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NATURAL RESOURCES IN LATIN AMERICA: ASPECTS OF RESEARCH AND DEVELOPMENT, IN RELATION TO ECONOMIC PLANNING *

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Introduction

The role of natural resources in the economic development of Latin America and its implications for the planning process have constantly engaged the attention of economists both in the Secretariat of the Economic Commission for Latin America (ECLA) 1/ and in the Latin American Institute for Economic and Social Planning (INST). 2/

> "Development plans must be based on practical and viable possibilities; they will therefore gain in precision and scope from a more complete and thorough knowledge of the resources of the country concerned." 3/

There is a shortage of the facilities that can be mobilized in order to acquire a more complete and thorough knowledge of a given country's natural resources. Moreover, this aim must be more clearly defined in relation to the ultimate objective: economic development.

Economic development planning techniques should include provision for the planning of research on natural resources, and this presupposes co-ordinated action on the part of professionals in three different fields: economics, natural sciences and technology.

The lack of such co-ordinated action has been largely due to the want of a clear definition of common objectives capable of inducing specialists in these three fields to pool their efforts. Economists, scientists and technical experts have to find a common language and keep up a constant exchange of views if this aim is to be fulfilled. Consideration must

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1/ See Los recursos naturales en América Latina, su conocimiento actual e investigaciones en este campo (E/CN.12/670), 1963.

2/ See Report of the Seminar on Natural Resources and National Planning (INST), 1962.

3/ See Progresos en materia de planificación en América Latina (E/CN.12/677), 1963, p. 35.

/also be given

also be given to its implications in respect of three different systems: the national planning and decision system, whereby demand is defined and decisions as to the use of economic resources are adopted; the executive system, whereby plans are translated into terms of concrete achievements; and the research system, which provides the groundwork of information needed for the operation of the other two.

The scientists and technical experts have to express the findings of their research in terms of data that can be handled by the economists, and these, in their turn, have to brief the research workers on orders of priority within the main fields of study, in order to ensure that the limited means available for research on natural resources and technology may be so applied as to produce maximum results in the shape of economic and social benefits.

The present document represents a contribution to the elucidation of the problem and to the suggestion of possible lines of action.

1. The concept of natural resources

" Man's potential is quite terrific,
You can't go back to the Neolithic.
The cream is there for us to skim it,
Knowledge is power, and the sky's the limit.
Every mouth has hands to feed it,
Food is found when people need it.
All we need is found in granite,
Once we have the men to plan it.
Yeast and algae give us meat,
Soil is almost obsolete.
Man can grow to pastures greener
Till all the earth is Pasadena.

Moral:

Man's a nuisance, Man's a crackpot,
But only Man can hit the jackpot. "

Kenneth Boulding4/

In primitive societies, production depends mainly upon human and natural resources, and increases at the same natural growth rate as the population. The combination of a low level of technology with a limited

4/ in Man's Role in Changing the Face of Earth, University of Chicago Press, 1956

/supply of natural

supply of natural resources results in diminishing returns. In modern societies, however, the general picture has changed considerably; in the contemporary economy, the process is much more complex, in so far as the incommensurable factor represented by culture (in the anthropological sense of the term) has metamorphosed scales of values and production functions. Technology has paved the way for capital goods and manufactured products to take the place of manpower and likewise of some natural resources. The accumulation of capital goods, and the more efficient utilization of these and of other industrial products, have broadened development horizons. Until a short time ago, energy threatened to become a factor which would set absolute limits to the progress of human society. This threat has been virtually dissipated by the prospects which nuclear research has opened up. Once all the energy that mankind can use is available at economically satisfactory costs, every physical barrier to development will have been demolished.

Given plentiful supplies of low-cost energy, substitutes can be provided for any natural resource of which there is a shortage. Sea-water can be converted into potable water by the use of power in the distilling process; hydroponics and artificial light enable crops to be grown in skyscrapers. The technical know-how that man already possesses has shown such expedients to be viable.

Hence it is clear that as economic and cultural development progresses the relative importance of natural resources declines.

However, the conditions in which the conquests of science and technology can be turned to account on an increasing scale are not uniformly distributed throughout the world. This heterogeneity of background has further aggravated the existing disparities, not only between the developed and the developing countries, but also within the less developed countries themselves.

In Latin America, one-half of the population still lives at the most primitive of cultural levels, in a pretechnological subsistence economy

/where belief

where belief in magic has not yet died out, while cybernetics are taught in the region's universities, in its institutes the physicists are discovering new components of the atom, and its industry is introducing automation.

In formulating development plans, economists must make due allowance for this characteristic heterogeneity of the substratum on which they have to base their work, and for its implications as regards the exploitation of natural resources.

In some respects, the planner should adopt much the same approach to natural as to human resources: or, more explicitly, to human resources at the starting-point of the economic cycle, when they are viewed from the angle of production, i.e., as manpower, not at the close of the cycle, when they are regarded as consumer potential.

Human and natural resources alike are primary factors of production, playing a part in all sectors of the economy, and for the purposes of planning their use, censuses, surveys and a whole range of statistical studies must be carried out in order to evaluate their potential in both quantitative and qualitative terms.

At this point a query arises: while human resources increase, will natural resources remain stationary? In order to reply to this question, a distinction must be drawn between nature and natural resources. Nature as a whole can be considered comparatively stable if the yardstick adopted is a time-scale related to the life of man. When that part of nature which can be incorporated into the economy is envisaged as a natural resource, the factors determining its incorporation - knowledge of resources and means of using them - may grow as time goes by, and their growth, for economic purposes, is equivalent to an increase in the resources themselves.

In view of the complexity of natural resources and of the production functions in which they play a part, and considering, moreover, how little is known of them on the whole, it is almost platitudinous to state that a

/proper plan cannot

proper plan cannot be drawn up unless a complete inventory of natural resources is available.

"A complete inventory of natural resources" is a somewhat equivocal expression, since the entire content of nature cannot possibly be listed. Part of it can be measured and part can be described. The range of detail included in measurements and descriptions alike can be extended virtually ad infinitum.

In order to obtain information on natural resources, it is necessary to invest other resources of which there is a shortage, such as skilled personnel, equipment and laboratories. The minimum amount of qualitative and quantitative data that will suffice for the attainment of the desired ends must therefore be established in advance. In other words, research on natural resources must be planned in such a way as to avoid squandering other resources on activities whose results will serve no practical purpose.

1.1. The integrated concept of natural resources

When a natural resource is to be incorporated into the economy, consideration must be given to its location and consequently to its spatial relationship with other resources, together with all the implications involved.

A given resource cannot be developed without prior study of others that are closely associated with it, or whose characteristics and interrelationships must be known before the first can be exploited. In planning the development of a mineral deposit, the aspects that must be considered include not only the physical and chemical characteristics of the mineral in question, the situation of the deposit in relation to relief and its overload (soil, water, forest), but also the additional knowledge of natural resources that must be brought into service in order to open up the approach roads by which to-and-fro transport between the

/industry and the

industry and the market can be effected; water and energy requirements for the project; and the resources that will have to be mobilized to provide adequate living conditions for workers on the development site.

Thus a mining project must be based on cartographical, geomorphological, geological, hydrological, pedological and other surveys, i.e., on an integrated study of the resources existing, in the area to which the project relates. Obviously, it is the geological studies that will be of chief importance and will have to be the most thorough, since the mineral deposit is the resource that gave rise to the project in the first place.

Natural resources must be considered from the standpoint of geography, and accordingly, the true natural resource is the land itself. What are generally regarded as resources, - water, soil, forests, minerals, etc. - must rather be taken to constitute "resource factors" which are the components of the true resource, i.e., the land. This concept has been developed in practice by Australian scientists under the direction of C.S. Christian, of the Council for Scientific and Industrial Research Organization (CSIRO), who has described it in a recent work 5/ from which the following extracts are quoted:

> " Land must be considered as the whole vertical profile at a site on the land surface from the aerial environment down to the underlying geological horizons, and including the plant and animal populations, and past and present human activity associated with it."
>
> " The many features of this total profile vary from site to site and their many combinations and interactions result in a vast array of land types, each with its own potential and limitations for agriculture or forestry, each presenting its own specific barriers to the achievement of maximum plant or animal production. Rarely does one feature alone determine productivity.

5/ C.S. Christian and G.A. Steward, Methodology of Integrated Surveys, UNESCO, Paris, 1964.

/It is the

> " It is the combination of all that is important, and if we are to understand land we must think of it in terms of this complex rather than only of the individual components of it".
>
> " This complex constitutes the habitat at any site, and it is the total complex which governs production possibilities and limitations, defines the technical problems which need to be solved by research, and determines what additional resources must be used to supplement the natural resources if the optimum level of economic production is to be achieved.
> It is this complex at each site, therefore, which is the true resource rather than the individual resource factors that compose it, and it is the variation in the complex from place to place rather than variation in individual factors alone that gives different potentials for development".

This idea is of great significance both from the standpoint of the development of resources and from that of their study and evaluation.

The importance of the integrated concept of natural resources is obvious when an area is to be developed for the purposes of expanding economic activity. This expansion can be effected not only through the incorporation of new areas as yet undeveloped, but also by the more efficient utilization of areas already in use. In these cases, it is not a matter of exploiting a specific "resource factor" but of developing all the resources existing in the area, so that integrated knowledge of these becomes essential.

The technique of integrated surveys of natural resources is being developed intensively of late in all parts of the world, mainly as a result of the increasing use of aerial photography. It is diametrically opposed to the traditional technique of carrying out geological, botanical, hydrological and other studies in isolation. Apart from the fact that integrated studies represent economies of scale, they have the great advantage of enabling an area's potentialities to be better evaluated inasmuch as knowledge of the interaction of the various "resource factors" is simultaneously acquired.

/"Natural resource

> " Natural resource stocktaking and assessment are not just a mere identification, inventory, and mapping of individual resource factors with a once-for-all determination of development possibilities. As information about individual resource factors in isolation is of little value, and balanced information about all resource factors in each subdivision of the landscape is necessary, there is need for teamwork involving a number of specialists, and integration of thought and effort at all stages." 6/
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> (Christian and Steward, 1964)

1.2. Natural resources: supply and demand

As a result of the progress of science and technology, the long-term significance of the expression "natural resources potential" has become merely relative. In the writer's opinion, the supply of natural resources should be understood to mean those possibilities of developing them on economic lines that are opened up by surveys and research. Thus, over the very long term, the potential supply would be virtually limitless, although efficient exploitation would depend upon demand and upon the human resources and capital available.

Economically speaking, the progress made in surveying resources and in the technology whereby they can be incorporated into the economy will be tantamount to an increase in the supply of natural resources.

Existing surveys of a country's natural resources, together with the corresponding technical know-how, constitute what might be called the "actual supply" of resources, in addition to which a "potential supply" must be considered, definable in terms of merely conjectural resources whose existence is inferred from empirical indications, such as correlations with other properly surveyed areas displaying features similar to those of the area in question. The fact that the level of

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6/ Methodology of Integrated Surveys, op. cit.

/knowledge

knowledge obtainable in respect of an area or a particular "resource factor" may vary greatly, both in breadth and in depth, makes the concept of the "actual supply" of natural resources decidedly elastic. At a later stage in the discussion there will be an opportunity of elucidating this concept and its quantitative implications.

The decision to develop a natural resource is generally motivated by supply. "There is a push for the sale of the idea, the project, the service, before demand is considered". 7/ This is largely due to a piecemeal approach on the part of those responsible for the basic ideas underlying the project, and is a common occurence when the person concerned is a specialist in a restricted field of research, such as, for example, a soil expert who comes across an exceptionally fertile area and sells the idea of a land settlement project without taking the other factors into account.

Economists and planning experts are trying to modify this tendency in the direction of strengthening the influence of demand on decisions relating to the execution of projects.

If the supply of natural resources is plentiful, or, in other words, if a given country has made an over-all survey of its resources and possesses the technical know-how for their economic exploitation, the task of the planning expert will be facilitated, since he will have a wide choice of possible investments from which to select those likely to maximize the social productivity of the limited capital available.

This situation is found in the developed countries, where research on natural resources and technology has reached a very advanced stage, but in the developing countries a different state of affairs prevails. Broadly speaking, their knowledge of their own natural resources is unduly fragmentary, and while in some of them the "potential supply" is

7/ See Report of the Seminar on Natural Resources and National Planning, op. cit., Appendix C, p. 6 (statement by Mr. Stephen Robock, Professor of International Business, University of Indiana).

/substantial, as

substantial, as is usually the case in countries with a low population density, the "actual supply" is very limited.

In Latin America the development of natural resources has followed two different courses. On the one hand there are the subsistence economies which date back to the pre-Columbian period and still absorb approximately one-half of the population of the continent; and on the other, the outward-directed market economies which started with the exploitation of metals, precious stones and forest products, undertaken by the colonizers themselves on the basis of their own investment, and then went on to the cultivation of crops such as sugar, tobacco, and, at a later stage, coffee and cacao, as well as to livestock production.

The quest for metals and precious stones spread over practically the whole of the continent, and the expeditions were frequently accompanied by naturalists and reporters who wrote a great deal about the "New El Dorado". The high estimates of the "potential supply" of natural resources in some of the Latin American countries are due to these frequently exaggerated accounts.

The location of the market economies in Latin America was determined by the presence of deposits of precious metals, by natural ease of access, by the availability of suitable points on the coast for loading and unloading operations, and only secondarily by the existence of areas appropriate for agriculture, which became a more important activity when Latin America developed into an exporter of agricultural raw materials.

As up to the middle of the twentieth century the highest productivity in the Latin American economy was registered in the export sector directly associated with natural resources, not much interest was felt in the promotion of studies outside the areas which were of immediate importance for export activities. In some parts of the region, and in respect of certain "resource factors", a reasonably satisfactory body of information exists, while elsewhere, particularly in the areas where a subsistence

/economy prevails,

economy prevails, practically nothing is known of the natural resources.

The factors restricting the "actual supply" of natural resources in Latin America create a difficult situation for planning experts who have perfected their set of instruments under the scientific and technical influence of the developed countries. Given a limited supply of capital, a limited supply of natural resources and a limited capacity to increase the "actual supply" by means of the traditional research system, the region must adopt a special strategy of its own.

In some of the Latin American countries a more accurate term to apply to the situation might be a "biased supply" of natural resources.

The traditional research systems which constitute the mainspring of the "actual supply" of natural resources were built up basically in order to satisfy external demand, and only recently are attempts being made in some countries to adapt the system to the new circumstances.

In Bolivia, for example, while geological research and cartographical surveys are reasonably advanced where mining is concerned (that being a sector directly linked to the external market), research on other resources is still at an embryonic stage. The same situation is observable in several countries. In Peru, the reserves of metal ores that have been identified and measured represent a volume about three times greater than the country's capacity to exploit them, while a start is only just being made on soil surveys in the Selva (or jungle area), whose development is essential for Peru's economic growth.

The Latin American countries' need to develop an internal market over and above their external market is introducing radical changes in the structure of production, which result in an intensification of demand for natural resources in whose case the "actual supply" is insufficient. As the "actual supply" was produced by a system and in a structural framework which are not adapted to present conditions, it can be described as "biased".

/2. Projects for

2. Projects for the development of natural resources

Development plans, if their objectives are to be attained, must be translated into terms of projects, which, in the field of natural resources, may vary widely both in scope and in complexity. As was previously pointed out, natural resources play a direct and indirect part in all sectors of the economy, but specific projects for the development of natural resources should be taken to comprise those directly relating to the physical basis of the economy and designed to meet a demand for goods or services, or to incorporate into the economy additional resources identified in the surveys, whose exploitation may open up new development prospects through the expansion of demand.

The whole evolution of a project, from the generation of its basic idea to the production phase depends upon the contribution made by professionals in various fields, working in different institutions.

The fields of action concerned, and their respective contributions to the project, are tabulated below.

FIELDS OF ACTION IN THE DEVELOPMENT OF PROJECTS

Field of action	Contribution to project
Research	Methodology; basic ideas for projects; solution of technological problems
Surveys	Field work to obtain basic data
Engineering and economics	Designing; evaluation of technical and micro-economic feasibility
Economic planning	Definition of demand; evaluation of macro-economic feasibility; consistency with economic development programmes
Policy	Decisions as to priorities and allocation of resources for preinvestment phases and for the execution of the project
Execution	Implementation and operation of the project

/The formulation

The formulation of projects for the development of natural resources depends upon the existence of an "actual supply", which is represented by the inventorying and evaluation of resources.

2.1. Inventorying and evaluation of natural resources

Research on natural resources is conducted in two different fields. In one, the aim is to quantify, with progressive degrees of accuracy, inventories 8/ of natural resources; in the other, the object is to determine the interaction of natural "resource factors" among themselves and in combination with other resources possessed by the economy, with a view to their economic exploitation. The first constitutes the inventory resulting from surveys and research at the level of the natural sciences, and the second, technological research.

2.1.1. Inventories of natural resources

The term inventory is applied to maps and/or tabulations showing where natural resources occur and defining them in qualitative and quantitative terms, with varying degrees of precision and on different scales. Inventories should be drawn up in accordance with the classification systems (taxonomy) internationally accepted for the sciences concerned, so as to permit comparison between areas and "resource factors" and the establishment of correlations at the world level.

Inventories are presented in physical terms, and in their preparation the possibilities for economic exploitation of the resources listed are not a basic concern. They are permanent documents, such as topographical, climatic, geological, hydrological and pedological maps, or maps showing

8/ The word "inventories" is not used in the restricted sense of "exhaustible resources", but also with a dynamic meaning that includes flow resources and biological or renewable resources.

/flora and fauna,

flora and fauna, but their permanence does not mean that they are static. They must be constantly evolving; maps should be drawn on increasingly large scales, statistical tabulations and data should be prepared with progressive degrees of precision, or the classification systems adopted should be modified, in accordance with development requirements.

Inventories as such cannot be directly used by planners; an evaluation of resources must come first.

2.1.2. Evaluation of natural resources

In order to convert the inventories, which are lists of available natural resources, into data whereby their value in economic terms can be established, i.e., for the purposes of evaluation, the existing technical know-how, and the alternative possibilities for applying it in the exploitation of resources, must be taken into consideration. As technology varies in the course of time, so too the evaluation of resources will be variable, in contrast with the permanence of the inventories.

The evaluation, like the inventory, can be prepared on different scales and with varying degrees of precision. If the technology for exploiting the resources concerned is familiar, a preliminary evaluation is usually made concurrently with the inventory.

When the techniques suitable for the exploitation of a specific resource in the natural conditions in which it is found are not known, special research and experimental work must be carried out before an evaluation can be made. The findings of the evaluation and the alternative techniques applicable are the data that are of interest to economists and planning experts. These data enable the inventories to be restated in terms of alternative production possibilities.

/2.1.3. Degree of

2.1.3. Degree of precision of inventories

For the purpose of development planning, inventories of natural resources can be classified at a number of levels according to the precision with which surveys are made. Each level suits the requirements of one stage in the process of project design, which proceeds by successive steps.

The following levels have been considered:

(i) Exploratory

The exploratory survey is based on the information available contained in a document prepared by a group of experts with a minimum of field control, corresponding to a definition of the "potential and actual" supplies of natural resources. The survey includes a brief description of an area, country or region, indicating its main geographical characteristics and the current utilization of its natural resources. It is an inventory with a high degree of generalization. Studies such as these are useful in providing basic ideas for the preparation of projects. Their high degree of generalization demands adequately qualified professionals and not specialists in a narrow field of learning. As an illustration of an exploratory survey's degree of precision, it can be mentioned that the maps that supplement it are usually drawn to the scale of 1:1,000,000 or even smaller, and thus do not require great cartographic precision.

(ii) Reconnaissance

Reconnaissance surveys are carried out in selected areas with a view to determining their main natural resources in approximate quantities, so that at the evaluation stage, it may be possible to define the scope of projects properly. Exploratory surveys should be used as the starting point to select the areas to be surveyed, which may be river basins, geological formations, political units, or others. According the particular purpose of the reconnaissance.

Reconnaissance surveys should be carried out by highly experienced professionals who are capable of taking the broad view in their work, or by interdisciplinary teams, since unsuspected development possibilities may thus be brought to light that would have remained unnoticed by a single specialist in a field other than that in which the discovery is made.

Reconnaissance studies have the advantage of singling out, at a relatively low cost, the major areas or resources of interest for development purposes and thereby indicating where more investment should be made in studies, whereas the areas that hold out no prospects for development in the foreseeable future can be discarded and unnecessary expenditure avoided.

As these studies have a scientific basis, they are acceptable to politicians and have proved to be the most effective means of arousing interest in hopeful projects and distracting attention from those that, while often imaginative and seemingly full of promise, are based on false premises. In view of the influence that reconnaissance studies should exert on political decisions, special care should be taken not only in establishing the priorities for the studies themselves but also in choosing the teams to carry them out.

Reconnaissance studies can be prepared more efficiently and quickly if small-scale aerial photographs are used (1:40,000 to 1:70,000), and greater emphasis is laid on field work than in the case of the exploratory studies.

The surveys are generally accompanied by maps scaled from 1:50,000 to 1:250,000 from which preliminary road tracings can be made. In default of proper maps, uncontrolled mosaics of aerial photographs could be used together with available altimetric data.

The data to be collected from studies of this kind should be sufficient to prepare and assess the preliminary designs of possible development projects.

/(iii) Semi-detailed

(iii) Semi-detailed inventories

In order to work out pre-projects that will serve as a basis for technical and economic feasibility studies, pertinent natural resources should be described and quantified with a fair amount of precision, as well as their relationships with the constellation of factors and applicable technologies. Comments will later be made on the criteria that determine how precise the data to be obtained in this kind of study should be.

Mapping scales may range from 1: 5,000 to 1:25,000 the project.

Semi-detailed studies need the co-operation of specialists in the various disciplines, with a much higher intensity of use of professionals and equipment than reconnaissance studies.

One aspect brought up by semi-detailed studies is that they often create a demand for technological research of an experimental type, when known technologies are not perfectly adaptable to the conditions found in the project.

(iv) Detailed studies

The detailed studies are needed for drafting the final project design, which has to meet certain technical standards for which more precise information is required than in the earlier stages.

The final or executive design is the instrument to be used by the engineers as a guide in the execution of the project. This phase consists largely of surveys, with research work proper taking a minor role.

These studies are not begun until it has been definitely decided to undertake the project, since they represent a fairly heavy investment per physical unit of resource involved and are usually of little value beyond their particular aim and object.

2.2. Project phases

Natural resources development projects are not worked out all at once but following a number of steps in whose succession the engineering design will have its details gradually filled in.

/This step-by-step

This step-by-step approach is the only way to deal with the problems posed by the limitations in the "actual supply" of natural resources and the fact that in order to progress from "potential to actual supply", a process of successive approximations has to be followed, as was explained earlier.

The project phases are as follows:

(i) Basic idea - project generation
(ii) Preliminary design
(iii) Pre-project
(iv) Final or executive design
(v) Execution
(vi) Operation

The first three are the pre-investment phases while the next three correspond to the investment itself. In the foregoing section (2.1.3) the meaning of these stages has been explained and the fact that each should be preceded by research at the corresponding level.

All this process is time consuming and often entails heavy investment. The step-by-step approach has the advantage of enabling investment decisions to be taken gradually while a project is crystallizing, and thus making it possible, when necessary, to change the orientation of the research work or even to stop it, should it emerge from the preliminary appraisal made at the end of the second phase that the project ought to be rejected.

Decision-making responsability increases from one phase to the next not merely because of the volume of investment involved but because of the expectations brought up by the project.

2.3 Demand for research

Mention is made in the preceding sections of the correlation between the different degrees of precision needed in the surveys and research of natural resources and the various steps in project development.

/Reference has

Reference has also been made to the existing tendency to impose the ideas for project generation in the field of natural resources from the supply approach, and also to the limitations of the "actual supply".

It is up to the planning and decision-making system in the different countries (in other words to the Government and entrepreneurial groups) to decide on the amount of investment for research, surveys and project development. It is also their responsability to decide whether it is better to let research generate spontaneously the "Actual supply" which will determine the development of projects, -as has been done traditionally- or whether it would not be better to adopt a more productive procedure, in which demand, as identified by the planning and decision-making system itself, will determine the generation of projects. The ideas for projects inspired thereby would give rise to a demand for natural resources for which the research machinery must provide the "actual supplies" starting from known "potential supplies", which means that the research system will thus act under pressure from a "demand" for research.

Once the idea of planning has been accepted, the second alternative is the only acceptable one. Research is considered as an economic activity and, as such, should be planned in the light of demand and available resources. The point at issue then becomes how best to determine the demand for research.

2.3.1. Factors determining demand for research

As the amount of information on a particular area or resource is apt to vary widely, the concept of "actual supply" is fairly elastic. It owes its elasticity to the fact that surveys can be undertaken at different scales, measurements can be made with a wide range as to precision, and statistics and production functions can be determined with varying degrees of reliability.

All projects imply risks resulting from uncertainties in the knowledge of the physical, economic and social factors involved.

/The present

The present document will confine itself to discussing the risks that arise from physical factors and the economic implications thereof.

The operational risks that have their origin in physical factors can be divided into two groups: first, the risks of material disasters resulting, for instance, from structural defects, floods, drought or earthquakes, and, second, the risks of failure due to a lower economic productivity than that estimated for the project owing to inadequate assessment of the relevant natural resources or production functions considered in the design.

Because of their implications as to human safety, the first group of risks is self-evident for those who have to take executive decisions, who try to avert such risks by ensuring that the safety standards laid down for engineering works are observed.1/

Technical standards in civil engineering can be quite easily transferred from one country to another provided that the necessary minor changes are made to adapt them to local geographical, social and economic conditions.

Risks that are not directly connected with the safety of structural works and whose implications are purely economic have not inspired such clear-cut safeguards and it is often impossible to establish technical standards that are universally acceptable.

In mining projects, the volume of reserves proven by the studies, their location and grade, should be sufficient in quantity and quality to guarantee the operation of the project at least until the fixed investment has been completely written off. The executor's guarantee rests on the accuracy of the data used as a basis for preparing the project and, in view of the vast common fund of knowledge that has

1/ Building codes specify the minimum basic data required to transform the design into sound projects, and their principles from part of an engineer's professional training. There are specialized organizations that carry out research on the subject and establish the relevant technical standards, as, for instance, the American Society for Testing Materials (ASTM). Many of the Latin American countries also have similar bodies.

/been built

been built up in this field, demand for research is easily determined in relation to mining projects.

The common knowledge amassed on water resources, hydro-electric power and irrigation can also be utilized, after the necessary adjustments, at the engineering stage of water utilization projects.

It is much harder to transfer standards and experience for projects in such branches of activity as farming and forestry. The developed countries, where technology has evolved to a higher level, all lie north of the 30th parallel and a map will show that of the 20 million square kilometers constituing the Latin American region barely 3 million in Argentina, Brazil, Chile and México (i.e. 15 per cent) are in the temperate zone.

In principle, it is physically possible to transfer to those areas techniques of soil and forest exploitation, etc., that are widely used in the developed countries with similar conditions. The key work is "physical" because physical limitations not only make it difficult to transfer technology, but they constitute an insuperable obstacle for over 85 per cent of the continent. The experience of Africa, Asia and Oceania in comparable latitudes can be used to some extent for traditional export crops such as coffee, oil seeds and cane sugar. Very little is known about production techniques of staple food crops or about soil fertility and conservation.

Hence development projects for specific areas, particularly those concerned with the agricultural sector, imply a high degree of risk and the innumerable failures recorded show that the resources and production functions involved in such projects must be investigated more thoroughly, as well as the non-technical factors that are so often at the root of such failures.

The second factor determining the accuracy of the basic data required for the preparation of projects involving an economic risk is the marginal value of the natural resources.

When the supply of a certain resource is far out of a current demand, opportunity costs of such a resource are said to be zero, or very low and that there will be no penalty involved in giving it a low

/productivity use.

productive use. With economic development, more intensive use of resources will gradually build up a pressure on those which are in limited supply, as is the case of most natural resources on a medium-term basis. Each new unit to be incorporated to the economy, if given a more productive use, will have a higher value, that is the marginal value of the resources will increase. If a less productive use is given to such a factor a corresponding opportunity cost will be entailed.

As the value of resources increases more precision will be needed in their measurement as error in measurement will represent losses proportional to the value.

Land and water can be taken as examples. Land, from its use for extensive grazing up to urban use, increases gradually in value, its surveys and assessments have to be made by more and more precise means which represents increasing expenditures per physical unit of resource, (in this case, the area involved). Water on the western slopes of the Andes is being used more and more intensively in irrigation, city supplies and generation of hydro-electricity. As the pressure on this resource increases available supplies have to be measured with increasing precision, which involves more numerous and more intensive surveys. On the other hand, in the majority of the basins of the eastern slope, where the opportunity cost of water is practically zero, the same expenditures in hydrologic study would not be justified.

A third factor to be considered to establish the demand for research is time. Research work means expenditure of time which in some cases can be controlled by the more or less intensive use of resources - human and equipment - or by the adoption of more advanced techniques. Research in which time itself is a factor as the biological, climatic and hydrological cycles is less flexible regarding the possibilities of reducing time schedules by more intense activity. Results are expressed as statistics in which time is one of the independent variables, which makes the duration of research or measurements one of the determinants of precision.

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In this type of research that takes a long time, it is important to observe the correlation existing between the intensity of use of resources and the increase in their opportunity cost. In the first stages of development a low opportunity cost of resources does not demand a high precision in their measurements. The demand for research is intensified with economic development as this represents an increase in the opportunity cost of resources. As this is a slow process, the research system can adjust gradually to the new conditions as has been the case in the more advanced countries, without necessarily constituting a limiting factor for development.

Another important aspect to be taken into account in relation to the demand for research is the risk of not achieving desired results. A decision to initiate research is reached in order to solve a properly equated problem through research; the conclusion may be that the problem is insoluble under present conditions, or the finding of the solution may open new perspectives whose existence was unsuspected.

The nature of research itself makes it impossible to foresee ex-ante what results can be achieved. An attempt is made to minimize risks by following the step-by-step approach mentioned before.

The direct benefits derived from research are related to its immediate objective and to the soundness of projects. When research has not succeeded because the desired solution has not been found, investment risk has been reduced to zero. Well-conducted research never fails; the results will always be positive even when immediate objectives are not reached. Past experience has made it possible to define the risk of certain types of development when based on an insufficient knowledge of the factors involved. In the case of specific projects, direct benefits can only be assessed in advance by employing an actuarial approach. Benefits can be estimated by tendencies observed in the past. Previous research plays the role of an insurance policy whose value can be estimated by the entrepreneur.

Indirect benefits ar the reduction in risks in the development of future research and projects and in the opening of new perspectives

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for development by the wealth of experience and knowledge accumulated not only in the files and documents but also and mostly in the brains of scientists, technologists and research personnel. Furthermore one has to consider the increasing chances for economic development deriving from insight gained of the constellation of resources and their inter-relations, which allows a better choice among alternative projects and prevents inconsistencies between conflicting techniques to be employed at a certain moment. The final result is an increase in the productivity of the economy as a whole, which is the real social benefit of research.

If research is considered from the point of view of the safety of project development the conclusion is reached that demand for research stems basically from a political decision: what is the acceptable risk in project development? This decision is highly subjective. To increase the chances of success of projects as far as physical and technical factors are involved investments have to be increased in the form of time and other resources for research, which means a delay in execution. In exchange this delay may lead to an increase in risks due to economic, social and political factors which suppose a cost. In this way there are time-risk functions which move in opposite directions. If both functions could be defined mathematically it wouldn't be difficult to calculate the time available for research which would correspond to a minimization of total risk.

Given the number of unknown variables which have a bearing on those functions, a mathematical solution cannot be applied; even in the case of the risk of disaster, the so-called safety coefficients used by engineers, on which standards for structural design are based are subjective. Whether a structure should be built with a capacity to support two or four times the normal load is a political decision. Engineering limits itself to a definition of cost increases corresponding to a certain increase in safety.

/3. Planning the

3. Planning the exploitation of natural resources

In the introduction of the present document it was stated that planning specialists should consider the planning of natural resources surveys and research as one of their tools.

Previous sections have dealt with the supply of natural resources as a product of research, and a definition was given of the factors that determine the demand for research; in addition it was shown that there is a close relationship between economic planning and the study of natural resources.

One obstacle to planning the exploitation of natural resources is the lack of adjustment between the supply and the demand for research.

There are two groups of professionals, on the one hand the scientists who think in terms of supply, and on the other the economic planners who think in terms of demand; the former have a more idealistic approach, while the latter take a more pragmatic view. If there is to be an understanding between these two groups, a common field of interest must be found in which they can communicate.

The scientists generally regard their research as an aim and not a means. A good scientist should be a person with a creative mind motivated by the aesthetic satisfaction of transforming chaos into order, and scientists often take position completely alien to the world outside their laboratory walls. This divorce from the outside world is particularly found amongst Latin American scientists trained at universities in the more advanced countries, where the world seems pleasant in contrast to the aggressiveness found in their own countries; this leads them to seek refuge in research work, which becomes the center of their lives.

The problem of the economists in the planning bureau is that they expect the scientists, who are living in an entirely different world, to be able to provide them with the data that they can handle with the planning machinery. The economists need to know about the resources available, the possible combinations of resources, and the results that might be expected from such combinations. This requires research by the scientists, but the economists cannot say what research should be

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undertaken, or how. If the machinery is to work well, the scientists, at least those in charge of scientific activity, must have a minimum knowledge of economics, and the resource economists must have some idea of the problems of research.

A strategy to ensure that the scientists deal first with those problems that economic diagnosis shows to be the most important for the country's development must be based on taking advantage of the scientist's eagerness to achieve something new, by transferring his interest partly from the purely scientific field to the field of activities that have a more direct effect on the process of development. Generally planners are in a position to offer this alternative which would be seducing to many a scientist.

The way to achieve such direct action by scientists is through specific projects, which should constitute the dynamic pole of the whole research system.

The research projects, demand for which will be determined by the economic development programmes (which lie in the field of the economists), will build up the primary demand for research. Research aimed at specific projects will generate a secondary demand for research directed to solving the problems identified by the scientists in the actual projects. If the process is left entirely in the hands of the scientist there will be an inevitable tendency to extend it <u>ad infinitum</u>, since a true scientist can never say that he has reached the end of an investigation - there is always something that needs improvement or clarification. Between the scientist and the person who is to use the results of the research there should be someone capable of judging what is the minimum level of knowledge necessary for action without undue risk. The professional who budges the gap between the scientist and the economist is the engineer or technologist, the man of applied science.

The criteria governing the demand for research, and consequently for the allocation of resources for research, will be subjectively based only as regards the establishment of the degree of risk considered

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acceptable. Once this degree of risk has been agreed upon, the volume of research necessary can be determined, as previously stated.

3.1. Co-ordination between planning, research and execution of projects

In section 2 mention was made, in relation to projects for the exploitation of natural resources, of the contribution of various professionals and institutions at the different stages of what constitutes the life of a project, from the basic underlying idea to the production stage.

The institutions referred to participate in three systems, already referred to:

(i) The planning and decision system covers the State agencies responsible for the country's economic development policy, and private agencies.

(ii) The research system, one part of which may be outside the country, includes the institutes, universities and other public and private agencies that participate in one form or another in the study research and surveys of natural resources, and in the technological and basic research in the fields of knowledge needed for the exploitation of natural resources.

(iii) The executive system includes the sector of public and private administration responsible for the direct execution of field operation, from the stage of surveying up to the construction and operation of the projects concerned.

To provide a general picture of the dynamics of the complex mechanism of research, planning, decision and execution of natural resources development projects, as covered by the three systems, of the relations between them, and of the sequence of the studies, surveys, evaluation and decisions, up to the stage when the projects begin to operate, a flowchart (table 1) is provided as an annex to the present document, to which reference will be made.

The basic ideas for the generation of projects may be defined under the research systems, as the result of new discoveries or of exploratory studies, and this will represent a generation of ideas through the supply of resources, just as ideas can also originate from demands as defined in the planning system. This is represented in block 1, in the column headed "steps in project development". The basic idea may be described in a simple document outlining the aims of the project, the existing knowledge of resources, and the possibilities of exploiting them. This document may originate at various levels of the public administration or the private sector.

The first stage of economic evaluation is the determination of consistency of idea with the development plans. If the project has originated from the demand side, this consistency is more or less self evident, but if the idea comes from the supply side of resources, it may be necessary to incorporate the idea in a long-term development plan, since in most cases it is not possible to pass from the basic idea to the execution of a project for the exploitation of natural resources within a period short enough to be included in a medium-term or short-term plan.

Once the idea has been fitted into the plans, the research system must define a programme of study that will permit the formulation of a preliminary design as indicated in section 2.1.3. This programme of study has its own budget, represented in the flowchart by the small triangle on the line numbered 2. Thus we arrive at the first political decision that will lead to the formulation of the project. This decision will result in a demand for research, for which the corresponding funds will be allocated. This is the first step towards the project for which a Project Unit will be set up within the executive system. The first task of the unit will be to undertake research and surveys (Step 2 of the research) reconnaissance under the guidance of the research system, which will analyse and evaluate the results from the scientific standpoint (line 4 on the flowchart). The engineering and economic sector of the

/project will

project will prepare a preliminary design on the basis of the data obtained from the surveys and research. The design is passed over (line 5) to the planning system, where a preliminary evaluation is made, followed by a second stage of decision. The process follows similar lines to those of the first stage, but, as previously indicated, the decisions are more weighty because of the larger volume of investment needed for feasibility studies, and the expectations that the project may have aroused at these levels. From this point on the flowchart is self-explanatory. Attention is drawn here to the secondary demand for research generated by the semi-detailed studies, which call for further work from the research system.

The working out of the projects at the feasibility stage requires a definition of the technological alternatives applicable in the conditions found. The semi-detailed studies define, with a reasonable degree of precision, the quality and quantity of the natural resources which offer some prospects for exploitation. This is the crucial moment for deciding on the technology to be applied, which often calls for technological research of an experimental nature. For mining projects it is often necessary to make tests in experimental plants to determine the best ore-dressing technique.

Generally speaking in agricultural projects, even though they can define the environmental conditions, the data obtained from the studies may not be adequate for determining possible production functions, which will call for agronomic research and experiment.

Technological research aimed at solving specific problems that arise during the project studies should be carried out in the field, but with the backing of the laboratories and scientists of the traditional research system. This work could be financed by the projects, which should pay for solving the technical and scientific problems that arise in working them out.

The experience acquired through the projects, and the training of staff and transfer of funds, means an increase in the capacity of the research system, and this leads to new discoveries. These in turn

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encourage the generation of projects, which are the "market" of the research system. The direct contact of the research system with the projects permits the operation of this important feed-back mechanism.

If research is regarded as an economic activity, the systematic studies should be considered as representing an irrecoverable investment to expand demand.

The model presented in the flowchart will result in a rational planning of the exploitation of natural resources, with the smooth collaboration of the three systems involved, and will involve an exchange of ideas and resources. Its adoption under the conditions obtaining in most Latin American countries, in the context of the present framework of their systems of research on natural resources, and the lack of connexion between the three systems, requires the introduction of institutional changes particularly in the research system.

3.2 Co-ordination of research

Much needs to be done in the Latin American countries to improve the co-ordination between those who carry out long-term research and those who do research work directed towards project development.

The defects in co-ordination are the main reason why the systems for research on natural resources are not usually capable of generating new projects, or even project studies, on the scale needed for economic development.

Thus there is a vicious circle: there are not enough projects for the development of natural resources, because there is insufficient knowledge of those resources; this lack of knowledge is due to the lack of institutions equipped to study them on an appropriate scale; the institutions are not thus equipped because there are not sufficient funds available; the funds are not allocated because there is no effective demand for research, and the demand is lacking because there is insufficient project promotion.

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If there is no direct connexion between the studies for projects and the traditional research system, the feed-back mechanism referred to is impossible, and this mechanism is the only one capable of transforming the vicious circle into a process of vigorous and self-sustaining growth.

In the more advanced countries the machinery for research on natural resources developed under pressure from the need for ever more detailed information about natural resources, because of the multiplying uses for them and the consequent rise in opportunity costs. This explains, for instance, the present great demand for institutions, technicians and scientists whose field of action is narrow and deep rather than broad and shallow. In the more advanced countries exploratory and reconnaissance studies belong to the past.

In the more advanced countries the reconnaissance studies were undertaken systematically, but in most cases were completed in the last century, when there was not yet any great pressure on natural resources, and consequently the studies were conducted on a purely scientific basis.

In the developing countries, on the other hand, because of the general lack of an organized body of knowledge of resources, it is much more difficult to make a rational choice of areas or resources as the basis for semi-detailed and detailed studies for the purpose of working out projects, and moreover the situation imposes the use of the latest advances in science and technology on a basis which has a time lag of at least fifty years.

The need to tackle projects on which a political decision has been taken does not permit basic studies to cover a long period.

The result is that action is taken simultaneously over a very broad field, and this leads to the use of two very different procedures. Some advocate a study of the country as a whole with a view to determining the best means of attaining its integrated development, while others, on the basis of existing information, confine their efforts to a limited sphere in the hope of achieving the immediate development of a particular area or natural resource. These two procedures are not alternative ways of achieving the same end; but are two different ways of dealing with the

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problem of a study of natural resources by those whose immediate goal is not the same.

The first method has a long-term aim, and starting from broad generalizations, descends gradually to a more detailed level. In following this path there must be an appropriate structure of research, and some staff with long experience and broad vision. As this procedure does not yield immediate results, it is much harder to obtain the necessary funds from those who administer the budget, since they are interested mainly in investments likely to yield prompt results.

The resources available for this type of study at the exploratory and reconnaissance levels are never sufficient to complete a map of the country within a reasonable short period by current procedures. Thus, for example, geological mapping programmes in many countries may drag on for several decades before being completed, if they follow the prevailing rate of progress for such work. The work programmes are usually governed by purely geographical criteria, with no consideration for priority areas. The maps are made in sections between the parallels, progressing systematically from one meridian to the next.

Although from the scientific and cartographic standpoint, the systematic ordering of the basic studies is the right solution and has undeniable advantages, from an economic point of view it is inappropriate because the frequency with which areas of importance for economic development are dealt with is entirely a matter of chance.

The scientists responsible for the systematic studies should maintain the closest contact with the planners in order to introduce changes in the principle governing progress in the study so that the resources available are devoted to those areas that offer the best prospects for development in accordance with the step by step procedure described in section 2.1.3.

The second procedure, with the short-term approach, results from the pressure exerted by those who need basic data for immediate use in the execution of projects. This pressure usually goes hand in hand with the financial funds for the execution of the studies, and since the data are always needed in a great hurry, the studies are often contracted out to private international groups which use the most advanced techniques. These studies are generally not linked up with the traditional research system, which makes it difficult for that system to benefit from the indirect results of the studies.

The analytical work and the compilation of the reports are carried out abroad in the offices of the contractors. Those conducting this type of research project are not really concerned with training senior staff in the country concerned, and thus one of the most important benefits of the research are lost. The technicians who participate in the analysis of the results and compile the reports are thereby trained to work out future projects, and if no effort is made to train national technicians on actual projects the country's public administration will never be in a position to formulate suitable policies in the field of research.

In the research projects on natural resources sponsored by the United Nations Special Fund there is concern for the training of national staff and the improvement of research institutions. As long as there is no machinery in the country capable of following up the work and benefitting from the experience acquired on a project, its only legacy is a report and a group of frustrated technicians who in many cases leave the country to work in some other place where there are more favourable conditions for their professional activities.

The planning agencies will no be able to rely on a steady flow of data on natural resources and on the technology needed for working out development programmes and projects, if the authorities do not take the trouble to organize institutions capable of meeting the demand of the planners.

Research on natural resources must be conducted on a continous basis, so that the level of knowledge increases both in extent and in depth. Even the more developed countries, whose territory has been fully exploited for many generations, cannot dispense with these studies. Furthermore, it is impossible to import this sort of knowledge, because of the special features of each area.

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Latin America has a great human and creative potential and conditions that will permit the utilization of this potential for the common good should be created.

CONCLUSIONS:

In conclusion, in order that a country should make more effective use of its potential in natural resources for economic development, its natural resource research system should be reorganized so that it can carry out the following activities:

(a) in a central Bureau connected directly with the planning and decisions system it should plan, prepare and co-ordinate natural resource research projects in the country;

(b) operate efficiently with a limited number of high level scientists and technologists;

(c) use a high proportion of unedaquately qualified scientists and technologists in such conditions that in service training will be fostered, as well as special courses and fellowships.

(d) meet the requirements of intensive research on specific projects to the benefit of systematic studies;

(e) use efficiently costly installations, equipment and instruments;

(f) reduce the cost of field work by co-ordinating and integrating interdisciplinary studies;

(g) use modern methods of data processing, analysis and publication.

(h) incorporate into it's assets, on a permanent basis, the contribution of international technical assistance.

Action in the field of natural resources development should take into account the following considerations:

1. Research is an economic activity;
2. Projects are the "market" of the research system;
3. Systematic studies are a long term effort of the research system to increase its "market" and of the planning and decision system to base their economic development project plans on a sounder basis;

4. Executive

4. Executive systems should define correlations between qualities of basic data to be obtained by research and the soundness of development projects;

5. The planners should establish priority criteria for project development and the demand for natural resources that sould lead to the generation of projects;

6. Administrators should define acceptable risks for the decisions taken in each stage of project development, allocating necessary funds so that the research system can make the necessary studies that will allow projects to be designed, executed and operated without undue risks.

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Fluxograph of the research, planning and decision process connected with natural resources development projects