IDRC-133e

ence and technology for development:

planning in the STPI countries

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Postal Address: Box 8500, Ottawa, Canada, K1G 3H9
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Sagasti, F.R.
Aráoz, A.
IDRC IDRC-133e
Science and technology for development: planning in the STPI countries. Ottawa, IDRC, 1979. 178p. :ill.

/IDRC publication/. Compilation on the integration of /science/ and /technology/ into the /development planning/ process of several /developing country/s — examines issues in science and technology planning, and its /economic implication/s; presents /case study/s of science and technology planning experiences. /Bibliography/s.

UDC: 600.001.1 ISBN: 0-88936-182-7

Microfiche edition available

IDRC-133e

Science and Technology for Development: Planning in the STPI Countries

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Contents

1. Science and Technology Planning in Developing Countries

Francisco R. Sagasti

This essay presents some reflections on the nature of and the problems involved in S&T planning in underdeveloped countries. Rather than seeking to provide answers, it highlights some of the issues usually left aside, with the aim of stimulating discussion.

The Context of S&T Planning

In the broadest sense, *planning* is anticipatory decision-making. It consists in making choices for situations that have not yet occurred but are envisioned to occur, are interrelated and interdependent, and are not known with certainty. The decisions are concerned with the generation, identification, and evaluation of alternatives. *Policymaking* can be distinguished from planning because it involves establishing the criteria for generating, identifying, and choosing among these alternatives. *Planning methods* are the procedures followed in fulfilling the commitments made by the planners and in translating anticipatory decisions into actual decisions. A plan consists of statements spelling out the anticipatory decisions taken, their interrelations, and the criteria used in making them.[3]

S&T planning can thus be defined as the process of making anticipatory decisions about S&T development and insertion into the socioeconomic development process. The criteria for making such decisions are derived from S&T policies, which in turn reflect, either explicitly or implicitly, the will of the government and the groups in power.

The growing attention that S&T planning has received during the past few years has distorted somewhat the perspective from which it should be viewed. S&T planning has become a kind of mirage that disappears as soon as the harsh political and budgetary realities are faced. Of course there are exceptions, and on occasion S&T planners have been able to convert some of their visions into realities, but usually in a limited way and only after bruising contact with others in the political process.

When development planning in general is not given great importance by the government, S&T planning is paid little attention. This may be either

[3] For a more detailed explanation of these principles, see Sagasti, F., 1973. A conceptual systems framework for the study of planning theory. Technological Forecasting and Social Change (USA), 5, 379–393.

because such planning is marginal to the socioeconomic life of the country or because the planning establishment — when it commands attention and power — does not consider S&T planning as a significant component of development planning. But even when S&T are considered important, they usually are not awarded the same priority as other social and economic activities. This may lead to a pushing aside of S&T when funds are allocated, particularly in times of economic crisis.

S&T planning requires the active participation of the scientific and technological community, which usually takes place under the stimulus of vague political commitments at the highest levels of government. However, when other pressing issues take precedence over S&T, the scientific and technological community becomes disenchanted with the S&T planners, who are seen as failing to deliver their promises. This may jeopardize the chances for effective S&T planning in the future. Furthermore, there is often a cleavage between the "establishment" scientists and engineers (who obtain resources and funds through their influence on ministries, government agencies, foundations, or foreign organizations, and who resist planning efforts) and the younger scientists and engineers (who see planning as a way of redistributing resources and developing S&T in a more organized fashion, with definite objectives).

These remarks have been made to show the constraints within which S&T planning operates in most underdeveloped countries so that the discussions that follow will not be interpreted as giving S&T planning more importance than it really has. Only the government, if and when it can influence the socioeconomic system, will legitimize S&T planning and, in the face of resource constraints and adverse political pressures, give S&T planners enough resources and political support so that they can maneuver S&T development in the directions they establish.

Economic Planning and S&T Planning

At the outset it is necessary to establish a difference between the planning of S&T activities and the integration of technological considerations into economic development planning. The body of what can be called S&T activities comprises basic research, adaptive research, development, engineering design, support activities such as information systems and special training courses, and so on. It is to these areas — broadly speaking, the generation, importation, and absorption of technical knowledge — that the anticipatory decisions involved in S&T planning are directed.

Economic planning aims at regulating the activities of the productive system and the services related to it. From a particular structure of productive activities postulated by economic planners it is possible to derive the technological implications and, in turn, to examine the types of S&T activities required. The insertion of technological considerations into economic development planning involves both the explicit introduction of these considerations into all phases of planning, and the identification of technology policies implicit in the economic plans. These explicit and implicit aspects of technology in economic development planning shape, to the extent that the plans are implemented, the patterns of demand for technology.

It is not sufficient to devote attention to S&T planning alone, for this excludes the essential component of the pattern of demand for S&T activities. Whether economic planning aims at defining the types of activities in which the state will be involved (through direct financing, allocation of credit, activities of state enterprises, etc.) or at regulating the activities of nongovernment sectors (primarily private industry), the result is an economic strategy in which a technological strategy is embedded and technology needs are defined.

The first task is to spell out the technological implications of the plan, pointing out the types of technology required (for example, to satisfy growth and employment targets, or to exploit natural resources), the constraints imposed by the projects selected, the technical demands imposed by export targets, and so on. The second task is to introduce technology as a strategic variable (in the same way as with other multidimensional variables, such as employment and financing) in the making and implementing of economic plans.[4]

Table 1 lists the types of technological considerations that could be introduced into plans of various levels and durations. Another dimension that could be introduced is the regional, which would add specific environmental conditions to the issues being considered. The linkage between S&T planning and the incorporation of technological considerations into economic planning takes place through several mechanisms, as can be easily inferred from the table. Each type of technological consideration can be associated with a group of S&T activities and hence will affect the process of S&T planning.

Attitudes Toward S&T Planning[5]

The attitudes of scientists, engineers, planners, and politicians to S&T planning are of three types. Although these types are rarely found in pure form in individuals or institutions in underdeveloped countries, such classification does help in understanding the conflicts that emerge in S&T planning.

The first attitude is that of the *liberal scientists*, whose main interest is promoting the growth of science for its own sake; they assume that technology will follow automatically. They resist any intervention in the conduct of scientific affairs as an infringement of the freedom of research. They distrust the idea of S&T planning and prefer to see the evolution of science as linked to the world system for the generation of knowledge. "Science has no frontiers" and "Priorities must come from the evolution of science itself" are two of their favorite slogans. Liberal scientists can adopt a radical stance, rejecting any form of intervention in scientific activity, or a moderate one, accepting that there must be some government interven-

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[4] See, for example, Sachs, I. and Vinaver, K., 1976. Integration of technology in development planning, report submitted to the field coordinator's office, STPI project.

[5] This section elaborates as proposed in Seidel, R., 1974. Toward an Andean common market for science and technology. Ithaca, New York, Cornell University Press. 164p.

Table 1. Technological implications of economic development plans.

Level	Long-term	Medium-term	Short-term
Global	Design of technological styles closely linked to development styles and consumption patterns	Identification of general strategy, priorities for the development of skills and capabilities, and overall targets for resource allocation	Definition of total budget for S&T activities and project
Sectorial	Identification of requirements to build up domestic capabilities in priority sectors	Definition of sectorial strategies and identification of programs for S&T activities	Definition of project activities and budgets linked to sectorial strategies
Project (investment)	Assessment of impact of investment projects and identification of technological constraints introduced (particularly for large projects)	Analysis of components of technology package and identification of those to be supplied locally	Identification of firms and institutions to perform project-related activities (engineering design, adaptation, construction, etc.)

tion expressing preferences about the activities performed. Radical liberal scientists are becoming rare, although they can be found among older renowned scientists who do not face difficulties in obtaining funds for research. Moderate liberal scientists usually become leaders in the scientific community; their view is that the government must support scientific activity and that in exchange scientists must accept general regulations, but that planning is not necessary and that with time the growth of scientific activity will lead naturally to the development of technology.

The *technoeconomists* view scientific activities, and technological activities in particular, as a means for accelerating socioeconomic development and, indeed, an essential component of a development strategy. They view government intervention as necessary to promote the growth of S&T activities and emphasize the importance of national objectives in guiding S&T development, rejecting the "internationalist" view of science. Technoeconomists may come in "pure" form, in which case they play down the importance of scientific activities and favour technological activities, or they may see both types of activities as necessary, although they emphasize technology and accept science only in so far as it is necessary for technology. Technoeconomists are most frequently found among the young technocrats, politicians, and scientists who become involved in S&T planning.

The third attitude is that of the *growth advocates*. Whereas liberal scientists justify the pursuit of science for its own sake and technoeconomists are concerned with the integration of S&T activities into socioeconomic development, the growth advocates do not award S&T activities a distinct role in development. They view technology as part of economic growth and do not care about its origin. Unlike the technoeconomists the growth advocates are not prepared to accept any postponement in the achievement of growth targets for the sake of developing local technological capabilities. Through either open hostility or benign neglect, growth advocates oppose the idea that the acquisition of indigenous S&T capabilities is integral in socioeconomic development.

These different views and interests inevitably lead to conflicts in S&T planning, and they largely determine the impact of such planning. For example, liberal scientists and growth advocates often form a coalition against the technoeconomists, which results in the abandonment of technology considerations in development planning. At best, some of the funds available through established government channels, which are usually at the disposal of liberal scientists, are allocated to the technoeconomists, who are squeezed out of the planning process; and the S&T plan thus becomes an aggregate of research projects.

Technoeconomists may gain the upper hand in some instances, but usually at the price of alienating the liberal scientists and irritating the growth advocates. Initially the liberal scientists may see some advantage in following the point of view of the technoeconomists, particularly because it may lead to additional sources of funds, but later they resist the degree of control that the technoeconomists see as necessary for linking S&T activities to development objectives.

It is usually harder to find common interests between technoeconomists and growth advocates. This may be why technological considerations have not become an integral part of economic planning. To the extent that S&T planning is seen as a separate exercise, growth advocate planners have no objection to it. However, when technology impinges on growth, as it must when being integrated into the economic plan, they reject it flatly. One familiar example of this controversy arises when technological self-reliance is considered a legitimate development objective. The achievement of moderate technological self-reliance requires learning through the performance of engineering and research activities that may delay the completion of a project. This is anathema to the growth advocates, who favour the complete importation of technology rather than facing such delays.

S&T Planning and Resource Allocation

The margin for maneuver of S&T planners is determined by their capability for directing the allocation of resources to S&T. One approach to securing this capability consists in consolidating into an S&T budget the funds allocated by various government departments. This may simply mean listing together in the budget the appropriations made by different agencies and ministries, showing their relation to wider development objectives. In this case S&T planners are just coordinators, with no power to interfere in the allocations made by the agencies: they suggest or induce rather than decide or execute.

A second way of influencing resource allocation is to establish a special fund, fed by government appropriations and managed by the S&T planners. This fund constitutes an additional source of financing for S&T, complementing allocations made by other agencies. S&T planners thus acquire an executive capability, although its impact depends on the relative magnitude of the fund. At times of economic crisis the fund tends to shrink because the activities financed by regular sources demand more aid.

A variation on this approach consists of feeding the special fund from directed appropriations that do not depend on budgetary negotiations. The resources may be obtained by establishing a tax on exports, credits, net income of enterprises, sales, and so on. Resources obtained from enterprises can be managed in a centralized way, or the enterprises can be given a say in the S&T programs to be supported. This approach would grant the S&T planners more room to maneuver and widen their support base.[6]

S&T planners may decide to adopt both these approaches to influencing resource allocation. Certainly the coordinating role is important, but it may prove sterile unless reinforced by the capacity to intervene directly through the creation of one or more special funds.

The Content of S&T Planning

S&T planning is frequently confused with research planning. There is a tendency to leave aside S&T activities other than research when discussing S&T planning; yet research may not be, particularly in underdeveloped countries, the most important component of the S&T plan. Assuming that planning should lead to the identification of S&T activities[7] to be supported with priority so that S&T development objectives can be linked, it should be possible to identify activities as important as, or more important than, research that are related to the importation and absorption of technology (identification and evaluation of technological alternatives, regulation of technology importation, engineering design, technology adaptation,

[6] This is the approach followed by the Peruvian government through a network of sectorial funds and research institutes. For an example see: Sagasti, Francisco, 1975. The ITINTEC system for industrial technology policy in Peru. World Development (England), 3 (11-12), December, 867–876.

[7] For definitions of S&T activities adapted to the needs of developing countries see: Junta del Acuerdo de Cartagena. 1973. Resumen de estudios sobre política tecnológica. Lima, Peru. Sagasti, F. 1972. A systems approach to science and technology policy making and planning. Washington,department of scientific affairs, Organization of American States. Sagasti, F. and Guerrero, M. 1974. El desarrollo científico y tecnológico de América Latina. Buenos Aires, BID/INTAL.

experimentation in plants, etc.), to support services (documentation centres, information services, education and training programs, etc.), and to the promotion of the demand for indigenous technology (use of incentives, of industrial credit, etc.).

There are many ways of defining and classifying S&T activities. One that appears to be fruitful because it spans both S&T planning and the insertion of technology into development planning is to divide the activities into those related to the production of technology, the absorption of technology, the regulation of technology, importation, the supporting services (primarily information and training), and the promotion of the demand for indigenous technology. Given that these categories are primarily linked to technology, a sixth category comprising basic and curiosity-oriented research should be added. Subdividing each category by problem area, discipline, sector, type of activity, and so on, gives rise to the overall spectrum of S&T activities to be considered in planning.

Although S&T planning covers activities that are considered as part of science and others that belong to the realm of technology, the differences between the two types require that they be treated differently. Thus, under the overall umbrella of S&T planning and policymaking it is possible to distinguish between the set of criteria for anticipatory decision-making associated with science and that associated with technology, and hence between a science policy and a technology policy, the two of which are integrated within the framework of S&T planning. Table 2 lists some of the differences between the two types of policy. The confusion between the two has caused problems in S&T planning because the criteria and ways of thinking associated with one have been transferred to the other without consideration of their inherent differences.

The anticipatory decisions contained in S&T plans have usually referred to the definition of S&T activities and the allocation of resources. The idea that a plan is a collection of projects has prevailed in most S&T planning exercises, and this has led to a neglect of other issues involved in relating S&T to development objectives. The most important among these are the anticipatory decisions regarding the institutional structure for the performance of S&T activities, the patterns of interaction with the economic and educational systems, and the definition of a desired image for the development of S&T. The contents of S&T planning should be expanded to incorporate considerations of this type.[8]

The Organization of S&T Planning

The anticipatory decision-making that constitutes S&T planning has certain organizational requirements. Because so many people are involved in each planning exercise, the exercises have adopted the same personnel structure, consisting of a coordinating group with an executive secretariat assisted by a number of technical committees. The committees usually integrate researchers, staff members of the S&T planning agency, and, in

[8] These concepts are elaborated in Sagasti, F. 1973. Towards a new approach to science and technology policy making and planning. Social Sciences Information, 12, 67–95.

Table 2. Differences between national science and technology policies.

Aspect	Science Policy	Technology Policy
Objectives	A. To generate scientific (basic and potentially-useful) knowledge that may eventually have social and economic uses, and will allow understanding and keeping up with the evolution of science	A. To acquire the technology and the technical capabilities for the production of goods and the provision of services
	B. To produce a base of scientific activities and human resources linked to the growth of knowledge throughout the world level	B. To acquire a national capacity for autonomous decision-making in technological matters
Main type of activities covered	Basic and applied research, which generates basic knowledge and potentially-useful knowledge	Development, adaptation, reverse engineering, technology transfer, and engineering design, which generate ready-to-use knowledge
Appropriation of the results of activities covered	Results (in the form of basic and potentially useful knowledge) are appropriated by wide dissemination. Publishing is the way of ensuring ownership.	Results (in the form of ready-to-use knowledge) remain largely in the hands of those who generated them. Patents, secret know-how, and human-embodied knowledge ensure the appropriation of results.

Reference criteria for the performance of activities	Primarily internal to the scientific community. The evaluation of activities is based mainly on scientific merit, and in a few cases on possible applications.	Primarily external to the technical and engineering community. Evaluation of activities is based mainly on their contribution to social and economic objectives.
Scope of activities	Universal: activities and results have worldwide validity	Localized (to firm, branch, sector, or national level: activities and results have validity in a specific context.
Amenability to planning	Only broad areas and directives can be programed. Results depend on the capacity of researchers (teams and individuals) to generate new ideas. Large uncertainties are associated.	Activities and sequences can be programed more strictly. Little new knowledge is generally required, and existing knowledge is used systematically. Less uncertainty is associated.
Dominant time frame	Long- and medium-term.	Short- and medium-term.

some cases, engineers and users of the results of S&T activities. They may be "vertical," dealing with a particular sector, problem area, or discipline, or "horizontal," cutting across these divisions and dealing with issues such as human resources, information, and policy instruments.

The variations among planning exercises arise out of: (a) the power and mandate of the coordinating group; (b) the number, type, and composition of the technical committees; (c) the mandate given by the coordinating group to the committees; and (d) the degree of intervention of the coordinating group and the committees in the implementation of the plan.

The coordinating group may be subordinate to the central planning agency, the S&T planners being part of the agency and reporting to it. But more frequently the coordinating group is given, at least formally, equal status with the economic planners; thus, the S&T plan is supposed to be "coordinated" with the economic plan. However, even when equal status is granted to S&T planning, the disparity of resources, political access, and power relegates it to a secondary position.

The number of committees set up by the coordinating group usually exceeds the number of ministries in the government. With the defence ministries excluded (S&T planning normally covers civil science and technology only), a certain number of sectorial committees correspond roughly to the departments of public administration. Other committees deal with special problem areas (energy, water resources, etc.), basic science (usually subdivided by disciplines), and "horizontal" issues, such as human resources and measures to enhance the productivity of research organizations. One planning exercise may involve several hundred participants.

Differences among S&T planning exercises arise to a large extent out of the composition of the technical committees. The scientific community may dominate the membership, most committee members may belong to government departments, or there may be a balance of planners and administrators, of scientists and engineers, and of users of the results of S&T activities. The implementation of the plan depends on such a balance because S&T activities cannot be carried out through imposition, and the use of their results cannot be forced, which requires that those in charge of making the transition from anticipatory decisions to actual decisions be involved in all phases of planning.

The committees may be given a high degree of autonomy to define priorities, strategies, resource allocation and even specific projects from the beginning, the role of the coordinating group being limited to assembling the committees' proposals. When such a broad mandate is given to the committees it is almost certain that the S&T plan will be derived from a collection of projects defined after hard bargaining among committee members. Another approach is to give the committees, under strong central guidance, the task of defining first a strategy for the sector, problem area, or discipline of their competence, outlining areas of concentration and general priorities. After revision and integration of committee programs the coordinating group may ask the committees to review their programs within a framework of maximum and minimum resources. At this stage the committees may be asked to outline specific research projects to be contracted out, or the S&T community may be invited to present projects in accordance with the program.[9]

The degree of intervention of the coordinating group and the committees in the implementation of the plan will depend on the relative power of the S&T planners and on the resources at their disposal, particularly in relation to the traditional ways of channeling funds to S&T activities through government departments. If the plan is put into practice the committees may be given the task of monitoring its progress in their field of competence. When no role is reserved for the committees after the plan has been designed they may be disbanded, in which case monitoring becomes a function of the coordinating group. For important problem areas or issues that require attention over a long period, permanent committees may be set up under the aegis of the S&T planners and the corresponding government agencies.

Limits of S&T Planning Methods

There exists a relatively large number of methods devised to help S&T planners define priorities and allocate resources, particularly for research activities. Most of them have been used in demonstration exercises, but only a handful have been applied in real situations.[10]

The general impression left by a careful study of the available methods is that theory runs well ahead of practice in S&T planning. Most of the quantitative methods require a wealth of data and introduce many assumptions that simplify the problems to the point of triviality. There is a manifest need for a systematic framework for the analysis of such methods and the value they may have for S&T planning.

In addition to the shortcomings inherent in the planning methods, S&T planners often compound the problem by expecting too much from methods. The technocrat's dream in which S&T planners plug data into a model to define priorities, resource levels, and projects, never becomes reality.

With regard to the identification of priorities, a few rules may provide some guidance. The first is to diversify as much as possible the sources of priorities, examining initiatives from the S&T community, problems posed by the users, government policies contained in the plan, invariant problems that will remain important for long periods, concerns arising out

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[9] A highly imaginative and successful exercise of this type is reported in Quinn, J.B. and Major, R. 1974. Norway: a small country plans civil science and technology. Science (USA), 83, (4121), 18 Jan, 172–179.

[10] See: Cetron, M. and Goldhar, J., eds. 1970. The science of managing organized technology. New York, Gordon and Breach. Sagasti, F., 1972. A systems approach to science and technology. New York, Gordon and Breach; Sagasti, F. 1972. A systems approach to science and technology policymaking and planning. Washington, department of scientific affairs, Organization of American States; Maestre, C., and Pavitt, K. 1971. Analytical methods in government science policy. Paris, Organization for Economic Co-operation and Development. An annotated review of the literature has been prepared by W. Mostert and will be published by the Escuela Superior de Administración de Negocios, Lima, Peru.

of short-term social or economic problems, and so on. Priorities for S&T activities should reflect an interplay of various forces, rather than the planners' views.

The second rule is to avoid treating the development plan as the primary source of priorities for S&T activities. There is no automatic relation between economic development priorities and S&T priorities. Their time frames are different, and giving too much importance to the economic development plan may lead to the ignoring of key contributions that S&T can make to development. There are probably many projects that are not included in the economic development plan because the necessary S&T capabilities are not available. If S&T priorities are extracted from the development plan the necessary knowledge may never be acquired.

Determining the appropriate level of resource allocation for a sector, problem area, or discipline has been a perennial problem of S&T planners. Allocations for existing activities are limited by the absorption capacity of the S&T system, and by the minimum needs of the programs. For new activities the limits are difficult to establish, although they can be related to the possibility of assembling a team of scientists and technologists that can absorb the resources without undue waste.

Concluding Remarks

S&T planning in underdeveloped countries is just beginning. It has not yet been fully legitimized and confronts the double opposition of liberal scientists and growth advocates. Therefore, S&T planners find it difficult to introduce technology considerations into economic development planning and to guide S&T activities. To perform these tasks adequately it is necessary to pay attention to the organization of S&T planning and to devise practical procedures to simplify the process of planning.