SCIENTIFIC RESEARCH, TECHNOLOGY DEVELOPMENT, TRANSFER AND DISSEMINATION: SOME GUIDING CONCEPTS*

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INTRODUCTION

Modernization of the Nepalese economy cannot be envisaged without proper utilization of science and technology in the production of goods and services in all sectors of the economy. The most rational and effective exploitation of physical and human resources for production enlargement requires the application of both traditional and modern technologies. The development, transfer and dissemination of these technologies require quite a sizeable investment in expenditures. Effective utilization of financial and non-financial resources demands a planned programmatic approach towards the use and application of science and technology.

In view of the present needs of the country, highly advanced and sophisticated technologies may not be viable in our context. Nevertheless, the potential of certain sophisticated technologies and their underlying science as accelerators towards development should not be overlooked. The country must have a long range strategy on national development through the utilization of science and technology generated in the country. In our context, some science and technology areas have immediate relevance for the short-run whereas other areas may be considered for the long-run.

There are seven relevant short-term areas:

1. Use of remote sensing for natural resource survey

2. Agricultural bio-technology and genetic engineering

3. Industrial bio-engineering

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4. Modern communications technology, using micro-wave links and geo-stationary satellites

5. Micro-electronics, and electronic data and information management and processing

6. Renewable energy technologies; e.g. photovoltaic, wind, water and bio-energy technologies

7. Systems analysis and operational research; e.g. in modelling and the study of the ecology and environment

In addition to the science and technology areas listed above, there are other potentially beneficial areas which are too numerous to be listed here. To be able to take advantage of the progress made in various areas of science and technology, we have to significantly uplift our present low capability in science and technology (hereafter abbreviated as S&T). The present S&T capabilities should be raised at least to a level conducive towards promoting rapid technology transfers. Moreover, the new S&T capabilities to be developed should be flexible enough so that we can assimilate and develop the needed technologies in the future.

Planning for a rapid enhancement of present S&T capabilities requires the strengthening of national capabilities in a large number of science and technology areas, encompassing a rather wide field. The strategy must be broad enough to encompass not only multi-disciplinary approaches but also broad sets of inter-disciplinary methods which can show immediate results. The improvement of S&T capabilities demands an integrated approach which incorporates the following four essential program elements:

1. The provision of *infrastructure* for S&T activities

2. The provision of *incentives*, and the creation of *environment* conducive towards the promotion of S&T activities and scientific methods

3. The creation of *institutional mechanisms* designed to develop and disseminate science and technology in general

4. The setting up of *institutions* specifically designed for conducting *research* and *development* (R&D) activities in important priority areas

The essential components of infrastructure for S&T activities include laboratories and physical facilities with which to carry out experiments and prototype testing, libraries and information centres, which may cater to the minimum information and data demands generated through S&T activies, and other support services.

Incentive provisions and the creation of an environment conducive to the promotion of S&T activities and scientific methods are a complex and challenging task. There must be a reliable mechanism through which major contributions in science and technology are justly rewarded. It also appears essential to have in operation a central information centre capable of disseminating scientific knowhow and technology in general. Institution programs for conducting scientific and technical seminars, meetings and conferences in important areas of S&T must also be provided for. The other dissemination schemes such as science and technology exhibitions, journals and shows are also needed.

Provisions for institutional mechanisms, specifically designed for transfer and development of S&T, and for dissemination of S&T are highly essential. These institutional mechanisms may have narrow specific areas of focus and yet may combine transfer, development and dissemination activities within the given area. Where such broadly defined activities are not envisaged in the make-up of institutions, new institutions may be required to undertake activities hitherto ignored. New institutions may or may not be created, but coordination becomes essential to the extent that transfer and development activities are not integrated with dissemination activities within a given institution. For this, coordinating institutions may be created and/or existing institutions at higher levels may be assigned the work of coordination. In some select very high priority areas research and development (R&D) activities must be undertaken in the present. Institutions capable of undertaking such research activities must be supported and/or new institutions with adequate capabilities should be developed in such areas.

The improvement of S&T capabilities will be fast when the four major program components, infrastructure, incentives (and environment), institutional mechanisms and R&D activities, can be well integrated with each other. Thus planning and programming for the improvement of S&T capabilities must attempt at determining the optimum levels of effort that must be applied to each of these four components. Any imbalance among these components would entail loss of financial and human resources and would slow down the S&T capability growth.

It may be noted that within each of the four broad areas of program elements, specific areas of importance and priority must be identified and selected to maintain the highest level of complementarity with similarly chosen areas of priority under other program elements. Within each of the broad program element areas, the following type of basic questions must be answered. For example, in the provision of S&T infrastructure, one asks: what kind of infrastructural facility would be most useful to have? The answer to this question can come only when one knows exactly the type of S&T activities that such infrastructure is expected to support. Similarly, in establishing institutional mechanisms, an understanding of the nature of S&T activities to be institutionally carried out is of utmost importance. The need for a certain type of R&D institution ultimately depends on the type of R&D activities which are required to effectively support other S&T activities (in the areas of application or in problem areas).

The above discussion brings forth the conclusion that demands for infrastucture, institutional mechanisms and R&D institutions are all essentially derived from application of S&T in production and in increasing efficiency of services presently existing or having good future potential. A proper balance of the four program elements can be achieved only after completing the following exercise. Such an exercise is aimed at working out backwards, (if one likes to call it so), the demand for infrastructure, institutional and incentive mechanisms, R&D institutions, as derived from the priority areas of S&T application (i.e. technologies of certain types which are relevant in providing solutions to problems).

A purely application-oriented planning strategy, though rationally justifiable on economic grounds, must be soft-footed on account of other considerations. One major fact that has immediate relevance to S&T planning is as follows. It is generally observed that in planning for future technologies, the planners tend to be too optimistic about short-run technologies (one tends to ignore various elements which may lead to failure) and too pessimistic about long-run technologies (one may be in total ignorance of some possibilities which may help in achieving the planned objectives in creating a new technology). Under such uncertainty, it is not rational, even on purely economic grounds, to define an S&T planning strategy only in terms of currently identifiable technologies (and the areas of application). The planning strategy for S&T must be flexible enough to include within it some scope for investment in pure science, which would improve the possibility of the discovery of a hitherto unimagined technology of high value. The other consideration which also demands flexibility in strategy is that access to newly created technology elsewhere is crucially dependent upon the diversification of scientific capability within the country. This consideration has overriding operational significance in formulating a strategy for S&T development.

The present paper attempts to highlight the priority areas for the application of S&T in Nepal. The paper broadly outlines the most important S&T activity components within each priority area. This, it is hoped, will help identify the basics of program elements for operationally defining a comprehensive and coherent program of action for the Royal Nepal Academy of Science and Technology. Such a program of action can be finalized, only after working out the demand implications of identified S&T activities within each priority area for the provision of S&T infrastructure, institutional and incentive mechanisms, and R&D institutions.

OBJECTIVES OF RONAST

The Royal Nepal Academy of Science and Technology (RONAST) has been created to formulate and implement science and technology policies supporting development objectives of the country. These policies also provide a sound basis for formulating

strategies for economic and social development. All economic development policies and strategies are related to identification and exploitation of means through which the existing physical and human resources can be transformed into the fulfilment of needs and wants. The "means" may be very broadly interpreted as "technologies" i.e. application of scientific knowledge and methods. Thus science and technology policies must provide the physical basis for economic development processes. The human and other resources for development may be exploited only after these prerequisites are attained. Thus science and technology policies constitute one of the corner-stones in formulating development strategies.

The following objectives have been formulated for RONAST to catalyze the rapid development of the national economy through the use of science and technology.

1. To increase the capability of science and technology to further the overall development of the country

2. To mobilize science and technology in the development of water resources and other natural resources available in the country

3. To increase science and technology capability in the expansion of industrial and other productive sectors

4. To create an environment conducive to the development of science and technology itself

5. To make policy recommendations to His Majesty's Government in the area of science and technology and to initiate and coordinate science and technology-related activities within the country

To achieve these objectives, science and technology policies need to be reformulated in the light of national goals. In the following section, specific development objectives will be re-examined in order to formulate the most appropriate science and technology policies to be adopted by RONAST.

In what follows, a perusal of national goals is attempted with a view to provide the backdrop against which the current Five Year Plan objectives may be scrutinized. The role of science and technology in furthering the prospects of achieving national development goals could then be specified.

NATIONAL GOALS

The national goals for the development of the country are explicitly enshrined in the constitution as well as in other major policy documents such as the current Sixth Five Year Plan (1980/85). The overall long-term objectives of national development may be listed as follows:

1. To maintain and preserve the sovereignty and independence of our country under the dynamic leadership of His Majesty the King

2. To promote cooperation and coordination amongst various creeds, groups and sectors within the country through the medium of the partyless panchayat system for the creation of a dynamic, just, democratic society free from exploitation

3. To promote the overall welfare of the Nepalese people through the exploitation, mobilization and development of existing human, physical and scientific resources, and in this process, by catering to the basic needs of the people, and to maintain regional balance in the country

Thus the role of science and technology in the process of development is obvious. Science and technology must be applied to the promotion and development of existing human, physical and scientific resources for the fulfilment of the basic needs of the people. The next sections of the paper take up this theme in detail. The Sixth Plan objectives become the starting point for discussion as these objectives are wholly commensurate with the national goals mentioned above.

ROLE OF SCIENCE AND TECHNOLOGY

The role of science and technology is to further the prospects of achieving national development objectives. All science and technology activities should not only be related to the existing and potential production processes but should also be directed towards increasing the efficiency of services. Obviously, science and technology policies cannot be divorced from the overall planning strategy. However, science and technology policies adopted in the country must be inherently different in character from those adopted in more industrialized countries; in our context these are focused more towards the immediate future rather than long-term future. In big countries like India, because of large domestic markets, the fees and royalties for using imported technologies are quite substantial, and it becomes cheaper, in the long run, to develop one's own technology through basic research and establishment of national research laboratories. In the case of Nepal, given its limited market, technology import becomes the cheapest alternative in many instances. Thus the focus on adaptive research is justified in the case of Nepal, because in a majority of cases

the import of technology requires some degree of adaptation of foreign methods and techniques.

Science and technology policies, at present, must lead towards the adoption and transfer of already existing technologies rather than the creation of new technologies. And so, the emphasis should mostly be put on adaptive research rather than on pure research. This, however, should not ignore specific instances where fundamental research may become highly advantageous in the immediate future. The essential function of the present science and technology policies is to provide maximum impact on production within the shortest possible time. This may require a rapid transfer and adaptation of existing technologies and their extensive diffusion. One of the major bottlenecks in rapid technology transfers stems from the lack of manpower. Training programs for technicians thus become a priority area.

Though manpower constraints are often the most crucial constraints limiting S&T capabilities, there are also other constraints which must be eliminated. The other major bottleneck appears to be the lack of facilities, both academic and technical in nature, which must be available for conducting S&T activities. Even for carrying out adaptive research, reasonably good technical equipment and laboratory instruments are indispensable. Similarly, lack of good library facilities and inadequacy of available technical information and data further reduce the effectiveness of existing manpower and laboratory resources. Thus the role of S&T in promoting economic development in the country is severely limited at present. Lack of infrastructure necessary for S&T activities and absence of appropriate institutions to carry out S&T activities in general and R&D activities in particular, appear to be responsible for the present constrained S&T situation.

Thus a back-up program is most essential to improve the existing infrastructure for S&T in the country. It appears that, given the capital intensive nature of modern laboratory facilities, our limited investment capacity urges centralization of sophisticated and expensive laboratory equipment and decentralization of inexpensive laboratory and physical facilities. A similar approach appears necessary in providing for information and library facilities. A central library, specialized to cater to the needs of high level scientists and technologists in specialized disciplines, appears absolutely necessary. Besides, for specific areas that are accorded highest priority, such as water resources development, it may be essential to provide some basic research facility, such as a hydraulic laboratory.

From a broad perspective, it is essential to devise a mechanism for providing incentives to the rare and scarce skills of scientists and technologists. A proper evaluation system of scholarly merit as well as of ingenuity in S&T application must be developed. Major contributors must be duly rewarded to accelerate the development of scientific methods. Conscious efforts should be directed towards the promotion of an atmosphere conducive to the development of S&T. A prerequisite for which would be the ability on the part of competent scientists to secure funds for research to promote S&T application in priority

areas. Such an environment can be created only when an egalitarian approach is taken in planning and coordinating S&T institutions.

ELEMENTS OF PROGRAM STRATEGY FOR RONAST

The basic rationale for determining the broad program strategy for RONAST requires the identification of management, coordination and control activity spheres. Thus the following identifications are put up:

1. Identification of gaps in the infrastructure required for carrying out basic scientific research activities

2. Identification of gaps in the infrastructure required for carrying out technology research activities (i.e. activities which relate to adaptation, transfer and dissemination of technologies made possible through basic research activities

3. Creation of a set of institutional mechanisms and programs designed to fulfil the gap in scientific and technological infrastructure

4. Identification of the elements of a back-up program specifically designed to promote science and technology activities commensurate with national science and technology policies to be adopted at present and in the future. The elements of such a promotional program should be based on the following considerations:

   a) The mechanisms for providing incentives to promote both scientific research and technology research activities (i.e. incentives to individuals, institutions and various groups)

   b) The provision of back-up infrastructure to minimize the problems and hurdles in the promotion of scientific and technological research activities. (The creation and/or strengthening of various research facilities are in focus here. Reorganization of existing facilities may also be desirable in certain areas)

   c) The provision of back-up facilities to facilitate the availability of scientific data and information required in carrying out research activities in relevant areas of science and technology

5. The identification of institutional gaps in relevant areas of technology application and dissemination is also basic to the determination of broad program strategy for RONAST. The priority areas of technology application and dissemination, when identified, should form the basis for identifying the existing gaps and this would make it possible for RONAST to identify its emphases:

a) The creation of technology disseminating institutions

b) The coordination and management of existing disseminating institutions

c) The identification and deployment of non-institutionalized (or semi-institutionalized) methods of technology dissemination (e.g. through market mechanisms and/or through private commercial establishments)

[Editor's Note: This constitutes half of Ratna Rana's article. The balance follows in Chapter 5].