase of population between 1959 and 1965 has required China to import approximately 6 million tons of wheat annually in recent years to maintain food consumption at the near minimum level of approximately 1,900 calories per day.

I come now to the main problems in my study of China's economy, which has reference to Saha's proposals for capital accumulation in India, according to the Russian model. In a country with a low level of per capita income and consumption it usually results in a low level of voluntary savings and capital accumulation. How has Communist China been able to accumulate capital needed to finance production goods, military equipment and export ?

Savings and Capital: One of the major tasks of the People's Republic during the 1950's was to divert resources from the production of consumer goods to the production of producer goods, for military equipment, and export. They were eminently successful in achieving one of the highest rates of savings and capital accumulation in the world—between 20 and 30 per cent—but they did so by restricting consumption, and per capita consumption has not grown significantly over the last 15 years. To an economist these are forced savings.

The Chinese Communists did not rely exclusively on direct taxes, however, to acquire the needed funds for investment in industry. Two important sources of funds for this purpose were really hidden taxes—forced deliveries of grain to the State at less than market prices, and the profits of State enterprises. Another hidden tax was levied on factory workers and consumers simply by keeping increases in wages far below increases in productivity and by maintaining existing prices when productivity increased and costs declined. A somewhat less important source of funds came from bond sales to the public and from individual savings deposits at the State bank, but there is some doubt as to the extent to which they were voluntary in China. The Chinese Communists did not, however, resort to one of the most onerous and inequitable forms of forced savings: inflation. The financing of development by inflation has been very popular throughout the world, possibly because it is so simple and appealing to irresponsible governments. The government prints paper money and uses it to purchase the necessary resources for investing in heavy industry, leaving the public to scramble for the available consumer goods with money that soon loses its value as prices rise. Despite the various taxes both direct and hidden utilized by the Chinese Communists, the public still had sufficient income to buy more than the available consumer goods, and it was necessary to resort to rationing as early as 1953.

In another article, 'The Developing Economy', in the same issue of the *Bulletin of the Atomic Scientists* (p. 86), James A. Duncan lists the priority now being given in China 'to industries serving agriculture, such as chemical fertilizers, simple farm tools, synthetic fibres (to relieve cotton shortage); and industries supplying the machine tools and equipment required by these are given priorities. Military arms and equipment (including MIG aircraft), oil production, nuclear development, trucks and transportation vessels were included in the priority list . . . the government is still determined to divert a growing share of the country's national income to the expansion of its military potential at home and its political ambition abroad.'

It would be worth while undertaking a comparative study of the accomplishments and failures in China and in India in the implementation of their respective plans during 1960–65. After the failure of the commune and the Great Leap Forward drives, at present the Chinese leaders are facing the situation with great resolution and have decided to give greater attention to agricultural production, with industry oriented mainly to serve agriculture and to some essential industrial and military requirements.

The same foreign observer (James Duncan) has remarked: 'In the development of all aspects of her economy, China's asset lies in the remarkable intelligence, resourcefulness and serious-minded application of her students, scientists and technicians. Invaluable too is the broad range of her workers, the zeal to catch up with and surpass the achievements of the Western

countries and now of the U.S.S.R.—and particularly their willingness to accept sacrifices which such dedication entails.'

The driving and directing forces behind this mobilization of China's resources in manpower is the fanatically dedicated Communist regime who have succeeded in conditioning the people to make such sacrifices. Our admiration would have been more unstinted if this relentless drive had not been motivated by China's present rulers' desire for world domination.

During the same period India has accomplished much, without attaining her targets of self-sufficiency in food requirements and a self-generating industrial economy in which India's requirements for some essential equipments and know-how could be acquired from India's foreign export. India's progress during the last 15 years has been at some cost; I shall enumerate a few of them:

(1) Her foreign indebtedness up to April 1965 has come up to Rs.3,689·2 crores; interest payment and capital repayment has to be met out of her not-too-ample exports.

(2) India has not been able to unearth and confiscate the large amount of black money, whose underground circulation contributes to hoarding of food materials and of other essential commodities, thereby raising their prices as well as that of urban land. If this hidden wealth could be unearthed and applied to capital goods production, there would have probably been less cause for deficit financing and resulting inflation.

(3) India has not been able to introduce an equitable system of food rationing. If food hoarding could be prevented and a per capita rationing of 1,900 calories as in China could be universally introduced, then probably import of foodgrains could be substantially curtailed.

(4) India, like China, is compelled due to population explosion to import foodgrains mostly from the U.S.A. under the PL-480 plan. Our present year's requirement of about 8 million tons is large compared to China's import of about 6 million tons, if comparison is made on population basis.

(5) India has not been able to introduce an equitable distribution of land amongst the cultivators, thus depriving the latter of incentive for improved crop production. Capitalistic Japan after the war has done so.

(6) Only recently the foreign exchange crisis has compelled the Government to institute a drive for self-sufficiency in industrial production and to developmental research for adapting foreign know-how and hardwares to Indian conditions. India has till recently adopted the easy way of depending on foreign collaboration in know-how and for imports of needed hardwares for developing new industries.

Acceptance of foreign aid is not always harmful to the accepting country. Such aids received from the U.S.A., through the Dawes plan, Marshall plan, and similar aid to Japan, have enabled several war-devastated countries of Western Europe and Japan to recover and even surpass their previous industrial production. These countries through several centuries of experience of 'blood, sweat and tears' have been able to build up a very stable political structure, not necessarily democratic. They have as well mastered the techniques of industrial production—consequently it was not difficult for them to be rejuvenated by foreign aid.

India's declared policy of non-alignment and her adoption of the Western democratic form of government did create a genuine desire amongst the Western democratic powers to establish India as the largest democratically governed country in the world and a challenge to the totalitarian claims. Hence India received large foreign aid in many forms. But our response to such foreign aids has been on the whole disappointing. It now turns out that India has adopted the outer paraphernalia of democratic government without developing the hard core of common agreement which centuries of struggle for realizing democracy has developed in the democratic countries of the West; this has built up an emotional reserve which enables democracies to willingly accept sacrifices in times of national difficulties. India has not mastered the techniques of industrial production before the foreign aid came.

Within fifteen years the outer façade of democratic government is showing signs of wear and tear.

Compared to China, India suffers from two major drawbacks:

(1) The Chinese common people are exceedingly industrious with innate capacity for skilled labour.
(2) The ruling cliques are dedicated to men who do not allow set-backs to deflect them from their objectives; they have been able to regiment the people to accept their leadership.

Our present situation, external, and at present specially the internal, is very critical. Except for the short period of the conflict with Pakistan, there is lack of evidence of a common will to suffer hardship and deprivation for attaining some common objective for the country—at present there is a tendency towards separatism and formation of linguistic States. Whether it will be possible to generate such general will in the people, either through democratic government or by some form of autocracy, is the present problem. Whichever form of government produces stability, it must also be able to persuade the people to willingly share in some common deprivations.

The importance of Meghnad Saha in this connexion is that he is the first leading scientist who has stressed the need for common sacrifice and for confiscation by the State of all kinds of unlawful hoarded gains. If Saha were alive today, we would have heard his denunciation of the present impasse: the problem is more serious than it was fifteen years ago when Saha began his criticism of Government plans.