# Endogenous Generation of Technology instead of Imitated Innovation

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## THE NEW WAVE OF INNOVATIONS

There is a general agreement that we are entering one of the most important periods of technological change in history. The wave of technological innovations — the central element of which is microelectronics — affects all fields of human activity. Its low cost and low demand of energy, combined with its enormous capacity to accumulate and to process information, can lead to unprecedented gains in productivity and, above all, these innovations can accomplish the old dream of liberating human beings from drudgery and routine.

In the Third World the new innovations, due to their low cost, small-scale applications and possibilities of decentralization, have aroused, at least among governments and international agencies, the hope for a new and more egalitarian development. In particular, some of the new technologies are seen as especially suitable for the upgrading of traditional technologies, thereby preserving to a great extent the social and cultural advantages of the latter.

There is no doubt that the new technologies have the potential of greatly improving the situation of the Third World; it is not so clear, however, which are the conditions and prerequisites for that promise to come true. A brief look at the past will clarify the point.

# THE EXPERIENCE OF THE PAST

The present wave of technological innovation is but the culmination of the process of technological change that began with the Industrial Revolution. Those innovations started to enter the Third World at the very beginning of the expansion of capitalism, but the so-called process of "modernization" acquired its real momentum only after the Second World War and the ensuing wave of decolonization.

The technologies introduced in the Third World during that process, if sensibly used, held also the promise of more and better distributed wealth. This can be clearly seen in the industrialized countries; despite the fact that the basic characteristics of the capitalist system have not changed, it is undoubtedly true that the benefits of increased productivity have reached the great majority of the population of those societies. The same can be said of most of the socialist countries. The result is that for the first time in history a sizable part of humanity has its basic needs satisfied at an adequate level.

As we all know, the impact of the new technologies in the Third World was very different. Benefits have only reached privileged minorities, and the majority of the population live in conditions which are not much better, and sometimes worse, than before the beginning of the process of modernization.

The causes leading to the frustration of hopes in the Third World countries are many and complex, but we may select for brief consideration only those most directly associated with the application of science and technology for development. We will refer specifically to Latin America because it is the region we know best. Besides, it is a particularly relevant example, as Latin American countries have been politically independent for more than one hundred and fifty years, and thus did not have the problems which in other Third World countries could be attributed to the historically recent direct control by the colonial powers.

## Latin America: a case study

During the post-war period Latin America created the institutional elements and the intellectual capacity necessary to implement science and technology policies adequate to its own development needs. Nevertheless, and despite some encouraging developments, the appraisal of those decades is far from positive. It is true that in some sectors of the economy, particularly in industry, there was some improvement in technological capability, but the general picture is one of frustrated expectations.

Scarcity of human resources, deficiencies in the state planning organizations and in the planning methodology have been considered to be the main causes of the lack of success. But this is not a very convincing explanation in view of the historical evidence of other countries. The USSR, starting almost from zero with little planning methodologies at hand, became a scientific and technological and economic power only comparable to the USA. It is not sufficient explanation that the USSR has a socialist economy: France, confronted with the challenge of European economic integration, managed to correct its post-wa. technological inferiority and to harmonize its scientific and technological development with national needs. And Japan had

almost no research and development planning available when it first emerged as a competitor on the world markets.

As for the scarcity of human resources — one of the factors always cited in relation to the supposed inefficiency of the region's R and D systems — the historical evidence of continuous emigration of scientists and technologists seems to show that they, far from being scarce, are excessive in relation to demand. This "brain drain" has, in the last years, been caused more by internal expulsion — for political reasons, or for lack of governmental support to R and D — than by demand from advanced countries in which many highly trained professionals up to the doctoral level have difficulties in finding a job. What else can explain the failure of the expectations of three or four decades ago?

The basic paradigms for economic and social development based on scientific and technological planning originated in the developed countries, and particularly in Western Europe, in the post-war period. The Marshall Plan for the reconstruction of Western Europe which provided capital and consequently an acceleration of technological progress, brought to these countries a prosperity without precedent in history. The process was of course more complex, but the two elements — influx of capital and technological progress — were converted by the ruling classes of the developing countries into the two pillars on which economic and social development could be built. This approach offered two important advantages: first its simplicity, which allowed the mechanical translation of that strategy from the countries where it was conceived to the periphery; second, and perhaps more significant, the fact that it seemed to ensure progress without substantial modifications of prevailing social and economic structures.

As to the scientific and technological components, the same imitative criteria were applied. The structure and the general principles of the R and D system of the advanced countries were imitated. It was assumed that a "modern" scientific system — in the sense of subjects of research, quality of personnel, type of equipment, etc. — was going to be naturally linked with the productive system through the classical chain of basic research, applied research and experimental development.

As we know now, the above plan did not work as foreseen. The "first wave" of innovations failed to generate a better distribution of wealth in Latin America — despite the fact that the aggregate GNP increased in most countries of the region at a greater rate than the population.

The reasons for the failure have been amply analyzed by Latin American social scientists who have made important contributions to the understanding of the structural backwardness of the Third World countries. In regard to Latin America, one of the main causes was the imitative character of the development strategy. Related to this are also the following reasons: (a) the strategies or styles of development were not geared to satisfy the needs of the majority but rather to stimulate a pattern of consumption based on the model of the upper and middle classes of the developed countries, and only accessible to a small minority of the Latin American population; (b) the R and D systems were unable to generate new technologies, or to adapt the imported ones to the specific social, economic, and cultural characteristics of the countries of the region; (c) the pattern of consumption and production so generated made the Latin American countries strongly dependent

on the industrialized powers — one of the indicators being the external balance of payment deficit — making it increasingly difficult for the countries to adopt more endogenous and self-reliant development strategies.

The above refers to Latin American countries but we believe that it can be applied in general terms to the whole of the Third World, although local differences should be taken into account in a more detailed analysis.

# THE NEW TECHNICAL INNOVATIONS: A CHALLENGE FOR THE FUTURE

## Characteristics of the new technologies

Are there any reasons to believe that the new wave of innovations will be better absorbed by developing countries than the previous ones? To try to answer this crucial question, we must first examine some characteristics of the new wave of innovations.

The three major earlier waves of innovation were associated with the steam engine and the expansion of the textile industry; with railways, mechanical engineering and iron and steel industry; and with the chemical industry, electric power and the internal combustion engine. The central feature of these waves of innovations was their radical impact on the profile of the entire productive system, including the services sector. In the first place, they changed the energy basis from animal power to steam, electricity and liquid fuels. Secondly, the system of transportation shifted from animal-powered land vehicles and sail or oar navigation, to railways, steam-powered vessels and a transportation system based primarily on electricity and the internal combustion engine. Finally, each wave, particularly the second and third ones, produced an enormous increase in the variety of the final consumer goods produced.

The characteristic of the present wave of innovations is that its impact seems more pronounced in the organization of production and in the process of work than in the profile of the productive system as described above. The energy basis will surely diversify, but it will not change radically; even if nuclear power overcomes its present difficulties, it will be used mainly in the generation of electricity. The transport system will remain essentially the same, as well as the type of final consumer goods produced.

## The socio-economic impact of the new technologies

The fact that the new innovations will affect mainly the organization of production and the process of work does not mean they will be less important than those of the previous technical revolutions. On the contrary, from a social point of view the new technological wave will surely be the one with farthest-reaching consequences since the inception of capitalism.

The first modern technological revolution — the most important after the

neolithic revolution — modified the whole structure of Western society — by creating the proletariat and consolidating capitalism. The ensuing waves of innovations changed, as we have already said, the profile of the productive system, but they left essentially untouched the structure of the capitalist world. The present technological wave will change the very social structure of that world.

To demonstrate the above statement it is enough to consider the central protagonist of the present wave of technological change; the process of automation and robotization, based on microelectronics.

Even in the developing countries, one of the obvious causes of unemployment — besides some transitory factors — is the fact that every day less labour is needed to produce the same amount of goods and services. This tendency, which has been present from shortly after the Second World War although its effects were concealed by fast economic growth, will now accelerate enormously through the rapid progress of microelectronics technology. We cannot expand here on the consequences of that tendency; for the purpose of this paper it is enough to point out that it will have a tremendous impact on the divison of labour, the very basis of our whole societal organization. The elimination of physical and routine work will gradually eliminate the proletariat in the Marxist sense. It embodies the old aspiration of liberating human beings from routine work which does not require creativity. In this sense automation is *per se* a positive phenomenon, entailing one of the deepest revolutions in human history. The rational attitude therefore is not to oppose robotization, or to wait passively for its impact, but rather to work for the introduction of those social changes which can prevent the transitional stage from becoming, as happened with others in the past, a period of suffering and misery for the poorer sectors of society.

We can now return to the previous question of whether or not there are reasons to believe that the new wave of innovations will be better absorbed by the developing countries than the previous ones. We will start with a critical assessment of South-North relations.

## A new starting point

We are now in a new starting point which leaves little room for the kind of superficial optimism that has prevailed in the past. The development strategies adopted in the last decades — based essentially on the influx of external capital and technology — will become much less viable in the future. Due to their great external debt, most Third World countries are not in a condition to absorb more external capital. Besides, the crisis that affects the industrialized countries will restrict the flow of capital to the Third World.

As for direct and indirect aid from the industrialized countries, the prospects are still worse, as proven in the Cancún and Ottawa meetings. In these events there was little agreement among the participants, but one thing remained clear: the advanced countries will take all the measures they consider adequate to solve their own problems, without much consideration of their effects on the developing countries.

The above view is shown clearly in all the prospective studies and global models elaborated in the past years, predominantly in the developed countries; as in

*Interfutures* (OECD); *Presidential Report on the Year 2000* (USA); *Brandt Report*, and in the UNITAR models of the North-South relationship. All of these present more or less the same picture for the developing countries at the end of the century: the gap that separates them from the developed countries will be the same or greater than now in relative terms or, in the best hypotheses, will diminish only marginally in some of the relatively more advanced developing countries. In absolute terms — the provision of basic needs — the situation in a great part of the Third World will probably worsen.

Are those prospective studies reliable? We believe they are. If we accept their implicit premise — that the objective of Third World countries should be to close the gap in quantitative terms, which basically means to accept the prevailing criteria of socio-economic development — the situation is indeed hopeless.

This becomes clearer if we consider the quality of the gap, not only its numerical values: At the end of the Second World War, the development objectives of both central and peripheral countries were, to a certain extent, similar. In developed countries, particularly in Western Europe, poverty was still a problem, and part of the population had not reached an adequate level of satisfaction of its basic needs. Servicing these needs was therefore a common objective of developed and developing countries alike, although their starting points were different.

Today that situation has changed radically; for Third World countries the satisfaction of the basic needs of a great part of their population — in other words, the attainment of the benefits of industrial society — is still their fundamental objective. The central countries, on the other hand, are entering what A. Touraine calls the "post-industrial society" and A. Toffler the "third wave", a stage of development whose problematique is very different from the one the developing countries still confront.

As is well known, moreover, historical changes do not follow regular chronological sequences; there is always overlapping among them. This implies that the developing countries, although they have not completed the previous stage, will nevertheless suffer the impact of the new one. In other words, they will have to confront a problematique far more complex than the one facing advanced countries.

## The capacity to confront the challenge

There are few indications that the governments or the ruling classes of developing countries have any clear ideas about how to confront the new situation. In Latin America at least, the common reaction to the recession has been the traditional one: to restrict economic activity, to impose more sacrifices on the mass of the population, and to wait passively for the end of the crisis, as if it were a natural phenomenon that we have no means to control. There is no indication that the basic premises of the style of development are being questioned. It is manifest therefore, that from the point of view of socio-economic conditions, developing countries are not in a better position to absorb the present wave of innovations than they were when they received the impact of the previous one.

As for the scientific and technological systems of the developing world, there is no doubt that in most countries the R and D systems have considerably improved in the

last decades. Leaving aside India — which has a R and D system comparable to those of the advanced countries — there are other Third World countries — Brazil, Egypt, Mexico, Philippines, Argentina to name only a few — which now have sizable R and D systems. However, in most cases the old problem of the relative irrelevance of those systems in solving the specific problems of their own societies still remains. The cause of those problems is well known: in an imitative style of development which imports the patterns of consumption and the life styles of the central countries, it is almost impossible for the local R and D systems to compete with the advanced powers in generating different or better technologies to produce the same goods and services. Despite their improved capacity, practically all of those systems are still far from the goal of being able to participate on equal footing with the R and D systems of the central countries in the more advanced fields of scientific and technological research.

The above is aggravated by the fact that the most important new technologies are highly science-intensive. It is a well known fact that in the field of microelectronics, for instance, only a few countries — mainly the USA and Japan — can compete at a world level, and within them, fewer and fewer enterprises can remain in the market. Besides, the traditional vertical integration of the electronics industry is rapidly increasing under the impact of microelectronics: the output of the large corporations comprises a complete spectrum of production and a rapidly diversifying set of final goods.

In most developing countries the main participation in the electronics industry is in assembly, and this is only due to the relative advantage of cheap and abundant labour. The result of this division of labour between developed and developing countries is that there is little or no transfer of technology. Due to the rapid advance of automation, the central countries will most probably start to transfer the assembly factories back to their own territories. The relative absence of Japanese electronics assembly factories in the Third World seems to be attributable to the higher degree of automation in this country relative to the USA.

In biotechnology — one of the most promising innovations for Third World countries — the concentration and control by advanced countries seems less than in the electronics industry, but it also requires a high R and D capacity. In addition, it depends very much on local conditions and bio-resources and, consequently, most of the solutions must of necessity be endogenous or adapted to the local milieu.

It is clear that to absorb the benefits of the new technologies, the R and D systems of Third World countries will have to meet a formidable challenge. A most important point is their ability to work on the new technological areas from the level of basic research, because the technical options diminish rapidly down the chain of basic-applied-development research. If we try to enter mostly in the last stages — as has happened in the past — the result will be, as before, that we will use technologies developed entirely in the advanced countries, and thus adapted to their own conditions and possibilities.

The other obvious option is to let the multinational corporations devise our own "appropriate" technologies — an option already offered by some of them. We have enough experience about the consequences of the type of dependency generated by such a policy. There is no doubt that Third World countries will have to import foreign technologies — no country in the world is entirely self-sufficient in this field — but

they should form an integral part of a strategy whose final objective is to reach an adequate level of autonomy in technological decisions.

In conclusion Third World countries do not seem to be in a better position than they were in the past to absorb the new wave of innovations and to generate through them more and better-distributed wealth. On the contrary, the mounting economic crisis, the tendency to concentrate capital and technology associated with the new innovations, and the social impact of the process of automation, telematics and robotization, make the incorporation of the new technological wave even more difficult than the previous one.

# A STRATEGY TO CONFRONT TECHNOLOGICAL CHANGE

## Technological prospective

The above analysis may appear to be a gloomy picture of the future but it is not meant to be so; it is only an attempt to show the magnitude of the task ahead. Although the future looks difficult there is also a positive point for Third World countries: they have now experienced the heavy social and economic price paid for the indiscriminate introduction of foreign technology. If adequately used, that experience can help them to avoid past errors, and to absorb the new technological wave in such a way as to improve the lot of the majority of the population.

The above objective depends basically on the political will to attain it. Without that political will, little can be done by the R and D systems alone. However, all societies are dynamic and evolve, even if at the level of political decision making there is little will to change. These processes of transformation are protracted and complex, but there is always a degree of freedom for action.

One of the errors of the past was the rigidity of the R and D planning, based on the implicit assumption that development was a more or less a linear process; the result was a lack of flexibility to adapt to changing conditions or to new options.

To avoid or minimize the type of errors made in the past, it is absolutely necessary for the developing countries to make their own studies on technological prospectives, rather than to rely on studies from the advanced countries which invariably assume that the future of Third World countries is a dependent variable of the future of central ones. These endogenous studies should not only include the question of the future development of the new technologies but, more importantly, of their impact on the economic, social, political and cultural characteristics of the countries involved.

Two basic criteria should guide these studies. The first one is the impossibility of "projecting" the future, because in a period of deep crisis (as the one we are living through) the areas of uncertainty — political, social, economic, technological — are too large. So the aim is to detect main trends and possibilities, and to explore the degree of freedom of the national and international systems. The final goal should be a flexible strategy allowing the R and D systems to profit from the degree of freedom and from the resulting new options. The second criterion is that these studies should be normative. There are no "objective" visions of the social future in the sense of

scientific, detached predictions of events. Any forecasting is a selection among possible futures and a contribution to the shaping of the future. Consequently, the scientific and technological strategy resulting from those studies should be based — within the frame of reference of the possibilities and constraints resulting from the identification and evaluation of the main trends of change — on the conception of a viable and desirable society. We cannot describe such a society in detail, but we can say at least that it should tend to be participative, equitable from the point of view of wealth distribution, and intrinsically compatible with its physical environment.

## The new technologies and the strategy of development

The main objective of all the above considerations is to stress — although it may look redundant — that the *integrated application of emerging and traditional technologies* can only be a part of a holistic strategy — socio-economic, political and scientific — on the part of the developing countries to absorb positively the impact of the new technological wave of innovations. Without that wider strategy, any attempt to create appropriate technologies, which includes the upgrading of traditional technologies, will have the same fate that it had in the past. We know that substantial effort was and is being devoted to the generation of appropriate technologies. However, the success of those activities up to now has been very limited, with the significant exception of China. The technologies of some importance that have been produced are few, the dissemination poor, and in many cases they have been rejected by their supposed beneficiaries. In short, appropriate technologies have been unable to stem, in any significant measure, the indiscriminate influx of Western current technologies into the developing world.

To sketch a frame of reference for a policy on the generation of upgraded technologies, we should first look at the role that those technologies should play in the global strategy of development.

We know that technologies — in the wide sense, which includes "hardware" as well as "software" — are an integral part of the culture of any society. For that reason "traditional technologies . . . are not just one type of existing technology. To the degree that they are economically viable, they also stand for cultural pride, socio-economic functioning and political stability. They still constitute the backbone of the economies in most developing countries" (quoted from a UNCSTD Secretariat paper prepared for the panel).

The above is true, but requires some qualification. Traditional technologies are used mostly in rural areas and, at least in Latin America, there are few places where it can be said that they constitute the backbone of the economies. In most of those countries — a typical example being Mexico, with a large rural population — modern technology, in the form of agriculture based on the organization and technology of typical capitalist enterprises, now accounts for the greater part of agricultural production. Of course, the situation varies widely in different countries, but it is generally true that in those places where traditional technologies still predominate, economic and political stability is attained at relatively low levels of standard of living. Migration to the cities is only one of the consequences of that situation.

As for the cultural values, all societies are dynamic, they change over time, as do the technologies they use, and this does not imply the loss of their cultural identity. Europe totally changed its technological basis during the Industrial Revolution preserving, nevertheless, the central features of its culture. It should be noted that Europe developed those new technologies endogenously, starting from its own traditional technologies and its own creative capacity. However, Japan also transformed its productive system during the 19th century through the introduction of technologies generated in Europe, and it cannot be said that Japan lost its cultural identity during the process.

In fact what seems important is not so much whether the technologies are endogenous or imported — transfer of technology has been present all through history — but rather the way they are introduced. Japan imported foreign technologies on its own terms. All the decisions on the ways and forms to absorb them, including the necessary modification of the Japanese society, were taken internally. As a result, and this is paradoxical, Japan's transformation seems to have involved less hardship for the population than the same process in Europe, despite the fact that in the latter case the technologies were endogenously generated.

The above does not signify that the traditional technologies are not important, and should be replaced indiscriminately by "modern" technologies. What we want to stress is that the upgrading of them is only a part of a wider strategy of transition to a new society. That society will emerge not only through the present wave of new technologies but also through the process of political, social and economic change taking place all over the world.

## The upgrading of technologies

On the basis of those premises we can now see what characteristics the upgrading of traditional technologies should have. In our view, the main ones are the following:

The first, and obvious one, is to increase the productivity of the traditional technologies, to improve the working conditions of the labour-force, and to ensure that most of the economic benefit of those changes will remain inside the community.

The second one concerns the technologies to be upgraded: hardware as well as software should be selected carefully, not only from the point of view of their economic or ecological merits, but also considering their capacity to preserve *positive* local cultural or social traits.

The third characteristic is that technologies should be compatible with the global strategy of social and economic change. A technology may bring some immediate benefits by its upgrading, but it can also introduce or maintain rigidities that might pose obstacles to the process of transformation.

The combination of these criteria will allow the selection and upgrading of a coherent set of traditional technologies to facilitate the transition to the new conditions with the least possible hardship for the population, above all the poorer segment. Most processes of social change are traumatic, basically because new ways of production are introduced before the social organization has had time to adapt to the new conditions. In a certain way, it can be said that new technologies "explode" inside

society, forcing it to adapt to them, whatever the social disruption and human suffering involved. The upgrading of traditional technologies, if accompanied by a careful strategy of selection and timing in the introduction of the new technologies, can minimize the hardships of the process.

The fourth characteristic, and perhaps the most important one, does not refer to the technologies, but to the process of generating them. The local population, whenever possible through their own organizations, formal or informal, should participate in the whole process, from the identification of problems up to the management and control of the resulting technologies. The recognition of the importance of people's participation is based not only on an ideological position — the admission that people have the right to participate in their own development — but also, and mainly, on pragmatic and operational considerations: it has been shown repeatedly that development plans fail when the opinion of the people involved is not taken into account. This is not because peasants are especially "conservative", but mainly because people generally tend to reject changes in their ways of living and doing things unless they have participated in some way in their generation.

This is particularly important in the rural areas of Third World countries, where the direct or indirect mechanisms of participation existing in the urban areas or in the advanced countries are almost completely lacking. Moreover, and this also differs from the urban areas or the advanced countries, scientists and technicians of the R and D systems belong to a different economic and cultural milieu, so they lack an adequate frame of references as to which type of technology is best suited to the needs and conditions of the rural people.

The need for the participation of the peasants becomes more evident considering the fact that the local population is the depository of the traditional empirical knowledge of environmental conditions and technological solutions as well as of the socio-economic and cultural characteristics of the community. This knowledge can only be transmitted through an active interchange between scientists and the local people.

Finally, one of the difficulties peasants face in identifying and explaining their problems is their ignorance of the possibilities and limitations of modern science. Participation in the process of creation of technologies will help them to overcome this difficulty and to incorporate an awareness of science as a normal element of their lives, as is the case in the richer parts of the world. Moreover, it is an important objective that the technologies should be produced, as much as possible, by the local people with local resources. Participation of the local population will contribute to generating the skills required for their use and production.

## A METHODOLOGY FOR THE ENDOGENOUS GENERATION OF TECHNOLOGY

To generate technological solutions through the integrated use of the new and traditional technologies, taking into account the criteria enumerated above, is not an easy task, as past experiences and our brief analysis show.

Our contribution to the subject of this volume will not consist of suggestions for the implementation of specific technologies; instead we are suggesting a methodology to generate technologies. This methodology has been applied for more than three years on a project sponsored by the United Nations University: R and D Systems in a Rural Setting. The participating countries are Mexico, the Philippines and Ethiopia. R and D teams from those countries collaborated closely with the local population to generate technological solutions appropriate to their conditions and possibilities. The results are very encouraging, above all in Ethiopia, where the recent revolution greatly facilitated the participation of the peasants in all stages of the project. The stages of the methodology are as follows (see Herrera [1981] and Herrera [1982] for more details).

## Stage 1

The general socio-economic characteristics of the selected region should be evaluated, in order to understand the dynamic social elements in which a technological problem is always immersed. The approach of the study is based on the principle that the technological problems identifiable as obstacles to the development of backward rural sectors of poor countries, can only be understood in their true dimensions, by taking as a starting point the socio-economic processes and conflicts in which each social group is involved; that is, by recognizing that such problems are but one of the aspects of a "problem situation". In many cases the solution of a technological problem depends more on political, social and economic issues, than on scientific research. The failure to recognize this fact has led many well-meaning scientific institutions to solve the wrong problem, in the sense of devising a technological solution that does not fit the conditions of the "problem situation". One of the reasons for those mistakes is that the organizations involved tend to forget that the problem situation cannot be adequately identified without the participation of the local people, as the power problems are normally ignored in the higher echelons of decision-making. Through direct contact with the peasants it is possible to identify problems of power — even inside the peasant community — that cannot be perceived by a research institution working in the 'conventional' way. The final result of this stage should be the selection of the technological problems on which research should be concentrated (see Gebre Egziabher *et al.* [1982] for an interesting application of the methodology).

Among the problems with a viable technological solution, some or all will be selected by the peasants and researchers for immediate action. The selection will be based on the peasant's priorities and on the possibilities of the R and D system.

## Stage 2

This part of the work is concerned with the determination of the functions that the required technology is expected to fulfil.

The first step required in any scientific research into a new area is to ask the very basic questions about the specific technological field selected: what is the purpose of

the technology? What need or needs must it satisfy? Who will really benefit from the solution? These are only a few of the many questions to be answered. What we want to emphasize is that one must start by rejecting, as far as possible, any preconception or prejudice about the nature of the multiple needs (social, economic , psychosocial) the technology has to satisfy.

Clearly, this kind of question is always asked when a technology is developed. The real point is that in the customary work of R and D systems the answers generally appear to be obvious: the scientist is working with problems that belong to his own economic, social, and cultural background so that he is inclined to apply the same criteria to a completely different environment. He frequently assumes that he has to satisfy the same needs, but on a lower level, due to limitations posed by the local economic conditions.

## Stage 3

This stage consists of the analysis of the solutions that the local community has traditionally used. A point that should be kept in mind is that this analysis does not imply that local technologies or ideas *necessarily* have to be incorporated into the one being developed. In some instances, no worthwhile idea will be found embodied in the traditional technologies.

The utilization of local knowledge is not an easy task because in most cases it is not a problem of simply adopting or upgrading the traditional specific technologies being used, but one of extracting the original ideas they might contain, studying them, and applying the resources of modern science. The most important local contribution would probably be, more than any specific technology, new approaches to the solution of old problems, that might stimulate scientific research in hitherto unexplored directions. Besides the methodological difficulties, this approach requires an unprejudiced and open-minded attitude. This attitude has never been one of the most remarkable characteristics of the R and D systems in connection with traditional knowledge.

An interesting example of a valuable idea contained in a traditional technology relates to the preservation of meat, a difficult problem for countries with poor transportation, particularly in the tropical regions. In many rural areas of Latin America people expose meat to solar heat under certain conditions that they know through long experience. The resulting product can be stored for long periods. The central idea of this technology is the utilization of solar radiation, a cheap and always available source of energy. This idea, coupled with modern science to improve the process from the biological, sanitary, nutritional and economic points of view, could help to solve an important rural problem.

## Stage 4

The most important concept to adhere to in this stage is that there is no such thing as a 'natural resource'; 'resource' is an economic term, and nature does not produce

economic things. It produces only physical entities that, with the application of knowledge and in certain economic conditions, can be used for the benefit of society.

This elementary concept is frequently forgotten in developing countries, and there is a tendency to consider as natural resources those regarded as such by the industrialized countries. Thus, the research must include not only the products of nature that have been already used as resources, but also those that can have a potential application for the problem area being studied.

## Stage 5

With the information gathered in the previous steps, a set of assumptions or paradigms will be derived forming the frame of reference for the final step to develop the required technology. The set of assumptions — which will contain scientific, technological, environmental, economic, social, psychosocial and anthropological information — will define a 'technological space' which is basically the set of requirements and constraints that the technology has to satisfy (Gebre Egziabher, Tewolde B., 1982).

In finally building the technology, all possible solutions that fit the technological space should be considered. From a certain body of scientific knowledge many technological solutions to a given problem can be devised. The existence of an adequate frame of reference allows the exploration of a multiplicity of possible paths, and the selection of the one best suited to the particular situation. Another result of this procedure is to give coherence to technologies pertaining to different fields of activity. Once the set of paradigms has been built, in some cases the required technology will already exist, and there may simply be a question of adaption and introduction into the area. In other cases, it may be a problem of combining existing technological elements in a different way. Finally, in other cases, it will be necessary to devise an entirely new technology. In most instances, however, the problem will consist of combining some of these alternatives.

It should be emphasized, finally, that in this methodology endogenous generation of technology refers to the process through which the desired characteristics of the technology are determined. *Endogenous* concerns the process of definition and not necessarily the technology itself, which can be imported, provided it is appropriate. In this way the transfer of technology becomes an integral part of the process of generation of technology.

## Notes

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