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SOME CONSIDERATIONS ON SCIENCE, TECHNOLOGY AND PLANNING*

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SYSTEM OF CO-OPERATION AND CO-ORDINATION AMONG
PLANNING BODIES OF LATIN AMERICA

Set up at the First Conference of Ministers and Heads of Planning of Latin America, held in Caracas, Venezuela from 13-16 April 1977 and endorsed by resolution 371 (XVIII) adopted at the seventeenth session of the Economic Commission for Latin America (CEPAL), held in Guatemala City from 25 April - 5 May 1977.

SOME CONSIDERATIONS ON SCIENCE, TECHNOLOGY AND PLANNING

Foreword

All human activities are constantly undergoing a process of modification in form and objectives which stems from the new and increasingly rapid advances in scientific and technological knowledge. We may even say that we are living under a system that enforces permanent change.

The world has undergone a new scientific and technical revolution since halfway through World War II. Among the many outstanding characteristics that define this revolution is the awareness that the quantitative experimental approach may be applied to any problem, a fact which is proved by recent progress in the different branches of knowledge. Another characteristic, as mentioned in the present document, is the fact that, for several decades now, the importance of Technology in the development of industrialized countries has been accepted. However, unlike the attitude prevailing in the people and governments of the developed countries, the developing nations have only recently become equally concerned. This statement can be verified in the implicit acknowledgement contained in the "Declaration of the Presidents of America":^{*/}

"Latin America will participate in the benefits of present-day scientific and technological progress to gradually bridge the growing gap between techniques and living conditions in the region and in the highly industrialized countries. National science and technology programmes will be formulated or extended and a regional programme will be launched; advanced multinational training and research institutes will be created; existing similar Latin American institutes will be reinforced, and the exchange and development of scientific and technological knowledge will be encouraged."

^{*/} Pan-American Union: "Reunion of the Heads of American States." Punta del Este, Uruguay, 12-14 April, 1967.

/Since that

Since that moment, the region has shown a growing and better directed concern in promoting Science and Technology activities. It is undeniable that the Universities, Academics and Institutes of the continent were already engaged in such activities to a greater or lesser extent depending on the circumstances and people involved. However, it was not infrequent to find negative attitudes regarding the possibility of, or interest in, carrying out activities of a scientific nature, which obviously restricted the countries' technological level and their capacity for autonomous decision in this field.

In the years that followed 1967, the OAS Regional Programme for Scientific and Technological Development was created. In accordance with the Action Programme accompanying the Declaration of the Heads of State, it "aims at increasing the level of science and technology progress so that it can contribute in a substantial way to speed up the economic development and welfare of the people and also encourage pure and applied research activities of the highest possible quality." This Regional Programme has carried out a large number of studies on the regional scientific and technological development, on the scientific and technological potential of certain countries and areas and on policies and planning connected to these activities. Its specific contributions of funds for some research projects in a large number of Latin American and Caribbean countries are worth emphasizing.

Also, at the end of the sixties, the National Councils for Science and Technology (CONACYTS) were created in the majority of the countries of the region, under the auspices of UNESCO. Their purpose, as stated in their statutes, is highly ambitious since they assign themselves responsibility for the global scientific and technological development of their respective countries. In practice, their legal authority and availability of resources have somewhat restricted their field of action to merely strengthening the scientific

/and technological

and technological capacity within certain limits and to designing policies and programmes for the national scientific and technological development. ★/

These interesting early attempts at coordinating national actions within the field of science and technology were accompanied by efforts we may call horizontal or, in other words, involving cooperation between the countries of the region. To recall just a few of them we can mention the "Andres Bello" agreement, several institutions in Central America (INCAB, ICAITI, CSUCA and others) organized between 1945 and 1970, regional scientific centres (Biology, Chemistry, Physics and Seismology) created in the last eighteen years with the active cooperation of UNESCO and other organizations as appear in several documents. ★★/

There is a growing interest in knowing and handling the scientific and technological phenomenon. Such concern is not just the mere materialization of innate human curiosity but stems from the explicit acceptance of the role that Science and Technology play in the development process on the part of the Governments, leaders and peoples of the region.

We are currently facing an unprecedented accumulation of scientific and technological knowledge in the history of mankind, largely resulting from the managerial spirit, innovative zeal, historical circumstances, deeper consideration of social values, etc., of the developed nations. The extent and quality of scientific and technological knowledge is so great that were there no other constraints - it would be practically possible to solve all the

★/ Jaime Lavados. "Organization of Scientific and Technological Development in Latin America" appearing in Integration of Science and Technology with Development. Editors: Babatrude and Wionczek, New York, 1979.

★★/ See E/CEPAL/ILPES R. 19, Santiago, 3 November 1980, p. 41, f).

problems of the productive apparatus of the industrialized countries and most of the problems affecting the developing world.

We may go as far as to say that the underdeveloped world in general and the region in particular have utilized only a fraction of this vast "archive" for the purposes of economic growth, through individual and managerial national action or the participation of transnational companies. Fortunately, in other fields, particularly those related to social aspects such as health, the utilization of human knowledge has been greater and the positive attitude of the State more significant.

However, we would like to point out that in recent years the State has taken deliberate action - with varying degrees of intensity and concern - in connexion with the accumulation of knowledge and the use of the science and technology (S and T) variable in an integral conception of development. The strategic action of the Governments, which aims at rationalizing by different means the use of resources in order to build a "better future", has seen the need for taking part in the generation of the scientific and technological process. Science and technology are in the very centre of the productive function. However, they are inserted in countries possessing certain heterogeneous physical, social and cultural structures conditioned by the natural systems. In other words, the solution to the problems of quality of life not only depend on know-how but on the type of know-how required for the particular circumstances accompanying the problem in each country as, for example, the limitation of resources, human limitations, national and international power structures, and the obligation of avoiding producing an irreparable damage in the environment. Stated in other words, it may be said that although our region could avail itself on the accumulated knowledge, its use should be learned and its gestation rationalized.

/In the

In the last decade, Latin American thinkers have produced a large number of studies related to Science and Technology matters characterized by their strong emphasis on industrial aspects, the transfer of foreign technology and important considerations on the role of science. Several international conferences and many national and international organizations connected with regional development have permanent programmes of a scientific and technological nature (United Nations, UNESCO, OAS, Universities, National Institutes and Foundations, etc.). However, the coordination of this effort at a regional level as well as their coordination with the other activities typical of each national reality has on the whole been precarious.

There is no doubt that the countries of the region are interested in a stronger effort regarding the Science and Technology phenomenon. This fact has been observed by ECLA, which paid attention to this matter in several documents dealing with development and opened an office in ECLA-Mexico in order to do some research on this phenomenon. ¹ Just for the purpose of reminding the reader of some of the latest developments we must mention in the first place the "Latin American Preparatory Regional Meeting for the United Nations Conference on Science and Technology for Development" ² (Panama, 16 - 21 August 1978). At that meeting, among other recommendations on funding, industrial protection and transfer of technology, it was suggested:

"That the science and technology variable should be incorporated in an explicit way to the national development plans or strategies as a fundamental instrument to meet the different objectives and targets contained therein with both a global and a sectoral consideration of specific needs in connexion with generation, location, transfer and utilization of information". ³

¹/ This office has recently moved to Santiago, Chile.

²/ See Document ST/CEPAL/Conf. 66/L.3/R.1 September 1978.

³/ See p. 23.

A few months later, the Second Conference of Latin American and Caribbean Planning Ministers and Directors which took place in Lima in November, 1978 resolved "to include planning and integration, regional and government planning, and technological development and planning among the topics to be dealt with in the next reunion". ★/

That same year, the Second Latin American Preparatory Meeting for the United Nations Conference took place in Montevideo. ★★/ Some of the recommendations made at the meeting in Lima were reaffirmed. In connexion with planning it was stressed that "the science and technology variable should be included in an explicit way in the national plans or strategies for development to act as a fundamental tool to attain the different objectives and targets contained therein..." ★★★/

Among the different preparatory meetings for the International Conference on Science and Technology and Society that took place in Vienna in August 1979, special consideration is due to the Symposium on Science and Technology for Development Planning that took place in Mexico City in May 1979 and was organized by the Colegio de Mexico, ECLA and ILPES. On this occasion, it was acknowledged that "the countries that have achieved a successful integration of their science and technology policies and plans and their development planning are not very numerous". Similarly, mention was made of the need to incorporate a wider selection of techniques to the process of development planning with special emphasis on the assessment of technology. Specifically and with regard to science and technology planning, the symposium stated that "it should be incorporated to

★/ See preliminary version of Document 79-1-138-50, Lima 15 - 18 November, 1978.

★★/ See Second Latin American Preparatory Meeting for the United Nations Conference on Science and Technology for Development. Montevideo, Uruguay, 29 November - 1 December 1978. Doc./CEPAL/1059.

★★★/ See CEPAL Doc. E/CEPAL/L.183/Rev.3 December 1978, "Ciencia y Tecnología en América Latina: diagnóstico regional y programa de acción". December 1978.

the general long-term planning" and that, in any case "it should ensure a basic compatibility between scientific development lines and technological patterns on the one hand and the strategy for socioeconomic development on the other, whether the latter may or may not be based on formal planning procedures". ★/

Finally, as additional information, we must not forget that in the 18th Period of Sessions of ECLA, that took place in La Paz between 18 and 26 April 1979, there was satisfaction for the preparation of "recommendations for an action programme for the utilization of science and technology in the development process" (Resolution 389). ★★/

Naturally, the Science and Technology issue has received attention at other important conferences although with a different approach to the relationship between the S and T variable and national planning from the one we have used in our foreword. The valuable participation of UNESCO in all the relevant aspects of the problem should be noted, especially the recently published UNESCO document on "Scientific and technological policies in Latin America and the Caribbean" which sheds light on the state of regional science and technology. ★★★/ Although it is not possible to even attempt to sum up this important document, we can point out that it stresses the generalized concern of all the countries for the correct linking of scientific and technological development to the national socio-economic development. However, the document also remarks on "the

★/ "Dinámica de la Ciencia, la Tecnología y el Desarrollo", a statement made by the plenary session of the above-mentioned symposium.

★★/ See Doc. E/CEPAL/1083/Rev.1 - 15 June 1979.

★★★/ UNESCO: "Scientific and Technological Policies in Latin America and the Caribbean." Fifth Meeting of the Permanent Conference of the Leaders of the National Councils for Science and Research Policies of the Latin American and Caribbean Member-Countries. Quito, 13 - 18 March 1978. Doc. ISBN 92 - 3 - 201741, Paris 1979.

/not always

not always happy approach to the solutions advocated, which may be threatened on the one hand by the predominance of economic motivation with the underlying danger of stifling scientific creativity and harm in a permanent way the authentic progress of the country and, on the other hand, by the apparent lack of interest in the national problems on the part of some scientific élite groups." Furthermore, the document also points out that despite the increase of the resources allocated to scientific and technological activities, absolute figures and percentage of the GDP are, on the whole still inadequate.

The remarks made by UNESCO correspond to those made by ILPES. In fact, the Institute has produced a document to be presented at the Third Conference in which it points out that "the majority of the countries have only recently begun to tackle the primary aspects of the definition of a science and technology policy". Not many of them are endowed with an effective institutional apparatus capable of undertaking the formulation and launching of a scientific and technological policy that may integrate the objectives of social and economic development. */

Due to the importance that the governments of the region have assigned to the incorporation of the S and T variable to development planning, a position fully shared by the Institute, ever since roughly eighteen months ago this problem has been the object of reflexion. The first important effort was closely connected to the above-mentioned Mexico City Symposium. On that occasion, a document prepared under the auspices of UNESCO aimed at approaching the relationship between Science and Technology and Planning. A revised version of the said document entitled "Notas sobre Ciencia y Tecnología y Planificación del Desarrollo", has been presented

*/ ILPES: "El Estado de la Planificación en América Latina y el Caribe" Doc. E/CEPAL/ILPES October 1980.

to the Third Conference of Planning Ministers and Directors as a background paper. Although this support document is based on different activities performed by ILPES, it expresses the personal views of its authors, which are their sole responsibility: their opinions may not necessarily coincide with those held by the organization.

The authors would like to state that they have been unable to perform an exhaustive analysis of all the publications that have appeared in the last ten years. They have also been unable to take a closer look at existing institutional conditions, Science and Technology programmes and private activities connected with innovation. Although are well aware of the danger of repetition and omission, the report was written with the aim of stating their views on the urgency to increase the efforts made in the Science and Technology field and the need to link such efforts with development strategies and planning processes. This aim has been given priority over considerations involving claims for "academic originality".

The document has not been written by scientists or technicians but by people who have been involved in planning and development. Therefore, some readers may think that their assessment of the scientific and technological accumulation is somewhat superficial and not quite objective. The writers consider that the accumulation of knowledge has been the result of a long historical process in which not only is each innovation conditioned by the existence and relative value of the factors prevailing at the time of its generation, but also that its own implementation conditions later innovations (once again as a result, at least in part, of previous technological accumulation). The writers therefore believe that any organization dealing with the problems of planning in Latin America, that is at the same time aware of the great importance of the S and T variable for development and the need for systematic and permanent efforts

/to handle

to handle it in a correct way, should pay special attention to the historical, political, cultural economic and natural circumstances of both the region and each country as regards the incorporation of the variable.

It is, therefore, within the context that we have already described that the present support document is handed in.

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Chapter I

DEVELOPMENT, SCIENCE AND TECHNOLOGY

(a) What is Development?

1. In the opening pages of his study on "Elusive Development", Marshall Wolfe points out that "the sustained concern about development has failed to bring about a definite international consensus on either a definition of development or how to reach it. It is surprising that different conceptions and approaches may still co-exist and overlap, without being affected by the demonstrations of their mutual incompatibility or incongruity with experience that have appeared in several polemical and critical publications".^{1/} Consequently, the definition of the process of development has experienced a permanent evolution in the last thirty years, from the initial concept of it being equivalent to "economic growth" to the current prevailing definition of development as every nation's aspiration to a better society.

2. Conceived in these terms, development acquires multiple dimensions that make it necessary to describe its content to attain a certain degree of accuracy in its definition. Thus, when the United Nations passed the Development Strategy for the Second Ten-Year Period ^{2/}, they acknowledged the fact that the ultimate objective should be to attain a permanent improvement of individual well-being and to contribute to the general welfare. They also clarified such a general statement as follows:

"Considering that the aim of development is to give all human beings greater opportunities for a better life, it is indispensable to attain a fairer distribution of income and wealth in order to promote social justice and efficiency of production, increase the level of employment in a considerable way, reach a higher level of income security, expand and improve education, sanitation, nutrition housing and social assistance resources and preserve the environment. Consequently, a rapid economic growth should be accompanied by qualitative and structural changes in society

/and, existing

and, existing differences, be they regional, sectoral or social, should be substantially reduced. These objectives are not only determining factors but also final results of development. They should therefore be considered as integrated components of the same dynamic process and require a unified approach.^{2/}

3. Development, as defined above, appears to be a combination of economic growth and transformation of the structures upon which such growth may act. It implies not only quantitative growth within the present set-up of any given society, but also the necessary modifications to reach a more just and fair distribution of welfare. Otherwise, if economic growth is the only aim taken into account, the social structures of developing countries --also called "two-nation societies"-- will remain unchanged: the poor will continue to be poor, whereas the rich will become wealthier. Although it is no easy task to interpret the behaviour of the process in countries which are nowadays classified as developed, some of the experts that have analyzed their take-off claim that "what took place at the end of the XVIIIth century in England and France was not mere economic growth: there were concurrent changes in civilization, and political, moral artistic and philosophical transformations, which were accompanied by changes in the structure of the family. In short, there was a complete change".^{3/}

4. Despite the apparent consensus as regards content and description of the development process, it is frequently still measured in terms of mere economic growth. Very rightly so, the report of the Brandt Commission states that "It is necessary to put an end to the persistent confusion between the concepts of growth and development"^{4/} In order to distinguish between the necessary condition for development, i.e., economic growth, and development proper, the present document regards the latter as a continuous process of change, whose final aim is to improve the "quality of life". To improve involves the

^{2/} See 2/, No 18.

concept of progress or, in other words, of movement towards a desired aim.

5. The definition stated above has generated some questions that demand answers. What type of quality of life should be considered as desirable? How is it to be measured? Which are the ways to attain it? Is there a wide choice of options to reach the expected goal? It is obvious that many other questions could be asked. However, suffice it to say that the above are examples to clarify the relationship between development and Science and Technology.

6. Development is, in fact, a process and should therefore be regarded as a "spatio-temporal sequence of events, any of which is connected to the preceding one and affects the one that follows. Some of them are well-known, others are likely to be known, whereas yet others may be ignored".^{5/} As development is a continuous process, it undergoes different states, each constituting a different stage. Each stage should involve progress: there should be a movement away from the initial stage of a system to a more advanced stage, characterized by different and better conditions. Since the later stage is determined by the preceding initial stage, which is different for each country, especially if development intends to preserve the positive values which are typical and characteristic of each nation, both from the viewpoint of human values and ecosystems, the development of each nation should necessarily consist of different elements responding to the particular existing conditions. This implies the responsibility of finding and preparing solutions that are not imitative but new. The creation of such solutions requires scientific expertise, investigation and research on suitable technologies to apply to particular conditions, be they technico-economic or social. For this reason, the process of development needs an intelligent combination of adapted imitation and originality of innovation. Combining both will therefore involve an effort based on Science and Technology.

/(b) Definition

(b) Definition of "quality of life"

7. Progress means to move in the right direction, which for the purposes of this document, has been identified as the ultimate objective, i.e., the "quality of life". However, it is not easy to ascertain whether any one nation is in fact moving in the right direction. The diversity of political forms, culture, economic structures and the variety of forms of expression of expectations and ideas by the different societies in the world, explain the impossibility of attaining a common definition of the ultimate ideal goal. It is easy to understand that if the initial states from which the different countries start are not identical, if their culture and attitude to life are different, if their natural resources, geographical environment and position in the world are dissimilar, their priorities and expectations must necessarily differ. It would be a fallacy to assume that the "quality of life" corresponds to a pre-determined model worthy of total imitation. The "desirable quality of life" for any country or people should contain a significant proportion of originality in relation with their individual characteristics. At any given moment in time, the "possible quality of life" is that which can be attained at each of the successive stages of development and its definition and measurement should be assigned to the social sciences and to the execution and evaluation methods that such sciences may prepare.

8. Because of the importance assigned to the concept of "quality of life" in the definition given above, a few lines should be devoted to a general analysis of the main points. This matter has been the object of intense national and international concern expressed in terms of indicators both objective and subjective that are not necessarily directly related to one another or, much less so, to the Gross National Product, which has been designed to measure economic growth only. Some typical objective indicators are, for example, food, health, education, clothing, housing and related services, employment, labour conditions, recreation and culture. Examples of

/subjective indicators

subjective indicators are participation and alienation, security, justice, human rights, freedom of choice and, in general, personal evaluation of past experiences. Some of these indicators measure factors related to economic growth or social advances of the country, and others, to the degree of well-being.^{6/ 7/}

9. Defining, recording and measuring the elements that compose the concept of "quality of life" is no easy task, even with the best available conceptual and statistic tools. Because of this, it is not uncommon to choose simple methods that account for only one important part of the objective under study, as is, for example the statistics supplied by some indices that evaluate the physical quality of life ^{8/} _{8/}, and, particularly, the change occurring between two situations.

10. The term "real progress" ^{9/} _{9/} is sometimes used to express a change in levels of life resulting not from "monetary" facts such as a larger overall or per capita expenditure on one or more of the components of the indices used, but from an effective variation in the criteria employed to evaluate the situation. The purpose is not to find out whether there has been, say, an increase in health expenditures or a larger investment in housing, but whether there has been any real improvement in health or whether some negative features such as overcrowding; lack of sanitation and quality of housing have experienced any significant changes. In some cases, the statistics obtained from some criteria and indices are measured against "norms" whose purpose is to establish standards of basic human needs. One of the most interesting studies in connection with this point is the work carried out by the "Fundación Bariloche" ^{10/} _{10/}, which postulates the satisfaction of some needs at minimal levels for the group placed at the lowest end of the social scale. The satisfaction of "norms" tends, in practice, to be represented by a

^{8/} The POLI index is based in only three components: child mortality, life expectancy at age 1 and literacy.

/minimal subsistence

minimal subsistence wage susceptible of satisfying basic needs and may thus be confused with the poverty line.^{11/}

11. The present document neither intends nor thinks it necessary to elaborate further on the different aspects of the problem. Level of life, poverty line, "subsistence norms", etc., are all important aspects of the wider concept of "quality of life", that also embraces other elements many of which are subjective. What really matters is to point out the relativity of these concepts according to the degree of development and individual characteristics of a nation. The development of a country does not imply the repetition of the stages reached in the past by more advanced nations. "Underdeveloped countries cannot progress through imitation of the patterns followed in the past by countries that are nowadays developed, not only because of the historical improbability of following their steps under the socio-political conditions prevailing at present, but also, and to a larger extent, because it is unadvisable to do so".^{*}

12. To determine the "desirable quality of life" and the "feasible quality of life" at any given stage of development is information that policy-makers cannot dispense with. In the case of economies possessing a certain degree of planning, it constitutes a basic element in the formulation of plans and policies for their implementation. In market or mixed economies, this information becomes an instrument for the analysis and assessment of major political decisions regarding distribution of income and generation of a greater welfare. In these decisions, the subjective elements may be assigned more or less weighting. It is the State who, from the very start, should be in charge of the task of defining the "quality of life", sharing the load with workers and entrepreneurs but, at the same time, getting the greatest possible support from research institutes in order to obtain information on present-day reality, desirable objectives and possible expectations. Many of the solutions, for example, in the fields of health and nutrition, should be founded on Science and Technology;

^{*}/ See 10, p.31.

others, such as those regarding income, savings and formation of capital, should be based on economic growth.

(c) Technology and economic growth

13. The importance of science and technology for the accurate determination of the objectives of development and the possibility of reaching some of them can be clearly surmised from the preceding lines. At the same time, the fundamental role of knowledge and know-how in economic growth is nowadays no longer questioned. Schumpeter, in his now classical "Theory of Economic Development" ^{12/}, says that "the slow but constant increase in the national availability of productive and savings resources with the passage of time, is certainly an important factor to explain the course followed by economic history throughout the centuries. However, it is also completely subject to the fact that the essence of development is employing existing resources in different ways, in putting them to new uses, regardless of the fact that such resources may or may not increase". These changes are the result of the application of new technologies.

14. The process is as old as Mankind. However, in the last few years, it has acquired an altogether different significance. "What is different now is that the discovery of natural laws through scientific research has given technology a new dimension. This phenomenon has been accompanied by such a massive effect that technology not only offers the hope of relief from poverty or the provision of healthier living conditions but also, and as a result of its strength, brutality and lack of systematic control by human wisdom, it threatens the patterns of life, the ecology of the planet and even the "survival of the species".^{13/} The part played by technological progress in growth has long been acknowledged: the same amount of capital and labour generate a higher productivity because of technological advances, more efficiency and an improved training of labour. Some research has been carried out in this area, the results of which have received some criticism concerning their quantitative value, but which reflect /the enormous

the enormous importance of the technological component in the rate of growth. According to studies prepared by Denison ^{14/}, if the rate of growth of 4.02 per cent of the National Income in the United States for the period comprised between 1948-1969 is broken down into its component factors, labour is accountable for 36 per cent, capital for 22 per cent and advances in technology for 34 per cent. Studies carried out in European countries and Japan show somewhat similar results.^{15/}

15. Consequently, it is undeniable that the knowledge supplied by Science and Technology is of crucial importance in the generation of goods and services. As early as ten years ago or so, a joint study prepared by OAS/ECLA stated that "the modern economic theory has definitely admitted that in the production function, technological innovation is as important a factor as the classical, namely, capital, labour and raw materials". The present document wishes to stress that the development function depends on several variables. Among these, the most "classical" are directly linked to economic theory, but that there are other just as important variables which are linked to the environment, social, political and cultural systems and problems of behaviour or ethical patterns. The Science and Technology variable is closely connected to all of them, economic or otherwise. However, going beyond official statements, programmes and development policies of the region, an analysis of the facts shows that the position stated in this document has only received an incidental consideration on the part of the decision-taking levels most closely involved in the development issue.

(d) The Science and Technology variable as Development factor

16. Technological change must therefore be accepted as a development variable. It may well be said that without technological change, the possibility of "growth" and development could not be conceived. Even in the hypothetical case of "economic growth" seen as the result of the sole increase in the classical variables, capital, labour, and natural resources, handling these augmented factors would involve

/a problem

a problem of management demanding technological changes. However, on the whole, a significant development will imply either a greater efficiency in the productive function or its radical transformation. Both alternatives must necessarily possess a strong technological ingredient, i.e., a shift aimed at higher levels of technology both in the productive and the social sectors. The necessary skill to achieve technological transformation requires, in turn, a higher educational level. The need for technological changes and higher educational levels are conditions to be fulfilled, regardless of the type of economy to be adopted or the possible "development styles" chosen. Whatever the case, market, mixed or centrally planned economy, the Science and Technology variable should play a crucial role in development.

17. What is the role of science and technology in this process of change for development? The question is valid for all aspects of the process, although it is easier to deal with when it is related to the production of physical goods. The technological change in these cases is any modification in production methods used by an enterprise. In general, the result will be an increased production with the use of the same, or of fewer resources, and will imply modifications in the physical capital, in work quality, and in the organization of resource. For all purposes in this document, change is a synonym of innovation; in production innovation is introduced through the initiative and capacity for organization of entrepreneurs prepared to replace old methods with new ones. In other sectors of society the change will be brought about by administrators representing collective interests. Innovation is therefore the application of existing knowledge or processes which have not yet been applied in the desired field, whether the field be an enterprise, a country, a region, or the world. Innovation differs essentially in this sense from invention, which is the result of a new combination of resources giving rise to a new product or process; innovation can be considered as the putting to practical use of an invention.

/18. Invention

18. Invention is thus the more or less finished product of a lengthy previous process of "scientific-technological activity" or of a "Scientific and Technological System". UNESCO considers these terms too vague, preferring "Research and Development Activities" and "Related scientific-technological services", including in this latter expression the whole range of activities designed to collect data and for which scientific and technological criteria and processes are involved, but which do not necessarily imply research and development. The major concept of "research and development activities" includes scientific as well as technological aspects at every level in which these activities are present, from basic research to project engineering; from the objective study of empirical phenomena in order to discover causal relationships which account for phenomena, to inventions and the design of production methods and processes which transform inventions into applicable "innovations".

19. In this document, under the heading of Science and Technology, in development, the wide range of items referred to above is included. However, a further consideration is required. In the ordinary sense of the term, the way in which the public and even some authorities understand it, Science and Technology has a connotation clearly limited to the natural sciences and to industrial application. When the concept is extended, it covers a far wider field and includes applications of the natural sciences, the vast area of living creatures and ecosystems, for example. The relationship between science and technology and development is both obvious and undeniable, even with this magnified scope. However, in this document the intended scope is even greater, since economic growth and development have many facets which affect profoundly all the structures of society. But there is clearly a reluctance on the part of the scientist, the technician and the engineer to reflect upon the social consequences of their achievements, to avoid being dragged into the political controversies which are generated.

/20. But

20. But reluctance to become involved in certain problems does not mean a denial of their existence nor a minimization of their importance. Every problem which concerns man as an individual or as part of a community affects the prime resource of development as well as the final objective of development, which are one and the same thing: man himself. For this reason the present document also underlines the part to be played by the social sciences.

"The social and behavioural sciences can and must play an important part in the productivity of our society by contributing to an efficient use of our most valuable resources: our own human behaviour, our way of thinking, and our procedures for solving problems".^{18/}

It is possible that the difficulty and reluctance to apply the social sciences is largely due to the fact that these have not been studied with the same experimental rigour and with the same objectivity that characterize the natural sciences. However, as progress along these lines is made, it is clear that the benefits of such an approach will be increasingly recognized. In any case, any assessment that is made at present with the social sciences in mind is obviously more practical, more sensible, and far sounder than one which is made without their contribution. Moreover, mathematical instruments nowadays do not belong exclusively to the natural sciences; they have been widely used for years in economics and in other social sciences, and to an even greater extent in the study of individual behaviour. What is true for mathematics can also be said of other instruments: systems analysis and operative research, for example. "The dialogue between engineers, economists and sociologists began on a cautious note, and although it has positive aspects, it is still insufficient".^{17/} ^{#/} The new trends in monetary thinking and their concern with inflation and its expected effects come up against the absence of a fully-accepted theory about the way human beings form such expectations. At the present time there is a "rational theory of expectation" in economics, which for a number of people does not seem to properly represent

^{#/} See 17/ p. 23

real human behaviour. This is a field where the joint work of economists and psychologists can be fruitful.

(e) Research and Development activities in the World

21. With the above outline of the scope of scientific and technological activities that the present document considers as important contributors to development (and which as such should be taken into consideration at the level of decision-making in development programmes), it is worth remembering what is happening in this field throughout the world, and the many words which have been spoken and written on the subject. To repeat the fact that the inequalities of our international order are of crucial importance, is to state an obvious truth. To mention that there are two worlds in one, and that between rich countries and poor countries no comparison can possibly be made, is to emphasize the obvious. But on this particular subject it is worth drawing attention to the situation with regard to science and technology, where the inequalities take on gigantic proportions. The concentration of research and development in the hands of a small number of highly-industrialized countries is perhaps one of the most typical characteristics of this inequality. Of world expenditure on "research and development", developing countries account for less than 3 per cent of the total. Latin America's share is estimated at 0.94 per cent, or slightly less than a third of the developing countries' total. The world average expenditure is 1.97 per cent of its GNP, whereas the figure for Latin America is 0.37 per cent of the region's GNP. Of the total number of scientists and engineers engaged in research and development throughout the world, 12.6 per cent belong to developing countries whereas 87.4 per cent work for industrialized nations.*

22. This enormous expenditure on science and technology, which is currently estimated at several hundred thousand million dollars,

*/ These figures are provisional, from the World R. and D. Survey (1978) and are for 1973. See 19/ Tables 1 and 2.

/is mainly

is mainly invested in research and development which favours industrialized countries. Apart from the increased knowledge resulting from research and basic scientific discoveries which enrich mankind's heritage and which is a freely-available commodity, the majority of technological innovation thus obtained comes under the heading of "industrial patents" and is aimed at solving problems of the developing countries themselves. One such problem, for example, concerns the productivity of labour, which is scarce in industrialized countries; technology of this type is therefore intensive in capital and energy. A very high proportion of expenditure on research and development (between 25 and 40 per cent of the world total according to different sources) &/ is assigned to the improvement and design of armaments. The relation between the volume of armaments produced and funds assigned to research and development is considerably higher than in any other area of productive activity. Technological know-how, particularly in its most recent and effective forms, is generally the property of individuals, of transnational companies, or of industrialized nations, and is a valuable commodity which is marketed subject to conditions and restrictions in its use which limit the benefits obtainable from its application by those who are not its originators.

23. It should be stressed that not only is there an enormous difference between the amount of technological knowledge available to the developing world and to industrialized nations, but also a substantial difference in its quality. In fact, in industrialized nations "Scientific and Technological Policies are influenced by the specific problems of these nations' economies, and the relationship between the objectives of 'research and development' and their socio-economic context means that present day projects are overwhelmingly aimed at the problems existing in industrialized nations, whose economic social and cultural structures differ radically from those in developing countries".21/

&/ See 19/ and also 20/.

These facts account for the difference in the concept of Science and Technology held by the masses living in industrialized nations, and that of the masses in developing countries. Industrialized nations have lived through the gradual progress of techniques and skills of the industrial revolution, and have witnessed the process of technology and scientific knowledge taking root over the last 200 years. Technological advances are the answer to their citizens' problems and needs, and there is a general understanding of the relationship between scientific discoveries, technological changes and improved well-being. Such an attitude provides a suitable atmosphere for the advance of research and development; the concept is part of their way of life. In developing nations, on the other hand, even though they have benefitted greatly from the use of technology applied in the area of health, for example, and to a certain degree in agriculture, the concept of science and technology is unknown to the masses and in many cases it clashes with their customs and beliefs. In this sense, even if their attitude cannot be considered negative, it certainly lacks a positive approach.

24. This lack of understanding on the part of the great majorities in the developing world no doubt stems from their general levels of insufficient education and culture. Besides, the available technological changes have not been created, and are sometimes "inadequate", for the environment where they are to be applied. The relationships established on a universal scale in which developing nations have been assigned the role of providing raw materials and inexpensive labour-intensive activities is constantly threatened by technology. Technology tries to solve the problems which affect the developed world and these problems are precisely lack of raw materials on the one hand and high cost of labour on the other. Synthetic materials, genetic engineering and industrial robots are all examples of solutions provided by technology. The answer to the dilemma is not to reject scientific and technological efforts since this could only widen the gap and inequalities existing between . . . /developing and . . .

developing and industrialized nations. There is only one possible alternative and that is to incorporate actively and positively the science and technology variable to the development effort in the lesser developed world.

(f) Creation or imitation: a false dilemma

25. Three hundred years ago or so, the most advanced nations of the "glorious" East, China, Persia or India had a standard of living comparable to the most advanced nations of Europe; South America, because of its riches, was given the name of EL DORADO. European nations had a per capita income of possibly not more than 6 or 7 per cent of their present level.^{22/} The Renaissance, a Western Europe phenomenon, together with the forms of government and economies which were formed at that time gave rise to the "new international order" and to the enormous difference which exist today in the three areas of the world. The rich and powerful nations of the world had no model to imitate; the results obtained were due to an extraordinary creative force, offering original solutions which were possible only as a result of the scientific and technological efforts, independent of each other at first but progressively more coordinated, and with an increasingly intense process of logical and ordered development. The objectives and the means were very different from the ideal or possible means available today. Some years ago a distinguished American intellectual wrote "The present determined campaign by American blacks to obtain and assert their civil rights, after a century of so called emancipation, serves as a reminder to Americans of the reason for the low cost of the development of their country".^{23/} Present behaviour norms, ethical patterns, and educational and cultural levels have given rise to different needs and expectations and to a wide variety of different resources. It is worth pointing out that the most advanced countries among those of the industrialized world which for some years have been classified as being at the "post industrial" stage, have placed
/greater emphasis

greater emphasis on the social aspect rather than on the economical aspect in their objectives. Moreover their actions are primarily aimed at strengthening their scientific and technological potential in order to attend to the ever - increasing evolution of their production.

26. On the other hand, poor countries live permanently awed by the living conditions in developed countries, which become a model worthy of imitation. The improvement and massification of means of communication and the establishment in national territories of "modernized enclaves" that only favour a small elite but that also fix tangible patterns of these living conditions, increase the wish to imitate. The illusion, however, does not take into account the measurement of the required inputs, energy, efforts and knowledge needed to achieve the desired model. Developed countries, with less than a third of the world population use 75% of the world's non-renewable resources; "each American, who needs a million calories in food and thirteen tons of coal per year ... is consuming the resources available in the biosphere at least 500 times faster than a person living in India ...".^{24/}

27. In other words, conditions existing at the start of the industrial revolution were very different from present ones; the level achieved by developed countries is superior by far to that of the developing world, and the objectives and perspectives of rich countries are channeled to solve more complex needs and problems than those in the poor countries. The fact that they view their development as a mere imitative option appears to be both pointless and senseless even if the proposed model is worth imitating.

Diametrically opposite the imitative option there is the one hundred per cent creative option which attempts to find solutions for all the problems that a society presents, using for this purpose only knowledge which is freely available. Between these two options, the imitative and the creative, there is an infinite number of

/possible alternatives

possible alternatives for solutions which are more compatible with the resources available and the state of development, with the historical, cultural, social and other factors which determine the character of a nation in the present moment and which set desirable objectives compatible with the available means. Within this intermediate option there is an important proportion of imitation as well as an unavoidable need to adapt what is necessary to imitate, but, above all, there is a substantial part of original creativity. It is possible to claim that in the case of Latin American countries, because of their historical relationship with the western world and the economic dependence of their origins, and because of the cultural inheritance and their position in the western power scheme, the imitation component of the industrialized countries will be predominant. It is a well known fact that the first model imitated by Latin American nations was that of Spain and Portugal through a type of legislation which attempted to set up systems of administration, of property and ways of life copied from these models and imposed on societies for which the models were unsuitable. During the first decades of independence, Latin American countries attempted to imitate the English and French models and more recently these countries seem to have been impressed by the American model. The choice of these models without sensible adjustments to prevailing conditions in the societies where they have been applied probably explains in part their relative backwardness.

28. The rapid progress of industrialized countries was the end product of their extraordinary creative strength. The stream of English scientific thought stemming from the teachings of Francis Bacon and broadened by the genius of Boyle and Newton, wrote T.S. Ashton "was one of the major contributors to the industrial revolution". This statement cannot be argued with, although many of the first inventors who transformed production methods were not exactly scientists.^{25/} The road to development was not an easy one; it was paved with "hardships" which present societies could not tolerate since they
/would imply

would imply on the one hand the sacrifice of their most cherished ideals such as freedom and survival or, on the other, the acceptance of coercion and submission to its decisions. However, the problem seems to have a positive answer if the need for a revision of the use given to development factors is accepted, and particularly, if the Science and Technology variable is assigned more importance. The proper application of the Science and Technology variable will permit to optimize the use of the other variables, as well as, in itself, being able to provide original solutions to problems characteristic of a particular country and which have no answer in the accumulated experience of other regions which are physically and humanly different.

29. The disadvantages facing late starters in the process of development can now be tempered by the presence of a universal science and a technology which is accessible to varying degree and with the limitations already mentioned. Theoretically, it should now be possible to make faster progress along a better road by pursuing, not the mirage of the image of the developed world, but simpler and more realistic goals. All this implies a suitable use of the science and technology variable and the deployment of this variable as a creative instrument for dealing with original problems, by adapting technology acquired abroad, and by actively studying accumulated local knowledge, since even the most primitive societies have managed to accumulate experience and know-how which undoubtedly has its technological value. In order to use science and technology it is necessary to be able to create it; Science and Technology are required in the process of development from the very start and in all subsequent stages. The contribution of science and technology is of fundamental importance, and with this in mind the study of some problem areas with typical examples of its application now follow.

Chapter II

PROBLEM AREAS: SOME EXAMPLES

(a) Definition of a "problem area"

30. A process of development implies moving from a present situation into a future situation, in several stages, with the achievement of objectives which bring about an improved "standard of living". Whether a planned system for development exists or not, countries advance in a given direction with fairly well-defined general objectives. Development is a dynamic process; therefore time and speed are its characteristic elements. The time factor, which concerns decision taking, is therefore an important feature. "A week is a long time in politics" is a true statement, as is "the great majority of decisions taken by enterprises and private individuals, as well as by governments, concerns either the present or the immediate future. In periods of uncertainty, this time factor tends to be shortened even further". 26/

It has been acknowledged for some time that in the socio-economic field forecast of more than 6 years is unlikely be effective since both the complexity of the socio-economic systems and the statistical behaviour of the past hardly offer satisfactorily reliability beyond a six-year limit. For this reason, realistic long-term objectives can only be guidelines with relatively imprecise images or alternative future settings of the proposed model. The image-objective will consist, on the one hand, of "active" elements which will imply modifications of the existing attitudes and the creation of new attitudes and mentalities, and on the other of "conditioning" elements which will take into account both the potential and the limitations of all kinds of resources, the international situation, etc. 43/ Within this time factor, in a generation or more, some of the knowledge that scientists at present can only guess at, or the technology which will apply today's most recent scientific advances will be present, and will alter any

/prospect of

prospect of attempting to visualize that distant future. For this reason concrete Government decisions (and those of enterprises and individuals) rarely lay down objectives beyond a 3 or 5 year period, but they make commitments of expenditure and other kinds for a longer period. It is under these conditions, and within these limitations that concrete projects of development should be conceived. However, sub-systems or minor units of reality which are meant to be dealt with --particularly within natural systems--obey behavioral laws which require longer periods of projected study.

31. Once the objectives of development are established what is necessary to be modified in the present situation can be identified so as to reach the desirable long-term goals or the shorter-term goals of each intermediate stage. Some problems which are immediately identified and concern present difficulties are not necessarily a priority if the goals in the following stage or long term goals are borne in mind. In the language of development planning the term "problem areas" 27/ 28/ is often, though not widely used to refer to activities and all kinds of physical or social structures which require modification before desirable goals in the desirable development model can be achieved. The more general, the more complex and the further removed in time these objectives are, the more general and the more complex the problem areas will be.^{*} However, as the pursuit of these objectives is carried out in planned stages with intermediate goals, the "problem areas" will become more reduced and manageable, and will give rise to "project areas" whose expected results, and the volume and variety of resources required will themselves gradually become a priority within the process of development and planning.

^{*} The concept "problem-area" has been recently accepted by ILPES in its planning activities. It is not a term fully incorporated into the "art" of planning, but it is a useful item planning and projects.

32. What are the relationships between these "problem-areas" and the Science and Technology variable? In what way does the Science and Technology variable help to identify problems and solve them? At what moment in the decision-making stages is it useful to introduce this variable? The purpose of this chapter is to clarify these and other similar issues. For this purpose it is necessary to understand how to identify a "problem-area".

(b) The nation as a suprasystem or "system of systems"

33. For a long time it has been said that "man inhabits two worlds. On the one hand the natural world of plants, animals, earth, air and water which preceded him by thousands of millions of years and to which he belongs. On the other, the world of social institutions and of appliances, built by himself, his tools and machines, his science and his dreams, to obtain an environment at the service of human will". ^{*/} Sometimes these two worlds are referred to as the biosphere and the technosphere. In this way, man turns out to be the final link in the complex relationships between his natural environment and the environment which he himself has built and in which he cannot be conceived as a being removed from these environments, nor can he be separately considered as a biological economic or social being. These concepts accepted for individuals are equally as valid on a world scale, and can also be applied to each individual nation. Unfortunately when problems are considered from the point of view of communities and not from the point of view of the individual, there is a tendency to consider only measurable and quantifiable elements, which then acquire greater importance than elements which are merely qualitative. The measurable and quantifiable elements are considered objective and reliable. The qualitative elements are subjective and doubtful. To avoid this distorted breakdown it is useful to conceive individuals and

^{*/} See 24/ p. 31.

their environment as a system. This is certainly not a new approach; it was used by the MIT for the Club of Rome in a world model it analyzed. This system has five principal variables: population, capital expenditure, natural resources, pollution and capital investment in agriculture. To support or contradict the conclusions of the Club of Rome numerous other systems have been analyzed; among them the aforementioned Bariloche Foundation. A/

34. The system approach gives greater emphasis to the whole than to its parts; in an organized system the behaviour of its parts has in the last instance some effect on the rest of the parts which form it; much of this effect is insignificant or undetectable. In systems analysis, determining significant interaction produced by action or any part of the system is important. As far as this document AA/ is concerned a country is considered a system of systems or a very simplified suprasystem. Like all models this suprasystem intends to give reality a more accesible image and as such it is useful only for desired ends and not for more complex purposes than those it intends to explain or analyze. As has already been said the individual on this planet and in a particular country inhabits two different worlds; the same is valid for a group of individuals who live in a country. These two worlds, the biosphere and the technosphere constitute two different systems, on the one hand, a natural system with all its resources, advantages and difficulties and on the other, what the individuals themselves have built into it i.e. a man-made system.

35. The latter, upon examination, shows to be made up of the juxtaposition of two perfectly distinguishable systems. One consists of the individuals themselves, the forms of organization that govern

A/ See 10/.

AA/ In this presentation the analysis of Hernán Calderón and Marcelo Robert, shown in 17/, has been used with some modifications.

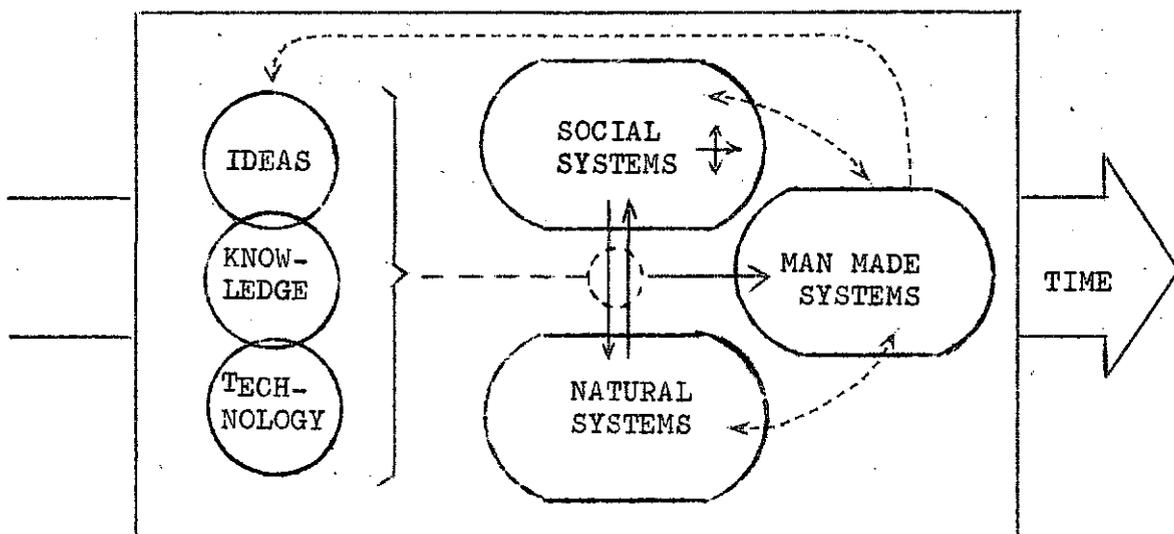
their relationships, enterprises and other ways of carrying out collective activities, the social forces which shows different attitudes towards problems, cultural traditions, etc.; all this combined constitutes what is called the "social" system. The second system includes all the material facts brought about by the action of man, be they cities or means of transport, genetic variations in zoologic or botanic species, changes in the landscape or the environment, and any other work or its consequences; this is the "man-made" system in the usual sense of the word, and is characterized by its greater permanence and indifference. The social system could be described as an oscillating or unstable equilibrium in the sense that it is subject to frequent conflicts which keep it in motion round a central position which in turn suffers slow changes and shifts in accordance with the sluggish changes in beliefs and ideologies. It is here where man-made systems are different since, apart from catastrophes, changes occur on a more stable and permanent basis.

36. It is important to point out that the suprasystem constituted by a nation is an open system, i.e. it is a part of the world with sustained and frequent exchanges with other suprasystems of the planet. What distinguishes a "closed" system from an "open" system is that the former is able to react only to the stimuli for which it was conceived. For example, a thermostat only reacts to changes in temperature of the environment it is meant to control. "Open" systems, on the other hand, are able to react to stimuli for which they were not conceived; they are essentially "live" systems. A nation is a "live" system and, as such it is possible to reach the same final stage starting from different initial positions along different paths. 32/ Whether the stimulus is internal or external is immaterial for such systems; in any case the suprasystem and its three components have their own "built-in self-regulation mechanism", which alone gives a certain degree of freedom. This subsystem of regulation consists of at least three fundamental elements: i) ideologies and beliefs; ii) education and

/knowledge or

knowledge or science; iii) technology. It should be noted that the imbalance of these three elements generates an unbalanced regulation capacity, which causes the three component systems to act in a distorted and less rational way; on the other hand it makes the suprasystem particularly sensitive to the action of the external universe i.e. to other countries, especially the most powerful ones. Developing nations have intensely active ideologies and beliefs; the other two elements of the regulation subsystem are weak; consequently the expected reaction of these nations would be very different from that of a developed country under the same stimulus. The reflection behind the above comment is that the "ideology and sciences" element acts principally in relation to the Social System and to other external suprasystems whose actions are important. The second element, "education and knowledge" acts above all on the three internal systems and the external stimuli of the same kind, and Technology acts on the man-made and natural systems, and to a lesser degree on the social system and the external effects. Such an interpretation is intended merely to point out differences in emphasis.

FIGURE NO 1



(c) The

(c) The systematic concept and "problem areas"

37. Every development process, even when the implied activities only involve the man-made system, modifies the other two systems. If, for example, the actions are productive processes, the three systems must contribute to their concrete effectiveness and the result obtained will somehow be controlled by the efficiency of the three elements of the regulating subsystem. Science forms part of the three and technology itself is the third element; if the model is accepted as a good representation of the national development, the importance of science and technology becomes particularly relevant. This model is obviously dynamic; the time dimension is permanently present, as is in every process. However, in development it is necessary to bear in mind that difference in speed between the various systems and its component parts will necessarily occur. This difference in speed is specially noticeable between "Ideologies and Sciences" on the one hand, and "Science and Technology" on the other; the former within the planned target dates and, with the exception of deep revolutionary changes in a country, can be considered as relatively rigid; the latter are characterized nowadays by the very speed of their changes and by the results produced, which become identified with the concept of "modernization". These differences in speed will therefore bring about not an enlarged original model but successive different models; the point is that future models become increasingly identified with the image-objective selected, and therefore represent improved living conditions.

38. When development is considered in the light of this systemic approach, it is easy to see that a group of actions meant to attain a certain number of goals or objectives, are bound to make demands on the three systems and their component parts i.e. a great number of problem-areas will be identified. From these it is essential to select a reduced and relevant group to submit them to the policies and decisions at the higher levels of Government and to the instruments

/this government

this government is likely to use. To try to act on all the spectrum of the problem areas implies such a complex action that it is avoided even in centrally planned systems. ILPES analyzed the planning practice of the countries of the area and found that there are residual effects. Among these effects there is the tendency of the processes and of the planning mechanisms to use up their energy in making a "book-plan". In trying to cover the whole universe of possible actions which generate foreseeable or unforeseeable interaction of the changing conditions in an internal system of a country and of its external suprasystems, the planning efficiency and the achievement of goals is reduced; planning becomes isolated from the organisms of real policy making and from the operative bureaucratic mechanisms. 33/ This field will be dealt with again when the relationship between the Science and Technology variable and Planning is analyzed below.

39. In order to achieve the purpose of identifying some problem areas and to establish their relationships with the Science and Technology variable, it is obvious that several paths are available. In this paper, two possibilities were considered; the first possibility from the point of view of the objectives and the second from the point of view of the analysis of the major actions. Obviously, as soon as the study of the problem areas became deeper, the two possibilities lead to common considerations and conclusions, consequently in this paper the analysis is presented as a single entity. The starting point is that in any stage of development there is a present situation which, within the target date compatible with the possibility of real actions and decisions of the community, is expected to become a desirable future situation. In this future situation, certain definite goals will be achieved within the general direction of development, characterized by the image-objective proposed as a long-term end. For example, at the present time, industrialized countries, as one of the elements of their long-term image-objective, conclude that for the 2020-2030 decade living conditions, the structure of the economic activity and the use of the

/inhabited environment

inhabited environment will undergo such great changes that the demand for energy will be greatly modified compared to the present demand. 4/ For this reason, policies are nowadays fundamentally directed towards energy-saving and towards a separation of energy and growth.

40. If any development problem is examined within the frame-work of the two perspectives mentioned above, the medium-term, concrete and practical stage and the longer-term image-objective, the possibilities for the former are based on technologies and innovations currently available in the world. On the contrary, meeting long-term objectives formulated with a perspective of one or two generations in mind --a reasonably acceptable maximum--calls for some actions that sometimes require new science and, most certainly, original technologies resulting, in a large proportion, from new inventions and innovations. The general guidelines are well-known today, but their practical materialization needs a long process of applied research, experimental development and basic engineering. To continue with the example drawn from the energy sector, whoever is familiar with it will immediately remember such fundamental aspects as the development of breeders, nuclear fission, hydromagnetic energy, and to quote a more familiar and tangible example for the layman, solar energy and timing of its materialization. It is obvious, from the first approach to the problem, that if the targets and objectives set by any country take the time factor into account and are considered from the view-point of initial state and degree of information on all available resources, it will be necessary to count on the informed advice of scientists and technicians to assess their realism and prospects. In other words, experts on the science and technology variable should be consulted at an early stage of planning conducive to development by top --level policy-- makers. Their participation may have a more crucial importance for objectives than for targets, although the latter may often be set on the basis of

4/ 26/, p. 15.

external information that take imperfect account of internal "knowledge" and "state of the art", and which are therefore unattainable within the time assigned as normal limit for any stage.

(d) Examples of problem areas in the three classical factors of growth

41. On evolving from an initial present state to a new future situation, the "quality of life" will necessarily suffer modifications in some of its objective and subjective aspects and, obviously, there will have to be some economic growth as a necessary condition for development. Within growth, the three traditionally essential classical factors are natural resources, human resources and capital, all of which belong to each of the three systems already mentioned. Furthermore, because of their importance, two main elements of the man-made system, transport and energy, deserve special consideration since their role in the productive process is crucial for all the activities that compose it and since, depending on their availability at the initial state they may constitute important external economies or problem areas of a great magnitude. Proposed suggestions for growth for a developing country will naturally have a direct relationship with its natural resources, on which there may or may not be information, and technology for their better use, if there are similarities with what has already been done in other parts of the world. On the whole, that would be the case of non-renewable resources, but the situation would be completely different in the case of sub-tropical or sub-antartic woods or arid zones. Only in later years have renewable resources caught the attention of scientists and experts in the developed world and, to a certain natural extent, also in the underdeveloped world. */ In other words, renewable resources are largely dependent on the ecosystem to which they belong. In agriculture, for example, scientific knowledge possesses general

*/ This document does not ignore what has been accomplished or is being done in this respect. It only wants to point out that the effort has been most inadequate due to the importance that these resources have for the world and their significance in some countries with a tropical climate. In this connexion, and as way of example, see 34/.

general validity and applied technologies are normally available without any limitation imposed by patents or other restrictions preventing their dissemination or use. However, "agriculture requires a scientific approach of rigorous research on the reality and interaction of atmosphere and climate, water, soil and plants. Answers should not consist of broad generalization but should rather be 'thorough particularities' and specific instructions on what to or not to do in a particular place, at a given time with specific things". 4/ This case, as all processes having to do with live systems and with the ecosystem in which they take place is perhaps the most important example of exploitation of natural resources in developing countries, requiring the services of science, basic original research for each nation and a permanent technological adaptation at a real micro level. This requirement is indispensable to optimize results, whose cost would, on the whole, be lower than if other inputs were to be used. It does, however, call for technological innovation whose origin or, at least, adaptation, should be endogenous. Within the field of exploitation and use of renewable resources, developing countries have accumulated traditions based on observations and experiences transmitted for generations. This is particularly valid in the case of societies that have occupied the same territory for several centuries. This accumulation of knowledge and customs constitutes the collective knowledge of the society in question or, in other words, a basic socio-cultural archive of knowledge, a real endogenous technology which, before suffering alterations through the application of "scientific" or "modern" techniques should be investigated in a rational way. This investigation also belongs within the field of science and technology.

42. An analysis in further depth of the necessary natural resources to bring about "growth", shows the need for a closer look at a very important example --energy-- which may serve as pattern for any

4/ See 24/, p. 102.

other resource since it is characterized by being based on different natural sources of a renewable or non-renewable nature, and on traditional, new or budding technologies. Within this vast problem area at least four stages can be identified: (i) inventory of and information on resources available in the country; (ii) choice among the different possible sources of those that can be better used at any given stage of the national development; (iii) rational use of energy; (iv) the necessary policy elements to provide guidelines for their use. The science and technology variable plays an active part at all these stages from the very start and, consequently, a rational dialogue between policy-makers and experts should be encouraged. For example, the first stage should be assigned to such activities as have been classified under the "connected scientific-technological services" label, even in such cases as may generate both applied research and, in exceptional cases, basic research. The second stage, i.e., choosing between different alternative energy sources is a problem that is frequently solved by technico-economic considerations and by established evaluation procedures. Depending on the level of foreseeable national development, these procedures should be adapted by conditioning factors related to the environment, the social needs arising from the use of energy, etc., whose weighting may modify the decisions that are taken. In the case of the utilization of the country's own natural resources that may possess characteristics that differentiate them from similar sources already studied elsewhere or whenever the country may wish to make progress in the use of resources which are also at the innovation stage in the rest of the world, the country itself should contribute with its own share of adaptation or invention. The present document does not advocate the creation of a specific Science and Technology apparatus for the purposes described in the stages (i) and (ii), but availability of the necessary internal knowledge on the "state of the art", use of resources, location of the necessary sources of information and ability to interpret and assess the available data in an accurate

way. In other words, the purpose here is to recommend the need for the implementation and reinforcement of some institutions such as research centers, universities, or others, which, in addition to their own duties should be permanently capable of supplying this type of data. The information thus obtained would be consolidated and processed for future use by the decisions system or whenever science and technology may be required for the utilization of such national resources as demand "original" solutions.

43. How to use energy in a rational way or how to save energy is one of the primary issues of our time. Rather than act at the supply end, as has been the "consumerist" policy of the industrialized world until the last decade, the idea is to affect demand. Saving energy in all its forms, not in the sense of merely reducing waste but of focussing creativity and innovation of new processes, machinery and productive operations that need less energy to produce the same commodity or service, has become the dominant trend of technology in this field. Thus, there is a need for the creation and application of new techniques and solutions to a diversity of aspects. What the industrialized countries invent may not necessarily be what the developing world needs, since different sets of factors are at play. Consequently, local production of original solutions should be expected in this aspect of the energy issue. The fourth stage mentioned above, energy policies, will be guided by considerations that somehow escape the control of the Science and Technology variable: the decision-taking center must respond to the different influence sectors which conform the structure of power and which represent varying interests that sometimes conflict with the "national interests". However, coincidence with the "scientific rationale" of any given moment does not always take place to the expected relatively reasonable extent. It is pointless to ignore this reality. However, its degree of gravity will decrease significantly if due account has been taken of the Science and Technology variable in the previous stages. Only if this is done will mere political

/decisions have

decisions have a considerably lesser degree of freedom and will on the whole be structured within rational constraints.

44. Among the classical factors considered to be necessary for "growth", the human resource holds an undisputed first place. The human resource is both the principal means of growth and the ultimate objective of development. If it were not an apparent contradiction in terms, it may very well be said that it is both input and finished product. The human resource may be perfected by all the means that are directed to improve "the quality of life". In other words, the purpose of development is the improvement of Man. It is not the intention of the present document to give an exhaustive treatment to this point. For the purposes of analysis from the viewpoint of the need for science and technology, the following were considered among the elements that permit a more reliable evaluation of the "quality of life": food, education, housing, health, urban development, environment, transport, culture and recreation, participation and ethical values. If these elements are analyzed with reference to industrialized countries from the perspective mentioned in this document, the result will be positive in general: there is a great scientific and technological knowledge about all of them. The research and development capacity that industrialized nations possess has been and will continue to be applied in an intensive way. If, on the other hand, the situation prevailing in developing countries is examined, results will per force be different since all the above-mentioned elements refer to a social system composed by individuals who are unique human beings living in natural systems entirely different from those for which the knowledge and technology of the industrialized countries was created. The table that follows sums up what has been estimated as the present average state of the science and technology variable in the countries of the area. The table does not intend to submit a thoroughly informed evaluation accompanied by rigorous scientific weightings of each of the factors, but is based on estimates derived from a vast knowledge of the region.

/If the

If the table is examined in a global way, we may see that specific science and technology efforts in problem areas involving an improvement in quality of life are considerable but no quite as complete as they should be. To quote an example, efforts made in connection with production, commercial processing and enrichment of autochthonous foods seem insufficient, despite the fact that they compose the nutritional fare for a large number of people living in many of the countries of the region. Finding original solutions for housing and accompanying environmental problems is also necessary. This effort should attempt at reconciling customs, local resources and economic limitations that constitute almost unsurmountable obstacles to solving the problem by means of a mere adaptive imitation of models imported from countries with other climates, requirements and economic levels.

Table 1

THE SCIENCE AND TECHNOLOGY VARIABLE (S AND T) IN THE MOST CRUCIAL ASPECTS OF "QUALITY OF LIFE". ESTIMATE OF THE SITUATION IN LATIN AMERICA

S and T State		Remarks
<u>Food</u>		
(i) "western"	▲	There is a moderately satisfactory knowledge of S and T from the viewpoint of imitative "western" food. However, the knowledge has not been disseminated at a massive level.
(ii) autochthonous	○	There is a totally insufficient analysis from the viewpoint of autochthonous food S and T, despite such food being consumed by a considerable number of people.

/Education

S and T State	Remarks
<u>Education</u>	▲ A considerable effort. However, integration of "original" values is insufficient from the viewpoint of S and T.
<u>Housing</u>	△
(i) Modern	There is sufficient knowledge for imitative housing.
(ii) Transition and local materials and designs	○ From the viewpoint of suitable adaptation to existing levels of underdevelopment and, above all, of the exploitation of local materials and designs, the S and T effort can be estimated as non-existent.
<u>Health</u>	▲
Prevention and Medical care	Quite satisfactory for the level of development but requiring additional permanent efforts.
<u>Urban development, environment and human transport</u>	▲
<u>Culture and recreation</u>	△ Save for the undeniable need for a bigger effort in connection with autochthonous values, the S and T variable does not seem to be missing.
<u>Participation and ethical values</u>	▲ This area is not easily assessed in a global way. More efforts are necessary.

△ Existing and sufficient for the level of development.

▲ Partially existing and being developed.

○ Insufficient or non-existent.

45. The question of education is worth special consideration because of its direct and immediate connexion with the main point of this document. It is difficult to conceive the introduction of new technological innovations in the national activities, if the people who are going to handle them do not possess a higher level of education and training. Consequently, it is only logical to expect a strong and rigid link between the education factor and development possibilities. The basic underlying problem is that the introduction of innovations requires not only being informed about them, but also being able to absorb such information. This will be dealt with more fully elsewhere but, it is worth stressing its importance here and now since it is one of the most frequently underestimated aspects both in global studies and, particularly, in studies connected with specific projects. The natural answer in such cases would be to train the specialized staff needed for those projects. ¶ It is undeniable that such an approach may be useful for specific projects. However, specific projects are the exception rather than the rule in the development process and affect only a small proportion of the active population that must play a part in the process of innovation. For example, in the agricultural, construction, transport or general services sectors, the whole of the employed population should be able to absorb the available technology through a process of dissemination and this requires a better level of general education. Furthermore, it must be pointed out that the process of training a specialized worker, and to a higher degree, a professional with a university degree needs a minimum dimension or scale. Very small countries may not be the right size to carry out the necessary task in an efficient way. This is the reason why developing countries have frequently organized common bilateral or multi-lateral programmes. This type of cooperative effort should be borne in mind

¶ For example, a report on energy reads as follows: "To improve the absorption capacity of developing nations in the energy technology sector, it is absolutely necessary to train specialized staff". 35/

for this and other purposes related to Science and Technology. Adam Smith's position, stated over two hundred years ago, in the sense that the prosperity of the nations is fundamentally determined by "the ability, skill and good sense with which their labour is used" 36/ is still completely valid.

46. Determining whether there is an easily established relationship between the science and technology variable and the generation of surplus susceptible of capitalization is, no doubt, an important aspect because of the important role assigned to capital as one of the key factors in growth. Despite the fact that some attention has been paid to the problem, and although there may be an obvious answer provided by Economics, particularly from the approach of basic concepts in the formation of capital, there is no such obvious answer regarding the connexion between the problem-area of capital and the science and technology variable. It is an undeniable fact that such connexion exists, but it only makes its presence felt through the interactions of other elements of the suprasystem. This is, in fact, a problem of efficiency in the use of capital and efficiency in consumption: both actions have a technological nature and contribute in a positive way to the use and generation of capital. However, the subject has not been dealt with in greater depth. This is a good reason for emphasizing the latest report published by the World Bank in connexion with human resources and capital: they state that the development of these resources, by means of a better education, health, food and family planning is not only a goal but also promotes economic growth in as effective a way as capital investments in works of a physical nature. 37/ Even the commitment of financial resources per unit of growth may possibly be lower than the capital demands involved in other type of investments. It is always worth repeating that the results shown by every single study attempting to measure the return rates of education are most impressive. The "social" rate of return or, in other words, the rate that measures cost for society and that therefore considers

both public and private cost, is 27.3% for primary education in countries with a low level of literacy (less than 50% of adult literacy) and a low income, whereas in countries possessing a medium-scale income and over 50% of adult literacy, it is 22.2%. The "private" rate of return i.e. that which only considers private cost and benefits after taxes, is generally higher. †

(e) Problem areas in joint aspects of development: styles, the territory issue and relative position in the world

47. The identification of problem-areas and their relationship with the Science and Technology variable has been analyzed within the framework of the direct demands that both growth and quality of life make upon the factors to be activated in order to obtain results (natural and human resources, capital) or the work or action to be undertaken (food, education, health, housing, etc.). However, there are also other aspects that condition or provide alternatives for the development model and which must therefore be defined and taken into consideration to choose and meet certain targets and objectives. The fact of meeting such conditions or modifying them and the choice of certain types of action may also generate problem-areas whose nature appears to be different from those examined up to now and whose relationship with the Science and Technology variable should be identified. Here are some examples of such aspects or approaches: the "style" of development, the territorial issue and the relative position in the world or region are typical decisions or situations which define some of the characteristics of possible development. This document cannot analyze these matters in great depth because, in some cases, they may correspond to concepts for which there are no universally accepted definitions and, in others, because of their complexity since they involve the simultaneous presence of many elements which, were they considered in isolation, might facilitate, up to a certain point, the identification of the need for the science and

† See 32/, pp. 46-53.

technology variable. At any rate, since they are formulae commonly used when performing analyses of development, their brief examination is necessary.

48. The definition of the expression "styles of development", seems to be open to debate. Some critics think that "attempts at introducing the styles of development subject to international dialogue is not free of having fallen into the trap of using new 'labels' for targets as old as the hills, or of offering nominal solutions that do not correspond to the magnitude of the problems that they intend to solve or to the philosophy of the power structures in charge of their application". 38/ It is not the purpose of this document to take sides in such a debate. Therefore, to admit the possible relationship between the science and technology variable and "development style", some simple concepts will be assumed. There exists in the contemporary world a struggle between two forms of organization that correspond to two main schemes: the capitalist and the socialist. If either is chosen, no matter which, once again it is possible to choose between different actions that will favour development. Thus style of development-- at least from the economic point of view --could be defined as the way in which human and material resources are organized and allocated in order to answer queries as to who, who for and how will goods and services be produced within any given system (capitalist, socialist). 39/ Such definition involves queries of its own, and the immediate reaction is to ask whether in the implicit taking of decisions there is an active and essential participation of people who can handle the science and technology variable. Needless to say, any decision on style of development will be of a political nature, depending on the power relationships between social classes and groups, state and prospects of the economy and social image or future goals that the dominant group or combination of groups may have set. 40/

/49. There

49. There are other definitions and queries in connection with this topic. 41/ However, they do not appear to be necessary for our purposes, since the concept, at least along its essential lines, seems to be clear. All countries, at any given moment in their history, have a "real state of development", in which some important aims are met, to the exclusion of other equally important ones to which the dominant social forces may have assigned a lower priority. No country has yet attained a situation generating total incapacity for change and innovation aimed at their estimation of Progress. If that should happen, there would be grounds for a reasonable doubt about the feasibility of such a society in the future. Once basic choices have been made --capitalist, socialist or other future forms-- within each of them there are options to change the present situation into a future image-objective that may seem better. We must once again stress that this is independent of whether there is a market, centrally-planned or mixed economy: there are alternatives for every case. In order to tackle the problem of how the science and technology variable participates in the style of development, it is necessary to accept some of the characteristics defining the different possible options. To illustrate the point, some of the possible ways of grouping characteristics will be stated below, on the basis of six basic dimensions: (i) economic growth, (ii) social development, (iii) political participation, (iv) cultural identity, (v) ecological sustentation, and (vi) national autonomy. 42/ The breakdown of these dimensions will show the presence of problems whose correct solution will involve an accurate consideration of the science and technology variable. For example, with reference to some dimensions that have already been dealt with in a slightly different way, the ecological sustentation capacity of the development process is expressed mainly in the way in which any society uses the resources of the natural system or of the man-made system, in how it disposes of waste or channels the externalities resulting from its economic activities, the pressure applied to the ecosystem and its

long-term prospects. In a large proportion, such problems depend on their correct consideration through the science and technology variable. It would be easier to say that something similar occurs in other aspects, but it would imply ignoring reality and refusing to acknowledge the fact that decisions concerning style of development will be strongly influenced by political ideologies and by power groups. From this we can derive that although the science and technology variable should be applied at the early stages of the process and before any course of action is taken, it will be taken into account only to such an extent as the quality and strength of its arguments may overcome considerations of an entirely different nature. In any case, whatever decision is taken, problems will appear in each of the above-mentioned dimensions, many of which will necessarily require the use of the science and technology variable. What is more, there is no doubt that the larger the seriousness of the mistakes made because of not having taken due account of suggestions made by experts on this variable, the more intense will later participation of scientists and technicians have to be in order to minimize the negative effects of solutions that would not or could not accept the arguments in favour of a different alternative.

50. The territory issue is somewhat easier to grasp. Many elements must be analyzed in isolation in the development process. However, when they are reassembled to reconstruct reality, problems appear that are typical of the whole and not of the parts. The territory issue is precisely one such case of possible aggregates. This document will present a brief explanation, without attempting to go into a deep analysis of the subject. The questions to be answered are the following: What role does territory play in the development process? What scientific and technological demands are made by the need to overcome certain constraints? Which is the best possible use of a territory's potentials? What is the tolerable rate of development? In other words, what can be done with the territory and how. For the purposes of this study, territory is the geographical sphere within which the

/development process

development process we are concerned with takes place, not only with respect to all its geographical features, its landscape and natural resources but also to the accompanying man-made system with its advantages and disadvantages, its present favourable exploitation and its irrationalities. In other words it is the territory as can be characterized at any given initial stage of development considered to be the starting point. Thus defined and examined, from the viewpoint of the approach of this document the territory plays a dual role: the contribution function, by means of the resources that are available for the productive process, and the support function that is related to the people and the activities carried out within its frontiers.

51. Contributions may be classified under two headings: natural factors and resources. The former include features of the biosphere such as climate, relief, natural topsoil, availability of water, fauna, etc. The importance of research and development on these aspects as well as that of connected scientific and technological services strikes the eye. This is particularly valid for two different and complementary aspects. The first one is the full knowledge of the complexity of natural factors, one of whose essential and yet sometimes neglected characteristics is continuity. Knowledge should be continuous and because of this, it is one of the largest areas on which connected services must work. The second aspect has to do with the modification of the natural factors. It is the responsibility of science and technology to make sure that the alterations to the environment should be positive, both in the sense of recuperating conditions that man has destroyed (deforestation and erosion) and of preventing alterations from getting more serious (preservation of the environment). Science and technology actions orientated towards the second aspect possess two salient characteristics: they are long-range and long-term operations. Because of this, they are not easily accepted by policy-makers who pay them lip service but do not carry out the actions to reach the objectives that scientists and technicians consider to be

/necessary. As

necessary. As for natural resources, which constitute the other essential contribution of the territory, we have already referred to them elsewhere, assigning special importance to a particular case: energy and its direct and close links with the science and technology variable.

52. The support function is wider and less defined. On the one hand, it provides the physical foundation for people and activities and, on the other, it offers assistance to the man-made infrastructure which is marked by characteristics of its own resulting from all the elements that define the territory in physical terms. For example, from the point of view of people, it is the environment that defines the type of life (migrants, fishermen, farmers), their participation in the productive processes, migrations, environmental conditions, etc. Within the context of history, these have been determining factors in the relationship between population and territory, which is often called "human ecology". In the past, this relationship was strongly conditioned by the natural factors. In later years, as scientific and technical development have progressed and the economic activity has reached higher levels, the man-territory relationship has acquired a strong content of artificiality, which is particularly striking whenever the process of industrialization begins in any country. Possibly, artificiality is even more significant in the case of activities. Their nature and degree of diversification depend on territorial characteristics; the size, complexity and destination of the different activities are closely connected to transport and marketing, which are also conditioned by the territory.

53. From the point of view of human settlements and the system of cities, there is no doubt that territory plays an essential role: location, physical conception, internal urban functions and relationship with the rural environment, housing and internal and external transport, environmental conditions, etc., are all aspects on which territory exerts an essential influence. Similarly, the most suitable

/superstructure to

superstructure to solve health, educational and other problems in closely associated to the characteristics of the territory. The set of problems that have to do with man and his activities and human settlements, correspond to the physical approach to "quality of life". Their correct solution has a high content of science and technology and requires a long-term scope which may often be in open contradiction with local shorter-term approaches to activities considered in isolation, all of which results in actions that must be carried out within a severe time constraint. From the point of view of economic growth, the general infrastructure of a country, transport networks, energy, communications, services and their organizations, etc., are all obviously conditioned by the territory. Because of their relation with technology, there is no need to go into new detail.

54. As was pointed out in the systems analysis, any country is closely related to the rest of the world. The type of relationship that industrialized countries establish with one another and their relationship with developing countries are not stated in the same terms. The former constitutes an organized set of elements which are necessary and sufficient for any given purpose and there is a high degree of autonomy in their interrelation. Conversely, the underdeveloped world constitutes a "closed" system vis-à-vis the industrialized world, in the technical sense of the word, i.e., its reactions are conditioned by the actions of the latter. Technically, there is a variety of ways in which the underdeveloped world might co-exist with the industrialized countries, ranging from complete isolation, which in practice does not exist nowadays, to total colonial dependence, which is a formula that is rapidly becoming extinct. Between both extreme positions, there is a variety of possible associations ranging from decreasing dependence and ending up in an autonomous supra-system capable of freely establishing relations with the developed world without the condition of subordination being present. These different forms of association are the result of diverse historical processes such as occupation of

/the territory

the territory and its accompanying material and cultural influence, geographical proximity and progress in communication networks, conformation of predominance areas and power blocs, etc. There is in the process of relative position in the world a constant search for a formula for co-existence, for balance which may sometimes be negotiated and others imposed. Ideal co-existence therefore means striking the right cost/benefit balance for the two parties involved, which might be reached by means of the permanent improvement of the forms of association.

55. The relative position of a nation in the world and its relationship with industrialized and underdeveloped countries plays a crucial role in the development process and generates a large number of important problem areas. The most characteristic elements of such insertion are listed below. However, the list is by no means all-inclusive.

- (i) External market for raw materials;
- (ii) Problems derived from purchases of manufactured goods from the industrialized world;
- (iii) Means to perform the foreign trade operations mentioned above: transport and communications;
- (iv) Insufficiency of internal savings both for the development and channelling of world savings, including savings of the developing nations themselves, towards the developed world;
- (v) Lack of scientific and technological expertise and resulting dependence and limitation process because of the conditioned technological transfer on the part of big transnational enterprises and other sources of know-how based in the industrialized world;
- (vi) Close adherence to certain ideological positions and constraints to independent action that such adherence implies;
- (vii) Physical proximity of underdeveloped countries and common interests and problems; processes of regional integration and conditions on, and opportunities for, national production;

/(viii) Common

(viii) Common positions of integrated regions vis-à-vis the developed world (substitution of imports, capital goods, regulations for the transfer of technology, etc.).

56. The mere enumeration of the elements that characterize the insertion of a country in the world, provides a check-list of problem-areas whose solution is subject to the application of the science and technology variable. For example, it just would not be possible to postulate a development process involving an increase in raw materials exports without taking account of the industrialized external markets and the degree of elaboration required by such markets in order to purchase the products. Similarly, an improved use and transfer of science and technology calls for the setting up of new relationship norms between one or more underdeveloped countries and the industrialized world. Experts on the variable should have a say in the formulation of such norms.

57. Other problem areas related to the relative position of a country in the world could be analyzed in further depth, although we shall not go into that because the purpose of this somewhat extense chapter has, in essence, been orientated to demonstrate that the development process generates a large number of "problem areas" in whose solution the science and technology variable plays a crucial role. Because of this, policy-makers should give experts on this variable a chance to express their opinions and suggest the necessary resources required from the science and technology field.

From the above, we can derive another very important conclusion: policy-makers should need the advice of science and technology experts at a very early stage of deciding on the course of the development process. The need to reach top-level ears at the initial stages of the decision-taking process is an indispensable requisite, regardless of the degree of planning with which the economy of the country is conducted. The reason for this is that the contributions of science and technology will be just as important as that of the other factors that have been

historically accepted as basic. This variable, due to its nature, to the absence of a science and technology tradition in the underdeveloped world, to the magnitude of the financial and human resources that its use demands, and to many other typical characteristics, is difficult to grasp and escapes, to a large extent, the free play of the forces of the market. Therefore, in its consideration and use there should always be a policy formulation, as has been proved by experience in all the countries in the world.

Chapter III

FORMS OF ACQUIRING SCIENCE AND TECHNOLOGY

(a) General assessment on the present state of Science and Technology in the region

58. "Technology is a word whose time has come. Its emergence as a problem involving awareness of a large variety of social and political thesis requires further elaboration. We are in the midst of a peculiar situation in which observer after observer discovers technology and passes on the word as if it were news. Real facts are, of course, entirely different, because there is nothing new in technique, technological change or technologically advanced societies. We may well say that medieval Europe was not unlike a very technologically sophisticated society, immersed in a somewhat rapid and constant process of socio-technical change". ^{44/} If historical facts have such ancient roots, how is it possible to explain the relatively violent awareness of the need for Science and Technology in developing countries? For some decades now, there have been clear signs pointing to the importance of technology for the development of industrialized countries and the increasing speed with which it grew. This was accompanied by the feeling that one way or another, it would be available for developing countries. However, until a decade ago or so, no thought had been given to how this availability would materialize except by the somewhat restricted alternative of purchases of imported capital goods and "lock, stock and barrel" investments. The causes of technological progress were considered to be exogenous in terms of economic theory, and were not taken into account by the majority of the growth models. ^{45/} Despite the above, even as early as some twenty years ago, the economic science had already begun the conceptualization of the process of technological innovation, recognizing it as the main cause of long term economic growth. ^{46/} From the point of view of lesser

/developed countries,

developed countries, they have only recently begun to face and become aware of such an important issue. In fact, the problem is accompanied in the region by a large number of questions to be answered and heavy tasks to be carried out. As ILPES admits, "it may well be said that the seventies marked the beginning of a period of necessary reflection that will make it possible for the eighties to re-allocate resources and perfect the systems ruling the conduction of the scientific and technological phenomenon, in order to successfully raise to the challenge of an appropriate and mature integration to the world community and overcome present forms of dependent associations". 47/ 59. Despite the fact that it is risky and difficult to complete a global assessment on the state of science and technology in Latin America and the Caribbean and on the different ways to acquire a command of this variable, the study of recently published documents has allowed us to give a general outline of the situation, which is in no way valid for any particular country. Progress made in recent years concerning acknowledging the fact that a science and technology policy is an essential factor in the development of each country has become generalized. This acknowledgement has been accompanied by the creation of government structures suitable for the tasks of formulation and execution of such policies. However, the number of countries where such government structures have reached the necessary level of operativeness required to launch a scientific and technological policy integrated to the objectives of development is still low. A recent report by UNESCO makes the following global appraisal: "There is a persistent tendency in Latin America and the Caribbean for these activities to be concentrated in the universities. The second place in volume corresponds to the great sectoral Research and Development centers of the different ministries. The highest concentration can be found in the farming sector, although there are some other significant examples in the industrial and marine sciences sector. Activities related to non-traditional forms of energy are slowly appearing in the region". 48/

60. With regard to this general appraisal, it is necessary to add that "there is a very low level of R and D activity in the private sector". Most of the enterprises in the region have been formed with foreign investments that contributed with their technology or else have bought it. The economic system prevailing in the majority of the countries has not encouraged the generation of technologies of their own, and the enterprises have not felt the need for R and D tasks. */ There is a certain regional tendency towards change as a result of more competitive conditions, but, on the whole, R and D interest becomes manifest mainly in the large state-owned enterprises. At the same time, there has been some increase in the allocation of funds for scientific and technological activities, but, as can be seen in the table below, they still reach considerably low levels.

Table 2

TOTAL ESTIMATED R AND D EXPENDITURE IN TERMS OF
PERCENTAGES **/

Up to 0.15%	Dominican Republic, Nicaragua, Uruguay
From 0.15% to 0.20%	Colombia, Ecuador, Guatemala, Paraguay, Peru
0.20% to 0.25%	-
0.25% to 0.30%	Argentina, El Salvador
Over 0.30%	Brazil, Chile, Mexico, Venezuela

61. The information supplied by this table shows the state of the region in a global way. Real expenditure on science and technology is still excessively low and is mainly concentrated in the universities.

*/ See 47/, p. 20.

**/ 47/ p. 57.

Because of its very nature work at university level is essentially scientific and didactic, and, being scientific, it should aim at the systematic search for new knowledge. And it is at this point where a long and sustained debate on the futility of science for developing countries begins. This is nothing new and as Professor Saavedra 49/ says, its origins in the region can be traced as far back in time as 300 years "Colonial science was characterized by its stress on utilitarian aspects and an almost total lack of technical contributions. What is surprising is the fact that nowadays, after over 150 years of independent life, the same criteria should still be imposed. There may be an explanation for this: it may well be that we are still "intellectual" colonies and that, in the field of ideas, our independence is still to be conquered".

62. For the purposes of this document, the issue is settled: there is no questioning the importance of, and need for, science for the development process even in the so-called poor countries. This is so, not only because developing countries need scientific knowledge to solve problems that are exclusive to them but also because basic research even on fields that seem far removed from any practical application, create the necessary atmosphere for the existence of a scientific and technological community that may promote progress in a country. It has been said that the right to think for oneself is untransferable and it is precisely this philosophy the principle that originates the necessary scientific method to achieve creative science and technology.

(b) Necessary conditions for the development of science and technology

63. The training of people to obtain local scientific knowledge is indispensable in itself and to be able to assess and absorb in a suitable way the technology that comes from other countries. As Gunnar Myrdal admitted some years ago, developing countries have a point in their favour: "it is our accumulated scientific and technological knowledge. However, in order to use such knowledge they (the developing

/countries) need

countries) need new research of their own in every field". 50/ Science is responsible for having brought about many things that have been beneficial for the progress of Mankind, among others, the impulse given to the expansion of education throughout the world after World War II, which was in some cases based on the explicit admission that "knowledge of the Sciences is a necessary condition for economic growth and social progress". 51/ In fact, the scientific and technological community accepts as unquestionable the fact that the search for new knowledge --ultimate purpose of science-- must be accompanied by close links with other disciplines that apply basic knowledge and handle the numerous technologies that create wealth and development.

64. It must be borne in mind that total expenditure on technology already referred to several times in this document and, in the particular case of the region in Table 2, includes all kinds of research, from basic research or scientific knowledge proper, to development engineering and even in some cases, project engineering. In developed countries, where the chain is complete, there is a larger proportion of expenditure on the stages that follow basic research, which range from applied research to invention and innovation. Scientist J.D. Bernal, whose famous work "La Función Social de la Ciencia" ¶/ is acknowledged by many as one of the first important and well-founded studies on how science may contribute to change the world wrote fifteen years ago: "All this points to the importance of basic science. How can such importance be qualified? At present it represents between 5 and 10% of total investment on science... One of the most important tasks of political science is to obtain an estimate of these figures in order to use them as the basis for a scientific research strategy". 52/ Later studies more or less confirmed these percentages for other industrialized nations. 53/ Although there are no figures for Latin America and the Caribbean, we may well assume that due to the lower relative volume of applied research and innovation, the proportion allocated to basic

¶/ "La Función Social de la Ciencia" ("The Social Function of Science") was first published in January 1979. Some of its headings are: What is Science? and What could Science do?

science may be slightly higher than was indicated, but since overall investment on science and technology is very reduced, the actual amounts assigned to science are, in any case, small and insufficient.

65. Information on the volume of resources available for scientific purposes is an important requirement. There is a reason for this: it is generally accepted that, for work to be productive, it is necessary to have what, to draw an analogy from nuclear chain-reactions, has been called critical mass. In other words, what is required is a minimum number of scientists of the same specialized field and status, capable of mutual interaction in the generation of creative criticism that will feed the process and thus produce a competitive emulation. †/ An even better condition would obtain if resources permitted the co-existence of different scientific groups formed by different disciplines able to contribute diversified knowledge, experiences and points of view to enrich the field. The critical mass, minimum size and interdisciplinary approaches are very important, especially if we acknowledge the fact that many of the Latin American and Caribbean countries are small in size and population: it is physically impossible to obtain the conditions that might help to carry out some badly needed scientific work in certain fields. The above justifies multinational associations, integration and cross-fertilization. These features must be borne in mind in any process whose purpose is to overcome local science and technology problems.

66. What has been said above is important: as well as admitting that the universities are insufficiently engaged in basic science, it is necessary to repeat that in the majority of the countries of the region the private sector research efforts are very low, and, as far as basic science is concerned, non-existent. Therefore, there are very few options open to a scientist: he can either work at a university, or drop science or leave the country and encourage the dangerous

†/ See 49/ pp. 70-71.

"brain-drain" issue which will be dealt with elsewhere in this document. In order to neutralize this particular aspect of the problem, increasing the resources assigned to science is not enough. It is also important and convenient to create alternatives other than university research and teaching in order to take due account of the legitimate interests of other scientific mentalities.

67. It may be remembered that when referring to a recent UNESCO report in Chapter II we quoted that, in terms of relative importance, the second research and development nucleus in the countries of the region is formed by the specialized subsidiary institutes of the ministries or other public institutions. We also said that, in general, these agencies are engaged in activities related to the ecosystem: the first place is agricultural and farming processes, sea life and, in some cases, forestry. As has been stressed in the previous chapters, this is important because of the very nature of renewable resources, so closely related to the characteristics of each place and to all the natural factors that characterize them. Because of this, they render basic research necessary and, in general, demand an effort along the complete development line, going through field trial-runs before any innovation can be introduced. The problem is somewhat different from the case of the universities in the sense that for the mere fact of having to go through the whole spectrum of research and development, it is very high in cost. Because of the shortage of resources, the real-life situation can be described by an exceedingly reduced amount of simultaneous research that takes longer than required to produce the innovation and much longer to reach the necessary informational spread for it to have the expected impact. Up to now, we have only referred to the dissemination aspect as one of the necessary elements for the acquisition of technology. Since it plays an important role in the points dealt with in this chapter, we shall come back to it later on.

68. The insufficiency of resources implies not only research and development that is slow vis-a-vis the demands of development but, in some cases, also inefficiency in the exploitation of the human resources group formed by scientists and technicians. There are some other cases of neglect of some areas of natural resources that are not being studied and whose knowledge will depend on occasional and accidental research for other purposes. It has become more frequent to use technology developed elsewhere under other natural or economic conditions to the resulting detriment of the real values available in the country.

69. Sometimes, because of insufficient local research and development, knowledge and approaches that compose what this document has called "basic socio-cultural archive" are discarded and replaced by technologies tested under other conditions. This has resulted in far-reaching economic and social failures. Finally, among the approaches sketched in this document with regard to the importance of the quality of life as the objective of development, another aspect of research is worth considering in particular. Whoever attempts to draw comparisons from the equipment and the relatively high degree of sophistication in methods, and from the research effort required to determine the results of economic growth and the evolution of the numerous variables that accompany its assessment, cannot help out denounce the weakness of the research undertaken to provide information on the behaviour of the elements that contribute to detect possible progress in the quality of life.

70. The above means that most of the basic science and research efforts made in the region are concentrated in the universities. In turn, the most important part of applied research and endogenous innovation is carried out in public institutions, as was pointed out in N^o 64 above, the contribution of the private sector to creation of original technology is small. Although some of the figures available may be questioned on the grounds of possible lack of uniformity in

/their determination,

their determination, the UNESCO report ★/ states that research and development expenditure corresponds, to an overwhelming extent, to the public sector. The statistics are reproduced in Table 3.

(c) The transfer of technology

71. From the information already examined we can derive that "the efforts made by the governments aim at both improving the national R and D capacity and rationalizing and optimizing the transfer of knowledge from foreign countries". ★★/ Much has been said and written on the acquisition of science and technology for the countries of the region. Surely, one way or another, at greater or lesser depth, all the possible ways of acquiring this variable may have been pointed out. However, in active debates only one of them seems to be considered essential and is assigned "priority attention in the majority of the countries of the region, so much so, that there appears to be a tendency to place it in the foreground of the national scientific and technological policy issues", namely, the transfer of technology from abroad and the need for re-structuring existing mechanisms in order to obtain it. It is undeniable that the subject is of great importance and that it corresponds to past facts and possible situation in the near future, in the sense that imported technology will be the answer to many of the goods-production problems, especially in the industrial sector and in some services directly related to growth. However, from the basic approach of this document, strengthening the original capacity for science and technology must be assigned priority if it is conceived within the framework of the functions mentioned in previous chapters,

★/ See 48/ p. 87.

★★/ See 48/, p. 50 and p. 70. Like UNESCO, ILPES stresses the same points when analyzing science and technology policies for development plans. They state that "regional effort, highly differentiated in each country, has been fundamentally orientated to the problem of the transfer of technology from developed countries, and, in a lesser degree, to the creation of some focal points for the generation of original technology. (See 47/, p. 357.)

Table 3

RESEARCH AND DEVELOPMENT FINANCING DISTRIBUTION
EXPRESSED IN PERCENTAGE OF SOURCE OF FUNDS

Country	Year	% GNP	Govern- ment	Source of funds Productive Enterprises <u>a/</u>	Others <u>b/</u>
Argentina	1976	0.3	87	7	6
Barbados	1973	-	90	3	7
Cuba	1977	-	94	-	6
Mexico	1977	0.53	78	16	6
Peru	1976	0.17	95	5	-
Uruguay	1972	0.13	67	18	15

a/ May include state-owned enterprises.

b/ Mainly foreign contribution.

/in order

in order to satisfy the indispensable need of being capable to choose, adapt and absorb foreign technology in the most efficient way and, if necessary, to get the best possible terms, compatible with whatever international norms may be operating, when negotiating a technology lease.

72. It is curious to remember that despite the acknowledge importance of science and technology in our times, as early as 1944 this item did not even appear on the agenda for the Bretton Woods Conference. We have already said that, in a way, until the sixties it was commonly believed that the developing countries would get the necessary technology by means of a natural process about which there was no need to worry. In those years, the main idea seems to have been centered round the possibility of purchasing technology in the market. However many later studies appear to coincide in concluding that the technology market is imperfect due to several reasons such as legal protection to patents and trademarks, commercial secrets and advantages of the seller vis-a-vis the buyer due to the former's better preparation and know-how, generally accompanied by an inner knowledge of the advantages and disadvantages. To strengthen the technological and negotiating capacity of the purchaser has turned out to be one of the best resorts to reduce the negative effects of the imperfections of the market. 54/ Only in later years has there been an awareness of the fact that the use of this variable should not be left at the mercy of a market that operates under conditions of monopoly and legal protection.

73. It is a fact that developing countries pay too high a price for the transfer of technology. Even when available estimates possess a relative degree of unreliability, the figures are appalling. In 1968, direct payment for patents, know-how, trademark and technical services made by underdeveloped countries was an estimated 1 800 million dollars whereas ten years later, it was estimated at somewhere between 9 and 10 thousand million. Direct cost, though important, is only a fraction of the "dependence" that the transfer of technology involves. There are

/numerous examples

numerous examples of surcharge for inputs and equipment, inadequate technologies and other problems that generate expenses difficult to estimate but that may mean an effective cost of 30 or 50 thousand million dollars, as opposed to third world countries annual expenditure on technology of about 2 thousand million dollars. 55/ Such figures are impressive, to say the least. It is a well-known fact that the figures available in the countries are not always consistent or comprehensive and that many of the payments made to foreign countries are not properly listed. However magnitude indices may be reliable if the above-mentioned figures are compared with recent research. In 1974, thirteen developed countries received 6 460 million dollars for royalties and fees. Needless to say, the figure may have doubled by now, although it must be borne in mind that an important proportion of that figure corresponds to payments between developed countries. 56/ Table 4 gives some examples of payments on royalties and fees made by Latin American countries. We have selected the years for which the latest information is available.

As for indirect payments and their importance there are several factorial studies on some countries and industrial sectors that show how many times surcharge reaches astounding proportions.

74. The transfer of technology seems to be a wide and universally accepted concept. It consists "in transferring elements of technical knowledge necessary for the conception, design, construction and operation of units that produce goods and services and also for the performance of activities such as evaluation of natural resources, education, health, public administration and solving social problems". 59/ In general, it involves people, machinery and equipment, and techniques and ideas that may be imported from foreign countries and should be adapted to local conditions. The ways in which such transfer may take place are quite dissimilar but may be grouped in three categories:

Table 4

PAYMENTS ON ROYALTIES AND FEES MADE BY
SOME COUNTRIES OF THE REGION

<u>Country</u>	<u>Year</u>	<u>Payment</u> (US\$ millions)	<u>Exports</u> <u>Percentage</u>
Argentina	1974	101	2.56
Brazil	1976	272	2.68
Colombia	1975	17	1.16
Chile	1972	17	1.98
Mexico	1971	167	11.11
Trinidad and Tobago	1975	18	1.02

Source: U. N. Centre of Transnational Corporations, 1978.

(i) "Simple" transfer, consisting of buying capital goods from the producer of equipment and hiring professional assistance in the desired field, particularly in the case of consulting engineering for any project whose nature may require a multi-disciplinary participation.

(ii) "Lock, stock and barrel" projects for which the purchaser buys the complete package of the project to be undertaken. This is frequently the case of industries, but is also valid for hospitals, hotels, schools and other projects for which the contractor delivers from pre-investment studies to trained local staff to operate the productive unit.

(iii) "Package project" or "Complete project" in a way akin to the one above, but also including operation of plants and equipment and the marketing of services and goods produced. This type of project can be completely financed by domestic investments (e.g. hotels and tourism), but foreign investment with or without domestic participation

/is more

is more typical. The most representative case is that of the large transnational companies and their branches.

(d) Stages in Research, development and innovation

75. Once the two main sources of the technology required for the process of development have been defined, the production of local technology, and the transfer of technology from abroad, a series of questions emerges, such as when is technological innovation needed? How do we determine whether such technology exists and is available? Who decides, and how is the decision reached, that this technology is appropriate for an activity or enterprise that requires it? Is there, or is there not any compatibility of interests in the choice of a certain technology between what is convenient for an enterprise or for the country as a whole? This document does not intend to give either an exhaustive list of the questions to be considered or, least of all, to provide answers to these questions. The intention is merely to point out the complexity of the multiple factors to be considered and the need for these factors to be studied as part of a collective effort of interest to all. A brief outline now follows of some aspects of the points which are worth considering in order to specify the nature of the problems to be solved.

76. Among the many causes which motivate the need for a new technology and innovation, the main sources seem to be the following:

- (i) The existence of a natural resource;
- (ii) The existence of a potential demand for certain products or a pre-existing demand;
- (iii) The emergence of a new idea;
- (iv) The existence of a supply.

The above list has a strong bias towards the production of goods but it obviously also covers to a certain extent the services and social needs of the community.

77. A thorough analysis of these different sources will reveal some of the most important characteristics of the required technology

/and the

and the way to acquire it. The existence of natural resources is one of the most representative examples, since discovery and exploitation of natural resources require a very wide range of scientific and technological activity. It has already been pointed out that natural resources can be broadly classified into renewable and nonrenewable resources. Both require for their exploitation, knowledge of their physical dimensions and of a large number of other characteristics which have to be studied on the spot. However, to define the exploitation processes of non-renewable resources direct use can be made of both basic and applied research results obtained in other parts of the world with similar characteristics; in fact, in some instances laboratory or pilot plant research is required, it can be carried out abroad, usually without major obstacles.

On the contrary, although in the case of renewable resources, because of their fundamental dependence on the environment, use can be made of freely-available world-wide scientific knowledge, they need "original" basic and applied research specific to the particular resource in question, and carried out on the spot. It is in this case when local science and technology, or at least a local adaptation of existing science and technology, is required.

78. As pointed out above, the utilization of natural resources requires the use of the complete chain of actions forming part of the process of science and technology, and which can be expressed as follows: 60/ 61/ A/

(i) "Basic" research or search for new principles or theories to interpret nature;

(ii) "Fundamental" research which seeks to study and explain natural phenomena of a more particular kind in accordance with the new principles;

A/ See 21/ p. 50.

/(iii) "Target" or

(iii) "Target" or "applied" research, directed towards a technical goal without knowing beforehand whether the goal is attainable or not. In this type of research there is an important degree of uncertainty;

(iv) Experimental technical development through the manufacture and try-out of prototypes;

(v) Basic engineering, a stage in which manufacturing methods, machines, pilot plants, and innovation experiments and their possible modifications, are designed;

(vi) Project engineering: the design of a factory and its industrial equipment, ready to produce;

(vii) Production engineering i.e. all the operation techniques in the industrial plant;

(viii) The production of goods services and modifications or innovations brought about by experience.

This detailed list groups together the three major stages of an innovation process; the first four listed refer to R & D as such. The two first of these, often considered as only one, constitute science as such, and its results are freely-available. The third activity is the transition between science and technology and as such its methods have many of the characteristics of scientific procedures; the knowledge obtained is often, although not necessarily, freely-available. On the other hand, the fourth activity of technical development will in general be protected by patents if the results can be patented, which will usually be the case in industry. The two following activities constitute the innovative project engineering stage which will normally be protected by industrial licences, trade marks, patents secrets, etc. The last two correspond directly to the third stage, or operative technology stage; which, because of its nature is an area where technical assistance or transfer of technology at the production level can be most easily found.

/(e) Technical conditions

(e) Technical conditions for a better transfer of technology

79. The preceding observation seems interesting since it makes it possible to interpret the 8 activities or steps leading to development already described as an inverted pyramid where the bottom steps are represented by its apex and correspond almost exclusively to operational technology whose usefulness for purposes different from those for which it was designed is very restricted. As we gradually approach the higher stages, the science and technology content increases as does its possible application to purposes and activities other than originally intended. Finally, when we reach the upper-most stages of scientific research, we can see that the people capable of handling knowledge at that level cover vast areas of the national activity due to the wide use that can be made of the results of their research. In other words, if when technology is purchased the investment of any given country is restricted to the operational area i.e., the training of specialized staff to handle such techniques, the technological progress of the country will be limited since knowledge of this type can only be used in a very restricted field. This explains why it is frequent to hear that there is no such thing as technological transfer from the big transnational companies or that, at best, whatever transfer occurs is of a limited nature.^{62/} Even when the locally used equipment and processes may be extremely sophisticated, if the knowledge of the users is only circumscribed to its routinary operation and lacks the necessary background that experience provided for their development, the so called transfer will have made only a token contribution to cut down "technological dependence". Redundant as it may seem, it is only logical to expect that for technological transfer to be worthy of the name it should make some kind of significant contribution to the national access to technology in some of the many technical specialized fields needed for the projects. Otherwise, whenever a similar project is undertaken in the future, it will be necessary to purchase the required technology

/from abroad

from abroad once again since, in practice, the implicit transfer involved in the use and command of acquired knowledge will not have taken place.*/

80. Different things may be obtained from the transfer of technology depending on who the prospective user is and the way in which it is received. To draw an example from the industrial sector, the enterprises established in a country may be classified into the following somewhat heterogeneous groups: (i) transnational companies; (ii) national companies using imported technology; (iii) national companies using a basically original technology; (iv) medium-scale enterprises; (v) small-scale enterprises. The first generally operate on the basis of the "project package" already described and, therefore, their contribution to the national scientific and technological progress will be very reduced. As for the second group, of frequent occurrence in the case of joint ventures combining national and foreign capitals and some times in the case of large national state or privately owned enterprises, the transfer of technology may take place in different ways whose degree of significance will depend on the conditions or restrictions that the transfer contract may demand. National enterprises using original technology normally receive external technology through a method that has been called "simple" transfer. As for cases (v) and (vi) the transfer of technology from abroad is restricted to purchases of more sophisticated pieces of machinery than the ones usually available in the national markets, whose use requires a certain experience and specialized skills.

81. Risky as it may be to make such a broad generalization, we can say that most of the local enterprises that need external technology can only use their own and frequently small technical staff. This accounts for the fact that they may often lack the necessary ability

*/ One of the dictionary meanings of the verb to transfer is "make over possession of something or confer rights to somebody".

to select the best possible technological alternative available abroad through insufficiency of information, lack of definition regarding problems that need solving and hidden differences in certain local aspects such as quality of the inputs they intend to use and others. These difficulties do not exist or are less serious if the enterprise needing external technology has some previous experience and if, and this is more important, it has reached the necessary "critical mass" to absorb foreign technology at the highest levels of basic and project engineering. The countries of the region should encourage and protect such organizations as already possess or may reach an internal "critical mass" so that the quality of the applied foreign science and technology is high and can result in a significant improvement in the quality of the national science and technology variable. An example of the resulting benefits is the evident fact that the enterprises that reach this stage can buy only the technological package that they need or, in other words, they are not forced to buy a "lock, stock and barrel" project but can choose different partial technologies from multiple sources in order to assemble locally a project that will no doubt be more suitable for the country's particular needs and conditions. Fortunately, a certain number of enterprises in the region have already reached the "critical mass" stage and have thus become the channels through which an interesting part of the process of absorption of technology can flow.

If local enterprises lack the size required to operate with the necessary level of knowledge, it would be most useful to be able to resort to national teams of consultants and Research and Development institutes that can offer the necessary local assistance. By means of these mechanisms, it would be possible to make a better informed choice and to obtain the suitable adaptation to local conditions. However, from available data and the general assessment of the situation we can derive that this condition does not frequently obtain in developing countries and in the region.

/(f) "Domestic transfer"

(f) "Domestic transfer" of technology

82. There is a very important phenomenon which, apparently, has not received enough attention and which could be called "domestic transfer". The whole technological transfer issue seems to be centred round imported technology. However, another type of transfer is possible: that which may take place internally and is perhaps more effective because of its repercussions. There is in every country a certain installed scientific and technological capacity that has not been properly exploited. As Igor Saavedra says:^{‡/} "we have already pointed out that, in any case, there is considerable scientific development in Latin America. However, its impact on the technological development of the continent is completely out of proportion, not to say contemptible." It is not infrequent to find in the region some Research and Development institutes that possess good human resources and good equipment. However, they generally complain about the low demand for their services on the part of local industries whose requirements they would be fully prepared to meet. If this serious problem is true, what are its possible causes? There is no doubt that there are several: the first is lack of information on, and dissemination of, the national scientific and technological possibilities; the second, the enterprises' own technological weakness which prevents them from making an accurate identification of their particular technical assistance needs and that therefore prefer to resort to foreign consultancy services that offer a global approach to their problems. The third may very well be the guarded attitude of entrepreneurs vis-a-vis science and technology practitioners. Most of the national productive sectors--not only in industry--have been impulsed in their initial stages by businessmen of great initiative and drive with a large capacity to assess the commercial possibilities of a product and a certain sense of risk but who, however, often lack the necessary technical formation to understand the ways in which the

^{‡/} See 49/ p. 44.

national technical media might help them. They prefer to use the experience of people who have carried out similar activities abroad and are generally unaware of the different conditions that the national environment offers with the consequent need for adaptation, and of the dynamic aspect of any process, which calls for constant future adjustments in order to make the most of the new and perfected conditions that they will have to deal with. This situation has undergone a favourable change and its dangers are, in fact, less considerable the larger the importance of the industry, the more generalized the levels of secondary and tertiary national education, and the better the country's information and dissemination media. However, it is worth insisting on the fact that a healthy policy for the development of science and technology should promote in a systematic way the use of local resources with a maximum intensity.

83. It seems that the weakness in internal transfer is typical of developing countries. The national private enterprise sector does not contribute--or, at best, its contribution is scarce--to R & D expenditure at a national level. Comparatively, and in absolute values, the participation of the developed world is considerably high. Suffice it to say that in the United States, three fifths of the 610 000 R & D scientists and engineers were engaged in this activities in the industrial sector.^{63/} Although officially their work was mainly in the applied research field, at least 16 per cent of it was estimated to be basic research, although their initial motivation may have been different. What is the reason for this enormous difference in attitude? Summing up Dr. Sagasti's historical interpretation, "the evolution in thought and the transformation of the production techniques compose what is known as the scientific and technological revolution. This was a complex process of interaction between science and technology that took place accompanied by deep social upheavals and the simultaneous appearance of capitalism as a predominant form of production".^{64/} This is what took place in

Western Europe and was transplanted to, and took root in, the United States and Japan. At the time that this was taking place, and as a consequence of their colonial or dependent state the Latin American countries, Asia, the Middle East and Africa "did not lay down the bases for productive technology connected to original scientific discoveries. There was no organic connection between the development of activities for the generation of knowledge and the evolution of the production techniques, with the consequent mutual isolation of both areas".^{#/} It was this situation that originated the past and present lack of solid connection between national science and technology and technology and production in third world countries, whereas in industrialized countries there are relatively strong links between science and technology on the one hand and the corresponding industrial centres on the other. As regards the small-scale industrial sector, it has links with foreign productive sectors. We can conclude that only by strengthening the somewhat weak existing relationship between local science and technology and the productive sector will it be possible to boost domestic transfer, improve on the quality of technology transferred from other countries and use the whole potentiality of the science and technology variable.

84. A bird's eye-view of the levels of original science and technology required to reach a certain degree of action capacity may help to explain the importance of strengthening links, as shown by the matrix on the following page.

^{#/} See 64/ p. 17.

Table 6

NECESSARY REQUIREMENTS FOR ESTABLISHED
LEVELS OF TECHNOLOGICAL CAPACITY

<u>Degree</u>	<u>Requirements</u>			
	1	2	3	4
<u>Assimilation</u> : to assimilate technology as it comes	x			
<u>Modification</u> : to introduce the changes that adaptation and experience require	x	x		
<u>Imitation or duplication</u> : to reproduce technology with its modifications	x	x	x	
<u>Creation</u> : new technology	x	x	x	
<u>Export</u> : to be capable of exporting technology	x	x	x	x

1. Workshop skills and development of technical abilities.
2. Capacity for design of specialized engineering and productive capacity in the machinery sector.
3. Scientific, technical and applied knowledge.
4. Domestic international marketing facilities.

(g) The "brain drain"

85. It has already been said that technology may be transmitted in different ways. Whatever its origin, be it foreign in the form of technical assistance programmes from other countries, scientific or technological publications, imports of equipment, purchase of patents, "lock, stock and barrel" projects, consultancy and training services or resulting from domestic transfer, it is evident that it occurs exclusively through people. To quote an old saying, "any instrument is only as good as the skills and virtues of the user".

/In other

In other words, it is the technical quality of the receiver that conditions the transfer of technology. The conditions are more rigid in the case of adaptation, innovation or creation. These considerations reinforce what has already been stressed as regards the links between science, technology and education. This crucial aspect escapes the specific purpose of this document but we would like to emphasize the importance of coordinating the efforts of education with the objectives of development and, in particular, of taking account of the close relationship between education and the science and technology variable. However, this document would not be complete if it did not take a closer look at the "brain-drain" problem which for many years has been one of the main concerns of developing countries.

86. "The 'brain-drain' or flight of qualified human resources from economies where they can most contribute to human welfare to economies that possess a good supply of trained scientific and administrative staff, constitutes a serious loss of vital human capital. It is a loss for which there is no compensation." A/ We can quote dramatic examples and figures: the United States would have to build and operate 12 new medical schools to obtain the same medical labour force as it annually receives through immigration; more teachers go from Togo to France than vice-versa; 44 per cent of the younger generation of medical doctors in Great Britain is foreign. AA/ In 1967, no less than 24 per cent of the numbers of the Academy of Sciences of the United States had obtained their degrees in other countries. 65/ Both industrialized and developing countries suffer the brain-drain problem, but in proportion to availability of resources and the relative cost that such drain represents, the latter bear the brunt. If we consider only the figures for Latin America from

A/ See 13/ p. 424.

AA/ See 19/ p. 9.

1962/64 through 1972, 8 583 scientists and engineers and 6 398 physicians and syrgeons had emigrated to the United States, Canada and the United Kingdom.^{66/} In absolute terms, these figures may not seem spectacular, but if we think that in 1973 the number of Latin American engineers engaged in R & D activities was only estimated at 46 thousand,^{▲/} the number of specialists who have emmigrated is extremely serious. The situation is even more serious if we consider that, as an average, the people who emmigrate of their free will are more valuable than the average of the professional base to which they belong.^{▲▲/}

87. Several are the causes of the "brain-drain", but only some considerations of a general type will be made here. The causes may be expressed in two different ways: on the one hand the extraordinary "allure" that foreign countries have, which in the case of scientists and other valuable professionals can be explained by intellectual reasons such as the possibility of a better professional realization. On the other hand, there may be some type of domestic "rejection" or a lack of prospects in their own countries, which may generate in turn two types of reaction; the first, a simple escape to other countries and the second, what has sometimes been called "internal brain-drain". The latter may consist of either using their specialized preparation in an imperfect way or dropping out if those scientists and professionals are unable to find opportunities for a satisfactory professional practice. In any case, this phenomenon affects the creative and innovating capacity of the small scientific and

^{▲/} See 19/ p. 9.

^{▲▲/} If the amount of money spent on the preparation of a professional, from the moment when he begins his education until he emigrates is assigned a capital value, the total loss for the 3 countries mentioned above reaches an estimated 50 thousand million dollars. See 57/ p. 9.

technological community to the detriment of the demands of national development. In the last few years there has been only one positive fact: according to reliable information, there has been an increase in both the number of university graduates and the number of scientists, engineers and other professionals engaged in Research and Development in the developing nations.^{4/} It stands to reason that the most effective way to prevent the "brain-drain" is to eliminate its causes. "The development of policies and institutions in the field of science and technology is generally designed to eliminate or, at least, palliate the paradoxical phenomena of unemployment, underemployment or ill-employment of qualified scientists and engineers whose talents and capabilities are not made the most of in their own countries." ^{44/} This recommendation is only just beginning to be accepted in the region but at a totally insufficient scale for the magnitude and urgency of this problem. It might be useful to bring to mind the concrete example of South Korea where, in 1966 the Korea Institute of Science and Technology (KIST) was created. Its purposes were to carry out research and development, act as a resource centre for the transfer of technology and to help to solve the problems posed by the industrialization of the country.^{67/} In addition, the Institute has been used to reverse the "brain-drain" process at which effort it has been most successful in the short period for which there is information (up to 1974): 55 scientists and engineers possessing a wide experience in industrialized countries have returned to Korea and have had no difficulty in adjusting to the national somewhat more restricted research conditions. These repatriate professionals have produced a multiplying effect on other colleagues working abroad. Such a model may not correspond exactly to the needs of other developing nations although it provides an effective example of how

^{4/} See 21/ p. 35 and 19/ p. 10.

^{44/} See 21/ p. 35.

highly qualified staff may be recuperated. In any case, it is also necessary to bear in mind that both universities and governments should play an important role in this reversal effort.

(h) Government participation in the science and technology effort

88. A frequently quoted case to illustrate government cooperation to the effort of introducing science and technology is that of Japan. Although it may not be possible to duplicate it in the underdeveloped world, it is useful to exemplify government control in connection with the acquisition of technology and entry of industrial enterprises to the synthetic fiber sector. The philosophy underlying such control was orientated to accept entry of certain enterprises in a very flexible way i.e., a staggered-entry formula. This was done with three purposes in mind: the first was to chose the most developed enterprises in the field; the second to protect scale economies by means of restricting the number of enterprises (to begin with, by authorizing only two new enterprises each for a different type of fiber), and thus avoid producing an installed excess capacity that might harm economic results. The firms thus selected received government assistance for research and priority to obtain credits or raw materials in short supply, the latter particularly in the postwar period.^{4/} The preliminary research undertaken by the Japanese firms took in many cases the form of "back-chaining engineering", i.e., starting from the finished fiber, they determined its chemical composition and basic materials and rediscovered the processes required to obtain the product. In many cases they were able to discover new procedures or obtain new results which, although different from the original, were just as valid. On other occasions, the research procedure employed was based on "reproduction", starting

^{4/} This policy was laid down in May 1949 by the Ministry of Foreign Trade and Industry (MITI) in a document called "Policy for a Rapid Development of the Synthetic Fiber Industry."

from the available literature on the patent, which generally led to an original version of the technology. These research activities also enabled the Japanese to get acquainted with the real merits and disadvantages of foreign patents, to negotiate "no-strings attached" deals and, in cases, only certain areas of the patented processes, with the additional advantage of the above-mentioned fact of important original innovations introduced in the course of the "reproduction" process.^{68/} This procedure, which received a crucial assistance from government spheres, was repeated in many other fields of industry and other activities with slight modifications necessary for its use in other sectors. Support from the State in the field of Research and Development acquired thus a very significant influence.

89. This example saves the need for further justification on what Professor Sabato established in his well-known triangle diagram, each of whose vertices is occupied by the government, the Productive Structure and the Scientific and Technological Infrastructure. He says in this connection that "due to the great scientific and technological revolution of the XXth century, it is impossible to conceive a sustained effort in science and technology that does not acknowledge that the acquisition of an autonomous capacity for scientific and technological decision is the result of a deliberate process of inter-relationships between the three vertices previously defined".^{69/} It has been pointed out that in the case of Latin America and the Caribbean, there is no such effective triangular relationship. Consequently, a future task should consist of setting up these close relationships even if, to begin with, may only involve partially representative groups. This is another argument in favour of the need for having productive groups of the necessary "critical" size to take a constructive part in the dialogue. This can only be accomplished by means of some kind of local scientific and technological infrastructure and strong support on Research and Development matters from the third vertex of the triangle: the Government.

/(i) Integral assessment

(A) Integral assessment of technology

90. It should be remembered that expenditure on Research and Development has a very positive cost/benefit ratio. It is undeniable that there have been many cases of failure, but what is relevant to the point under discussion is global result, both from the perspective of R & D proper and from the technological progress that it generates and whose benefits to the national activity may some times appear to have no direct connection with the research and development programme undertaken. The agricultural sector, where local research is an inelludible need offers a clear example of direct returns. Table 7 shows the case of India over the periods indicated therein, where the returns on research expenditure have been the following: 70/

Table 7

BENEFITS FROM AGRICULTURAL RESEARCH IN INDIA

Period	Return from research expenditure	Internal ratio of return (%)
1960/61-1964/65	1.91	14
1967/68-1972/73	14.91	71.7

It is worth pointing out that the higher returns obtained in the second five-year period may have been due to closer coordination between research centers, agricultural university schools, experimental centers, etc.

91. Such results constitute one side of the Technology assessment coin, from a strictly economic point of view. However, it is evident that the assessment of any definite project should go beyond mere economic evaluation and take account of indirect benefits and costs that may appear, which may involve profits or losses for the community. However, in the case of technology, this may or may not be related to any definite project or may well be related to the acceptance of

/the utilization

the utilization of any given technology for a multiplicity of different purposes. Such would be the case, for example, of certain agricultural technologies, or of the introduction of certain crops, the use of nuclear energy at a national level for electric power supply, or the development of new types of fuel to be used as hydrocarbon substitutes. Before deciding in favour of any given technology, it is necessary to perform a critical analysis and definite assessment of its nature, conditions and advantages. However, apart from these primary factors, other aspects should be examined such as secondary and tertiary effects and direct and indirect consequences in areas unrelated to the project itself. The idea would be, as the United States legislation on the Office of Technology Assessment points out to "obtain unbiased information concerning the physical, biological, economic, social and political effects of such actions as Congress may undertake in programmes that involve science and technology".71/

92. The subject has become increasingly important. A recent seminar conducted by the United Nations concluded that "integral assessment" has become nowadays a very important tool to analyze the policy options opening before developing countries. This critical examination was defined as "a process for the systematic analysis of the different public policy options in order to foresee and assess their wide range of impact on society--as a consequence of change and technological choice--in order to identify the most favourable ones. It helps to make technological development and national objectives compatible".72/ The process will be of great help to choose any given technology. In the case of such technology being local, there will be much valuable background information to such effects. If it is external technology, the assessment process will help to choose the "best" and to prepare the necessary battery of arguments to carry out the negotiation in the best possible terms.

93. Possibly there is no universally accepted methodology to carry out an integral assessment process. Neither is this the time or the place for a lengthy exposition on this matter. However, it is worth

stressing two salient points: the first is the need to perform the analysis in a systematic way, that is to say, as a dynamic system whose components are defined by themselves and in terms of their interaction and the second, the need for a complete inventory of direct and indirect effects on all the elements composing society in the short-, medium- and long-term.^{73/}

94. Assessment of all the said effects or impacts is crucial. However, although some of them may be measured by means of technical or economic criteria, others may not be quantified. In the case of the former, it must be borne in mind that both their solution and possible alternatives must necessarily contain a strong dosis of "scientific and technological future prospects". It is a fact that problem situations are very dynamic and that they are inserted within an environment or context. Both the situation and the context may be quite different, once the project becomes operational, from those existing at the time the idea was conceived. For the second type of impact, and in some cases for the first type as well, it is necessary to apply the so called "multi-criteria" analysis. This is done by means of a check-list of all the effects that the analyst wants to consider and to assign each effect an explicit weighting. Should the effects be non-quantifiable, the analyst must write subjective notes on each of them, trying that his notes should reflect the opinion of all the affected sectors. The more basic the project for development, the more rigorous will the application of the methodology be. Naturally, due to the characteristics of the "integral assessment" of any given technology, the scientific and technological community should be strongly represented in this process.

(j) The "appropriate" technology

95. The integral way of assessing technology, because of its contribution to the satisfaction of basic human needs, the use made of local natural and human resources, its impacts on the environment, its social and cultural effects, etc., permits us to state that there

/is great

is great affinity between this methodology and choosing the "appropriate" technology. Such an assertion no doubt implies some kind of definition of what should be understood by the "appropriate" technology. This is a concept about which much has been written, but also, of which we daresay there is no universally accepted definition.^{74/} Rather than define what an "appropriate" technology is, it is usual to describe some of its main characteristics: whether a technology does not require much capital and is labour-intensive in countries where the former is scarce and the latter abundant. On other occasions, a technology may be described as non-polluting, as if this were not a basic factor. On yet other occasions, the ruling criterion appears to be the fact that an "appropriate" technology should first and last be an original creation of the developing countries themselves.^{74/} 96. The most commonly accepted labels are "appropriate", "intermediate", "soft" or "low cost" technologies. Many of them are in fact very important also in industrialized countries and it is a generalized mistake to believe that if a technology is suitable for the needs of a developing country it may not be equally suitable and even generated and used in a highly industrialized country. As Eduardo Neira says: "appropriate technologies may well be modern, traditional, empiric, endogenous, exogenous, intermediate, soft, hard, etc. The important fact is for them to respond to contextual adaptation criteria".^{76/} He goes on to reproduce a long set of characteristics defining what contextual application is, which was passed in 1976 at a conference on Technology of Human Settlements. One way or another such characteristics would no doubt turn up in "integral assessment" as described above.

^{74/} According to Amilcar Herrera: "At a meeting that I attended 2 years ago, 29 different terms cropped up to give a name to 'appropriate technologies'. He adds later: "In connexion with the term in use I believe that 'appropriate technology' is equivocal. Every technology is appropriate; the question is for what". See ^{75/}.

97. A study we have already referred to in this document 4/ admits that "the concept of appropriate technology is necessary for industrialized and Third World countries. It is not just an euphemism, as many believe, to describe the acceptance and adoption of lower technical, and consequently, economic levels by Third World countries. An appropriate technology is the invention and utilization of processes accompanied by such an organization of the work as is better adapted to the particular circumstances both economic and social currently prevailing in a specific country or sector". Many of the technologies currently in use in the industrialized countries are not suitable for the conditions prevailing in the world now since they may involve a high consumption of energy, may produce pollution or may have other disadvantages that any community considers to be inadmissible nowadays. To assess whether any given technology is appropriate or not is also a problem of a scientific and technological nature, although this is in no way the only criterion to take into account. However, it points to two aspects: the first is that developing countries must have a scientific and technological infrastructure to permit them to have the necessary support in this field. The second is that any local technological innovation is, on the whole, meant to be utilized in the country where it was generated and that consequently, from the moment of conception it has already incorporated many of the local constraints, for which reason it may fully qualify as "appropriate". Even in the course of "imitation" of a product whose manufacturing process undergoes some kind of adaptation to local conditions there is an element of adjustment that reinforces the need to develop the national science and technology.

(k) Information services and diffusion

98. In the foregoing pages an attempt was made to draw attention to how science and technology are acquired, and to the complex process

4/ See 13/ p. 414.

of reaching a decision as to whether a given technology is "appropriate". The more streamlined this process is, the less likelihood there is of a developing country adopting "inappropriate" technology, and judging by some of its consequences in the light of a rapidly-changing context, it would seem that inappropriate adoption has occurred quite frequently in the past. In countries which have their own scientific creativity and invention there is a relatively long delay between discovery, the idea and the invention. Although it is true that in many cases these delays have been reduced because of scientific and technological advances, there are still many examples of long delays between an idea and its practical application; a clear illustration of this is to be found in the field of energy, where the time-scale for new sources is measured over several decades. There are similar delays in invention and innovation before a new product is conceived, together with the technology required for its production or use. In both cases, invention and innovation, and in technology, information is of utmost importance. Information resources can be the key element in the use of science and technology, and the creation of these resources is an essential requirement in any co-ordinated programme incorporating the science and technology variable.

99. However, an information system is not merely at the service of scientists and technologists wishing to create new technology or study its adaptation to local conditions. Information systems must also be designed to classify and store information in such a way that it becomes available for transfer to or exchange with its major consumers. This implies the study of techniques and the processing of available information so that it is made easily accessible to those who need to use it.^{☆/} In the case of large-scale industry it is apparently not necessary, given the assumption that this type of industry has the technical personnel capable of accomplishing the

^{☆/} See 21/ p. 42.

task. This is not the case of the medium- or small-scale industry and of home industries, which have to be given the technical assistance which will allow them to operate with new technology and new inputs. This problem is even more evident in the case of agriculture. Here, ecological relationships are implied; important interactions between human activities and the specific characteristics of the natural environment are produced. In this area, the degree of uncertainty with regard to the application of new techniques is far higher.^{4/} The problem of the replacement of traditional technology is encountered yet again in all its intensity: The need to study this technology carrying out of essential local research before altering traditional practices.

100. The process of making technological innovations available has been called "diffusion". As has been frequently said "in order to make a significant impact, an innovation must be adopted by a large number of individuals, firms or institutions".^{76/} To diffuse new technology or the product of a new technology is an expensive and slow process. This is shown by statistics which give the percentage of consumers who use innovation over a given period of time. On the other hand, experience shows that diffusion represents the most costly stage of an innovation process.

101. Efficiency in the diffusion process (and in agriculture this is closely related to land area) has a direct influence on economic growth, since growth depends on the speed at which innovation displaces older techniques. Here again the problem is twofold, in the sense that one factor is undoubtedly the degree of diffusion, but the other is the receptive capacity of the consumer, which again concerns his level of education and learning potential. Once more a close relationship is revealed between the science and technology variable and the need for higher levels of general and specialized education.

^{4/} See ^{46/} p. 186.

102. Innovation has clearly-recognizable effects on aspects of development which can be measured in terms of productivity. However, innovation also has profound effects on people's way of life. Examples of this impact are to be found in such simple things as long-term food preservation for home use, or the availability of industrially-prepared foods; further examples are found in the contact between the home and the outside world by means of the telephone, the radio, and television, and in the cultural influence that they exert. Furthermore, the enormous quantity of desirable effects accompanying the technological innovations which are continually being introduced, should also be considered from the point of view of their unexpected secondary effects, which are often undesirable. All these considerations lead to the fact that the problem of introducing the science and technology variable on a more intensive scale in developing countries cannot be left to chance, nor to what is largely private enterprise, nor to foreign influences. Because of the multiple and complex consequences of the introduction of science and technology, it is essential that this introduction be made in a thoroughly rational way, which means that economic considerations should on no account be the single determining factor.

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