SCIENCE, TECHNOLOGY AND DEVELOPMENT IN ASIA: NEW TRENDS AND OLD MODELS*

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This paper reviews the operation of the science and technology (S&T) for development strategy in the developing countries of Asia since its introduction in the 1960s. It is particularly concerned with the performance of S&T policy-making and planning in promoting the goals of that S&T for development strategy. The various problems which the strategy has faced are discussed, and the subsequent trends, especially towards greater emphasis on S&T policymaking and planning, are explained. The paper concludes by assessing the implications of these problems and trends for the entire S&T for development strategy in the developing countries of Asia.

Keywords: science and technology in Asia, public policy and development, S&T policy-making and planning

INTRODUCTION

After the nations of Asia achieved independence, they all gave a high priority to the promotion of science and technology. There was a pragmatic reason for that high priority which was related to each country's policy for national economic development. Such development policies were essential to the new nations of Asia because they aspired to transform their rural and underdeveloped societies into modern, industrialised economies which were capable of higher productivity and able to provide increased material benefits and higher living standards. A high priority was given to science and technology in the belief that science and technology were means for achieving economic development. History was responsible for this belief, for it had convinced the countries of Asia that science and technology were responsible for transforming Britain, Germany, USA, USSR and Japan into developed, powerful and prosperous nations. That history also indicated that science and technology (S&T) could develop the countries of Asia as well. Therefore, newly emerging nations of Asia immediately gave S&T a high priority

* A revised version of a paper originally presented at the 56th ANZAAS Congress, Palmerston North, New Zealand, January 1987.

in the hope that concentrated S&T investment would introduce development, and its benefits, even more quickly. In essence, history, nationalism, pragmatism, and great optimism all contributed to a science and technology for development strategy in Asia.

Now, looking at Asia's S&T investment in retrospect, it can be seen that the region has been very successful in promoting science and technology. Science and technology have been firmly institutionalised and are evident in every sector of Asian society. This has resulted in S&T capability levels in the 1980s which contrast starkly with those of two or three decades ago.[1] Nevertheless, despite this growth in science and technology and contrary to the hopes and promises which justified the high priority given to S&T promotion, the benefits of development have not yet materialised in most third world countries. Instead, there is much dissatisfaction with the science and technology for development strategy. This dissatisfaction first became apparent in third world countries after the development process, instead of being accelerated by S&T investment, encountered severe and unexpected problems. These problems were so pervasive that they generated a fundamental reconsideration of all the ideas about, and assumptions underlying, development.[2] Inevitably, this also questioned, and reappraised, the role of science and technology in third world development as well.[3]

One important result of this has been to change the original emphasis of the whole science and technology for development strategy. Initially, the thrust of that strategy was simply to promote S&T growth in the belief that, once an S&T capability was established, development would automatically occur. However, with most third world countries now failing to develop as expected, the emphasis of the S&T for development strategy has shifted onto the problems of S&T management and related planning difficulties. Consequently, this has focussed attention on the organisations and public policy processes which promote, plan and manage each developing nation's S&T capability and integrate it with national economic development.

S&T policy-making and planning, and the infrastructure which operates this within the framework of development planning, were conceived as part of the S&T for development strategy. Now, such S&T policy-making and planning processes are found in every country. However, they were very new in the 1960s when S&T policy-making and planning was introduced into developing countries to promote the S&T capability then lacking in former colonies, yet believed to be necessary for future development.[4] This paper is concerned with trends in S&T policy-making and planning in relation to the science and technology for development strategy in Asia. The paper begins by outlining the original S&T for development strategy as well as the S&T policy-making and planning model which was to promote it. Contemporary S&T policy-making and planning in the countries of Asia is then reviewed in the light of problems being experienced by the whole S&T for development strategy.

THE STRATEGY: 'SCIENCE AND TECHNOLOGY FOR DEVELOPMENT'

The aims and assumptions regarding science and technology for development crystallised after World War II.[5] The most important assumption was that a modern economy, which possessed an industrial capacity and a potential for economic growth, could be created in societies which had not previously undergone an industrial revolution. This assumption was based on experience with both planned development in the USSR, where the State had raised economic activity to a higher stage, and postwar reconstruction in Europe where international assistance was used as well.[6] Both these experiences confirmed that national development required capital. They also emphasised the importance of science and technology for national development, and even suggested that they were more essential than capital. This suggestion was supported by history because it affirmed the unique contribution of science and technology to the world since the Renaissance, especially through industrialisation. It was reinforced, as well, by World War II when war once again demonstrated, but on an unprecedented scale, the ability of science and technology to confer political, economic and military power on states. This all resulted in many writers not only claiming that science and technology were important elements in the public policy of nations, but also asserting that they were essential for countries wishing to eliminate poverty and transform themselves through modern development.[7]

Such sentiments about science and technology were widely accepted in the early 1960s, as the United Nations Conference on the Application of Science and Technology for the Benefit of the Less Developed Areas (UNCSAT) confirmed.[8] This conference, held in 1963, was optimistic about economic development and the possibility it offered for social transformation and improvement. It also strongly endorsed the idea that science and technology were essential to such development:

> There can be no doubt that the salient feature of the conference [UNCSAT] was the recognition of a basic truth: that countries can hardly hope to obtain economic independence — and political independence without economic independence is little more than a facade — if their own and autonomous scientific and technical potential remains below a minimum threshold.[9]

Leaders of newly independent countries were already committed to UNCSAT's view of the importance of science and technology for economic development, and their immediate concern was to increase the science and technology capability of their countries. Thus, it is not surprising to find that the main purpose of UNCSAT was "to identify the means by which science and technology could hasten progress in developing countries."[10] It is surprising, however, to find that UNCSAT remains significant twenty-five years later. The reason for the conference's continuing significance is because, after UNCSAT succeeded in identifying the "means" for hastening progress in developing countries through the use of science and technology, it then prescribed a strategy and endorsed a set of beliefs which third world countries adopted and, now, continue to use.

Most crucially, UNCSAT decreed that implementing science and technology for development in underdeveloped countries would be the task of governments, rather than being the task of intellectual scientists or entrepreneurial capitalists as had occurred in Europe. In addition, in order to ensure the utilisation of science and technology for development, UNCSAT advised governments to pursue certain policy objectives. These objectives, though visionary, accorded with the developmental ambitions of newly independent nations:

> A foresighted governmental policy for science will seek two main objectives: to develop the scientific and technical potential on the one hand, and on the other, to apply the creative and assimilation capacities of that potential to the cultural, economic and social progress of the country.[11]

While UNCSAT's objectives were profound, the means for attaining them were very practical and involved simultaneous, integrated action on three fronts. The first front required increased research and development (R&D) so that more knowledge was available to drive the productive sectors. The second required science and technology to be promoted in order to facilitate the increase in R&D capability. The third front required science and technology to be integrated with economic, social and political development.

All the underdeveloped regions of the world, including Asia, endorsed UNCSAT's objectives and took action on the three suggested fronts. In order to implement UNCSAT's complex S&T for development strategy, governments had to create sophisticated institutions which could plan and promote the rapid expansion of science and technology and integrate that expansion with overall national development. Also, governments had to establish scientific agencies capable of conducting research and development in diverse scientific fields, as well as providing necessary scientific and technological support services.[12] Consequently, an immediate task facing governments in Asia was that of creating financial and manpower resources for science and technology, especially R&D. Despite difficulties, all countries found some resources for this and R&D organisations were established on both a specialised, disciplinary basis, as well as on a 'user' basis in sectors such as agriculture, industry, manufacturing, or health. Having done this, the governments of Asia were confident that they had initiated the strategy successfully, for they believed their action would create the indigenous technology which would ensure continued growth in the productive sectors and, ultimately, sustained development and progress.

Thus, when Asian governments implemented this strategy, they unequivocally accepted UNCSAT's explicit assumptions regarding the role of science and technology in development. In addition, they also accepted other assumptions implicitly endorsed by UNCSAT in 1963. These were, for example, that science was universal, that technology was easily transferrable to other countries and cultures, and that the agencies performing S&T tasks in developed countries were suitable organisational prototypes for underdeveloped countries. Furthermore, Asian countries accepted the idea that their money could not be wasted on science and technology. This was because they believed that development would automatically occur if they invested in science and technology within the framework of a national development program.[13] As a result, those countries believed that there would be no need for further government intervention because, once the supply of new technology was secured, the market place would automatically diffuse technology, implement innovations, and resolve developmental difficulties.[14]

All these assumptions, beliefs, and hopes were shared by international agencies which promoted science and technology, such as those of the United Nations Organisation.[15] They were strongly supported, also, by regional organisations, as well as by both socialist and non-socialist developing countries. This unanimity was to prove significant, for it probably explains why countries of the 'South' still remain optimistic regarding the potential of science and technology to promote development despite many setbacks. Those setbacks have included the pessimism induced by theories of underdevelopment and dependency, the shortages of development capital, high interest rates, tariff barriers, global recession, and the developed world's control of R&D.[16] While these setbacks have caused some aspects of economic development to be questioned, nevertheless, the regional trend in Asia is one of continuing national commitment to the promotion of science and technology for development.[17]

This continuing commitment is most evident in the S&T infrastructure that now exists in the countries of Asia. This infrastructure routinely includes S&T policy-making and planning institutions which are responsible for planning, managing and integrating action on the various S&T fronts suggested by UNCSAT. Every developing country in Asia introduced S&T policy-making and planning because it was important for initiating the whole S&T for development strategy. Now, every country possesses some formal system and, while national diversity is normal in Asia, S&T policy-making and planning is structurally and conceptually uniform across the Asian region and is clearly derived from the S&T policy-making and planning model suggested by UNCSAT in 1963 for managing and promoting the science and technology for development strategy. Now, the important question is whether that model is still appropriate for the developing countries of Asia in their present circumstances.

S&T POLICY-MAKING AND PLANNING IN ASIA

This question can be answered despite some initial difficulties. For example, one initial and serious difficulty is that, after decades of experience with S&T policy-making and planning, reliable quantitative data are still not available in many countries. Originally, this was due to the novelty of S&T policy-making and planning in Asia and the fact that many governments did not have the resources to gather data systematically. However, now, that continuing problem probably reflects the essential pragmatism of the UNCSAT strategy which aimed at rapid S&T growth in underdeveloped countries. Therefore, because S&T growth was the goal, the means by which it was achieved such as S&T policy-making and planning were only of temporary significance.[18] Certainly, S&T policy-making and planning was conceptually and instrumentally important to the science and technology for development strategy but, while S&T growth remained the immediate and longterm concern, S&T policy-making and planning was only important as a means and not as an end in itself.

However, even as a mere instrument, that managerial component of the S&T for development strategy was seen to be important and was specifically considered by a 1966 meeting of Co-ordinators of Science Policy Studies which aimed "to identify the common features and general principles underlying science policy in countries with capitalist, socialist or mixed socio-economic systems".[19] The meeting did this, firstly, by defining science policy in terms which reinforced its policy-making and planning role in the S&T for development strategy, as well as re-affirmed beliefs underpinning that strategy:

> *Resolution 1. The Nature of National Science Policies*
> The development of science is one of the prerequisites for social, economic and cultural development. Science policy consists of the sets of general guides, actions and organizational arrangements through which countries undertake to develop science — basic and applied — in harmony with their economic, cultural and political circumstances. Both applied and basic research are important to full national development.[20]

In addition, the meeting laid down general organisational and procedural requirements in its second resolution:

> The development of science policy should be the responsibility of an organization *at the highest level of government* in the country, with *scientists* having a *decisive influence in the formulation of the science policy at all levels.* This *organization should co-operate* closely with other government departments, but *should not be a subordinate organization.*[21] [emphasis added]

These organisational requirements for science policy and for the decisive role of scientists in policy-making were amplified in subsequent resolutions of the meeting. The S&T planning, funding, and managerial functions of science policy bodies were identified in those resolutions, and principles of R&D management and planning were outlined. Other resolutions also specified the skills required by science policy-makers, the functions to be performed by them in the process of national science planning, and the statistical data and other research support needed to guide future policy-making and planning.

Those resolutions amplified the S&T policy-making and planning model originally prescribed by UNCSAT. In retrospect, they now describe the system which substantially operates in every developing country of Asia.[22] However this is surprising because, paradoxically, the 1966 meeting of experts deliberately avoided being prescriptive and only outlined a 'general guide' or 'general principles' for operating a science policy. Indeed, the meeting tried to avoid prescribing a detailed organisational prototype because it believed that specific organisational forms were "influenced by their historical development and their current fundamental political, economic and social institutions. Hence no generalizations relating to preferable organizational structures are possible."[23] Nevertheless, as third world countries pursued UNCSAT's S&T for development strategy they adopted, in fact, very similar organisational forms and procedures for national S&T planning and policy-making.[24]

This uniformity in S&T policy-making and planning in the Asia region is easily demonstrated from a comparison of S&T policy-making and planning now in Asia with that of the early 1960s. This comparison also illustrates the extent to which all aspects of S&T policy-making and planning have been adopted. A regional appraisal of S&T policy-making and planning in the 1960s is provided from reports to a meeting in 1964.[25] Those reports indicated that S&T policy-making and planning in Asia was very elementary.[26] For example, the S&T organisations that did exist in the early 1960s were usually subsumed in national economic planning institutions which controlled all aspects of S&T policy-making. Also, scientists and technologists were only formally involved in S&T policy through representative bodies, such as science councils, whose role was merely advisory. Thus, S&T policy-making was not directly in the hands of scientists and technologists at all. Instead, all aspects of S&T policy-making, planning, and implementation were not only controlled by economic planning bodies, but dominated by them. This domination occurred because there was usually neither an independent national S&T plan, nor any avenue for S&T advice to challenge economic planners.

These structural weaknesses in S&T policy-making and planning during the early 1960s were compounded by the lack of centralised agencies to control and direct R&D in developing countries. On this front, the characteristic pattern was one of research autonomy. The existing sectoral research agencies, private research organisations or universities, all conducted research without any national policy guidance and were only marginally directed by government research funding. Even countries which were relatively advanced in promoting S&T policy-making and planning, such as India, faced major problems in coordinating R&D. The same was also true for Pakistan, for that country reported that its Scientific Commission was only "considering" whether to establish a National Research Council in order to avoid research duplication.[27] The Republic of Korea was one of the regional exceptions, for that country had a Technical Development Bureau in the Economic Planning Board which centrally controlled R&D policy.[28] The Philippines was another exception because it had established a National Science Development Board responsible for ensuring an integrated R&D program.[29]

Such information confirms that the process of S&T policy-making and planning in Asia's developing countries was both embryonic and extremely fragile in 1964. Nevertheless, and in spite of the limited resources available for national development, a high national priority was being given to promoting S&T growth. The priority given to S&T education in the region demonstrates this. S&T education remained a priority throughout the 1960s and 1970s because the developing countries of Asia had lacked skilled manpower when colonisation ended and, as a result, were immediately concerned to train scientists, engineers and technicians.[30] For the same reason R&D was also given a high priority. In the circumstances, however, this priority took the immediate form of institution building with rapid creation of organisations for R&D and for research-related scientific and technological services (STS), as well as for S&T education and training (STET).[31] Thus, for some time, manpower training and institutional development consumed public funds without much actual R&D activity. One interesting and important consequence of this was a skew in the evolution of S&T policy-making and planning in Asia for, in the absence of appropriate machinery, the institutions created to meet the priorities of S&T education and R&D also played leading roles in national S&T policy-making and planning.[32]

During that period of rapid institutional buildup in both R&D and educational facilities in the 1960s, the real spending on actual research was not known. This was because the developing countries of Asia did not possess a planning infrastructure capable of accurately reporting on R&D funding.[33] For example, of the developing countries of Asia attending the meeting in 1964, only the Republic of Korea was able to authoritatively report their R&D funding (0.37% of GDP in 1963).[34] For most countries of Asia, the reality was that they did not possess an R&D infrastructure and were concerned with establishing the R&D system, not with gathering information on R&D. Finally, as the weak central control of science and technology in the 1960s would suggest, developing countries of Asia did not have the capacity to gather data on their national S&T potential, or to monitor trends in its growth. Only Indonesia could claim to be progressing in that regard when it created the Directorate for Science Administration in the Ministry of National Research.[35]

Thus, as expected, the region's S&T policy-making and planning system was quite immature in the early 1960s. With the advantage of hindsight, this is poignantly demonstrated by the exaggerated importance accorded its handful of proclaimed successes. For instance, the Philippines was noted in 1964 for having a much stronger S&T apparatus than normal because it had a National Research Council which directly advised the Office of the President.[36] Another highly regarded example in the 1960s was Indonesia which, in addition to having established a Council for Sciences (MIPI) responsible for supporting and promoting science in 1956, even superseded this in March 1962 with a Ministry of National Research responsible for planning and implementing national science policy during the First Eight Year Plan.[37] This Ministry had Cabinet status and Indonesia was, as a result, regarded as a country with one of the stronger S&T policy frameworks in the region.

So, although Asia's weak S&T capability in the 1960s was complemented by a very rudimentary S&T policy-making and planning framework, the situation in Asia now regarding both S&T capability and S&T policy-making and planning is very different. The extent of this difference was recently highlighted in reports to a regional ministerial conference (CASTASIA II). The information provided on 25 countries of the Asia and the Pacific region clearly shows that the S&T capability level of the countries has risen sharply, especially in science education and S&T infrastructure.[38] Indeed, all countries reported vast increases in research and experimental development and demonstration activities (R&D), in scientific and technological education and training (STET), and in the provision of scientific and technological services (STS).

This expansion involves quite surprising growth in S&T given the limited resources of many of those countries and their relatively recent entry into modern science and technology. For instance, among the 15 countries of the region classified by the World Bank as low income countries, six have programs in atomic energy research, while Bangladesh, India, China(PR) and Pakistan have institutions able to perform remote sensing. In addition, there are national institutions undertaking research and scientific activity which reflects that of the developed countries and international S&T trends; only the very smallest and poorest nations of the region do not have such ongoing S&T activities. Similarly, there has been a vast improvement of human resources in almost every aspect of science and technology as a result of policies which have promoted technical education and created educational institutions.

Furthermore, there is every indication that this significant progress in S&T capability levels will continue.[39] This is clear from national development priorities which envisage future growth in manufacturing and agricultural industries, as well as in advanced heavy or high technology industries. These priorities will require science and technology on an even greater scale in the future for, although every country has its own variation in the weighting and importance of its priorities, their common commitment to development ensures an even greater growth in S&T. All countries, even those whose overall economic development is weak, are adopting programs to promote R&D in frontline, emerging areas such as energy, biotechnology, electronics, or new materials technologies. Despite the considerable variation in S&T capability in the region there is, overall, continuing growth in education and high-level manpower training, continuing expansion of S&T research institutes as gaps are identified, persistent concern to improve S&T management, and strengthening of S&T services.

Not surprisingly, this national commitment to the rapid achievement of development using science and technology has caused S&T policy-making and planning to expand as well.[40] This has been assisted by economic planning which is now firmly and comprehensively established in Asia. These two trends have resulted in S&T policy-making and planning being expanded, and those processes now take place in specialised institutions with clearly delineated functions.[41] For instance, in 23 countries of the region it is possible to identify a ministry, board, national council or commission which directly offers S&T policy advice to the highest level of government. Generally, such agencies also formulate an S&T plan and coordinate the implementation of that plan in cooperation with an economic planning authority. These S&T planning and integrating functions are important and wide-ranging ones which normally involve coordinating the various regions of the country as well as technical agencies within the government and, frequently, organisations from the non-government sector. They also require planning of scientific activity in various productive sectors, which usually involves funding, coordinating and supervising governmental, educational, and private sector R&D.

These S&T policy-making and planning functions are carried out now in every country of the region, yet the functions are highly uniform and clearly derived from the S&T policy-making and planning model prescribed by UNCSAT and the subsequent meetings. This institutionalisation of the S&T policy-making and planning model has been accompanied by a greater appreciation of the importance of such policy-making and planning processes. This is shown by countries such as the Philippines, Nepal, Bangladesh, Pakistan, China(PR) or India, which all give greater importance to S&T policy-making and planning than they did in the 1960s when the overrriding concern was, simply, to promote science and technology in education and to establish S&T institutions. Now, all these countries are concerned to consolidate their institutional framework for S&T planning. This is because they believe that a science policy planning apparatus is even more essential for the successful promotion of science and technology for development than was thought in the 1960s. The result of this increased concern with S&T management is that all countries in Asia currently have a highly formal process for S&T policy-making and planning which attempts to define S&T policy by reference to national development objectives, specifies strategic priorities in S&T and R&D, outlines inputs needed by these priorities, and pursues the explicit goal of using national S&T capability to enhance each country's economic well-being.

Such progress in S&T policy-making and planning would appear to support the view that the original strategy to promote science and technology for development has evolved successfully. However, there is considerable evidence that grave problems now confront this strategy, especially in relation to S&T policy-making and planning. These difficulties were clearly indicated in Country Reports presented to CASTASIA II and summarised in the report of that conference. They included problems of limited funding, social and political ignorance of the potential of science for development, the gap between R&D institutions and productive sectors, poor R&D management, problems with the integration of S&T policy-making and planning, the shortages of skilled personnel to operate S&T management systems, and a general dissatisfaction with the developmental achievements of science and technology.[42]

While these problems are not new, they do suggest another reason for the increased emphasis on S&T policy-making and planning in the operation of the science and technology for development strategy. For it is clear that now, in the 1980s, Asian countries are more concerned with their S&T management rather than with, as in the early 1960s, merely raising their S&T capability level. While raising S&T capability levels remains a concern for all countries, even the newly industrialised countries (NICs), the less developed countries are more critically aware of their inability to deliver the benefits of science and technology to their society and, to overcome this, they look to improved management of their S&T capability rather than just S&T growth.

This concern with failings in the S&T for development strategy, and the greater emphasis on S&T management, embraces many issues. For instance, there are prevailing problems across the region which are attributed either, to confused national policies for applying science and technology to development, or to political interference in the national agencies which decide S&T for development policies and programs, or both. There are, also, frequent allegations that the existing national S&T capability is not being used effectively for national development. All these problems are difficult to isolate from one another because they frequently reflect the dependency of all aspects of Asia's science and technology for development strategy on other important factors. For instance, in 1985, China(PR), Sri Lanka, Bangladesh, Pakistan, Thailand and Malaysia were all experiencing changes in their science policy which derived from wider political or economic considerations. In China(PR), for example, new economic and political policies represented a dramatic departure in national development strategy which contradicted the UNCSAT strategy in many ways. Nevertheless, the new policies were being viewed with considerable optimism by the science community, largely because they benefited the science community in ways which constrasted dramatically with policies of the Cultural Revolution and were being accompanied by increasingly sophisticated S&T policy-making and planning. Another illustration of the complexity of science policy in operation is found in the Philippines before the 1986 revolution. Then, the official view was that the severe economic constraints facing the Philippines had redirected and even sharpened the S&T infrastructure for developmental purposes by introducing a "demand-pull" previously missing in the relationship between productive sectors and the indigenous S&T system.[43] Such illustrations of the interdependency of the S&T system with other factors are common in the region and emphasise, once again, that a successful strategy to use science and technology for development is very dependent on political and economic factors. Certainly, learning this from hard experience has motivated Asian countries to improve all aspects of S&T policy-making, planning and management in order to gain national development rather than continuing to rely, solely, on S&T growth to provide development.

While there has been a shift in the S&T for development strategy to emphasise S&T policy-making and planning rather than just growth in S&T capability, this shift is not just the result of evolutionary trends but, it is suggested, the result of the whole science and technology for development strategy having difficulty in two important respects. The first is internal, not new, and highlights weaknesses in the management of the whole science and technology for development strategy. Examples of such weaknesses are seen in both the persistent inability of S&T policy-making and planning organisations to co-ordinate effectively with economic planning authorities and in the recurring inability of R&D institutions to establish links with productive sectors. However the second is external, new, and highlights the context in which the whole strategy has had to operate. This area of difficulty was reconfirmed at CASTASIA II when developing nations reported that problems with their S&T for development strategy arose due to their lack of control over technology transfer, their inability to control transnational corporations, and their poor capacity for technology assessment and monitoring. CASTASIA II indicated that these problems are so common in the region, and their consequences so grave, that resolutions condemning them were readily supported.[44] Those resolutions suggested that, although the countries should take independent national action through their S&T policy-making and planning process, they must also plan regional action and seek international assistance to cope with such difficulties.[45]

In sum, it is the prevalence of these external and internal problems, and their implications for the whole S&T for development strategy, which explains the new importance being given to S&T policy-making and planning in Asia now.

PROBLEMS WITH THE S&T FOR DEVELOPMENT STRATEGY

Thus, it is suggested that the shift in emphasis from S&T growth to S&T policy-making and planning is not so much a sign of the maturation of the S&T for development strategy as a response to the serious problems Asia's developing countries are encountering in pursuit of that strategy. These problems are so serious and so common in the Asian region that they demand a re-evaluation of the whole science and technology for development strategy.

In re-appraising the S&T for development strategy it is clear that there were three important assumptions in UNCSAT's original strategy. These were, that development could occur in developing countries, that a science and technology capability could contribute to this development, and that S&T policy-making and planning would maximise the potential of science and technology for national development.

The first assumption, that development could occur in underdeveloped countries, has been severely questioned since 1963. While there has been great success in certain NICs such as the Republic of Korea, Singapore or Hong Kong, other countries in the region have failed to develop significantly. Elsewhere, in regions such as Latin America and Africa, the development strategy has also encountered grave problems. Such recurring problems have resulted in two major attacks on the conception of, and beliefs regarding, economic development. One of these attacks was framed in economic terms and challenged beliefs regarding the feasibility of economic growth and development. This radical critique began with the structural arguments of Raoul Prebisch and was extended by both the historical analysis of Andre Gunder Frank and the revived political-economy perceptions of Paul Baran and Samir Amin. It concluded by proposing the dismal truths of 'underdevelopment' and 'dependency' in direct contradiction to the more optimistic view that development was feasible universally.[46]

This challenge to the very conception of development was supported by a second series of attacks which accused development of not being socially beneficial. It was this second attack that severely questioned UNCSAT's belief that science and technology would, inevitably, contribute to development. As it evolved, however, the attack combined several distinct components. One component represented social science critics who were more concerned with development rather than science and technology. These social scientists were characterised by their rejection of the notion of 'convergence' in development and their hostility to the idea of 'modernisation'. Instead, they questioned whether development was linked to social progress and, as well, re-emphasised structural conflict in the development process. As a result, their critique raised fundamental social science questions about the norms and goals of development as well as its social and political costs.[47] These questions were important because they were equally relevant to the use of modern science and technology for development. However, it was not until the second component of this intellectual attack appeared, in the form of the 'appropriate technology' critique of development, that the focus of the critique shifted clearly onto the role of science and technology in development.

This happened when 'appropriate technology' critics attacked science and technology directly, and development indirectly, by arguing that science and technology should be evaluated according to their contribution to human needs and the extent to which they enhanced human control.[48] Initially, their critique was easy to discount because it was always fragmented and frequently technical. This was due to the diversity and complexity of the issues they invoked in support of their views on science and technology. For instance, they drew on issues such as ecological integrity, social impacts and costs, economic externalities, resource renewability, public accountability, or political control. Nevertheless, their critique clearly demonstrated that using science and technology for development produces losers as well as winners.[49] Most importantly, their critique also highlighted a structural bias in the international science and technology system which could operate to prevent developing countries achieving national development. Thus, the appropriate technology critics not only questioned the social benefits of science and technology but also raised serious questions about the whole S&T for development strategy. This was because they supported the 'underdevelopment' school's challenge to the notion of development, questioned international S&T inequity, and re-emphasised political conflict in the S&T for development strategy.

The repercussions from all those critics agreeing that both development, and science and technology, had failed to benefit society were serious for the entire strategy. For instance, this resulted in attitudes on the role of science and technology in development being polarised in ways which contributed to the North-South confrontation at the UNCSTD meeting in Vienna in 1979.[50] Such questioning of the whole social worth of the S&T for development strategy was also serious in relation to S&T policy-making and planning in Asia. The reason for this was that the critique highlighted two critical difficulties which developing countries of Asia now face in using their S&T policy-making and planning system to overcome current problems with the strategy.

The first difficulty is that new technology and knowledge continues to flow from the developed countries into developing countries rather than evolving from indigenous R&D in developing countries. This clearly indicates that indigenous R&D is not operating as a motor to drive national development, though this is what the original strategy to use science and technology for development required. It also results in developing countries being handicapped in using science and technology for development because of their inability to control technology transferred from developed countries,[51] For example, developing nations are not always informed of, or able to gain access to, appropriate technologies. In addition, the developed countries' science and technology are often quite unsuited to the different needs and circumstances of developing countries. For these reasons developing countries are anxious to ensure better communication of scientific information from developed to developing countries, to have greater control over the activities of transnational companies, and to strengthen regional cooperation and multilateral action as an answer to the present global disparities in science and technology.[52]

The second major difficulty identified due to the critique is a public policy one. This difficulty results from developing countries persisting with the strategy to promote science and technology for development by using the 1960s model for S&T policy-making and planning, despite evidence that the model is not operating in most developing countries as originally anticipated. Such evidence is significant because it questions UNCSAT's third assumption regarding the contribution which S&T policy-making and planning would make to promoting the developmental potential of science and technology. It is also significant because there is every possibility that the situation will get worse. This is because, in most countries of Asia, the formal system for S&T policy-making and planning is still being developed and strengthened in accordance with the original 1960s model. This is occurring despite all the evidence that centralised S&T planning and promotion has not produced development in the mechanical way which was expected and, instead, masks a confused, ineffective and fragmented policy process.

This public policy breakdown has always been evident, particularly in the poor integration of political, economic, and S&T organisations involved in formulating and operating S&T policy-making and planning for national development. Such policy-making and planning weaknesses are not exceptional in a region where failed integration seems to be the norm in all except the NICs. Nonetheless, even countries which admit to having difficulties, for instance with integrating the activities of their science policy planning organisations or co-ordinating between S&T planning organisations and economic planning agencies, still pursue a centralised, ideal-type, approach to their science policy planning process. Pakistan, Sri Lanka, Bangladesh, Thailand and Malaysia all illustrate this, for they are all having organisational difficulties with S&T at the moment despite their adherence to the science policy model of the 1960s. In those countries, fundamental questions are not asked regarding the effectiveness of their S&T policy-making and planning system for meeting declared national development objectives.

Instead, debates concerning S&T policy, S&T institutions, or the role of both in national development, are confused regarding both the problems and the solutions. For example, despite the cutback in S&T funding in the Philippines in 1985, the official view was that the role of S&T in national development was even stronger than when S&T were being heavily financed and supported five years before. As mentioned, the reason given for this view was that financial shortages had forced the Philippines' productive sectors to use the latent S&T capacity of the country for the first time. However, if that view were correct, it completely reverses the original conception of R&D as the 'motor' of industrial development. It also directly questions the whole basis on which S&T had been promoted previously by the government! Another case where the whole science and technology for development strategy should also be questioned is in relation to the even sadder and more confusing situation in Bangladesh. There, the S&T for development strategy is in complete disarray and without feasible economic goals. The science community is being criticised by a military-controlled government because that community has, allegedly, failed to contribute to national development. At the same time, the S&T infrastructure has been depleted and now lacks resources and government support. Nevertheless, despite the complete collapse of the science and technology for development strategy in Bangladesh, both the government and the science community persist with the classical S&T policy-making and planning model. This is clear from the science community's willingness to respond to government requests to formulate, even at this late stage in the development process, a national science and technology plan. It is also clear from the government's drafting of policies which, optimistically, aim to promote greater utilisation of indigenous R&D. While those two initiatives appear to conform to the 1960s model, their efficacy is very unlikely in the country's current circumstances for reasons which go to the heart of the original S&T for development strategy's weaknesses.

Such examples of unreality in implementing the strategy are common in Asia. The public policy constraints which surround S&T policy-making and planning are ignored as countries 'muddle through' in their effort to make the science and technology for development strategy work. Despite their difficulties with the strategy, they continue with S&T policy-making and planning and do not suggest that the model is wrong or that its infrastructure should be dismantled. Instead, the S&T policy-making and planning organisations have been institutionalised and fully accepted into the public policy framework of developing countries. Meanwhile, science, technology, and development are still subject to constant criticism both individually and collectively. They are attacked, for instance, because they are inappropriate to the country, ineffective in achieving development, overwhelmed by external forces, or exploited by privileged groups.

CONCLUSION

In the light of all this it is not suggested that the original strategy to use science and technology for national development, and to assist this by means of S&T policy-making and planning, was fundamentally wrong. However, it is suggested that the strategy did contain an elemental flaw. This flaw was that the strategy did not understand or appreciate the process of social change and its associated conflict. This was a weakness which the 'underdevelopment' and 'appropriate technology' critics identified but have not pursued in relation to the whole S&T for development strategy. Now, from the comfort of social science hindsight, that original strategy to promote science and technology for development seems to have relied on either mechanical or magical qualities for success. One result of this was that science and technology were not subject to political questioning while they were considered to be developmental levers which could magically produce a better social future. In addition, S&T management was only seen as marginally relevant to a developmental process which was regarded as automatic and inevitable. Another result was that while development was not subject to harsh questions such as 'what is development?', 'is development socially beneficial?', or 'development for whom?', neither was science and technology, nor S&T management. Incompetence, human greed, or political conflict either were not seen to be involved in the strategy or were regarded as irrelevant. Nevertheless, while the asocial and apolitical defects of such thinking are clearly evident now, the assumption that funding science would inevitably result in enhanced national development and social progress was appropriate to the mood of a post-colonial and post-war era.

Other difficulties with operating the original S&T for development strategy are now also evident. For example, even successful S&T growth has magnified the strategy's problems by creating a formidable 'science community' in most developing countries. This is because 25 years of institutional expansion in facilities for R&D and S&T services has resulted in increased technical manpower. Now the resulting 'science community' is privileged and well able to politically protect itself, often in ways that seem inconsistent with the widespread poverty and inequality which exists in many developing countries. Another difficulty arises from the strategy's success in heightening public expectations from national development, for this has generated greater and even more diverse demands on limited government resources. As a result of such success, expenditure on science and technology is being scrutinised more carefully and S&T priorities are debated fiercely. This situation contrasts with that earlier when governments were given a blank cheque on S&T spending because of development's over-riding priority.[53] In consequence, S&T policy-making and planning now performs in the public policy arena and is subject to political forces, rather than free of scrutiny in ivory tower isolation.

However, if the original conception of S&T policy-making and planning as a benign process which was free of conflict and certain to contribute to national development was merely disingenuous, then current problems have proven the whole strategy to be dangerously misleading as well. Pressing problems, which were unimagined by proponents of the science and technology for development strategy, now confront most developing nations in Asia. Such countries now confront a global R&D and S&T imbalance between developed and developing countries which continues to frustrate their assumption that science and technology would be harnessed by developing countries using their indigenous R&D.

As a result, developing countries should seriously doubt whether a national strategy to promote science and technology for development, no matter how well managed using the techniques of S&T policy-making and planning, can overcome the consequences of structural inequalities between developing and developed countries. This is because a continuing dilemma confronts the S&T policy-making and planning model and its original purpose of promoting the science and technology for development strategy. For instance, if the original 1960s model is to work effectively, then some measure of national isolation is probably necessary to ensure that indigenous R&D can fuel productive sectors over a period of time. However, from the differing experiences of Chile and China(PR) this does not seem to be feasible. If, nonetheless, developing countries do pursue the prescribed path of participating in the global science and technology system then they face real problems in attaining self-reliant, autonomous development or controlling the benefits of that development.[54]

Thus, if past experience is any guide, many difficulties confront countries wanting to gain the developmental benefits of science and technology, and there appears to be no viable way for them to avoid the difficulties. However, while developing countries remain committed to the idea that S&T policy-making and planning offers a fast track to successful implementation of the strategy to use science and technology for development, one option may be for them to adapt the inherited S&T policy-making and planning infrastructure and use it to enhance each country's ability to choose from the international S&T smorgasbord on the best possible terms.[55] However, this is a very different approach from the earlier one of relying on the hidden hand of indigenous R&D to initiate and fuel national development, and it certainly involves very different tasks. Furthermore, even using the existing S&T infrastructure tactically, so as to strengthen technological choice in the developing countries of Asia, still requires the present S&T policy-making and planning infrastructures to be substantially re-adapted.

While it might be pleasing to hope that there are other options which might allow human ingenuity to direct science and technology to social purposes, the sad fact is that the original vision of those who initiated the S&T for development strategy remains, as yet, unfulfilled in most developing countries of Asia. Instead, the pattern is one of muddling along with inherited S&T models and strategies while hoping that eventually, somehow, development will occur and overcome the very social problems which motivated the science and technology for development strategy in the first place. This is an abject situation for, while the present problems with the S&T for development strategy in Asia can be pardoned as necessary lessons in social change or cultural adaptation, there can be little justification for returning to the ethical starting point of the 1960s at this late stage.

Furthermore, it would be foolish for developing countries to turn their backs on the strategy now because Japan and the NICs indicate that the strategy can succeed; anyway the strategy also has too much momentum for it to be stopped. Nevertheless, the strategy does need additional support at the moment, and not only from better S&T management. Asia, and every other third world region, still suffers from colonial legacies or neo-colonial circumstances with regard to every facet of science, technology and development. Also, developing countries are encountering additional obstacles due to the social and political change that they deliberately promote in their developmental efforts. This means that old models for using S&T for development which rely on either S&T growth, R&D inputs, or S&T policy-making and planning, must be strengthened, adapted or supported by what we now know about the external context in which development, science, or technology operate, as well as by what we know about social change. Certainly, the old strategies and models also have to be modified to control the privileges and power which science, technology and development bestow on some countries and people, and the costs which technological change and development exacts from some countries and people.[56]

NOTES AND REFERENCES

1. Unesco, *Statistical Yearbook 1986,* Unesco, Paris, 1986.
2. See, for example, writings by critics such as Frank, Paul A. Baran, Paul M. Sweezy and Samir Amin.
3. For example, Eugene Rabinowitch and Victor Rabinowitch (eds), *Views of Science, Technology and Development,* Pergamon, Oxford, 1975; David Dickson, *Alternative Technology and the Politics of Technical Change,* Fontana/Collins, London, 1974; Charles Cooper (ed.), *Science,Technology and Development: The Political Economy of Technical Advance in Underdeveloped Countries,* Frank Cass, London, 1973. More recently, critics such as A.K.N. Reddy, E.F. Schumacher, Paul Streeten, Charles Moraze, Denis Goulet, Susan George, Frances Stewart and many others have criticised science and technology in development.
4. The early history of science policy in developed nations is succinctly reviewed in Sol Encel and Jarlath Ronayne (eds), *Science, Technology and Public Policy: An International Perspective,* Pergamon, Rushcutter's Bay, 1979; and more extensively in Jean-Jacques Salomon, 'Science policy studies and the development of science policy' in Ina Spiegel-Rösing and Derek de Solla Price (eds), *Science, Technology and Society: A Cross Disciplinary Perspective,* Sage Publications, London, 1977, pp. 43-70; and Ina Spiegel-Rösing, 'The study of science, technology and society (SSTS): recent trends and future challenges' in Spiegel-Rösing and Price, *op. cit.,* pp. 7-42.
5. Salomon argues that it was only after World War II that there was both a "policy *for* science (the provision of an environment fostering research activities) and policy *through* science (the exploitation of discoveries and innovations in various sectors of government concern)" on a complementary basis (*op. cit.,* pp. 45-48). However, the relationship between science and the state was sufficiently evident after World War I, particularly from the experience of the USSR, for J.D. Bernal to discern a future pattern in the relationship as early as 1939. (J.D. Bernal, *The Social Function of Science,* Routledge and Kegan Paul, London, 1939 (re-issued by MIT Press, Cambridge, (Mass.), 1967)).
6. The notion of state capitalism was vital because it could ensure implementation of the economic change described in Rostow's 'stages' or Lewis' 'turning points', and make planned development feasible for third world countries (W.W. Rostow, *The Stages*

of Economic Growth: A Non-Communist Manifesto, Cambridge University Press, Cambridge, 1960; W. Arthur Lewis, *The Principles of Economic Planning,* Dennis Dobson, London, 1949; W. Arthur Lewis, *The Theory of Economic Growth,* Allen and Unwin, London, 1955).

7. For example, J.D. Bernal, P.M.S. Blackett, M.J. Moravcsik, Don K. Price, Vannevar Bush, Stevan Dedijer, Michael Polanyi, Derek de Solla Price.
8. United Nations, *Science and Technology for Development. Report of the United Nations Conference on the Application of Science and Technology for the Benefit of the Less Developed Areas (Geneva, 4-20 February 1963),* (8 vols), United Nations, New York, 1963 (E/CONF. 39/63-I-21-28 [abbreviated herein as UNCSAT (1963)].
9. Unesco, *National Science Policies in Countries of South and South-East Asia,* Unesco (Science Policy Studies and Documents), No. 3, Paris, 1965, p. 9.
10. *idem.*
11. *ibid.,* p. 10.
12. United Nations (1963), *op. cit.,* Vol. 1 'World of Opportunity' (63-1-21), pp. 184-92.
13. *ibid.,* pp. 184ff. The belief that no expenditure on science could be wasted was made very clear by Stevan Dedijer after UNCSAT, and widely accepted (Stevan Dedijer, 'Underdeveloped Science in Underdeveloped Countries', *Minerva* II(1) (Autumn 1963), pp. 61-81, especially p. 73).
14. R.M. Bell, 'Approaches to national science policy', a paper prepared for the ASEAN-EEC Seminar on Science and Technology Indicators and Science Policy, June 13-17 1983.
15. The immediate consequences of this can be gauged from Jacques Spaey *et al., Science for Development: An essay on the origin and organization of national science policies,* Unesco, Paris, 1971. The retrospective significance of the endorsement is shown, for example, by the World Bank's report to UNCSTD (1979) in *Science and Technology in World Bank Operations,* The World Bank, Washington, 1980; and by the United Nations, *The Vienna Programme of Action on Science and Technology for Development,* United Nations, New York, 1979.
16. The World Bank's 'World Development Report', published annually since 1978, has documented the problems with economic development now facing third world countries.
17. United Nations, *Report of the United Nations Conference on Science and Technology for Development, Vienna (20-31 August 1979),* United Nations, New York, 1979.
18. Ina Spiegel-Rösing, *op. cit.,* pp. 16-19.
19. Unesco, *Principles and Problems of National Science Policies,* Unesco (Science Policy Studies and Documents), No. 5, Paris, 1967, p. 7. The participants at this meeting were mostly from European and developed nations, only India represented the Asian region.
20. *ibid.,* p. 87.
21. *idem.*
22. *ibid.,* pp. 88-90; and Chapter 2, 'Planning of scientific and technological policies' in United Nations (1963), *op. cit.,* Vol. III 'Science and planning', pp. 21-28.
23. See Resolution 6, Unesco (1967), *op. cit.,* p. 88.
24. See for example, Unesco, *Structural and Operational Schemes of National Science Policy,* Unesco (Science Policy Studies and Documents), No. 6, Paris, 1967; and Unesco, *La Politica cientifica en America Latina,* Unesco (Science Policy Studies and Documents), No. 14, Montevideo, 1969.
25. Unesco, *Science Policies in Countries of South and South-East Asia,* Unesco (Science Policy Studies and Documents), No. 3, Paris, 1965, Chapter 4. The 14 countries represented at the meeting were: Australia, Ceylon, Republic of China [Taiwan], Hong Kong, India, Indonesia, Israel, Japan, Korea [Republic of Korea], Malaysia, Nepal, New Zealand, Pakistan, Philippines, Thailand, and Viet-Nam.
26. For reasons of comparability and convenience, this infrastructure is reviewed using contemporary categories. See, for example, Unesco, *Science and Technology in Countries of Asia and the Pacific. Policies, organization and resources,* Unesco (Science Policy Studies and Documents), No. 52, Paris, 1985, (Annex A) p. 647.

27. Unesco (1965), *op. cit.*, p. 18.
28. *ibid.*, p. 17.
29. *ibid.*, p. 18.
30. See United Nations (1963), *op. cit.*, Vol. VI "Education and Training", especially Chapter 1, pp. 9-29; and Unesco, *Final Report. Conference on the Application of Science and Technology to the Development of Asia, Part I: Conclusions and Recommendations, New Delhi 9-20 August 1968,* Unesco, Paris, 1969 [CASTASIA I (1968)], pp. 9-17.
31. STS (scientific and technological services), includes services such as scientific and technological information and documentation, library and museum facilities, translation services, surveying and routine testing, standardisation and quality control etc. See the definitions for STS and STET in Unesco (1985), *op. cit.*, (Annex A) pp. 659ff.
32. An important example of this was seen in India's CSIR (Council of Scientific and Industrial Research) which for many years played a major part, nationally and internationally, in science and technology policy issues through its RSPO (Research, Survey and Planning Organisation which, in 1981, became NISTADS (National Institute of Science, Technology and Development Studies)).
33. Japan, however, reported an R&D funding level of 2 per cent of national income for 1962. Unesco (1965), *op. cit.*, p. 16.
34. *ibid.*, p. 17.
35. *ibid.*, p. 15.
36. *ibid.*, p. 19.
37. *ibid.*, p. 15; and Gordon Claridge, *Indonesia's Scientific Infrastructure,* M.Sc. Thesis, Griffith University, 1983, pp. 94-98.
38. See the Country Reports to CASTASIA II (1982) in Unesco (1985), *op. cit.*
39. In 1985, 13 of the countries which attended CASTASIA II indicated that a slowing of industrial growth had not changed their immediate or long term development priorities from those reported at CASTASIA II in March, 1982.
40. See the 'Regional overview' in Unesco (1985), *op. cit.*, pp. 9-20.
41. However in the case of very small countries, such as Samoa, Fiji, Singapore, Hong Kong or Papua New Guinea, the institutions are less specific in their policy-making functions. See the Country Reports in Unesco (1985), *op. cit., passim.*
42. See the Final Report of the CASTASIA II conference, Unesco (1983), *op. cit.*
43. National Science and Technology Authority, *Operationalising the Demand-Pull Strategy in Science and Technology,* NSTA, Planning Service, Manila [Philippines], April 10 1984, (Policy Forum No. 1, 1984 series).
44. See the Country Reports in Unesco (1985), *op. cit.*
45. See the Commission Reports and Final Report, Unesco (1983), *op. cit.*, pp. 135ff.
46. R. Prebisch, *The Economic Development of Latin America and its Principal Problems,* United Nations, New York, 1950; A.G. Frank, *Capitalism and Underdevelopment in Latin America: Historical Studies of Chile and Brazil,* Monthly Review Press, New York, 1969; P. Baran, *The Political Economy of Growth,* Monthly Review Press, New York, 1957; S. Amin, *Imperialism and Unequal Development,* Monthly Review Press, New York, 1977.
47. This vast social science literature has been reviewed in two recent books: Vicky Randall and Robin Theobold, *Political Change and Underdevelopment: A Critical Introduction to Third World Politics,* Macmillan, London, 1985; and Ian Roxborough, *Theories of Underdevelopment,* Macmillan, London, 1979.
48. David Dickson, *op. cit.;* A.K.N. Reddy, 'Alternative Technology: A Viewpoint from India', *Social Studies of Science* 5(1975), pp. 331-342.
49. The writings of A.K.N. Reddy, Ward Morehouse, or Frances Stewart (especially *Technology and Underdevelopment,* Macmillan, London, 1978), illustrate the nature and the significance of this attack.
50. *The Lund Letter on Science, Technology and the Future,* Research Policy Program (University of Lund), Lund (Sweden), December 1979, Letter No. 14+2; and Andrew Jamison, 'UNCSTD — a matter of involvement', *New Scientist,* Vol. 82(1158), 7 June 1979, pp. 830-31.

51. See, for example, the report of the Philippines' NSTA in: *Science and Technology for Development, Philippines Country Report, (A Review of Development in Science and Technology in the Philippines since 1979),* prepared at the request of the United Nations Economic and Social Commission for Asia (ESCAP), National Science and Technology Authority, Manila, Philippines, May 1984.
52. See the CASTASIA II (1982) Final Report, Unesco (1983), *op. cit.*
53. India illustrates this changed public policy context for science policy. Baldev Raj Nayar, *India's Quest for Technological Independence, Volume 1: Policy Foundation and Policy Change* and *Volume 2: The Results of Policy,* Lancers Publishers, New Delhi, 1983, especially Chapters 2 and 4, Volume 1.
54. The dilemmas inherent in this area are identified and discussed in Tisdell's study of S&T policy in OECD countries. (C.A. Tisdell, *Science and Technology Policy: Priorities of Governments,* Chapman and Hall, London, 1981, especially pp. 69-71 and 202-3).
55. A. Rahman and S. Hill, *CASTASIA II. Science, Technology and Development in Asia and the Pacific, Progress Report 1968-1980,* Unesco (SC.82/CASTASIA II/Ref.1), Jakarta, 1983.
56. Social impact assessment (SIA) is one new method for identifying such problems (W. Derman and S. Whiteford (eds), *Social Impact Analysis and Development Planning in the Third World,* Westview Press, Boulder (Colorado), 1985).