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Technology for Development

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A SYSTEMS APPROACH

BY

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"I do not see any way out of our vicious circle of poverty except using the new sources of power which science has placed at our disposal."
Jawaharlal Nehru
1958

1- Technology Systems in Advanced Countries

Scientific and technological capacities are highly concentrated in the presently advanced countries, with notable variations and histories of evolution in the separate countries. Initially, the main centers were in Western Europe. There followed expansion in the USA and Canada, where natural resources were particularly abundant and human labor was scarce and at a high level of motivation. North America was also spared direct effects of two World Wars. These features found their reflection in the science and technology activities. Japan, on the other hand, is very poor in natural resources and had therefore to depend on human skills, organization, and innovation to realize a very fast and expanding industrialization and to maintain viability in difficult competitive situations. The Soviet Union and the centrally planned countries of Eastern Europe, under a different socio-political system, accorded a high priority to technology and created an integrated technological system whose share in the world economy is gradually increasing. The USSR in particular is rich in natural resources, although it experiences certain recurrent difficulties in food and agriculture. We can thus recognize three different patterns of strong integrated "technological systems ". On further examination, other patterns may be noticed, for example, in the Nordic countries, in southern Europe, or in Australia and New Zealand, all of which belong to the industrially advanced countries today.

In all of these patterns, while noting the variations, certain features are common. These are systems of science and systems of technology. The scientific activities are there in Universities, research centers, learned societies, published research materials, and the many highly qualified scientists, research staffs, and institutions. The technology system which concerns us most in this study exists in the applied research and development centers, financing institutions, relations with industry, business, systems of patents, intellectual property and innovation, and the many institutions for training, testing, designing, standard setting, monitoring, information, publication and dissemination. These institutions exist in conjunction with universities and science centers as independent units financed by public and private funds, or in close relation with industry and other economic activities.

In the "technology systems" of advanced countries, there are channels for communication, the flow of funds, and ideas, and eventually for full application of technological innovation, generally by productive units which are not the site where the technology was first created. There is therefore a large movement or transfer of technology, first in the sense of nursing an idea or observation until it is ready for application technically and economically, and second in the sense of the leasing of technology by its holders to other units under certain conditions and costs.

There is also the reverse flow: recognizing difficulties, shortcomings or objectives and transmitting such problems to the technology system to solve.

Across many years of experience and through successive adjustments, the "technology system" works as an integral yet distinctive component of the total social and economic structure of the advanced country. This is not to say that the technology systems in the industrial countries have reached perfection, or became static. On the contrary, difficulties, limitations, criticisms and failures do persist; social economic and political conditions are continuously changing. Hence the system is dynamic. Nevertheless, these are systems which are in varying degrees, effective and operational.

2. Partial Technology Systems in Developing Countries:

The developing countries, generally speaking, have not yet succeeded in building integrated effectively functioning technology systems. They realize the need to do so, and certain steps have been taken. Some components of such a system have been established, but the effectiveness of the whole endeavor is still very limited. Should they aspire to build a complete system, or should they be selective in determining their priorities, given their limited physical, financial and human resources? What should their priorities and objectives be?

Here again, there are wide differences among the developing countries. For the purpose of this analysis, they may be divided into four groups. There are first the relatively industrialized developing countries which created a heavy industry base and/or a strong export movement of manufactured goods. These countries, mostly in Latin America, are not really very different from and maybe even more advanced than some countries of south and southeastern Europe as regards economic and industrial activities and technological capacities.

The second group includes the oil-exporting countries and other countries endowed with surplus export earnings from rich mineral or agricultural resources, although these countries are otherwise in almost every respect underdeveloped.

The third group of developing countries are those which are economically less advanced than the first group and financially less affluent than the second group, but which have already initiated programs of development and do have the natural and human resources capable of further development.

The fourth group includes the countries with hardly any industrialization, no great natural resources exports and very limited human and physical bases for development i.e. - The least developed countries.

We cannot expect these conspicuous and large differences in the situations of the developing countries to allow many meaningful generalizations. We hasten to add that this is more or less the situation among the advanced countries, too. In recent years there has been a considerable increase in the technological concentration in the USA and the USSR because of the huge volume of their activities and the ever expanding programs of armaments. Technological capacities, problems, and strategies in less-developed industrial countries such as Spain or Bulgaria must be different than the corresponding ones for the USA or the USSR. Similarly, problems of Somalia or Bolivia must be different from those of Saudi Arabia and Mexico. Because of limitation of space, however, and noting the political alignment in recent years, one must perhaps be permitted to speak about two groups of countries- industrialized and developing countries. In other words, one speaks about North and South.

Before leaving this point of classification we must mention China. In many respects it can be put into the third group, which contains also India, Pakistan, Egypt, Syria, Peru, Zaire and others, but because of its special cases China is referred to separately whenever necessary.

3. Viability of Technological Systems :

A viable "technology system " has internal features of structure, finance, stimulation, and interaction with the productive economic sectors, as well as with the sectors producing services of transport, education, health, housing, urbanization, art, culture, recreation, and information. The technology system, though interacting from day to day and at the micro-level with government, business, and social institutions, is itself at the macro- level and in its major features is closely linked with the objectives of the society as a whole, within the frame of social needs and insofar as resources permit. These controlling factors need not exist in the form of binding legislation, but they emerge as a result of social, economic, and political reality, and through interaction with the system of values and the structure of decision making. Scientific and intellectual advances, which are very different from technological application, may be accomplished within a frame which is not set by social, economic, nor political systems. Individual human innovation may come outside the technology system (in its formal structure of components), but the application of scientific discoveries or accidental innovations must come through the system.

A viable technology system can also accept stimulation and programming. In recent decades, and especially since World War II, directed technological developments on a large scale have become familiar. The examples of development of radar and micro-wave technology during the battle of Britain, the manufacture of the first atomic bombs, the development of ballistics and space programs unfortunately all seem to be military applications financed by public funds allocated to defense. Many other examples exist at the level of manufacturing industries, especially for durable and consumer goods. At one time one spoke about "technological factories" into which were put problems, men, resources to yield a technological product. Technologists are now more modest, yet there exists a large degree of association between the technology inputs in the form of resources, time, and men, and the outputs in the form of applicable new technological applications.

A third attribute of technology systems is their external relations, outside their country of origin. These external technological relations exist in unison with external economic, financial, and political relations. Technology moves usually, embedded in a machine or a product. In the cases where technology exists by itself as a tradeable good, royalities, licenses, patents, and other "know-how" agreements have become a major feature of modern industrial societies; total costs paid among the major western countries reach billions of dollars. One speaks now of the export and import of technology rights and duties and of the balance of payments of technology in different countries.

Payments for technological know-how , in the form of fixed costs, percentage royalties, service agreements and so forth have increased considerably in recent years with the growth in international trade, with product and equipment renewal, and increasing specialization. These payments are sometimes referred to as the costs of technology. In some developing countries these costs are almost identified with the technology itself, creating the impression that one can buy technology off the shelf. The danger in this expression and the possible concept behind it is that a developing country may pay for such "technology", but be unable to use it fully because of the shortcomings of its technology system, while an advanced country will benefit fully from the costs invested in buying the same technology.

Thus we have summarized three major attributes of viable technological systems: their internal micro interactions, capacity for planning and programming, and their external relations in the form of technology transfer, licensing, and know-how.

Technology in the physical and engineering sense is the method and technique of producing goods and services. It does not accomplish this production unless it passes an economic test. A specific technology will be economically acceptable when it proves that in combination with other factors of production (capital, labor, raw materials) it will lead to the most economic production. Theoretically, at least, one can choose between alternative technologies according to factor proportions. In another different way, technology will be developed according to the situations for these other factors. If capital is short, then the proper technology would save capital and use more labor. On the other hand, if labor is short, technology would respond with automatic equipment and heavy investment. All these examples refer to the production of some goods or services, as may be economically accepted and accounted in a free market within feasible limits of factor substitution. In real life, there are more complex situations- the high cost of premature innovation, the depreciation of technology generation and testing, the rate of penetration of new products into existing markets, and the continuous change of labor relations, prices of raw materials, competition, taxation, and other restrictions.

As a result, in modern industrial societies, the process of generation of technology, its adaptation, and its economic application is complex, and may not at any one time be fully in accord with theoretical conditions. In particular, social profitability as distinct from private profitability must be taken into consideration to bring micro-economic activities in line with public and social policies.

These and other factors create a technology mix within the same country and even for the same products, depending upon other factor proportions and social constraints. In making a technological choice, or opting for a certain innovation, decision-makers will have to take all these points into consideration.

With the continuous advance in the western countries, through many decades, human power has been successively replaced by mechanical and electrical power, which used larger amounts of fuel and resorted increasingly to stock energy resources -coal and oil-instead of timber and animal power. Human skill has been raised continuously by assigning many control and judgment functions to automatic and standardized feedback servo-electric mechanisms. There has been much substitution of raw materials, both natural and synthetic, metals, plastics, glass, fibers, and others.

In recent years, more attention has been given to energy conservation, raw material economics, and environmental constraints which were not carefully considered before. It is also hoped that the technology of the future in the advanced countries will be less directed by military expenditures or high consumption, non-essential demands, and more responsive to social needs and well being in all countries.

4. The "know-how" and the "know-why" for Different Developing Countries.

The technology systems in the developing countries can be summarily described as having fragmented components which are not harmoniously linked together, not reacting with business and industry, and not sensitive or responsive to public policies and social needs. This is a sweeping generalization which certainly is unfair to those in the developing countries who have exerted considerable efforts trying to establish a technology base under difficult circumstances and with limited resources and lack of supporting services or cooperation from the other sectors. Likewise the above seemingly favorable remarks about technological systems in the advanced countries should not overlook the fact that those systems have been wasteful of energy and raw materials, creators of squalor and slums, pollutants of air and water, and producers of weapons of destruction and war. In fact, modern technology is rich in "know-how" but very poor in "know-why".

Modern technology came to developing countries first through the extraction and export of raw materials. It came also with colonial power interested in keeping law and order and exploiting the human and natural resources of the colonized people. A limited bureaucracy was established, with minimum facilities for education and training of engineers and scientists who served in the mining and plantation enclaves, or in the control and supervision of exports to the colonial home country. For this latter purpose irrigation schemes, railways, and harbors were developed, as were laboratories for plant breeding, pest control, standardization and other basic services to support resource development for export .

With further development, scientific institutions in the universities, and government grew, but technological institutions did not because very little industry existed. The repair shops of state railways and the chemical assay laboratories of the custom departments represented in many developing countries the highest levels of mechanical and chemical skills.

With the development of education, the number of graduates in science and engineering increased but these could not be utilized in a technological sense because of the limited state of industrialization. UNESCO and other organizations do use the number of engineering and science graduates as one indicator of scientific and technological capacity, although they are no doubt the first to recognize the inadequacy of this yardstick.

After independence, in the absence of a strong local industrial sector (apart from enclave mining and export supported sectors), governments in developing countries expanded educational facilities and established research institutes. In India, for instance, a large number of national research institutes, well staffed and continuously supported by public funds for several decades, were set up. Departments of scientific and industrial research following the British pattern, or similar organizations, were established in many developing countries. Yet there has been little integration between these scientific and technological establishments and the industrial, agricultural, and urbanization, transport and other sectors of the economy. This alienation is continuing, even after modern industries have been established, and while all sectors of the economy need to solve problems, improve efficiency, and reduce waste, expenditure on research and development is in fisheries and marine biology, forestry and animal husbandry, in oil industries (as in Mexico and Brazil), as well as in military support industries, which sometimes supervised a number of civilian industrial activities (steel in Argentina) and became a focus for technological management and development.

In the second group of developing countries, the rich oil and mineral exporting countries, the export product-whether oil, tin,rubber, phosphate, or copper-began by being fully controlled, through licensing agreements, by foreign transnational companies. In certain cases the government received a share of product (e.g. oil) and established refining and other processing capacities. In recent years the share of national interests has been increasing, but nevertheless the important technological functions are generally still under foreign control.

Such countries, with surplus capital, have embarked on very ambitious programs of development and industrialization in an attempt to create a permanent source of income to compensate for the depletion of stock resources; at least this is the announced policy. These countries also embark, generally, on heavy armament programs and on related infrastructural investment. They stand a good chance of widening their technological base, but they develop many branches simultaneously and stress the purchase of hardware, and because of shortness of time, fail to build coherent and mature cadres of specialists.

These are countries which are financially rich, but still underdeveloped in many other respects. Their absorbtion capacity for development is limited but increasing rapidly. They attract skilled and unskilled labor in relatively large amounts from other developing countries. Their construction and other local costs are the highest in their regions, and the rate of implementation of projects is hampered by port congestion, bottlenecks in power and transport facilities, irregularities accompanying expansive programs and traditional bureaucracies, and other difficulties. These practical difficulties of contracting, executing, and later managing do not leave much attention to the less visible, although equally important, functions of strengthening the technology base and interlocking it with the total process of development.

These countries, in addition, play an equally important role in giving aid and credits to assist other developing countries through bilateral, regional, and international institutions, and despite c close economic relations with the advanced countries still maintain their solidarity with and political support for the cause of the developing countries in general at all international forums, discussions, and negotiations.

Their announced objectives of establishing an economic and industrial structure to maintain their relatively high present financial incomes for the future may depend in the final analysis on their technological capacity than on the equipment and machinery installed.

The policies of these countries as regards the use of their rich natural resources, and their over accelerated programs of economic and social development pose many problems, some of which could be solved or rather avoided by an effective and selective technological system.

The third group of developing countries represents a mixed bag of intermediary economies, usually with a predominant agricultural and rural sector and a limited export capacity for either raw materials or manufactured goods. Some of these countries are traditional centers of culture and intellectual leadership, and have developed through decades a strong and qualified technical and scientific base. They may have other assets in trade, merchant marine, financial services, tourism, or invisible income from migrant labor. Many of them have lately seen financial difficulties and mounting debts because they did not share in the oil boom and suffered increasing pressures from imported inflation, growing populations, rising consumption demands, and capital shortages.

Many of them have therefore become manpower exporters including the export of highly qualified but poorly paid and unutilized specialists. These conditions act adversly on local efforts and projects to develop economically and technologically, thus further reducing productivity and increasing unemployment.

The first group of countries, as we have seen, is already advanced enough in industry and in export to find adequate participation in international economic and technological activities with industrial countries East and West. The second group of rich exporters of oil and other minerals has enough financial resources to meet internal demand and maintain an atmosphere of prosperity, although newly established development projects may not have yet been completed. Here, as among the countries of the first group, there are elements of stability and hope and resources to cover eventualities. In the third group of countries, however, constraining economic and financial situations, together with increasing debt and decreasing flow of capital, create conditions of social and possibly political unrest and instability plus internal or external tensions, some of which may become serious at a regional or even an international level. It is in those countries of the third group that serious reflections are entertained about alternative patterns of development and new concepts of self-reliance and cooperation between developing countries. The point, for now, is not that these ideas in themselves are good or bad, but that they tend to arise at the same places where stirring and turbulence are likely to appear.

The least developed countries which form the fourth and last group have still a different position. Their poor endowment of natural resources and relatively backward human and infrastructural development make them heavily dependent on outside aid just to maintain their present levels of "development", especially because a majority of these countries in the Sahel and subtropical African regions are just emerging from a long period of drought and devastation. A strong and sustained flow of capital for ten years or more to be used in a balanced but limited development strategy to eridicate abject poverty has been suggested for these countries. Such a plan which is gaining increasing support internationally, would have to be accompanied by an appropriate plan of human resource and technological development (Tinbergen 1976, chapter 19). It has been proposed that a net real capital transfer of US

$10 billion per year for a period of 10 years may be sufficient, if properly planned and implemented, to eliminate much of the extreme poverty and destitution in this group of countries.

5. Science and Technology

It is usual in current studies to deal with science and technology, and not with technology alone. These are two different though closely related activities. Both represent a power of man in understanding the physical and material world. Science gives the knowledge and the concepts without concern about usefulness by any measure, whether social, economic or political. Technology requires application of knowledge, which may have originated in science or in practice, by design or by accident, in order to create economically valuable products tradeable for other products. The difference between science and technology is therefore basic, yet historically and traditionally there has been a close combination of the two. Science as a social system is characterized by search for knowledge following the scientific method of thinking. Items of knowledge are linked by hypotheses, which when more plausible may be considered theories, and if further documented may be elevated to the level of "laws" of nature in one view, or as axioms of scientific endeavour in another and lead to increasing knowledge and not necessarily to any useful result. Science as a system has been close to education and teaching in universities and higher institutes of training. This may be advanced science, but it is hardly technology. On the other hand, if advance technology exists it must have a strong scientific capacity to support it and maintain it. Science, in a suitable form and extent, is therefore necessary for but not sufficient to technology. The only technology necessary for science is that required for equipment and apparatus required for scientific research and study.

It has been found more appropriate to concentrate on technology in this study, while of course not neglecting science as a close and inter-related system. Science, at least until recently has always been an open and declared pursuit. Recent trends about intellectual property, confidential research, and state secrets may have tended to limit scientific announcements. Technology on the other hand, as a system, deals with restricted information which can only be transmitted at a cost, and in many cases not adequately by printed words.

In the advanced countries science-systems exist naturally side by side with technology systems. The developing countries need not assume upon themselves the development of science and technology side by side. The inter-flow between science and technology is not a one to one correspondence. A proper strategy of technology must take the need for scientific development into account, but this can be done in a variety of ways.

Frequently scientific information may become technological, and conversely technological information may lose its economic applicability and therefore become scientific in character. Astronomy as a science has been the basis for the technology of sea and air navigation, calender design, and time measurement; with the development of space technology, the most abstruse formulae of mathematical astronomy suddenly acquired immense practical value. Natural resources become economic objects when the technology for their exploitation exists. Uranium is valuable now because of the "discovery" of nuclear energy. Nuclear energy became possible among other reasons because of earlier scientific studies of radio-active materials and neutron physics. We therefore come to two conclusions. The first is that the real difference between science and technology systems does not reside in the information context embodied in them, but rather in the criteria of economic applicability, which may vary from time to time and from one society to another. This criteria defines technology. Science is however defined by its logic of observation, measurement, correlation, hypothesis, testing, and prediction. The second conclusion thus follows-that there will be in general a total body of open knowledge and a technology for research and investigation. There will be two teams of workers, the team of scientists who use the technology to expand the frontiers of knowledge, and the team of the technologists who seek economic feasibility on the basis of available knowledge (and confidential information) in order to create added economic value for usable resources. In short, technologists apply technology for development. For this purpose they bring to bear information from the fields of business, finance, demand, marketing, labor, and policy-making and combine that information in sequential procedures and successive decisions, which in total represent the functioning of the "technology system"

6. Technology and Development-Injecting Technology

Technological information, both open and restricted, whether derived from the scientific system, from previous technological activities, or from any other sources, is by itself not sufficient to create technological development, in the sense of increasing the capacity of production or the quality of goods and services using the same factors of production. For technology development to happen, the social-economic and political context within which it will take place must be considered. The qualitative and quantitative output of goods and services which meet an economic demand is the cornerstone of economic growth. The distribution of this output, directly and indirectly by a variety of mechanisms so as to reach different members of the society, is the cornerstone of social policies. The two sides of production and distribution define to a large extent the process of development. Technologies of production are applied after being properly tested and examined among the units and sectors of the economy. Most likely the technology developed and applied was stimulated by an expected and unsatisfied demand. This schematic interweaving of technology and development can be further elaborated by introducing value systems (in political, social, and cultural forms) which modulate demand expectations and allocate resources for supply, including resources for technological development. A further step of elaboration would recognize the different time scales required in these different steps and also to recognize the many rigidities and external disturbances which are usually present in the path of social and economic development.

In summary, technology and development are two closely related concepts reflecting in a simplified and aggregated manner the series of decisions and actions that take place in a developing society. At any one time, one may conceive that the scale of development and its pattern conform with the available and applied technology, the two being linked through institutions, the power structure, and the decision processes ultimately derived from value systems and from goals and objectives of the society.

This is a still-picture taken of a dynamically changing situation. Forces of change generally exist in all of the above-mentioned areas, and (in theory at least) equilibria regained at lower or higher levels according to the yardsticks of measurement, in successive intervals. It is not necessary at this junction to identify "causes" and "effects"; in fact this may not be possible. What is more important is association and interaction. Looking back to the development of industrial societies across the last two or three centuries, one can discover obvious and well known landmarks of major technological advance in the energy sector, machines, chemicals, electronics, biology, medicine, transportation, and others. Each major innovation could never have been applied nor stimulated except within successive socio-economic and political situations fully documented in reading histories of these societies.

What we are facing now, in trying to apply technology which exists essentially and almost completely in the industrialized countries, is an injection or "blood transfusion" for the process of development of the developing countries, in order to accelerate this process and imporve its prospects. Comparing technology in a society to blood in a human body is useful, but naturally can be taken too far. The technology system like the blood and its circulation system, is interwoven within the society, reaching practically every hole, every production and consumption unit; it helps to make the body develop and function according to a certain pattern. Blood by itself outside the body is not useful unless it is transferred to another body to replace a lost blood, or to support temporarily an inefficient body system. No body can live normally and forever on blood transfusion. The dose and quality of the blood must be acceptable by the new host without damaging the donor.

Can technology injection, or rather transfusion, succeed? How can the temporary strengthening of the blood stock through artificial transfusion be turned, inside the new system, into a permanent strengthening of the system as a whole so that future transfusion becomes unnecessary? As in medical practice, the host may refuse to accept the transfusion.

The system of the host may contain destructive elements, which would quickly destroy the new blood and force a return to the previous situation of weakness.

It may be noted that the patient is being generally subjected to three other transfusions and injections administered independently and without coordination by different doctors. First there is the economic injection in the form of capital transfer. This is important in this discussion, because in many cases technology does not move separately but rather comes with equipment and financing as an investment project in a combined package. The second injection is social attitudes, especially consumer aspirations, which are transferred more or less epidemically, by air, by travellers, by books, and films which create a feverish attitude, otherwise called the demonstration effect. This fever breaks the traditional immunity of the society, increases demand for goods and services coming from the outside, and reduces interest in traditional consumption goods and services produced locally.

The third type of injection affects the brain and the nervous system as if it were a virus of unknown nature. It changes the capacity of judgment, creates new images and ideas, and disrupts the perception and reflex systems. In short it changes values and concepts, espouses external ideologies, and philosophies in the name of **((modernization))**

These three major external influences are usually more influential in the developing societies than the transfer of technology for the production sectors.

Value systems and social concepts change rather inperceptibly, yet may be, after all, the most important. The demonstration effect and the ensuing craving for the gadgetry of advanced countries is very visible and expands unashamedly. Foreign economic influence in the form of capital or trade comes noisily and identifies quickly a class of collaborators who may be well-intentioned but may be easily smeard by the demagogue as stooges of new imperialists.

Who or what stands for transfer of technology? Hardly anybody or anything except an enlightened public policy, especially if technology must come by itself and not cloaked within the investment deal of a group of maligned "villains".

The above statements tend to picture all four of the external influences mentioned above as harmful. This must be immediately qualified. An interaction with the outside can be useful or harmful (by national and cultural identity yardsticks) according to local efforts to understand it, accept it, reject it, and eventually assimilate all that may be good in it. There have been many cases of societies almost wholly isolated from other societies by accident, choice, or command, which had eventually to open themselves to external forces. In a way the presently developing poor countries were isolated for centuries from contact with industrialization and technological advances in Europe. They were isolated first by their own rulers, and later by colonial powers. When in time contacts were resumed, they were completely incapable of coping with and benefiting from the new contact.

All countries more or less resort to closing borders and to the protection of barriers and walls of different sorts, usually for limited periods. The Soviet Union and other socialist countries follow the policy in order to create internal conditions of change uninterruped by external diversions. The European community protects an expansive agricultural system behind a high wall of subsidies and supported prices. All advanced countries have created strong barriers against international labor mobility, while they preach for free mobility of capital and trade. Closing borders, even if it were possible, would not prevent internal changes, changes unlikely to be positive of effective in the field of technology development unless strong public policy measures were established.

In conclusion, imported technology as well as local technology for development must have very strong policy support. The other forces of social and economic changes are, by their nature, not likely to assume effectively the technological task, especially in the early stages of a development program.

7. Elements of a Technology Policy

In trying to identify the different aspects to be considered in establishing an effective policy for technological development, the following questions may be successively examined.

A. What would be the objectives of the policy?

B. What would be the main instruments of implementing the policy?

C. How could technology policy be harmonized with the development pattern?

D. How could regional and international aspects be dealt with?

E. What will be the magnitude of resources required?

The objective of a national technology policy may be defined as establishment of a viable and effective technology system geared to and harmonized with the total development effort within the frame of the general values and objectives of the society.

This is a broad yet, it is hoped, a useful definition. It must be given precision and amplification by each country, or group of countries, according to its own situations. With the variations of social, political, and economic conditions in the developing countries, no one set of specific indicators will be adequate. It may be useful, to amplify the meaning of a "viable technological system" No one county, with the possible exception of either of the two superpowers is capable of establishing a science and technology base in all branches of knowledge and application. Even the USA, although a major exporter and generator of technology, does also import technology from other countries. In a developing country, there must, by necessity, be a careful identification of those branches or fields of research and development which are closely related to the social and economic potentialities of the country, other areas can only be covered slightly, even neglected, in the early stages of development. Japan, FRG, France, and other western Eurpean countries, all having a wide base of science and technology, aim at excelling in specific limited directions. This need for selectivity and concentration will be more imperative for a developing country.

The second requirement for a viable technology system is that it becomes integrated, in the branches selected, with the other sectors, especially business and industry, to create a flow of ideas, resources, and applications. The colonial powers created such a viability from their point of view in the export sectors which interested them. It will not be possible for the developing countries to spread their resources in establishing research institutes, turning out graduates and investing in spohisticated equipment, yet keeping all these isolated from industry and business.

There are requirements other than selectivity and integrability. The technology system should give priority to problems and to innovations which will sustain and expand the effectiveness of the existing machinery of production, and only secondary attention to foreign technologies which may be duly studied and eventually introduced. Efforts must avoid jumping after shiny, conspicuous, and exotic ideas. To maintain oil production and the technological level required for continuous exploration, extraction, transport, and processing of oil would, for instance, be priority consideration for an oil exporting country. A country poor in natural resources but rich in human resources should give first priority to the effective use of human skills as a source of national wealth. A third country financially poor and limited in human capacities may recognize that transport infrastructure is a priority if new opportunities for investment are to be opened.

To ensure the viability of the limited technology system, it should be designed with adequate attention to the elements of information, follow-up of recent developments, familiarity and direct contact with local industry and business, and a capacity to identify local problems, test solutions, and work out plans of application. The complete circuit of operations and procedures must be established for whatever limited branches of science and technology are chosen. One does not build a city by laying the foundation for every building. It is better to complete one viable center or quarter and move to the next; yet this coherence and integrability is lacking in many programs of technological development in developing countries.

Usually the objectives are seen to include:

A. The proper selection, transfer, adaptation, and application of foreign technology, most of it from the industrially advanced countries but also including technology from other developing countries.

B. The establishment of an effective local capacity to assist in the above mentioned objective and to generate indigenous appropriate technology;

and presumably to export it eventually to other developing countries.

All the arguments mentioned before about viability, selectivity, priorities and integrability naturally apply in each of these two objectives in the manner most appropriate to each country, politically, socially and economically.

Training of individuals and teams is undoubtedly the most important instrument of action in all fields of science and technology, which are essentially "knowledge and experience" activities. Training here is meant to be in a general sense much wider than formal degree and course education in schools and universities. It also means the full utilization of trained personnel through study, research, development, testing, control, analysis, follow-up and planning functions related to the different and consecutive stages of technology development. Training will demand and develop different levels of skills according to the applications of technology, including such auxiliary technological personnel as information, documentation, laboratory assistance, equipment design and repair and maintenance personel.

Individuals must often work in teams within appropriate institutions. Research and development centers are just one form of institution. Another is the design and consulting group, usually working by contract. A third form is the control specialists for standardization, testing, and certification, including cost accountants. Those can be public or private. Then come the government regulatory agencies, which surpervise the enforcement of legislation and rules, especially as regards foreign investment, tax incentives, and duties and rights related to intellectual property.

In technological activities, there will always be a need to establish, in addition to legislation and binding rules, institutions to monitor conduct and perhaps also ethics of conduct, through professional associations, chambers of commerce, and industry. These conduct monitors can participate also in arbitration functions and disputes. Financial instruments- through the fiscal and banking systems, are also important.

Research and development work is expensive and risky. Much of it is done in conjunction with the promotion of specific investments, and costs can be advanced subject to payment through project financing. Governments frequently agree to cover in grant form part of the total costs. The differential import taxation structure for raw material, semi-manufactured goods, and final products should be designed to encourage maximum processing of local materials before export, and maximum processing of components and intermediate goods relative to imported finished goods. These principles sometimes create loss of public revenue in the short term but should be carefully examined as necessary pre-requisites to a viable technological system.

The negotiations with foreign investors and technology holders by local public and private authorities should be supported by data,studies, research, legal and technical advisory services, and financial analysis. Contract drafting and implementation usually offer a variety of alternatives which can be critically examined before final decisions. The developing countries are usually in a weak bargaining position, because of inexperience and lack of information. More serious obstacles are the packaging of technology with "tied financing" which allows no consideration of competitive offers. Another hurdle is local pressures of political or popular nature, which may push negotiators toward unduly reckless and hesitant postures beyond the merits of the case.

8. Harmonization With General Policies

Central organs of development planning and economic management must be involved with the technological development process sector by sector (or even for separate large projects) and for the economy as a whole. Their role is to harmonize the building and functioning of the technological system with social objectives and the development pattern. Such organs cannot go into every detail, a job which should be left to more appropriate operators, and should not interfere in private sector decisions and confidentiality except when major interests of the State are involved. Their main function is to recognize the trends and requirements of the development process, consult with the qualified technological departments and institutions, and then propose the necessary legislation, rules, directives, or recommendations to ensure the harmony and coordination between technology and development. Needless to say, such bodies must have channels of access to and consultation with the highest political authorities in the country. In many cases, in both developed and developing countries, security and defense considerations are also involved, even in the selling of particular equipment and in agreements with specific companies.

The degree of economic and social development that has been accomplished in the developing countries since the end of World War II, some 30 years ago, varies considerably from country to country. An average economic growth rate of

5% has not been unsual; that figure compares very favorably with the historical growth rates of the present advanced countries but the benefits of that growth seem not to have been evenly distributed. Growth has apparently discriminated against lower income classes and has seemingly benefitted a small high income minority for the most part. Development, especially in the agriculture and food sectors, is often said to be neglected while industry as prestige projects and durable consumer goods are, unduly favored. Balance of payment difficulties and increasing foreign debts are multiplying, and the share of the developing countries in international trade gradually decreasing. Their share in world economic and industrial production has not increased in 20 years. They face serious problems of financing, food, poverty, debts, population, and more.

There is a prevailing opinion that economic growth in the developing countries, based essentially on local policies and resources but supported by foreign assistance and technology, must be designed to give priority to benefit the lowest income groups directly, to combat unemployment, and to eradicate poverty. To realize such objectives, attention has been increasingly directed to examination of "appropriate technology" to operate among developing countries, and to "self-reliance". Forms and contents of advisable technological policies must be studied to re-direct development efforts toward these objectives if they are accepted as a basis of national policies by the countries concerned, and as a basis of relations and cooperation internationally.

The developing countries have another case to present. They claim that the industrially advanced countries are wastefully and extravagantly depleting stock natural resources, polluting the environment, indulging in irrational desires for meaningless consumption, massing pointless armaments, and concentrating as much as 95% of their population in non-viable, costly, and unattractive urban centers. They-the developing countries-claim also that these policies of the advanced countries are more serious hazards for the world's future than the development shortcomings of the poor countries. They call for the revision of the monetary system, trade and capital flow rules, and conditions for transfer of technology, all of which, it is said, have been established for and directed toward the advantage of the wasteful military and comsumption ends of the advanced countries.

Every point is raised in the above summary of criticisms of the development pattern between poor and rich countries has a counter-part in the structure and functioning of the technological systems of different countries and groups of countries.

It is not the task nor the capacity of technologists to decide about development objectives. Nor is it the task of economists and development organizations to decide about national goals and objectives. Yet the policy-makers and the public must be enlightened by the technologists and economists about the costs and feasibilities of alternatives which may pertain not only to socio-economic development but also, and perhaps more importantly, to internal stability and external security. The priorities of technology must take all these factors in consideration. Both the USA and India allocate resources to nuclear research and development, an activity more relevant to security than to the feeding of the hungry masses.

Several developing countries have established "technological plans" of varying **forms** either as a part of the national development plan (India) or separately as a national program (Mexico). Such plans are not yet generally established in many countries. In the last two years, many countries have prepared "country reports" about their science and technology programs and objectives in relation to the forthcoming United Nations Conference on Science and Technology for Development, to be held in Vienna in 1979. These reports and the Conference may actually stimulate the establishment of other comprehensive national technology development programs.

Two important aspects of technology and development to be discussed at greater length below are the role of the transnational enterprises in the transfer of technology, and the technology for the satisfaction of basic human needs.

9. Technology for Basic Human Needs

Technology in the industrially advanced countries had to be developed and sustained within the economic system; therefore it had-in a general and total sense--to develop those innovations which could eventually prove acceptable to the main spenders, the public treasury in the case of weapons and state subsidized activities, and medium and high private consumers, directly or more frequently via business' basic and intermediate activities. Low income groups, because of their relative large numbers, represented a considerable market, especially if stimulated by advertisement and other incentives to aspire to the consumption pattern of higher income groups. Because of these considerations technology, even in the advanced countries, tended to neglect those aspects which pertain specifically to the basic requirements of the lowest income strata. Such blind technology becomes even more inappropriate to the requirements of the lowest income groups in the developing countries, especially because the economic system and limited public subsidies do not allow the necessary financing to maintain the purchasing power of the poor for these basic needs. In addition, the increasing income disparities in the developing countries more or less created a dual society in which the upper-income minority moved toward the consumption patterns prevailing in the industrial countries, while the large masses had to struggle, aided by limited subsidies and welfare measures, to maintain a much lower standard of living.

Attention has been directed recently to the question of basic human needs. During the last few years, national development strategies, international negotiations and global organizations have begun to be deeply concerned with the simple notion that the purpose of economic development and international cooperation is to meet the human requirements of people, and especially the minimum needs of the neediest. Combined with new attitudes toward economic growth and environmental damage to the emergence of basic human needs at the center stage heralds a new act in the continuing drama of World Development" (Cleveland 1978, P.3).

Technology for basic needs has been the subject of extensive studies (Singer 1977), but it is realized that the identification of the technology appropriate for basic needs, however defined, is one thing and the ensurance that it could be applied effectively within the economic system of the developed and developing countries is another thing. Certain important structural, institutional, fiscal, and economic policies would have to be applied to direct the necessary resources and to create the incentives and stimulation necessary for effective research in and application of technologies for basic human needs. Then, a second set of policies would be required to create purchasing capacity for the products of such technologies in the hands of the lowest income groups. Increasing financial income of such groups may lead to diversion of proportionally large expenditures to non-basic needs (as clearly observable in many cases); the expansion of subsidies and distribution of physical rations seldom represent viable economic alternatives and pose extremely difficult social and psychological costs. These short remarks show that the question is not just the identification of "technology for basic human needs". It has wider social, economic, and institutional aspects.

Many of the technologies identified under this rubric used to be called "intermediate technologies", labor intensive technologies,alternative technologies and "appropriate technologies". The known ones and the ones to be discovered are claimed to fit the factor proportions and natural endowment of the poor masses in the developing countries, especially in rural districts. Many of those proposed or hoped-for technologies are designed for small-scale operations and/or local marketing, thus dispensing with heavy infrastructure in modern large scale equipment or in roads, railways, and other costly investments. They also presume implicitly, that the consumers have not yet been corrupted by "inappropriate" aspirations for other consumer goods produced by the "modern" system, and that they will order their priorities of consumption according to the assumptions of the proponents of the new approach.

It is becoming generally accepted now that "appropriateness" of technology does not necessarily mean primitive or backward technology, nor is it a requirement in the developing countries only. All depends on the criteria of "appropriateness". One can come to the conclusion that technology for non-essential luxurious consumption, war, and private profit motives is either inappropriate or most appropriate according to the criteria used for judgment. This is not a question of mere semantics. It is of much deeper significance because this judgment by its implication is a judgment about the total process of development in its dynamic sense.

Technologies, when applied, need always adaptation. In the developing countries, such basic processes as steel and petrochemical industries must essentially follow standard technological procedures very like those used in the advanced countries, but ancillary or marginal operations such as handling of materials, storage and control can be adapted with corresponding capital savings and no loss of quality or competitiveness. There are many more possibilities of adaptation, but what is meant by "appropriate" technology generally is the "core" technology of production. Here the choices and alternatives are much more difficult and limited.

The "basic human needs" approach is now under active consideration. It represents an acceptable guiding principle for the development effort as a whole, and a desirable criterion for technology stimulation and development. However, more efforts and time will be needed before large scale successful application of the approach will take place. It is not totally new, nor totally undesirable. The question is however in which form and according to which procedures will it become feasible and preferable? This stage will come as a part of the total process of socio-political and economic change and not only as a result of isolated efforts to promote "egg-container making" technologies and the like.

It is generally expected that the slow economic growth of the developing countries, with their increasing population, is likely to create a severe problem of unemployment, especially in Southeast Asia. This together with lack of capital formation, foreign financing, and food shortage, may indicate the need for serious examination of the "basic needs" approach as a major global problem, side by side with other approaches which imply the application of modern technology. Thus we are likely to find a "technology" mix in different developing countries according to the state of development, factors of production (especially natural resource endowment) and the set of relevant international relations.

10. Transfer of Advanced Technology

At the other pole, in some sense from"basic needs technology, we may examine the technology transferred to the developing countries from the advanced countries without major adaptation or innovation. This technology is represented, mostly, by investment and production agreements, between host countries and transnational enterprises (TNEs) in varying forms. The growth of the TNEs is a major phenomenon of the post-World War II period. Of the 650 largest TNEs (in 1972), 638 have their headquarters in the western industrialized countries and Japan. The largest 300 US enterprises have more than 5200 foreign subsidiaries and alone account for 28 percent of World exports, including 47 percent of exports of primary products and 20 percent of manufactured goods. Without changes in the curent trends, transnational enterprises could control more than 40 percent of World production (excluding the centrally planned nations) before the end of the 1980s (Tinbergen 1976, P.39). TNEs have accumulated vast technological and marketing knowledge and they have developed a highly effective process of transnational decision-making. They can therefore be powerful engines of growth, yet their activities are not geared to the goals of development of the host countries per se, and therefore TNEs may accentuate rather than resolve some of the problems of increasing technological dependence of host countries unless government policies and codes of conduct lead to a correction of recent trends, and thus "force" TNEs to play a positive role in improving the living conditions of the poor masses in the developing countries (Tinbergen 1976).

The international trade in technology (including payments for patents, licenses, know-how, royalties, etc) has risen rapidly in recent years, from around $2700 million in 1965 to over $11000 million in 1975. Developing countries account for about 10% of this total. It has been estimated that developing countries will be paying over $6000 million for technology by 1985, if the current trends of growth are maintained, (TNCs in World Development UN, p.70).

These estimates should be taken only to indicate orders of magnitude and to suggest that "the foreign exchange cost of transfer of technology represents a considerable burden on the balance of payments of developing countries and on the overall balance of payments of individual investment projects" (UNCTAD 1976, p.15). Specific project analysis might indicate negative value added and a negative aggregate impact of the activities of the transnational corporations on the balance of payment of host countries. TNEs tend to draw on local sources of finances, thus denying them to other allocations, although they may have been partially stimulated by the TNEs investment. TNEs activities may also create restrictions both formal and informal on exports and sources of supply for their affiliates and independent licensees. Very frequently, too there is over-pricing of imports, including technology costs, and under-pricing of exports between those enterprises and their affiliates, a situation which amounts to outflow of resources and reduction of taxes and other resources to host governments. These are all beyond incentives already offered by host governments, such as generous tax holidays, low cost credits, and under-pricing of utilities. The developing countries are often in such a weak bargaining position vis-a-vis the transnationals that countries go into competitive bidding to attract these enterprises.

For these and other reasons, the transfer of modern technology by the TNEs to the developing countries has been considered to perpetuate the dependence of host countries and set up one more barrier to domestic technological **initiatives.** Licensing agreements usually embody high costs and restrictive conditions. Trademarks have no time limit and hence involve large-term accumulated costs. The TNEs, as compared with domestic industries, out-compete in continuous flow of innovations, sophisticated advertising, and highly technical marketing techniques, especially for consumer goods. All of these factors lead to the further alienation of science and technological institutions in the developing countries from the domestic productive activities (Charles Cooper: Science, Technology and production in the Underdeveloped Countries: The Journal of Development Studies. Oct. 1972).

These observations should not be taken to mean that the developing countries can successfully realize their development objectives (whatever these may be) without resorting to foreign advanced technologies. The basic assumption or presumption that latecomers can benefit considerably from the experiences (positive and negative) of the pioneers and holders of technology appears still to be sound. The problem lies in examining the conditions and procedures of such a process and in ensuring that transfer leads to a net positive gain to the host countries in both balance of payment terms and longrange criteria of national development and policies. The developing countries themselves must be in the last analysis the main operators in securing these advantages, while maintaining by necessity a net advantage to the TNEs and other holders of technology. But in addition. there are a number of international measures that have been discussed and recommended as regards the process of technology transfer and its close relations to development. Before passing to these international approaches, it may be useful to reiterate that the developing countries must in any case find their way to establishment of what was earlier described as "an effective and viable" **tech-**<u>nology system,</u> which is much more than the training of technologists, the establishment of Research and Development Institutes, legislation for foreign capital, transfer of technology, and patent registration As mentioned before, these and others are components of the system, but the system is not merely the **sum** total of a number of composits; it is before all that a series of working procedures and concepts geared to and fully coordinated with national developmental objectives.

11. Some Regional and International Aspects

We live still in a world where major policy decisions are taken at the national level. This applies in particular to natural resource policies, the central concern of natural resources studies, and to technology policies, the subject of specific concern in this study. National policies should take into account the policies of other countries and agencies, especially those countries with which they have close economic relations. Undoubtedly there are a number of institutions, practices, and policies which can be described as international, although it is the contention of the developing countries that most of those international policies and practices have been established with a strong bias toward the developed countries, and in the absence of consultation with the developing countries.

Earlier paragraphs have discussed the strengthening of the technological capacities and the bargaining power of the developing countries: the identification and application of appropriate development approaches including specifically the basic human needs approach: the selection, transfer, and application of advanced technologies; and the agreements with transnational corporations. All of these aspects must be dealt with essentially at the national level. By national decisions, regional and international measures could be established in which the countries concerned will cooperate on specific items in certain ways. Private sector activities, especially in western-type economies, are very important and cannot be fully accounted for and incorporated by national policies in their home countries. The same applies to the transnationals, who formally or informally have ways and means of acting to a certain extent on their own. More serious however is the fact that governments in many instances (including also governments of industrially advanced countries) do not always have a fully developed and coherent set of policies and positions in international discussions and dealings, or at least are unwilling to reveal such positions explicitly. Under these circumstances, international consultation seems always a rambling series of claims and counter claims rather than clear-cut sharp decisions. Clear-cut sharply defined decisions do take place directly among business partners, financial institutions, and (often behind closed doors) among politically and militarily associated states. Yet "the power of vested interests is vastly exaggerated compared with the gradual encroachment of ideas" (Keynes). It is ideas which appear on the surface of open international discussions and "agreements". Vested interests are those actually taking decisions now, usually on the basis of ideas and concepts of yesterday.

Technology is closely related to investment, financing, development, and trade in agriculture, industry, transport, education, health, housing, urbanization, shipping, tourism, and culture. More recently, one has to add environment to this long list of subjects. Practically all of the international forums, intergovernmental and non-governmental, when dealing with one or more of the above subjects must invoke technology development and transfer directly or indirectly. With the multiplication of regional and international organizations, institutions, conferences, seminars, periodicals, societies, and groups, can one hardly escape the eventual turn to technology, whether as a culprit that has led to some ill effect, or as a potential saviour from some future calamity. Some of the most currently discussed issues which refer specifically to the developing countries although not in the order of importance, are:

a. The establishment of a code of technology transfer, which may be partly mandatory and partly optional, to balance the interests of technology owners and technology recipients and to establish the necessary institutions and procedures to dessiminate relevant information and ensure fair and balanced bargaining positions of the parties concerned.

Additional questions relevant here are the revision of the patent system and the modifications of copyright and intellectual property agreements.

b. The establishment of a similar code of conduct relating to the functioning and operations of the transnational enterprises, especially in their dealings with the developing countries. An important step in this direction has been the recent establishment of the UN Center on Transnational Corporations. in addition to the continuous activities of the World Intellectual Property Organization, UNCTAD, the World Bank, and a number of regional organizations, in particular the OECD

c. Most of the intergovernmental regional organizations in the developed and the developing countries have established programs of discussion, study, and technical assistance in matters related to technology transfer, technology development, brain drain, training, exchange of information and so on. In some cases regional and multi-country joint institutions have been set up to deal with transfer and development of technology as a whole or to cover a specific branch or set of subjects.

d. Bilateral major aid and technical assistance programs are increasingly allocating more resources to investment and aid in the field of technology as separate from economic and social investment and from science and education.

e. The developing countries in their collective efforts to discuss their development problems among themselves and in dialog with the advanced countries are recognizing the need to secure a greater degree of understanding of the political, social, and economic implications of technology policies. Calls for approaches such as collective self-reliance, technological independence, and greater cooperation and exchange of information among the developing countries themselves are often heard. These concepts do not aim at isolating the developing countries from the main current of economic and political forces, which are influenced essentially by the advanced countries. On the contrary the aim is to identify a unified long-term interest between the developing countries and the developed countries, an interest which can be approached on the basis of a new set of rules different from the past set of relations. To be able to realize this objective the developing countries as one may conceive may have to assert first their own identity and capabilities which, by necessity, will be increasingly called upon in world affairs.

f. Governments and institutions in the advanced countries are on the other hand coming, slowly and cautiously, to recognize that they have a certain share in identifying and establishing the technological capacities of the developing countries. They cannot do the job alone; because they recognize the need for the experience and knowledge of the developing countries themselves, and their efforts may be actually misjudged as a recommendation for "backward" technology to perpetuate the backwardness of the developing countries. These are doubts and pre-occupations which still exist on both sides, and these are explained, though not justified in principle, by current events.

g. There are "new" areas which by their nature are global or multinational. Examples are some environment problems or space and ocean management. The advanced countries, because of their predominant and superior economic and technological capacity are entering these new fields with only a limited and nominal participation from the developing countries. They recognize that eventually a more equitable global participation is required.

h. Many of these instances of regional and international activities in the field of technology will be discussed in the forthcoming United Nations Conference of Science and Technology for Development in Vienna in August 1979. The basic task of the Conference will be to translate the scientific and technological components of a New International Economic Order into a specific program of action (UPDATE CESI-UN-April 1978). There is a general agreement by all those engaged in the planning and preparation for the Conference (all member governments of the United Nations and the important international organizations) that there is no ready made formula for accelerated development of the application of science and technology. There is no one model applicable to all circumstances. Nations should be in a position to avail themselves of the entire gamit of technological options for development, from the most traditional to the most sophisticated. Five areas have been selected for examination by the Conference as practical illustrations of the issues involved in applying science and technology to development as follows:

I. FOOD AND AGRICULTURE

Agriculture technology and techniques and their improvement

Nutrition

Fisheries

Food storage and processing

II. NATURAL RESOURCES INCLUDING ENERGY

Renewable and non-renewable

Conventional and non-conventional sources of energy

Development and conservation

Rational management and utilization

III. HEALTH, HUMAN SETTLEMENT AND ENVIRONMENT

Medical plants and pharmaceuticals

Health services

Housing

Social services and environment

IV. TRANSPORT AND COMMUNICATION

V. INDUSTRIALIZATION INCLUDING PRODUCTION OF CAPITAL GOODS

Each country has been invited to prepare a country paper about the current situation in development efforts and policies related to science and technology. The country papers were also discussed at a number of regional meetings in different parts of the world, and reports from these regional meetings will also be examined. The objectives of the Conference will also help in assisting the developing countries to strengthen their technological capacities and to adopt effective means for the solution of development problems at the national, regional, and international levels under suitable instruments and procedures. As usual in the major conferences of recent years, the long periods of preparation and consultation,(more than two years) invloves governments and other bodies all over the world and is in itself a process of dialog, reflection, information, and consultation. The actual meeting of a few days represents the culmination of this process as one landmark in the open international discussion efforts. Because the resolutions will not be binding, their effectiveness depends essentially on their acceptance, implicitly or explicitly, as guildlines for further policy and action deliberations.

12. Technology and Natural Resources Policies

Technology adds value to resources which otherwise would not have economic uses. The process of technology development, as explained above, is an integral part of the process of socio-economic and political development. Natural resources that exist physically become economically valued with appropriate technologies to meet a certain demand for final goods and services. Natural resource development policies are therefore closely linked from the demand side with the uses of such resources for energy and manufacturing processes. They are linked from the supply side with the availability of technology for feasible economic extraction and generation. In addition to supply and demand, technology enters in the intermediate stages of transport, storage and marketing of resources. Natural resource policies include questions related to costs and prices, to scarcity and depletion, and to inter-generational linkages. Technology--whether known restricted or sought--is also related to those aspects, as well as to the important question of substitutability between factors of production and between different raw material inputs for the same or similar end uses.

Technological impacts and the content of economic activities are continuously changing, and the valuation, demand, and utilization of natural resources will consequently be subject to constant **variation**, some of which will be of a technological nature. There may be also cases of intentional policies of impeding change, but these too are a type of technology policy.

The reader will be able to discover a variety of examples of natural resource policies which have been or are likely to be affected by technological developments. The producers and exporters of natural resources, which include the majority of the developing countries, may well utilize transient aspects of wealth to develop the technological systems **to follow best alternatives** and make the best long-term use of their resources.

13. Resource Allocation for Technology Development

The major policy question still remains to be answered: how would the developing countries be advised to allocate resources and follow policies which will eventually create a viable (but limited) technology system to assist their development? What would be the appropriate resources and policies, and what are the results that can be expected from them?

Technology has been man's chief agent in his struggle upward from subsistence. Technology development and application, however, is not a mere technical process. Rather it is a complicated socio-economic process with many variables and many unknowns. It is difficult to show that there is one-to-one correspondence between expenditure on research and development and economic growth. The numerical estimates of "real" science and technology expenditures are still in a very preliminary stage. While the importance of scientific and technological capacity (measured in number of persons, publications, or dollars) is not doubted, there seem to be important qualitative factors of effectiveness which are dominant in most cases, and which cannot yet be quantified easily. The notion that "science is a good thing in itself, with the assumption that the more science that was done in a country, the greater would be the benefit to the economy--and presumably to the society...(has) proved to be false. Relating expenditures to economic results, has been swallowed by the elites in some developing countries, where academic snobbery has been indeed a significant export of the industrialized countries" (King 1978).

There are a number of components of the desired viable and effective technology system. There is the training of personnel at all levels; the building of research institutions and equipment; the auxiliary services of testing, standards and information and documentation; publication, review and assessment activities; identification of research programs; the interlocking with industry and other development activities; legislation and institutions for selection, transfer and dissemination of technology with or without capital and equipment; and the stimulation of domestic innovation and application in different branches and major fields. With limited resources, the developing countries must be very selective in choosing a limited field for technolgy development. They cannot approach all subjects at the same time. They have also to balance the growth of the components. Too many highly trained personnel without adequate equipment and opportunities for application are a prelude to brain-drain and frustration. Expensive research and development laboratories without adequate personnel and equipment are wasteful. If the programs of such institutions are not closely related to development requirements and opportunities they become isolated and sterile. Nationalistic restrictive policies about transfer of foreign capital and technology may stifle the process of development. Open door policies for foreign capital and technology, on the other hand, may lead to unreasonably high costs of technology, leakages of savings and domestic capital, and thwarted attempts to build an indigenous technology base.

There must be a balance between these alternative policies and components, especially if it is noted that they can be combined in different ways for different sectors and problems. One always deals with a technology mix, not only in the same country but also in a branch of industry. This multiplicity and diversity allows policies of transfer of technology for certain activities and policies of building local capacities for others. It would allow the use of labor intensive technology in certain activities, and capital intensive technology in others. The most essential element in all of these situations seems to be to stimulate the flow and succession of the component stages of technology from the stage of transfer or generation to the stage of economic production, and the opposite flow from the production and application front to laboratory analysis and experimentation. If these two necessary flows are maintained, supported, and stimulated, then the chances of building viable technological systems improve considerably. To do that, resources and priorities must be carefully arranged. Those priorities will be set by higher policy of decision-makers. Well intended policies of dis-proportionate development of some components of the system will not create the necessary flows.

On further reflection, it may be agreed that this process of flow has been historically effective in relating science and technology to development, and in introducing successful innovations and inventions, even by unqualified individuals, into the stream of economic growth. It is in essence the same process which is being used most successfully by the transnationals, where the central management is capable of stimulating all the successive stages of the flow and combining it with economic and other factors to reach the stage of successful application. A government, or a nation, cannot easily centralize and control the forward and backward technological flows. They can however recognize their importance and seek to maintain the flows.

If this can be done, then technology can become the spearhead of development. This may be in effect the most important criterion for selecting policies and allocating resources for the development of technology in the developing countries, rather than policies and resources which tend to build separate components which do not function harmoniously together.