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Science in Sri Lanka *

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For the next few decades, the development of this country will depend largely on the application of science and technology. "....the nation has to recognise that technology is a major national resource and a vital element in the task of achieving self reliance".[1] For example, the role of agriculture, industry and health care delivery in the national development plan— through increased agricultural and industrial production with the resultant savings of foreign assets; the increase of employment through expansion of agriculture and industry; the utilisation of natural resources; better health care delivery and the increase of manpower utilisation; the conservation of the environment and the avoidance of pollution — should be quite obvious.

"Investment of resources in science and technology can bring substantial economic returns as can investment in education and training. Yet, they must not be regarded as isolated activities deserving some support, but as components of a dynamic system to convert human skills and enterprise into new material, wealth, and social amenities. The effective use of the achievements of science and technology requires the removal of all obstacles of a political, social and economic character which have been inherited by the less developed countries from past stages of their history... Science and Technology contribute but one factor of change, which must be integrated into the overall economic and social plan".[2]

In Sri Lanka in the past, science was given just bare recognition by its control, firstly, by a Ministry of Housing and Scientific Affairs, which was followed by a Ministry of Scientific Affairs and Industries. The latter situation begged the question of the equally important but uncoordinated roles of science in agriculture, health, fisheries, etc. The inclusion of science with industry was apparently more for reasons of administrative convenience than for a fundamental liaison at the planning level. There are many examples of the lack of co-ordinated scientific impact on the national development plan. Some of these are discussed below.

Some of the constraints in the local scene which hinder the effective contribution that science could make to the development of this country are also briefly reviewed below, together with some general suggestions. On account of the basic similarities that exist between this country and India in respect of developmental needs, the scientific background and capability, extensive reference to the Indian science situation will perhaps be profitable.

Lack of recognition of the role of science in the National Development Plan

"We have in this country, a Planning Ministry monopolised by a group of economists—no doubt they may be important but that is only one aspect of planning.... They have no doubt emphasised the employment aspect but national planning is something far greater. It needs the participation of other scientific groups like the pure and applied scientists of at least the major areas of relevance to Sri Lanka".[3]

The National Planning Committee, at present, is represented by only the Cabinet Ministers amongst whom direct technical or scientific expertise is absent and whose deliberations on technical matters are often amateurish exercises, at their best. Shortcomings in technical progress are seldom evaluated or corrected. Compare this situation with the Indian scene. "There is a Scientific Committee of the Cabinet to deal with scientific matters. It consists of the Prime Minister and certain other Ministers. This Committee is assisted by a committee of scientists known as the Scientific Advisory Committee to the Cabinet....The functions of this Committee are:

1. To advise the Cabinet (*a*) in the formulation and implementation of the government's scientific policy; (*b*) the coordination of government and between governmental, semi-governmental and nongovernmental scientific institutions in the country, including scientific and technical departments of the universities; (*c*) on scientific and technical cooperation with other countries and with international scientific and technical organisations; (*d*) on such matters as may be referred to it.
2. To place before the Cabinet such proposals and advice as may improve and develop scientific and technical work in the country".[4]

The following simple example of the unfortunate consequences of the lack of scientific expertise and collective decision-making, bears mention. A few years ago, the Sri Lanka Association for the Advancement of Science inquired into the workings of some technical corporations; one of these was the Flour Milling Corporation. It was found that wheat bran was being exported at a low return of approximately 10 US cents per pound. At that time, the local supplies of animal feed were fast dwindling, with concomitant increase of the costs of running poultry and cattle farms which compelled some to close down. This resulted

* This article was written in May 1977

in a fall of egg and meat with milk output and a loss of gainful employment. This matter was brought to the notice of the Minister of Agriculture who was informed that the stoppage of the export of the bran and its addition to the feed of animals in this country would have provided the much needed support of poultry and dairy farming and of animal husbandry. Almost unbelievably, the reply of the Minister was that his business was to look after human health and not animal health and this matter was thereafter dropped.

To quote this document[4] further in illustration of the State patronage afforded by the Indian government to science... "The Council of Scientific and Industrial Research is a semi-autonomous body responsible to no one Ministry of the government. Its President is the Prime Minister, its Vice President is Prof. Humayun Kabir, the Minister for Scientific and Cultural Affairs, and a number of other Ministers are members of its governing body, on which serve also one member each of the Lok Sabha (Lower House of Parliament) and the Rajya Sabha (Upper House) as well as a number of the ablest industrialists and scientists of India." Noteworthy is the opportunity given at a national and official level for coordinated decision-making in the course of National Planning. "Scientific Research was not thought necessary to industrial development even though in neighbouring India, this was being given the highest priority with the patronage of the Prime Minister Nehru, himself"[5] wrote Wijesekara on scientific research in this country.

In our own context, in addition to such a general body, similar devices for co-ordination at more peripheral levels may provide effective links between such departments as:

Health-Engineering,
Health-Social Sciences,
Fisheries-Zoology,
Forestry-Botanical Sciences,
Industrial Development-Engineering, etc.,

as again, is being done in India "....The Council's Board of Scientific and Industrial Research supported research in the Universities and Research Institutions through the following fifteen research committees. These committees are composed of representatives of Universities, research institutions and industry, and function in effect as *National*" (my italics) "committees in their respective fields".[4]

Lack of Resources

Too low an input as Research and Development (R & D) investment.

One of the basic shortcomings of the local scene has hitherto been the very low investment on the national scale, in research and development in addition to the nonprovision of adequate funds for even the maintenance of routine service functions in Universities and scientific institutions.

The absence of a sufficient input as R & D is mainly due to the absence of a proper evaluation of the role of science in national development and the absence of a national science policy.

"Today between 15 to 30 of the 120 countries of the world with less than one-third of its population, possess practically all of its science. They spend more than 95% of the world's development and research funds....Furthermore, these countries reaped in the past and are now reaping most of the direct economic, political, social and general cultural benefits of scientific research..."[6]

Lack of literature.

This results from low financial allocations, sub-optimal utilisation of available funds for journal imports, absence of interlibrary coordination in journal imports, absence of readily available means of duplication of scientific literature.

Constraints with equipment.

The absence of essential items of equipment, absence of technical facilities and expertise for the repair and maintenance of existing equipment with consequent wastage of large sums of foreign exchange on the re-import of substitute equipment. For example, the Universities have several million rupees worth (in foreign exchange) of microscopes without any servicing facility for the cleaning of lenses and prisms to prevent fungal colonisation. A few years non-cleaning will result in the uselessness of the instrument due to opacity of the lenses. This, and other similar needs have been pointed out, at each year's estimates for development proposals, without response. The National Science Council is now investigating this matter but the implementation of whatever recommendations it may think necessary will be stifled unless there is full authority and patronage at the highest governmental level. The provision of the Council with more executive powers is dealt with below.

Lack of funds and grants for R & D — both in local and foreign exchange.

In Western and other highly industrialised countries a large part of the financial input for R & D is from private sources. This source has hitherto been untapped in this country, although private firms and institutions which could benefit from the results of basic and applied scientific research are also those institutions which could provide such funds. The present five-year plan placed great emphasis on the role of the private sector but "whereas the plan envisaged a total investment of Rs. 14,820 million expected from the private sector, the Finance Minister's taxation proposals dealt so severely with the private sector's capacity to save that the investment of anything approaching this scale is made almost impossible".[7] Suggestions for the cooperation of the private sector in this respect, are made below.

There is almost a total lack of an emergency fund for the import of emergency supplies of consumables and components of equipment (e.g. a spare part or bulb) of small cost, which however are vital for the continuation of work in hand; this leads to serious delays or even abandonment of the work. One cannot help but refer in contrast to the many fancy items of general merchandise (salmon and sardine included) which are imported freely.

There is a serious lack of proper perspectives and determination of priorities on the part of the University administration in respect of research. The lack of foreign aid, both as fellowships and grants for research, the need for locally oriented research and the training of scientists locally has meant increasing requirements of funds for these purposes. These increased demands have sometimes been met with even an inverse response from the University's administrators. One finds oneself in anomalous situations such as the University's directive on one hand that junior staff should obtain their qualifications (postgraduate) by research done locally, while on the other hand, insufficient funds are provided for these increased demands; even existing votes are sometimes reduced.

"The total expenditure on research, including salaries of research assistants has been only about 1.2% of the University's vote. On the other hand, the Kothari Commission[8] which examined higher education in India has emphasised that for a country like India, at least 25% of the University vote should be spent on research. So far, funds available to the University through the Ministry of Education" (in Sri Lanka) "has been inadequate even for normal undergraduate teaching".[3]

As an example of effective planning, one may again quote the Indian situation. In the 1950's, in the early days of India's postcolonial development, sufficient funds and expertise were invested in atomic energy research which today is the threshold of providing India with energy to replace oil which it imports at great cost.

Insufficient recognition of the worth of scientists.

"From a purely practical point of view, also, it is impossible to import technical know-how and to apply it successfully if one does not have available locally a corps of learned men to whom one can appeal for guidance on matters of pure scientific principle".[9]

In India now, there is a scientific talent search which goes out to recognize scientific talent amongst her young students, sponsor it and find effective outlets for its utilisation and expression. It is perhaps not untrue to say that hitherto in this country even the body of of practising scientists has been regarded by the successive governments as an expendable or dispensable elite. Whatever cooperation there has been in local applied projects, has been achieved through personal contact and friendly persuation. This country imported a team of Soviet scientists to report on the state of affairs at the CISIR, inspite of having sufficient men of internationally acceptable stature and more significantly, who would have possessed a greater insight into the constraints that exist within our own scene.

In any country, scientific research for its own sake as an intellectual pursuit is probably indulged in by only a small minority of scientists. On the other hand, some form of incentive is the more usual stimulus for research. This need not be only in financial terms but could and perhaps more effectively be in terms of such incentives as recognition of work, merit awards, merit promotions, state sponsorships of participation in meetings and congresses abroad for the presentation of research work and appointment to higher posts. The participation of local scientists in meetings abroad or in foreign training courses has not been as often as their competence or achievements, and the local need for such training, would demand. The main obstruction appears, sometimes, to have been bureaucratic red tape, the mere 'sitting on' a file by a subject clerk, but basically to the absence of a national appreciation of the usefulness of such foreign contact.

Obstructive administration

This is perhaps the most obnoxious of all constraints. Innumerable instances could be cited of virtual control of scientific affairs by petty bureaucrats, or even clerks, and the latters' abjudication on what really are technical or scientific matters. A treasury official would arbitrarily and unilaterally delete development proposals for the following year or a clerk will decide as to which scientist should attend the next technical congress abroad. These are real situations.

Excessive Bureaucracy

Especially in regard to the provision of technical needs for working scientists. "It is imperative that the scientific organization, institutions and laboratories should be exempted from having to go through the Directorate - General of Supplies and Disposals for procurement of stores and equipment and that they be allowed to set up their own purchase sections".[1] To have valuable, urgently needed perishable supplies rotting on the wharfs or at Customs, is an all too frequent occurrence.

Insufficient consultation of scientists on matters of technical or scientific importance. While this lack results, basically from an absence of an appreciation of the value of the advice which scientists could give, the absence of coordinating bodies of scientists and planners, has resulted in the situation where little or no informed opinion is brought to bear on nationally important projects such as deforestation, the problem of the coral reefs, rainmaking, fisheries in inland waters and wild life conservation. In some of these areas, it was left to private bodies and enthusiasts writing through tne daily press to provide the necessary perspectives.

The drain of scientists

Much has been spoken and written about this subject, but little of it is understood and much less has been even attempted in the way of reversing this trend. Apart from the constraints listed above which contribute to the absence of job satisfaction (one of the rewards of nearly any occupation), considerations of emoluments have been postponed for too long. The present day administration, especially of the Health Department is inefficient to the extent that even the stipulated salary increments of medical officers have not been paid, in some cases for as much as 2 to 4 years, double house rents have been recovered from staff after recent transfers and payment of arrears on correction of salary anomalies have not been made for several years. Salary scales have remained static for several years and in some instances as in the Universities since 1956, without increases compatible with the large increases in the cost of living over these decades.

Some Solutions

Apart from those already alluded to above, the following general suggestions may be considered:-

1. The Government should formulate a National Policy for Science and Technology and should indicate a program for its implementation. (*Vide* Premier Nehru's speech to the Indian Parliament in 1958).

2. Scientific Affairs should be included in the Ministry of Planning under the Prime Minister, who as in the case of India, can then be in coordinating control over the scientific aspects of the National Development Plan. The science area may also, as an alternative, be in a separate Ministry but with close links to the National Planning body.

   The advantages of bringing the science programe under the Prime Minister's own Ministry are—

   (i) The most cogent being that science should be an integral part of the National Development plan and is therefore an umbrella which covers many aspects of the plan and its implementation. Upto now, these seemingly disparate activities have come under separate Ministries and have been uncoordinated at a national level. In addition, to such an overall view, a central avenue for the exercise of scientific expertise may prevent the situation envisaged by the Indian policy document (a situation which our administrators have shown an alarmingly great tendency towards). "Special care must be taken to ensure that planning science and technology does not become a matter of acquiescing to the power of advocates of this or that project rather than a matter of rational" (and I would add national) "decision making".

   (ii) There is now little authority behindthe efforts at getting the science machine moving. For instance, the postgraduate training program in Medicine is being stifled by various impediments at a parochial level, by vested interests which are opposed to the National interest or more gravely by a lack of precise policy on the part of the Health Ministry. This situation may have been prevented had the program been given a backing by its inclusion in the National Development Plan.

   (iii) International relations (aid, development programs, grants exchange of expertise and technology) may be more effectively controlled.

   As important, perhaps, as any of these advantages is the recognition and patronage afforded to science and scientists by the inclusion of these affairs within the central ministry of the government. "The most significant reason why scientific research failed to develop in Sri Lanka, is, of course, the lack of high level, political patronage".[5]

3. Advisory Boards or Committees incorporating scientific expertise should be set up within the Planning Ministry in the major fields which are relevant to the National Development Plan (Agriculture, Health, Industry, Fisheries, Natural Resources, etc.) A good example of such a committee or commission is the one proposed by the symposium organized recently by the Sri Lanka Foundation Institute and the Medical Education Unit of the Peradeniya Medical Faculty—a National Health Manpower Development Council—for the training of personnel involved in health care delivery.

4. The National Science Council (NSC) should be a part of the Ministry of Science and be given wider powers and a more effective role through its newly formed committees. These should be given executive powers since many of the important functions which could be performed by these committees are now not possible owing to the lack of executive authority; for example, the enforcement of rationalisation of the import of scientific literature.
   The NSC should fulfil the role envisaged by the Indian scene "It will also require government to set up and adequately finance machinery that will monitor, evaluate, correct and redirect the implementation of the various programmes in the science and technology plan".[1]

5. Agricultural, Medical (or Health) Engineering, Fisheries, and other research councils may be

necessary to co-ordinate and integrate, sponsor and promote research and to disburse grants in their respective fields.

6. A research and development cess or fund may be created through a levy from private enterprise, for the general support of research; tax free grants, for specified research projects may also be allowed to private firms.

7. University science research. A University Grants Commission (UGC) is desirable. The corresponding Indian body is a Statutory Body, not responsible to any Ministry of the government, which coordinates and promotes University education and maintains standards of University teaching, examination and research.

8. Creation of a suitable climate for the working of scientists. Some possible approaches have been mentioned above. In addition, the following may be considered.

(*a*) Higher appointments to be made on the basis of merit although seniority may be taken as a minor criterion.

(*b*) Director's and other high posts in technical and similar institutions be filled on the basis of public advertisements and the appointment be made essentially on technical and administrative competence and perhaps on a contract basis. At the present time, such appointments seem to be made on seniority which may lead to the situation of a square peg in a round hole which is one of the most damaging of conditions for the proper development of an institution. A distinction should be made between holders of 'posts' and those who are actively engaged in specific jobs. The latter alone should be on advisory boards of technical corporations and institutes. The former are most often "flag wavers" in search of honourific titles and have no first-hand experience of any worth. Their *curriculum vitae* should be used in screening their claims.

(*c*) Science talent quests and sponsorship of such individuals for appointments to national posts.

(*d*) Proper utilisation of foreign technical assistance. It has been remarked that this country is characteristic in its under-utilisation of foreign technical aid, through improper selections (often made without guidelines or outside guidelines), non-utilisation, unnecessary official or political interference in selections, bureaucratic delays.

In relation to (b) above, this approach may also have another advantage. These high posts are prestigious and therefore much coveted but are few in number. Their accessibility to the many able persons in this country, through open advertisement may afford new avenues to professional advancement which otherwise would not have been available except to the senior staff. This situation, was commented upon by Dandekar writing on the Indian situation (which is quite similar to ours) on the Brain Drain.

"There are today, only a few senior positions available and they are all occupied. There are a larger number of junior positions below in a series of graduations and the gap between the salary and status belonging to the senior positions and those belonging to even the next immediate junior position is very large. This is a structure which we have inherited from the British administration. During the British administration, the top man everywhere was a Britisher and his salary was way above the salaries of the Indian subordinates working under him. Essentially, the same structure exists today, though the top positions are all occupied now by the Indians. Under the circumstances, all that the juniors can do is to wait and hope that the senior will one day pop off, so that at least one of them may move up and the others may begin another long wait. This is most frustrating. But when in their attempt to break through the frustration, the juniors began to show their ability and assert their competence, they made the positions of the senior, insecure. .

"There is little doubt that these two phenomena (one of which is the matter referred to above) are mainly responsible for the frustration and resentment which permeates the intellectual life in the country today".[10]

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Science and Technology Policy

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This brief comment is to discuss a few points affecting Science and Technology Policy, specially in the case of Sri Lanka. This is not a formal paper, but it is to be seen as largely an attempt to sensitize a few of the issues involved.

Science and Technology Policy has two dimensions. Firstly, as an academic discipline which studies the control, direction and progress of science and technology, and secondly, in the practical domain as action—oriented towards carrying out policies in Science and Technology so as to consciously influence social and economic changes. In the academic sphere, Science and Technology Policy rests on the interphase between hard and social sciences. Thus, if one were to enumerate; there is a sociology of science and technology, an economics of science and technology, and hypothetically one could even imagine a psychology of science and technology. The sociology of science and technology itself, could be broken down into sub-disciplines, so that we have sociology of medicine, sociology of technological change, and so on. There have been several workers in these spheres specially during the last ten to fifteen years, who have attempted to identify factors, social and economic, that have had an impact on science and technology and conversely, those factors in science and technology that have had an impact in the socio-economic sphere. These studies go back to several writings in nineteenth century Europe including those of the very important ones of Marx. Later, more detailed and sophisticated elaborations and studies like those of Burnham, Kuhn, Price and others have given a more complete picture of the relationship between science and technology and the socio-economic sphere. These writers have been working in the interphase between the hard and social sciences to point out the interactions between society on the one hand and science and technology on the other.

In the Western world, work in this sphere has become of extreme importance recently, within the context of a virtual near crisis in the hard sciences and the given technology. There is a deep questioning today in certain quarters about the direction development—of science and technology has taken over the last few centuries. The current concern at a symptomatic level on the environment, the quality of life, etc., are more visible associated aspects of this questioning that is occurring. Within the Third World, on the other hand, there has been a questioning of the appropriateness of imported technologies as leading, for example, to the strengthening of structures of dependence with the countries in the centre. In these imported technologies, the role of multinational corporations have been subjected to intense analysis and discussion in the Third World. Further, recent students of the Third World both from the Third World, itself, and sympathetic western scholars—have begun to question the entire life styles, as well as the science and technology styles that arose as part of historical development in the West during which historical process, we as members of the Third World were treated as raw material and manipulated objects of this development. In short, the science and technology that is available today in the West is—as it were, the congealed history and experience of western man in its phase of subjugation of the Third World. This questioning and new theoretical perspectives have removed much of the aura of the assumptions of an objectivity which was held as the basis of science and technology. It is now seen that scientific objectivity was an objectivity contained within certain social and historical limits and as such in an absolute sense was not 'objective'. The growth of science and technology in the West was a process by which scientific and technical progress was made through a historical process to which we were outsiders, as well as subject matter. The major aim now is to re-enter history as equal partners and may be to restructuie science and technology to our views and needs.

Science Policy in Sri Lanka has been laigely unconscious of the broad considerations that we have sketched above. Formal policies have not been formulated at a government level to incorporate even general policy guidelines even without recourse to the theoretical considerations that we have sketched above. Several writers, including G. C. N. Jayasuriya, Osmund Jayaratne, R. O. B. Wijesekera, as well as myself among others, have written on some of the dimensions of the problems of science and technology within a Sri Lanka context. However, these considerations have not crept in any degree into formal decision-making.

This lack of a formalised science policy is largely due to a lack of awareness among political decision-makers of the importance of science and technology. One has to contrast the experience of Sri Lanka in this regard to those of India and China. Although India has followed what may be described as an elitist science and technology policy and China has followed what may be described as a more mass-oriented science and technology policy, there are strong similarities between the two and has resulted in both being very strong scientific and technological powers today. In the case of India, this advance is due largely to the personality of Jawarhalal Nehru who in the very early years of the post-independence era, took science under his wings, gave it high priority and brought out a strong scientific structure. India today possesses a vast scientific infrastructure that can vie virtually with any country in the world.

In the case of Sri Lanka, unfortunately, no formalised science and technology policy has emerged due largely to uninspired leadership at the top in this regard. A Ministry of Scientific Affairs was created a few years ago as part of a larger Ministry of Industries and Scientific Affairs, but has not been given sufficient powers to have a strong impact on the country. Inspite of this lack of a formal scientific and technological policy there has been a commitment on the part of the government towards science and technology which has continued to grow, although somewhat haphazardly, and today Sri Lankan scientists in many fields fare very much better than those of many other Third World countries. Thus, our scientific and technological infrastructure is higher than that of many medium size countries of Africa and Asia, although we are a small country. Because of this virtually unconscious growth in science and technology, we boast today a brain drain of considerable proportion with flight of personnel to the more affluent countries for not only money but scientific recognition reasons. Many scientists and technologists affected by the brain drain give as a major reason, not so much the lack of money but the lack of job satisfaction, and the fact, that scientific and technological decisions in the country are being still left in the hands of amateurs specially from the Administrative Services. For the scientific community who is in close communication with developments elsewhere and who have witnessed a growth of scientific advisory bodies of a very high-powered nature in both capitalist and socialist countries, this amateur control in Sri Lanka stands as an irritating anomoly. Informal discussions with local scientific and technological personnel indicate a strong degree of frustration and resentment in this regard.

Another strong reason for frustration among scientific personnel is the inclusion as part of aid packages of sub-standard foreign expertise when local expertise is available in the country. There is a definite place in the country for foreign expertise in fields where no competent Sri Lankans exist, but many of the foreign expertise are in those fields where Sri Lanka has a high degree of competence. Perhaps one of the most glaring of these is the case of a foreigner, prone to making statements at academic gatherings of Sri Lankans on subjects virtually varying from rural development to atomic physics, subjects on which he holds no competence. The image evoked is that of white colonial Government Agents at provincial school prize-givings during the pre-colonical era.

There have been moves over the last few months within the National Science Council, the Association for the Advancement of Science and the National Academy of Science to get the importance of science and technology policy across to the political authorities. In the recent general elections, one major political party included science and technology policy in its manifesto whilst the others largely ignored it. It is essential that for further growth of science and technology, both regular and consistent patronage as well as formal recognition from the top is necessary for the growth of a viable scientific community. In this respect, scientists and technologists should continue applying pressure at all points for not only the recognition and acceptance of science and technology, but for the conscious use of science and technology in different spheres of the economy. These measures should include pressures from scientific associations, trade unions and lobbying of politicians. One lesson that the new academic subjects dealing with science policy reveals is that science and technology cannot be divorced from politics and *vice versa*, and that the structures of society and structures of science are intimately connected.

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The actual content of science and technology policy is determined by the concrete economical and political tasks of each country, and also by the intrinsic requirements of scientific development itself. Science, like other spheres of human activity, has a relative independence and actively influences politics; consequently, political tasks have a subordinated role to economic, scientific and technological objectives. Science and technology policy must change with the development of science, with the appearance of new scientific perspectives, and with changes in the social function of science within society. Each country establishes its own particular system of scientific institutions and science management structure and determines its specific direction for developing science and technology in accordance with the socio-economic development objectives of the country. Nevertheless, there are certain aspects of science and technology policy which are common to all countries.

UNESCO BULLETIN

The Magical, the Practical, the Beautiful and the Greatest

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This article discusses science and technology policy of the recent past and makes some suggestions for the future.

The Magic Solution

A few years back, the Sri Lanka Broadcasting Corporation announced the following 'main point' in a morning 'news' cast. "An uneducated technician from Rambukkana has developed an engine working on sea-water". This was shortly after OPEC had launched the energy crisis. Thus,on hearing the sentence the writer, like many others, "hit the ceiling." The laws of thermodynamics were no more. Civilisation and on further thought, the universe itself, as we knew it, had to end.

People travelled from many parts of the country to witness this miraculous invention. Some technologists burnt derivatives of the dwindling fossil fuels to travel to Rambukkana, perhaps in order to get their finger into the pie of the century. The inventor, in the company of technologists, was interviewed over the radio. A national newspaper 'adopted' the inventor. However, today, we continue to buy fuel from the Arabs. What lesson can we learn from the Rambukkana incident?

The lesson is that there is no magic path to technological progress. The Rambukkana incident was dramatic but not particularly harmful. Less dramatic but much more destructive 'magic solutions' abound in our recent history. Recall what one has heard of or read about 'Kohutex', D.D.C.s, one-university, job-oriented courses, the decentralised budget and the five-year plan to name a few. These colossal failures would have served a useful purpose if they impress on us the fact that technological progress is not the result of brilliant ideas only. Technological progress is almost always the result of painstaking work by interdisciplinary teams of workers. The obscure scientist laboriously gathering routine data usually contributes far more than the supposedly brilliant man whose name appears in the daily newspaper.

A good science and technology policy must therefore support and reward the routine research worker. Projects that claim to be major breakthroughs should be supported only if their viability is established to a high degree of certainty. Even then, such projects should not divert resources from the organisations that do the routine work and thereby maintain the infrastructure.

Practical Engineering

This is a particular type of magic solution which has been promoted heavily since *circa* 1966. Those who dabble in it attach mystical power to words like "practical", "job-oriented", "applied", "on-the-job", "in-plant" and "on-going". Judging by the queues at the bus-halts and employment exchanges, pot-holes on highways, frequency of power failures, the difficulty in getting a connection over the subscriber trunk dialling system and so on, *ad nauseum*, one may conclude that after a decade of existence, the contribution of the 'practical engineers' to the technological progress of this country has not been any better than of the old-fashioned variety.

The proponents of the new variety of technical training do come up with a never ending stream of magic solutions to our technological ills. These breakthroughs are described in the daily press, at seminars and 'work shops', and occasionally in the scientific literature. They are even known to have been the subject of paid advertisements in the newspapers.

The description of these 'practical' products of local technology and local raw materials is usually such that the non-specialist is left confused and suitably impressed. For instance, a windmill that can pump 200 gallons of water per hour over a head of 25 feet sounds terrific at a cost of only Rs. 2000/-. That is, until one realises that one is being asked to pay Rs. 2000/- for a gadget that generates less than 20 watts! That, too, when the wind velocity is more than 10 m.p.h. which is not that often.

Our policy makers must realise that there can be no good practice without a sound grasp of theory. A viable science and technology policy must therefore support and encourage the persons and the institutions that provide our future scientists and technologists with good, old-fashioned theory. This process must begin in the secondary schools.

The Local Genius

This genius is said to exist in Panchikawatta and in towns and villages all over the country. In order to make a living, he repairs motor vehicles or radio receivers. He has had no formal training in his trade. Therefore, in most cases the work is bad and needlessly expensive. However, to the technologist who has spent much of his time in the designs office, in development planning, policy-making or in social studies and therefore never learnt how to clean the spark-plugs of his car or how to replace the fuse in his radio, the village mechanic appears to be a genius. Respect for the knowledge and skills of others is admirable. However, very often, the admirer of the local genius does so with the object of pandering to the sillier side of politicians and economic historians. The result is that our national technological policies have made little or no attempt to provide the skilled worker and the technician with the formal training which is absolutely necessary to improve his skills and to exploit his abilities to the maximum. This situation should be rectified as a matter of high priority.

Intermediate Technology

This particular magic solution has been promoted for about the same length of time as 'practical engineering'. Purveyors of intermediate technology have recently discovered a new variant called 'appropriate technology'. Its local adherents often ignore the assumptions and theorems of the older conventional technology. Thus the laws of Newton, the equations of Maxwell and the laws of thermodynamics are treated with scant regard. The fundamental axiom of the new technology is "small is beautiful." Thus hand-made goods are considered more 'beautiful' than the factory-made variety purely because they are hand-made.

Before one embarks on a policy based on intermediate, appropriate or any other kind of new technology, it is necessary to consider the following arguments:

The power output of a human being is at most one-quarter of a horsepower .The product of this quarter horse-power can be much more valuable than that of a generator of equivalent power because the human being is intelligent, skilled, and may therefore apply the power in a complex manner. However, if we use the human being to perform a monotonous task that takes up all his energy, then his net contribution to the economy is no more than the value of one-quarter of a horse-power. Thus, for instance, when a man churns a barrel full of caustic soda and paddy straw or beats a piece of metal into the shape of a mammoty, the value of his work is less than five cents to the hour. Fiscal and bureaucratic policies that provide such a worker with a reasonable standard of living, do not change this fact. Such policies merely subsidise one worker at the expense of another.

The indiscriminate application of 'intermediate', 'appropriate' and other new-fangled technologies has done much harm in the recent past. Since we are faced with a massive problem of unemployment it is possible to argue that manual labour should be substituted for machinery. This argument is valid only up to a point. With manual labour, productivity is bound to be low. Therefore, labour-intensive technology can at best serve to arrest a decline in our standard of living. If the ultimate aim is a high standard of living, there is no alternative to a machine oriented mass-production technology. That is, although small may be beautiful, by definition it is bound to be small. Full employment is very desirable. However our aim should be to obtain increased employment together with increased productivity, even if this requires increased utilisation of machinery.

We are the Greatest

This theory rests on three assumptions and has misled many of our planners, policy-makers and politicians. The first assumption is that since we are the heirs to a great civilisation, progress should be easy. All that is necessary is to do things the way they did in Anuradhapura and Polonnaruwa.

Whether the ancient Lankians had developed a great technology is beside the point. Even if they had, we do not have the faintest idea what techniques they used. Therefore the best thing to do is to develop technology as we know it now. Modern scientific knowledge is equally applicable in the developed and the undeveloped countries. Dislike of the West, the East or foreigners in general should not stand in the way of technological progress. The developed countries got to where they are by applying science, based on inductive logic. Our progress too must be necessarily based on inductive logic rather than some nebulous 'indigenous technology.'

The second assumption on which the 'greatest' theory is based on is that Sri Lanka has enormous untapped natural resources. Periodically, the press reports the discovery of fantastic deposits of iron ore, enormously rich deposits of copper and the richest phosphate deposits in the world. The actual quantities are rarely mentioned. Hence one begins to suspect that these reports are designed to impress the.

One particular 'enormous resource' deserves special mention, firstly, because it is talked about so often and secondly, because detailed quantitative studies have been made by men who are too busy to canvass publicity. I refer to our resources of hydro-power. These are supposed to be so enormous that plans were made to export energy to India. Research on electric motor cars is said to be going on and plans to electrify the railway are afoot. A plan to extract aluminium from imported bauxite was mooted. Politicians have promised to provide electricity to every household in the country. Before being carried away by these glorious prospects, consider that even if we shut down the factories, air-conditioners, radios, lifts and all other electrical paraphernalia in the country and turn on all the hydro-generators full blast we cannot get enough power to provide a small reading lamp to every Sri Lankian! Given current patterns of population growth the situation will be no different in the future even after we have tapped all the available power.

Therefore, a science and technology policy for Sri Lanka must recognise the uncomfortable fact that our natural resources are severely limited. Many of our industries will have to depend on imported sources of energy and raw materials in the foreseeable future.

The third assumption on which the 'we are the greatest' theory rests is that our scientists, engineers, economists, etc., are the best in the world. This information is regularly conveyed to a gullible public by the daily newspapers and is usually employed to justify the appointment of persons of dubious abilities to responsible posts in the state sector (the N.S.C. not necessarily excluded).

Courtesy and the author's instinct for survival demand that he does not expand on this particular assumption any further. However, it is necessary to state that the responsibility of making policy should be given only to those who have real results to show. It should not be given to those who have merely held 'responsible' positions in the past and launched us on unproductive and therefore disastrous policies or not launched us on any policy at all.

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The examples referred to in the foregoing are all real, but the author does not wish to thank the originators. The author wishes to express his gratitude to the members of the Senior Common Room of the Faculty of Engineering, Peradeniya, who helped to sharpen some of the ideas expressed in this paper, to Prof. S. N. Arsecularatne who persuaded the author to write this paper and to Mr. M. Hameed who typed the manuscript.

The author accepts full responsibility for the opinions expressed in this paper, although many of them are not original.

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WORKSHOP ON THE SCIENTIFIC METHOD AND RESEARCH METHODOLOGY IN SCIENCE EDUCATION

The Workshop on "The Scientific Method and Research Methodology in Science Education" was held from the 15 to 26 August 1977, at the Medical Education Unit, University of Sri Lanka, Peradeniya Campus.

Research in science education in Sri Lanka has been a relatively neglected field inspite of the vast sums expended on Science Education itself. Since its formation in June 1976, the Working Committee on Science Education Research (a sub-committee of the National Science Council) was successful in compiling a list of priority areas for science education research. Applications were invited from universities and schools for the award of research grants. A total of twenty-five research grants were awarded during the last year. However a number of the research grantees had little practical experience with research in science education in Sri Lanka. Thus it was felt that a training course in Science Education research methodology would be most appropriate.

The organisation of a workshop under the guidance of an experienced research worker was thus undertaken. The workshop was scheduled so as to enable the grantees adequate experience with their projects before being subjected to the training course. Under the guidance of Professor R. F. Kempa, Professor of Education, University of Keele, United Kingdom, the research grantees received a basic training on the concept of science education and research methodology. A series of lectures delivered by Prof. Kempa introduced the research workers to the latest trends in science education and research in the United Kingdom.

The research grantees were trained in the art of questionnaire design and evaluation of classroom interactions. The workshop included the presentation of papers by the research grantees and their discussion. Finally, the workshop brought together isolated research workers and provided an opportunity for an interchange of ideas.

Technology, and the Transfer of Technology

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The transfer of technology is now a very important aspect of the development effort in any underdeveloped country. It is the subject of discussion in various United Nations and other forums. It has also been studied by the Pugwash Conference on Science and World Affairs, which has brought out a Code of Conduct for the International Transfer of Technology.

Technology is transferred from one country to another in the course of new investment on development projects. This could take the form of private, foreign or local investment, and public investment with or without foreign financial assistance. Foreign assistance could take the form of either bi-lateral or multi-lateral aid, the former from a foreign government, the latter from the World Bank, the Asian Development Bank or some UN Agency. It should be noted that "only official Development Assistance should be designated as AID. The flow of private capital and official credits undertaken for commercial reasons have no more the character of AID when they flow to developing countries than when they flow between developed countries". [1] The multi-national or trans-national corporation is wellknown in the field of private foreign investment.

From earliest historical times, in every civilization, technologies evolved empirically as a result of man's interaction with Nature, in his immediate environment. These technologies enabled man to meet his essential needs. Sciences were developed, independantly of technology, as a result of man's enquiry into Nature in many of these early civilizations. Both Science and Technology were "transferred" from place to place as a result of exploration and the movement of people, which was greatly helped by the discovery and invention of the magnetic compass. There was continuity in the development of sciences like Astronomy and Mathematics, down the ages, although this knowledge was generally the privilege of the leisured classes and the priesthood.

After a general transfer of knowledge from the East to the West, the Rennaisance in Europe was sparked off by a combination of fortuitous circumstances. Thereafter there was rapid development of both Science and Technology in Europe, but once again, independant of each other. The growth of technology was stimulated by commerce and trade, and by early colonial expansion, catalysed by the spirit of pioneering and by the protestant ethic, after the Reformation. Thereafter the Industrial Revolution was precipitated in Europe, starting in England in the 18th century. The Industrial Revolution more or less coincided with the emergence of the capitalist system of production. This resulted in the evolution of the factory system of production in industry with a concentration of capital in the form of technology, and a division of labour. This in turn eventually led to the growth of a centralised, large-scale manufacturing, distribution and marketing, system, which then became synonymous with industrial development and modernisation in industry. Modern industry was at first confined to urban centres, whilst the small-scale, traditional industry which it replaced, from which in a sense it grew, remained in the so-called traditional sector. Today, this sector has altogether disappeared in the advanced countries, but sustains a majority of the population in developing countries, where incipient modern sectors are also to be found, usually as a result of transfer of technology from the developed world.

In the United States, the industrial revolution took place in the 19th century, and was characterised by the extensive mechanisation of agriculture. As in Europe, the application of scientific technique to the deliberate development of technology was to come later and the early transformation of technology was empirical. Today, modern agricultural development is based on scientific research. This has resulted in the intensification of inputs to achieve increased productivity and increased outputs. This modern agricultural technology is also being transferred to developing countries, and is sometimes imposed on the traditional agricultural sectors of these countries.

In the construction sector too, modern technology is transferred to developing countries. In Sri Lanka, heavy construction equipment was first used during the restoration of ancient irrigation works, before World War Two and this work of piece-meal restoration gathered much momentum after the war. The use of heavy earthmoving and other equipment, enables engineers to dam any river. This has led to a new approach to the *design* of irrigation and multi-purpose projects. This approach may be described as one based on a centralised, large-scale system, which is in marked contrast to some of the ancient irrigation works which could be described as being based on dispersed, interdependant, small-scale systems.

It is thus seen that since the time of the Industrial Revolution in the West, large-scale centralized systems for production, manufacturing, storage, distribution etc., have become increasingly popular in developed world countries. These systems have replaced existing dispersed small-scale systems almost completely in those countries. There is a tendency to imitate the large-scale centralised systems of the developed countries in the developing countries and this is promoted by a transfer of technology. It may be argued, however, that it is only an accident of history that efficient, small-scale, de-centralised production and commercial, systems have seldom emerged which could compete with the large-scale centralised systems, although in recent times there appears to be some development in this direction, e.g. some large multi-national corporations are known to be dispersing their investments in a large number of smaller production factories in various parts of the world.

An interesting aspect of this evolution of systems, is a comparison of the eco-systems in which each of these man-made systems has evolved. Very broadly, eco-systems in the temperate regions of the earth tend to be large-scale and of limited variety and diversity. On the other hand, in the tropical regions especially in the humid tropics, eco-systems show a splendid variety and diversity, and an intricate basis of inter-dependance. For example, there are extensive areas covered by deciduous forests and also by coniferous forests in the temperate lands; in each of these large-scale systems there are comparatively few individual species of flora and fauna. In contrast, in the tropical forests there are a very large number of species in a small area. (This is well known in our country in the Sinharaja Rain Forest, for example). It would appear therefore that the dispersed, interdependant small-scale system evolved naturally in the eco-system of the tropics, whereas the corresponding eco-system in the temperate regions had inevitably to give rise ultimately to centralised largescale systems. Therefore, there seems to be a built-in contradiction in the transfer of technology from the developed world countries to the developing countries. The cause of this contradiction has been described in the statement, "Technology is like genetic material—it carries with it the code of the society which conceived it". Instead of "society", we could read "eco-system" in this statement.

In a developing country like Sri Lanka, these two systems, the modern or recent, centralised, large-scale, on the one hand, and the traditional dispersed, small-scale system on the other, should not be considered as alternatives. Rather they should be used as complementary systems that support, rather than compete with each other. The proportions in which the two systems should be used will depend on the particular context, and each case should be treated on its own merits.
In particular, each project should be viewed in terms of the factors of production in that sector.

In any economy, and especially in a developing economy, employment is available in 3 sectors of production which may be called the primary, the secondary and the tertiary sectors. In the primary sector actual production takes place from agricultural and mining activities. In the secondary sector, there is a processing and manufacture of goods, and in the tertiary sector there is the commercial activity associated with the handling and distribution of goods and the provision of services. In each sector of production, there are also three levels of employment called the blue collar level, the white collar level and the management level. The relative numbers of people employed in the primary, secondary and tertiary sectors, and at the three levels of skills, is an indication of the stage of development of the economy. In a developed country, comparatively few people are engaged in primary production. Furthermore, in the primary sector, because of high productive capacities of technologies used, there are comparatively few blue collar workers. In a poor developing country like Sri Lanka, on the other hand, more people are employed in the primary sector, and more people are employed at the blue collar level when traditional technologies are used.

Capital, Labour and Land are generally described as the primary factors of production, where land refers to resources. In engineering planning, it is usual to refer to Money, Men, Materials, Machines, Methods and Management. We can define Technology as consisting of Materials, Machines, Methods and Management, and identify factors of production, as Capital, Labour and Technology. We may further subdivide technology into two components, technological hardware consisting of materials and machines, and technological software consisting of methods or techniques, and management.

At any stage of development, there will be a certain mix of capital, labour and technology in any given sector of the economy. When development is deliberately accelerated, the "natural" mix of capital, labour and technology is deliberately changed, in order to force production. It is in this context that the transfer of technology should be viewed.

In the Sri Lanka situation, technology is often transferred to set up new productive capabilities, for example in the corporation sector. When a new factory, is set up in this manner, a number of skilled personnel (the factor Labour) together with a certain amount of Capital is brought into the country along with the technology proper, (both hardware and software) that has to be installed. The intention in such cases is to replace that imported labour and capital after some time with local resources. In practice, another aspect of the mix of factors exists. Before the new factory was set up, there would have been some local productive capacity in the traditional sector, however primitive. which produced the same goods, or equivalent goods, or goods of a lower quality to that which the new factory will produce. It is important to consider the impact of the new investment on the existing industries in the traditional sector. Furthermore, if the National Planners are aware of the existence of such an equivalent traditional industry, it is their bounden duty to examine the capabilities of the traditional industry, and the possibility of upgrading it before bringing in the transferred technology, lock, stock and barrel. This applies no less to the agricultural sector as to the industrial sector.

In practice we know that this has not been done in the industrial sector in many instances. The State Hardware Corporation was set up with a transfer of technology to produce some 46 different products ranging from mammoties and other agricultural implements to tower bolts, hinges and other building accessories, all of which were being manufactured by artisans in the traditional sector at the time, inspite of competition from high quality mass-produced imports. The plywood complex was set up at Salawa to produce various treated timber products like tea chests and chipboard, without reference to the productive capacities of existing saw mills and carpentry workshops in the country, and so on.

In the agricultural sector too, transfer of technology is now a regular part of development planning and various technology packages have come in to Sri Lanka under so-called Aid Programmes. Special mention may be made of the technology of the Green Revolution which has now been described as a maximum input—maximum output technology. In otner words, high-yielding varieties (of rice, wheat, maize, etc.) were developed which needed high-inputs of fertilizer, pesticide, etc. which inputs are freely available in developed countries but are scarce resources in developing countries. What the developing world needs are *optimum* input *optimum* output technologies which will be appropriate to our factor endowments.

It is thus seen that "appropriate technology" in the broadest meaning of the expression stands for an optimum technology, a technology which makes optimum use of available resources. Such a technology in a developing country may often be an "intermediate technology", being less complex, capital-intensive and large-scale than other existing technologies, (in developed world countries) and less labour-intensive than some previously used primitive technology. However it should be noted that an intermediate technology is not necessarily an appropriate technology, in the above defined sense of being an optimum technology, making optimum use of available resources.

The expression intermediate technology was originally popularised by the late Dr. E. F. Schumacher who set up the Intermediate Technology Development Group in London in 1965. The concept of intermediate technology has been given various attributes, including roots in the philosophy of Gandhi and Ananda Coomaraswamy, and religious sanction from Buddhism (*vide* chapter on Buddhist Economics in Schumacher's classic, "Small is Beautiful"). Not surprisingly, some intermediate technologies are now being made to measure in developed world countries for developing countries, and transferred like any other technology.

Meanwhile, the development effort in developing countries often flounders on the question of choice of technology. The image of developed world societies always looms large before decision-makers who "choose technology" for planning, design and construction of projects in developing countries. In such a situation. choice of intermediate technology is difficult and designing an appropriate technology becomes well-nigh impossible. It is therefore necessary to counter the psychological effect of the developed world image, before getting down to the task of designing appropriate technologies, and choosing transferred technologies, in Sri Lanka.

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Another important element of science and technology policy is international co-operation in scientific research, including the transfer of research findings to industry. Specialization and co-operation in research, with a clear sharing of scientific labour at the international level, is one of the preconditions for the development of science and technology at the national level. This international co-operation should start with the definition of priority fields for collaboration, the preparation of a programme of action, and the choice of the most effective modes of co-operation. These latter might include the exchange of information and scientists, joint research projects, and mutual assistance in training scientific personnel and in construction of scientific facilities.

UNESCO BULLETIN

Science in a Developing Country

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(Excerpts from the inaugural address delivered at the annual congregation , University of Cape Coast, Ghana).

Any discussion of the basis of science in a developing country has often been justified both in terms of science as a human aspiration as well as a base for technology. For centuries, science and technology remained and developed independent of each other. Technology, known as the industrial arts, was largely empirical and provided little interest to the intellectual classes and it did for a long time remain their monopoly. It was only about the middle of the nineteenth century that it was realised that science and technology stimulated the growth of each other. Technology is now more science-based than ever before. Today's science is tomorrow's technology. The distinction between the roles of science and technology in our strategy for development is of great significance to any developing country. Although it would appear that the present need is for a greater emphasis on technology, it is essential to promote and sustain science in all its aspects. After all, to apply science, one must first know it.

The effects of Science are long range. *Ad hoc* solutions could never be an alternative to planned scientific activity. There is a remarkable passage from a lecture by Clerk Maxwell over a hundred years ago. "For us who know only the spirit of our own age, and the characteristics of contemporary thought, it is as impossible to anticipate the general tone of the science of the future as it is to predict the particular discoveries it will make. Experimental science is continually revealing to us to new features of natural processess and we are thus compelled to search for radically new forms of thought for their description."

It has often been remarked that it took 50 years for Faraday's experiments in electromagnetism to reach practical fruition. Farsighted programmes are therefore needed to train our own scientific community, tradition and institutional base for science.

Science in developing countries.

This should be supplemented by a few words on what is understood by development. It is very appropriate to quote Professor Colin Leys of the University of Nairobi from his address to the 5th Commonwealth Education Conference in which he states "The very expression 'the developing countries' has come to sound embarrassing because it so obviously rests on the linear conception and frequently refers to countries which are in fact stagnating or even regressing. It begs the central question which has been asked, namely, what is development? and the critical questions which follow from it. What are the causes of underdevelopment? What are the solutions to be adopted? What kind of society should development create? How valid are current development policies? How far even, can existing governments claim to be the sole interpreters of of what should be done? I add this last question for the sake of candour. We used also to assume that development would bring benefits to everyone. There was a tendency to ignore the fact that some would even lose."

A fairly reliable indicator of a country's development is the extent of its scientific and technological activity. In this respect countries in the developing world— the 'third world' as they are politically labeled are characteristically underdeveloped. There is little evidence of any indigeneous science and what little has been needed has for the most part been imported. It is only recently that there has been any real concern for development.

The organisation of science on a national scale in Sri Lanka. is very much of recent origin. But in this task much has been achieved through the efforts of voluntary science associations.

A small band of scientists got together in 1944 to found the Ceylon Association of Science. It is particularly relevant to note that the intitiative for this venture came from the Ceylon Chemical Society founded a year earlier in 1943. The chemists have always been in the forefront of scientific activities in Sri Lanka. As an Association, its objectives have been to promote the application of science in two broad ways: (*a*) by promoting scientific research, (*b*) by dissemination of scientific knowledge. In promoting science through research, all that the Association was able to achieve in its formative years was to make available a forum for the local scientists to present and discuss their researches through the holding of annual sessions. It was soon realised that this alone was not adequate to provide all that is required to create a favourable climate for for scientific activity. It was also recognized that the Association should bring into its fold all disciplines of science and encourage in them discussion among themselves as well as among the scientists from other disciplines. The Association was soon re-named as the the Ceylon Association for the Advancement of Science following perhaps the pattern of the British Association for the Advancement of Science and aimed at establishing live contact between scientists and the people. As the late Prime Minister of India, Jawarharlal Nehru once said at one of the annual sessions of the Indian

Science Congress "My interest largely consists in trying to make the Indian people and even the Government of India conscious of scientific work and the necessity of it." Politics cannot be kept out of science nor science out of politics. After all politics does matter and no amount of preaching on the glories of science is going to bear fruit unless our politicians are conscious scientifically and begin to show their faith in science by giving much support to its organisation.

Apart from sectional activities of the Ceylon Association for the Advancement of Science, the Association began to achieve its second objective of dissemination of scientific knowledge. The general image of scientists that they are far from the understanding of the common people working in some sort of ivory tower needed to be erased if this live contact with the people had to be established. As science and technology affects lives of ordinary men and women, it is essential for scientists to put across to the people what they are doing and also to get to know the thinking and viewpoint of the people. This the Association realised as one of its primary functions. It set up a committee for the popularisation of science pledged to raise the level of science consciousness among the entire population. One major problem has been to try to bring home to the layman the close relationship between science and its environment.

The Association in its early years gave much emphasis on the organisation of scientific activity as a whole and persistently campaigned for the creation of a National Research Council for overall co-ordination of scientific activity and to define a National Science Policy. Successive governments in Sri Lanka were urged to give this matter its urgent consideration. It took over 15 years to realise this long felt need. In the ensuring years, a shadow committee referred to as the General Research Committee was formed by the Association to promote scientific research by the awards of research grants and the undertaking of documentation. A directory of scientific personnel and a union list of scientific periodicals in Sri Lanka was produced by this Committee. It also undertook to visit industrial corporations to identify scientific problems with a view to bringing to bear scientific knowhow among the members on these problems. In 1968, the government instituted a National Science Council to promote and co-ordinate scientific research and science-based activities. Shortly afterwards, the government created a separate ministry for scientific affairs. Much remains to be done but the infrastructure, hopefully, has now been firmly established.

Having considered, in brief, the status of science development in Sri Lanka, the need for each developing country to formulate a national science policy appropriate to each country is apparent. In any area of scientific activity, whether it be agriculture or industry, there is a need for the development of a science policy for maximum utilisation of science, to assess indigenous, scientific and research capability within the country, to refine techniques for acquiring and distributing technological information for effective use, and more important to lay down scientific priorities for that country. In manpower planning, much attention should be paid to the question of a critical mass, because scientists need interaction with others. This generates criticism, discussion and teamwork which is of importance in the creation of new science. It should also be one of the features of a National Science Policy to give due attention to the study of areas where benefits may be derived through more intensive application of Science and Technology. Most developing countries could aptly be described as poor rich countries—rich in their resources and potentials but their people are poor. The focus of attention of any development strategy should necessarily be on

(i) a comprehensive survey of the physical and human resources,

(ii) the utilisation of science and technology in the exploitation of the natural resources of a developing country.

On the question of autonomy in scientific institutions, the stress has always been on autonomy for spending. It is the intellectual autonomy for operational freedom to handle scientific problems that should be provided. Apart from a National Science Policy, there should emerge a national resolve of dedication to science. Ours is essentially an agricultural economy. The way which we use such assets as land and water require a stable scientific and agricultural policy. Improved agriculture is often the outcome of the work of the laboratory scientists where overall co-ordination and teamwork is an essential component. It is necessary to provide an improved atmosphere for research for such scientists to assist in the solution of problems related to their own national agricultural plan.

In industry, the limiting factors facing most developing countries are the lack of cheap power and the inadequate knowledge of our resources. In Sri Lanka, (and I am sure that this is true of most developing countries), much of our resources have remained untapped or not exploited with maximum benefit. A few examples will illustrate this situation. In the eastern coast of Sri Lanka, black beach sands rich in titanium containing minerals, ilmenite, could virtually be scooped off by thousands of tons. This is exported to Japan at minimal cost where it is refined and beneficiated to recover from it the much priced titania and titanium. Could not this enrichment be accomplished locally? There is much chemistry and chemical technology in these studies. There are a variety of scientific and technical problems that need to be solved to achieve this end. I have read of similar problems elsewhere. Much of the concern in mineral exploitation in a country like Guyana has been to make the bauxite industry more efficient and more productive. Problems such as determination of moisture control to improve the efficiency of the calcination process and separation of clay from the refined bauxite leads to the more technical such as the recovery of bauxite dust to reduce losses. Effective utilisation of waste products is another area requiring development. There is in this bauxite industry a growing interest in the red mud waste which contains as much as 10% titanium and quite naturally is seen as an abundant source of this valuable metal. The use of this red mud in making clay bricks could well be another concern of this industry. This is where identifying local material for use and applying modern science and technology to bring them to a point where they can be used becomes important.

A recent find in Sri Lanka are vast deposits of apatite phosphate mineral contaning about 35% P_2O_5. The economic potential of this apatite bearing rocks is yet to be realised. One major problem associated with this is the improvement of water solubility and consequent release of P_2O_5 to the soil. Much of the chemistry in the beneficiation process is still to be carried out. The experience of Uganda in establishing the superphosphate industry in Uganda is worthy of emulation. In a contribution to the 'Chemistry in Britain' Mr. Dyson who was a Managing Director of an industrial organisation in Uganda described the saga of development of the apatitite deposits in the Sukulu Hills in Eastern Uganda as a basis for the introduction of a fertilizer industry in Uganda. Such enterprises, he reports, had involved the education and training of skilled operatives and technicians in Uganda. This deposit first recognized in 1939 had to wait until the late fifties for economic exploitation. It is now a flourishing industry making granular superphosophate entirely acceptable to the farming communities of Uganda, Kenya and Tanzania.

In the food industry, much recent interest was shown in the use of cassava or sorghum in the manufacture of bread. The Tropical Products Institute in England has shown that these can be mixed in an almost equal quantity with wheat to give bread of excellent quality. This could be of great importance to some developing countries in saving imports by using locally available materials and even perhaps in efforts to 'fill the protein gap' since bread is one food in which protein supplements are acceptable to consumers. Work is also reported on a new technique for extracting coconut oil and at the same time isolating the protein which is present in the coconut milk—in the established process for obtaining oil via copra, the protein is largely wasted, yet there is often protein deficiency in these areas.

There are scientific as well as economic advantages in developing scientific and technological co-operation on a broader basis than the nation, particularly in a world as small and interdependent as ours. Problems of developing countries present common features where the experience of one developing country could be of mutual benefit to the other. The intensification of economic and technological linkage among the developing countries through both bilateral and multilateral exchange programmes can, to my mind, be of great mutual benefit.

There are one or two other matters which require mention. There is often the psychological aspects of the rather widespread feeling prevailing in most developing countries that anything foreign is superior to anything local. I believe that this pervades in our science and technology. In industry, nothing ensures the success of a product better than a foreign name tagged to it. It is necessary for the scientific community in particular to propagate a new wave of confidence in our own efforts and achievements.

Science and technology are only a part of a complex set of forces moulding society. Scientific and technological progress do not automatically result in human progress. A deeper understanding of the individual and society is important. It is here that the development of behavioural sciences play a useful role. The mental stresses and ailments caused by highly industrialised societies need to be understood so that the developing world would not fall a prey to these disturbing problems. The scientific community in any developing country should take note of the growth of social science areas of sociology, anthropology, economics and other behavioural sciences for the solution of some of their complex national problems.

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One of the most important elements of science and technology policy concerns the training and utilization of scientific research personnel and the consequent relevance of the education system to the requirements of the development of science. The training of scientists and research cadres must be planned taking into account possible changes in the professional structure of scientific labour, as well as the needs for specialized personnel for the various tasks of developing science and technology according to the country's particular conditions. At present much importance is accorded to improving the ability of scientists and research cadres to change from one field of research to another. A solution to this problem may be found in improving the system of training, re-training, a utilizing scientific personnel.

UNESCO BULLETIN

Popularisation of Science

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Science can be considered as the biggest social force of today because scientific knowledge and methods have over the past century changed our manner of living more than any other form of human endeavour. Much of our lives is dominated in one way or other, directly or indirectly, by the scientific discoveries of the present era. Unfortunately, while the rapid advance of science and technology has brought much progress to the developed world, the selfsame science and technology has widened the gap between the developed and developing countries.

It is necessary, therefore, to re-orient science and technology for the solution of basic human needs of the rural poor in the developing countries. It is necessary to create an awareness of appalling problems, such as poverty, ill-health and malnutrition amongst the rural population.

However, the greatest tragedy lies in the fact that working scientists and educated people in the developing countries are getting alienated from the rural surroundings and the problems of the country. There is a massive communication gap between the scientists and the public. This gap is so wide that some people view our present dependence on science and the domination of our lives by scientific discoveries on what seems to them as a materialistic and perhaps directionless effort. Others are possessed with a vague and limited notion of the benefits of science and technology in their lives. Most of such misunderstandings and fears arise due to a limited understanding of what science is and what it is capable of achieving.

In this paradoxical and somewhat conflicting situation, it becomes necessary to have an effective programme of popularisation of science and dissemination of relevant science information. Methods used for dissemination of information have therefore to be geared to national problems and be appropriate to local conditions.

In dealing with unsophisticated illiterate and semi-literate masses, living under different conditions in farflung areas away from the urban-based information centres, one cannot overlook the cardinal fact that such rural masses also have some impressive understanding of some "Scientific Principles" in their own vocations. One cannot underestimate the importance of this traditional scientific heritage as a conditioner for the ready acceptance of additional scientific concepts.

In the developed countries, particularly in the West, there is little tradition to change or destroy in the introduction of modern scientific concepts. However, the greater sense of values and culture inherent in the developing countries, particularly in the Asian region, require a different approach to the popularisation of science programmes in such countries. The needs and priorities are different and the scientist needs to learn what the villager needs most, rather than the scientist teaching the villager what the former thinks the villager needs to know.

It is in the context and general background that a UNESCO-sponsored four-week training course-cum-seminar workshop was held in Manila, Philippines from February to March this year on the subject, "Promotion of Public Understanding of Science, Technology and Environment (PUSTE)"

The meeting at Manila was organised by the Science Foundation of Philippines, which is the official state agency set up with the specific objective of popularising science among the Filipino people. The very existence of this organisation (SFP) indicates the tremendous importance attached by the Philippine Government to the promotion of science consciousness among the people. The Manila meeting had as its field study the Philippine example of promoting PUSTE under the careful and systematic direction of the SFP.

The PUSTE programmes of the SFP aim at disseminating the underlying principles of the basic knowledge in science-developed technologies to the people. With a massive financial input provided by the Philippine Government, the SFP plans and implements research and development activities geared to the development of effective and economical tools for the promotion of PUSTE. There are science promotional officers appointed by the SFP working in every educational region in close contact with regional educational officers. The main target of the activities of the SFP is the youth of the country, for in them lies the hope of the land. The ultimate goal of the SFP is the improvement of the quality of life of the people.

The central pivotal tool of the SFP is the Science Club Movement of the Philippines. Science clubs under the guidance and direction of science club advisers provide the initial spark to budding scientists. Through such science clubs, a host of science popularisation activities are organised and among them mention must be made of out of school science education laboratories, science fairs (or exhibitions) science congresses, science quizes, youth research apprenticeship programs and and the youth science camps.

The SFP has an impressive public information service including hand-books, newsletters, magazines and science films. Several training programs are organized and much encouragement is given to the conduct of academic programmes in universities leading to post-graduate degrees in the promotion of science consciousness.

A science and technology museum, which would provide a focal point for activities related to popularisation of science is being set up shortly.

The participants at the Manila seminar-workshop were thus able to go fairly deeply into the question of the promotion of PUSTE with direct observation of the Philippine example. The workshop brought out as a result of this study, an Asian frame-work for the promotion of PUSTE. This is meant to serve as a model that could serve a useful starting point for the formulation of national programmes. Each country obviously has to map out its own strategy taking into account national priorities and not forgetting existing cultural patterns and traditions.

The seminar—workshop while formulating a series of resolutions and recommendations (and presenting them through UNESCO to national Governments) did recognize that it is no easy task to convince Governments to give more recognition, both moral and financial to PUSTE programmes. Professional and other organizations such as the Sri Lanka Association for the Advancement of Science and the National Academy of Sciences have therefore to play a leading role, both in getting that official recognition as well as getting the large scientific man-power in our midst to take this issue seriously and participate actively in an effective PUSTE programme for Sri Lanka.

The Sri Lanka Association for the Advancement of Science has particularly over the past five years launched a very effective science popularization programme in Sri Lanka. Its special statutory committee for the popularization of Science has during this period conducted a pilot project at Hanwella and is now extending its sphere of activity to other villages in different parts of Sri Lanka. Even more than finance, the Association requires manpower from our scientific community to successfully implement PUSTE programs in Sri Lanka. It is sincerely hoped that the vast man-power we have would offer their services so that we can use them to improve the quality of life of the people of Sri Lanka.

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ENVIRONMENT TASK FORCE MISSION TO SRI LANKA

An Environment Task Force Mission visited Sri Lanka for a period of four weeks in September. The visit was sponsored by the United Nations Development Programme. The primary aim of this project was to assist the Government of Sri Lanka as quickly as possible to take measures to deal with its environmental problems. The Task Force would be augmented by short-term consultants who could render advisory services to and engage in specific problem solving activities on behalf of and in association with the government.

The Task Force consisted of:

Mr. A. G. Menon (India), Senior Co-ordinator Environmental Planner)

Mr. R. C. Stubbs (Australia), Management/ Administrative Scientist

Mr. J. N. Shane (USA), Environmental Lawyer

Dr. K. F. Jebel (Bangaladesh), Environmental Engineer

Mr. M. K. Ranjitsinh (India), Wildlife Specialist

The first three are permanent members of the Task Force. Dr. Jalal was seconded for two weeks by ESCAPE with whom he is an Economic Affairs Officer. Mr. Ranjitsinh was seconded by UNEP.

The Task Force advised the Government on the following:-

1. Existing and proposed legal framework.
2. Organization and administration of an environmental programme.
3. Pollution of air and water.
4. Monitoring and Control: central/regional laboratories.
5. Soil erosion due to forest clearance.
6. Integrated programmes on public education, information and training.
7. Human Settlements.
8. Study Tours.

The Social Role of the Scientist

Osmund Jayaratne

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Book Review

A. Rahman: *TRIVENI: Science, Democracy and Socialism* (Indian Institute of Advanced Study, Simla).

Science policy, which relates essentially to the role and integration of science and technology in the social life and developmental processes within a nation, has grown in recent times into a many-faceted study which includes the history of science, its inter-relations with the social-economic fabric and the role of scientists themselves in the processes of social change. The rapid development of science and technology in the developed countries has posed a serious dilemma for for those countries that remain wedded to the traditional social structures of yesteryear. What is popularly referred to as the Third Industrial Revolution has generated new sources of energy and technologies based upon electronics and automation that give promise of a life of creativity and plenty for all, of leisure and freedom from drudgery, of a flowering of the real potential of the human race. On the other hand, these sophisticated developments themselves, constricted by and interacting with the prevailing social framework, threaten to reduce mankind to a life of poverty amidst plenty, authoritarianism and alienation, along with the ever-possible danger of total nuclear annihilation.

The thesis advanced by Rahman is that while science and technology are conditioned by society and its value system, their development generates major social changes, value systems and ideas.

What should the role of the scientist be in this situation? Should the scientist limit himself to his laboratory and to the exclusiveness of his intercourse with fellow scientists or should he concern himself also with the socio-political processes that, in the final analysis, determine his own activity? Scientists in Sri Lanka have invariably veered towards the first alternative looking on in helpless bewilderment at the policies of governments that fail to understand the role of science and often ignore it in the formulation of national policies. This is a special problem for the under-developed "Third World" countries. However, this dilemma has often manifested itself in the developed countries as well. It was exemplified in the immediate post-war years by the tragedy of Robert Oppenheimer, one of the pioneers of the atomic bomb at Los Alamos, whose crisis of conscience led him eventually to victimisation by the policy-makers of the Pentagon. The role of Edward Teller, the so-called "father of the H-bomb", who encouraged the murderous attacks on Hiroshima and Nagasaki, proves that scientific exclusiveness can only lead to scientists becoming the pawns of designing politicians and to the perversion of the fruits of their own brain-work. Scientific neutrality is a myth, an illusion in the twentieth century with its rough and tumble of clashing class interests, of the exploitation of the majority of humanity by a handful of rich nations. Despite the abstraction and attempted isolation of science and technology from socio-political processes, the problems of choice in scientific research—between objectives and goals of research, of different technologies and scales of investment are, in the last analysis, social and political.

If the objectives and goals towards which science is to strive are to become a vehicle for a different type of society, if culture, values and social organisation have to undergo a radical change, if rationality of decisions is to be part of culture and society, then it is not possible to achieve it within the framework of existing society and the goals for science and technology. Both have to be changed radically. "Scientific knowledge must be made the basis of a new culture, social organisation and political decision-making.....Scientists must transform science into a social movement of radical transformation."

Rahman analyses the dichotomy in attitudes among scientists from a historical perspective-from the time of the Carvaks in ancient India and the Ionians of Greece to the social activists of the contemporary period. Most historical studies of science have been unfortunately in the abstract, precluding an understanding of the interactions of society, culture and the political life of a period with science and technology. It is this lacuna that Rahman seeks to fill through the discerning analysis presented in this book.

Both in ancient India and Greece a sharp struggle existed between "those who aimed to apply scientific method to the study of social processes and the then available scientific knowledge to help in the organisation of society and those who tended to preclude society from the purview of science." This struggle developed in India between the Carvaks and the Brahmanical philosophies and in Greece between the Ionian and later Epicurean philosophies and the Platonic school.

"The basic difference between the opposing trends centred round the question; how to control people?" The Brahmanical and Platonic schools believed that if social organisation was to be effective, men must be made to obey—i.e. controlled. To do so fear must be created amongst them—through myths and superstitions and punishment. Science therefore must be isolated from society and remain the exclusive preserve of an elite. In fact, both these schools represented the interests of narrow ruling class that held a monopoly of wealth and knowledge. They looked down upon physical labour which belonged to the province of the illiterate masses. They preferred to dabble in abstractions, in postulates and hypothesises derived from pure thought. This attitude, arising from the nature of the social milieu, coloured a good deal of Greek science in antiquity.

The Carvaks and the Ionians, on the other hand, advocated that men, instead of being controlled, could be motivated to do things on their own through understanding of phenomena and the laws of nature. For this purpose they tried to establish societies of brotherhood, preaching equality and promoting knowledge. In doing so, their main attempt was directed towards exposing the fraudulent practices of the priests, the myths invented and the role of gods in the affairs of human beings,. They were, therefore, persecuted for their opinions."

With these philosophers, once again, we see social attitudes influencing the scientific approach. Unlike those of the Platonic school, observation and experimentation had a pre-eminent place in their work. Thus, Pythagoras experimented with musical notes. Empedocles proved the presence of air by thrusting a funnel into water.

Under the Ionian and late Epicurean influences, science was not conceived as a discipline limited to the laboratory. It meant an outlook which covered the entire field of natural as well as social phenomena. There were even attemps to use the rationality of sceince to shape society, in contrast to the Platonic philosophers who sought to isolate it from the masses in order to safeguard the privileged position of the social elite.

Today's scientific tradition once again seeks to limit observational and experimental techniques mainly to the laboratory. Rahman advances an interesting hypothesis to explain this: "The storm created by Copernican theory and the punishment meted out to Galileo for advocating it, had created a major social problem for the scientists as to how to avoid the social consequences of theories which came in conflict with religious and social philosophies and outlook. The problem was solved, or rather an escape route was found, by Descartes, as the news of Galileo's punishment came in, by dividing the world into the material, where the laws of science operate and the moral where the edicts of the church prevail. Contemporary science having inherited this legacy continues to operate within the framework of this decision, despite the effort of many from Bacon to our own period."

The scientific community in "Third World" countries such as Sri Lanka, having artificially absorbed the scientific and cultural traditions of the West, follows the same road, perpetuating and reproducing the dichotomy of science in the capitalist world.

However, much as they would like to sojourn in their ivory towers, scientists today are repeatedly brought up against the social consequences of their work —for example, the impact of automation on the employment problem, the rape of our environment or, worse still, the perversion of science by modern imperialism to prepare the destruction of the human race itself. Rahman's book deals with the critical role that scientists must play if science is to be an agency of social progress and not of destruction. Should scientists also be social revolutionaries in the ancient tradition of the Carvaks and Ionians? Or, atleast, should they not acquaint themselves with the socio-political problems of their countries and apply their scientific methodology to effect the necessary changes in the fundamentals of the social order?

Rahman's book is a valuable contribution to the ever-growing volume of literature on science policy studies. As Chief of Planning and Head of the Centre for the Study of Science, Technology and Development at the CSIR in India, Vice-President of the International Council for Science Policy Studies and a person recognised internationally for his work in the field of Science Policy, Rahman's views on science and its inter-relations with society will be of particular value and interest to scientists of the "Third World'. One word of criticism: it is regrettable that a large number of printing errors—dropping participles, etc.—should have crept into this edition. One only hopes that more care will be taken with future editions to eliminate technical shortcomings of this nature. However, this cannot detract from the value of the book and the provocative ideas it advances.

Any information concerning scientific activities, projects and current research as well as comments and viewpoints will be received with the greatest interest. As the publication is mainly for information purposes, the National Science Council takes no responsibility for the views adopted by the authors, the facts presented or the interpretation of these facts.

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