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# The Generation of Technologies in Rural Areas

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**Summary.** – Technologies are at present generated in the framework of a system of paradigms which originated in the developed world, which is not adequate for the developing countries. This article proposes a research methodology that, while generating technologies appropriate for rural areas, contributes at the same time to the building of a new system of paradigms adequate for the needs and conditions of developing societies. The final aim of the methodology, which presupposes local participation, is to define a 'technological space' which is the set of requirements and constraints that the technology has to satisfy. Any technology which fits that space is appropriate, whether locally produced or imported.



## 1. THE CONCEPT OF APPROPRIATE TECHNOLOGY

The realization that the indiscriminate transfer of technology from the industrialized countries is not an adequate solution for the developing countries is not new: it is contained in Gandhi's *Sarovaya* approach to development as early as 1909. This concept was based on the development of the villages, with the means of production for basic needs owned by families or by co-operatives of families. The basis of the fight against poverty was full employment. 'For the full moral and mental development of the individual – for the individual was, for Gandhi, the supreme consideration – it was essential to find work that gave him opportunity for self expression and development of creative intelligence . . .'[1] Education – based on work by hand and on the identification and solution of problems of immediate relevance – was the tool to develop creative intelligence. In short, self-reliance starting at the village level, concentration on the immediate relevant problems rather than on long-term fixed plans, fostering of creative intelligence through the full development of the individual, and social change through non-violent civil disobedience and non-co-operation, were the central elements of his approach to development.

Gandhi's concept of development included an explicit science and technology policy that was essential for its implementation. In his own words: 'if I can convert the country to my point of view, the social order of the future will . . . include everything that promotes the well-being of the villagers. I do visualize electricity, ship building, ironworks, machine making and the like existing side by side with village handicrafts. But the order of dependency will be reversed. Hitherto, the industrialization has been so planned as to destroy the villages and the village crafts. *In the state of the future it will subserve the village and their crafts.*'[2] Gandhi's insistence on the protection of village crafts did not mean a static conservation of traditional technologies. On the contrary, it implied the *upgrading* of the local techniques, the *adaptation* of modern technology to India's conditions and environment, and the encouragement of scientific and technological research to identify and solve immediate relevant problems. His final aim was the transformation of the Indian society, but through a process of organic growth from inside and not through an imposition from outside.

In Gandhi's social doctrine, the concept of *appropriate technology* is clearly defined, although he never used that term. Moreover – and we will come back to this point later on – he defined appropriate technology in the context of an integrated approach to socio-economic and cultural development.

Under Nehru's rule, the development strategy of India was based on planned large-scale industrialization with emphasis on basic and heavy industry, and Gandhi's ideas on technology were almost completely forgotten until the early 1960s. At that time, and in a different context, they emerged again; the best known names for this new concept of technology – *intermediate* and *appropriate* – made their appearance at

that time. The first one was proposed by Schumacher in the mid-1960s. It refers to a technology that requires less capital investment for work place than the ones currently in use. It should be small-scale, decentralized, with rural relevance, based on local resources, and of simple operation and maintenance. *Appropriate technology* was used by Indian planners in the early 1960s with a meaning, in practice, very similar to the one attached by Schumacher to intermediate technology.

From this rather modest beginning, and above all in the wake of the new-born concern for the environment, the terminology associated with the 'new technology: has greatly multiplied, sometimes adding confusion more than clarification to the underlying concepts. In a meeting organized by UNEP, the following terms in use were listed:[3] intermediate technology; appropriate technology; self-help technology; progressive technology; biotechnics; ecologically-based technology; soft technology; alternative technology; resource-conserving technology; new alchemy; low waste and no waste technology; environmentally sound technology; liberatory technology; people's technology; convivial technology; radical technology; community technology; soft technology II; alternative technology II; utopian technology; white technology; careful technology; humane technology; equilibrium technology; alternative technology III; inequality reduction technology; appropriate technology II; rational technology; alternative technology IV.

According to the same report 'unfortunately, some of the terms have never been clearly defined; and others may have been defined in one way, but used in another and understood yet in another way'.[4]

The literature on the subject has also expanded to such an extent that even a brief review of its content would be a major undertaking. Part of that literature refers to the conceptual approach, another part to specific applications, and a considerable portion finally adds very little to the clarification of the issues involved.

## 2. ACTIVITIES IN THE FIELD OF APPROPRIATE TECHNOLOGIES

Together with the terminology and the literature on the subject, the number of organizations engaged in appropriate technology activities has steadily increased in recent years. Several international and national institutions have prepared lists of such organizations, with a very brief description of their activities, in most cases reduced to the mention of the specific fields of research in which they are engaged.[5] The number of organizations included varied greatly in the different directories. For example ILO gives 22, the Canadian Hunger Foundation 81, and the UNEP, the most inclusive, gives 696, of which 443 are located in the developed countries, and 253 in the Thirld World.

Despite the impressive number of organizations registered, these lists and descriptions are not enough to give a clear idea of the real activity in the field of appropriate technology, mainly because most organizations are included only on the basis of an explicit declaration of interest in appropriate technologies. A good example of the heterogeneity of the lists is given by the UNEP directory which includes examples ranging from 'organizations which have some amount of experience and expertise in their staff, whose names appear repeatedly on lists as referrals, and which engage in research' to 'organizations for which only an address and an occasional attribute has been supplied, activities and publications are unknown'.

Despite the scarcity of accurate available information, it is evident that a substantial effort is being devoted to the generation and diffusion of appropriate technologies. However, the success of those activities up to now has been very limited – with the significant exception of China – as can be seen with a cursory examination of the literature on the subject.[6]

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, above all in the rural areas. In short, appropriate technologies have been unable to stem, in any significant measure, the influx of western current technology in the countries of the Third World.

Many explanations have been offered for this situation: from scarcity of financing, trained personnel and equipment, to lack of adequate socio-economic studies.[7] Although it is obvious that the shortcomings of the R and D systems of most developing countries constitute a great handicap in the development of technologies, they can partially explain the insufficient activity in the field, but not why so many supposedly appropriate technologies fail to reach the intended beneficiaries or are not accepted by them. In our view there are two causes of the poor performance of the R and D systems of the Third-World countries that have not been taken sufficiently into account. The first relates to the relationship between technologies and style of development, and the second to the

very process of generation of the technologies. In what follows, we will refer first briefly to the connection between technology and development, but most of the rest of this article will be devoted to its central theme: the methodology to generate appropriate technologies.

## 3. APPROPRIATE TECHNOLOGIES AND DEVELOPMENT

From the point of view of their acceptance, the main difference between 'modern' and appropriate technologies is that the former represents a *whole set of coherent technologies*, while the latter, up to now, is only a miscellaneous assortment of technical solutions. The explanation is that western technology *embodies an integrated concept of development*, while the existing appropriate technologies reflect a piecemeal approach without an adequate socio-economic context to give them the required coherence.

The problem we are confronted with here is the basic ambiguity of the term *appropriate technology*. All technologies are appropriate: the question is *what for*? If the objective of the Third-World societies is to imitate the style of development of the advanced countries, the western technologies are appropriate for them. The fact that the massive introduction of those technologies causes undesirable social and cultual effects is beside the point: it is the price accepted by the ruling classes to preserve a given socio-economic order.

It is obvious, therefore, that the very possibility of generating an alternative body of technologies to the current ones depends essentially on the capacity to conceive and implement a new approach to development. In other words, the term appropriate technology has no meaning unless located in the frame of reference of a clearly defined type of society. It is in this context that the original Gandhian concept of appropriate technology contrasts with the one that emerged in the 1960s, basically in the western countries. The former, as we already said, was immersed in a very concrete scheme of development, with all its social, economic and cultural dimensions unambiguously defined. The latter is based on a more or less vague concept of a 'better and more humane society' – deeply concerned with the rational use of the natural resources and the preservation of the environment – that evades most of the socio-economic and political hard facts implied in a change that would affect, directly or indirectly, most fields of human activity.

In the developing countries, however, a new concept of development is being constructed that can constitute the frame of reference of the new technology. Its distinctive element is that it is centred in concrete human beings; the well-being of individuals will not be the by-product of indiscriminate economic growth, but a specific target whose attainment will condition the whole social and economic organization of the country.

According to this approach, development will be centred around the concept of 'basic needs.' There are many definitions of this concept, but it is essentially the recognition that each human being has an inalienable right to the satisfaction of certain needs which are essential for a complete active incorporation into his culture. Some of these needs – such as food, shelter, health and education – are relatively invariant through time and cultures, and easy to identify. Others however, associated with consumption, or of a more spiritual nature, are more difficult to define. New needs are generated by the evolution of cultures, by new forms of social organization, and by technological change. In judging which of those needs are really 'basic', and their relative priority, a large dose of subjectivity, or social bias, is inevitable. The only way out of this dilemma is to establish mechanisms of participation to ensure that all social decisions really represent the will and aspirations of the populace.

The elements we have identified – not to repeat the path of the developed countries, to make the satisfaction of the needs of the people the specific objective of development, and to ensure as much popular participation as possible – are not enough to give a complete picture of the content and meaning of the new approach to development. History shows, however, that this is not an exception. All social changes in the past have started with a nucleus of very simple and basic objectives; the extent to which those objectives are attained, and the operative forms they take, are determined essentially by the characteristics of the process of change itself. In other words, and this is not new, the ends are largely a function of the means.

In the new vision of development, the mechanism of change is centred around the concept of 'self-reliance.'

In its essence, self-reliance is basically the recognition that the main responsibility for solving the problems of underdevelopment lies with the developing countries themselves. It is also the awareness that development, progress or evolution – whatever we choose to call it – is not simply a techno-economic phenomenon:

it is also, and mainly, a process through which a society continuously creates and reasserts its own identity.

Finally, it is obvious that the new development cannot be implemented with the capitalist structures prevalent in most developing countries, based on private benefit, and on the exploitation of the majority of the population. It would require a radical socio-economic transformation, but its exact characteristics will vary widely, given the social, economic and cultural diversity of the Third World. For the countries that have already transformed their structure the starting conditions will be more favourable, but it should not be forgotten that some of the elements that have lead to the present world crisis – such as material consumption as the main social goal, lack of popular participation, alienation – are, in varying degrees, shared by both the capitalist and the socialist systems, as they exist today.

## 4. METHODOLOGY FOR THE GENERATION OF APPROPRIATE[8] TECHNOLOGIES

### (a) *How technologies are generated at present*

The framework given by an integrated development scheme is the necessary but not sufficient condition to generate appropriate technologies: it also requires an adequate methodology of research. Before discussing this last point, we will analyse briefly how technologies are generated at present by the R and D systems, starting with the developed world.

The determination of the adequacy of a technology for a given society is a problem with many variables, only a few of them being strictly technological. Most of these belong to the fields of economics, sociology and social psychology, and form what might be called a set of assumptions or paradigms, which constitute the frame of reference of the R and D system. Some of them for the advanced countries can be stated as follows: the scarce factor of production is labour, so the more capital-intensive technology is the better; it is necessary to stimulate consumption by producing as many varieties of goods to satisfy the same needs as possible; the dynamics of the economy depend to a great measure upon a rapid circulation of goods, so a relatively fast rate of obsolescence is desirable; a considerable part of the population has its basic needs more than fulfilled, so its consumption can only be stimulated by the production of more and more sophisticated goods, irrespective of their real social value; it is a highly competitive economy in which innovations are essential to survival, and they have to be stimulated even when they waste resources, in the sense that they result in the production of more complex and expensive goods that add nothing, or very little, to the rational satisfaction of the needs to which they are directed; natural resources or their substitutes, with a very few exceptions, are available in unlimited amounts.

These are only a few examples of the set of assumptions that direct the effort of the R and D systems of the developed countries of the capitalist world. They have mostly evolved since the beginning of the Industrial Revolution and are the expression of the most basic characteristics of those societies; they are seldom explicitly stated as they have become assimilated by every member of the R and D systems. This is the reason why any scientist or technologist of the developed world, whatever his personal social position or political ideology, when faced with a technological problem rejects automatically, almost unconsciously, any solution which does not conform with the accepted assumptions.

In the developing countries the process of generation or introduction of technologies is more complex. We will base our analysis on the following assumptions:

(a) Most developing countries are dual societies, composed of a modern and a traditional sector. The modern, or more appropriately, the rich sector comprises between about 10 and 30% of the population, has an average income *per capita* several times higher than the traditional sector, and has the cultural habits and patterns of consumption of the middle and upper classes of the advanced countries. The traditional sector lives mostly on a subsistence economy and its cultural patterns are still greatly based on those prevailing in the past. In the last decades mass media communications have started to change its cultural habits, without much improving its material situation. According to many social scientists, particularly those from Latin America,[9] the relationship of the traditional sector with the modern one is one of dependency which closely resembles the relationship between developed and developing countries. The traditional sector produces the raw materials that are exported or required as inputs by the modern sector. Most of the benefits of international trade are invested in the modern sector which,

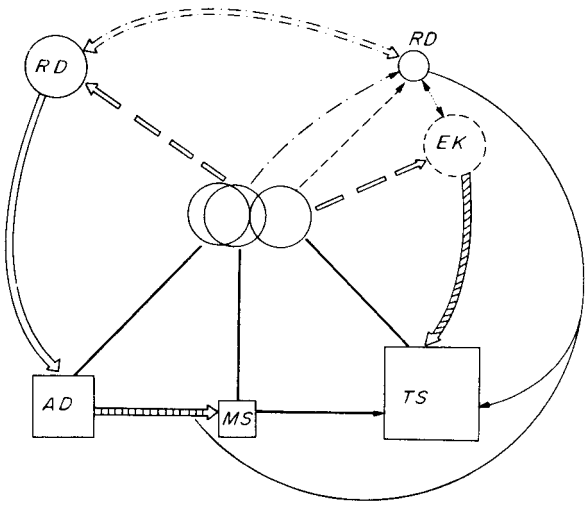


Figure 1.

added to the great wage difference between urban and rural areas, tends to continuously widen the economic gap between the two sectors.

(b) We will consider technology broadly divided into two types: modern or scientific technology, and traditional technology based on empirical knowledge. This distinction is important because about half of humanity and a great majority of the population of underdeveloped countries uses traditional technologies to solve most of the problems of the subsistence economy in which they live. It is obvious that this sharp division between traditional and scientific technologies is somewhat artificial. In modern societies there are technologies in use which include some elements of empirical knowledge. Conversely, in the traditional sector of society there is some penetration of scientific technologies. For the purpose of our analysis, however, these exceptions do not alter the overall picture. For the study of the behaviour of the R and D systems, we define as the problem area of a society the set of problems that can be solved by the application of technologies, either scientific or empirical.

Figure 1 is a very simplified representation of the mechanism for generation of technologies as they work today, and its relationships with society. It refers to the whole world, but can be applied with a few modifications to any particular underdeveloped country.

The boxes at the bottom of the diagram represent the sectors in which we have divided world society; advanced countries (*AD*); and modern (*MS*) and traditional sectors (*TS*) of the underdeveloped countries. The sizes of the boxes are approximately proportional to the size of the population included in each of these categories. The circles at the centre are dimensionless and depict the relationship between the problem areas of the three sectors: the amount of overlap reflects, in general terms, how much they have in common. The circles at the upper part of the diagram represent the sources of technological solutions: the R and D systems (*RD*) of the developed and developing countries, and empirical knowledge (*EK*). The sizes of the *RD* circles express their relative importance – although not in exact quantitative terms – as reflected by investment, personnel etc. The broken arrows indicate the demand upon the sources of technology. The full arrows depict the 'flux' of technological solutions; their width represents the relative importance of the directions of circulation. Finally, the dash and point lines reflect the interconnections between the sources of technology.

The diagram can be clearly divided into two parts: the left-hand side represents the relationships from the point of view of circulation of technology between the advanced countries and the modern sectors of the developing countries; the right-hand side depicts the situation of the traditional sector of the underdeveloped countries. We will first analyse the left-hand side of the diagram.

Most of the features shown in this part of the diagram are well known, so we will consider only those which are more relevant to our purpose. The characteristic that determines the overall pattern of the flux of technology is the overlap of the problem areas of the two sectors

under consideration. The rich sector of the underdeveloped countries, having the same cultural trends and values of the developed countries, has the same patterns of consumption and, hence, exerts a similar type of demand on the productive and R and D systems.

As about 98% of the R and D capacity of the world is concentrated in the developed countries, it is obvious that the overwhelming majority of the technological solutions for the area of common problems was to come from the R and D systems of those countries. Moreover, the overlapping of technological problems is continuously enhanced by a feedback mechanism created by the way in which technology circulates in the whole system.

This mechanism is based on the fact, sometimes overlooked in the representations of the R and D systems, that the productive structure of the developing countries is not directly connected with the technological systems of the advanced countries. Of the many technical solutions explored by the R and D systems of these countries, only those that are accepted by their internal markets are finally introduced in the developing countries. In other words, the society of the industrialized world operates as a 'filter' through which the production of their R and D system has to pass before reaching the developing countries. The result – as the advanced countries move towards a welfare society based on the consumption of increasingly sophisticated goods – is that the R and D system of the developing countries is confronted with a technology that changes so rapidly that it makes it very difficult for them to be up-to-date with information and practically impossible to influence its direction.

Another effect of this mechanism of circulation of technology is that the industrial systems of the developing countries tend to concentrate on the production of increasingly expensive and sophisticated goods, thus diverting human and material resources from the backward parts of society.

The overall result of this mechanism of generation of technology is to accentuate the dual character of the developing countries. The modern sector tends to be more and more integrated with the advanced countries – at least from the point of view of cultural habits and patterns of consumption – widening the gap with the traditional sector, even if the latter has some marginal improvement in its living conditions.

All the characteristics of the traditional sector in relation to technology stem from the basic fact that its problem area, as we have defined it, has very little in common with that of the modern sector. The most relevant features of the traditional sector are too well known to require detailed description: it still greatly depends on a subsistence economy – despite the fact that it is the producer of the raw materials on which the growth of the rich sector is based – and is therefore subordinated to the market integrated by the modern sector. Most important of all, it lives for the most part in a state of utter material misery. Its central problem, therefore, is to satisfy the very basic needs of everyday life.

The technologies used by the traditional sector are based on empirical knowledge, which is transmitted by verbal tradition and is the result of centuries of struggle for survival. This knowledge is comprised of a great amount of useful information on the physical environment and on the ways to use it to provide for the essential needs of life.

As we have already seen, the connection of the traditional sector with the sources of modern technology is very weak. The technological solutions produced or adopted by the modern sector of the economy are generally not suited to the particular conditions of the traditional sector and, besides, this sector lacks the economic capacity to accede to them.

The relationships between the three sources of technology also reflect the overall situation. The R and D systems of the developing countries are strongly interrelated with the R and D systems of the advanced countries – mainly through basic research – and make their contribution, however small it might be, to the generation of the scientific knowledge that constitutes the basis of modern technology. On the other hand, the body of empirical knowledge of the traditional sector has practically no connection with the R and D systems of the modern parts of society. It is not considered, in general, an object of scientific enquiry.

By comparing how both parts of the world generate technology, it is easy to understand why the developing countries have not been able to solve – even in those fields where the political will does exist – the most pressing problems of their societies. In the developing countries the R and D systems have evolved with the modern sector of the economy, and are closely connected to the R and D systems of the advanced countries. *Their paradigmatic determinants are very similar to those of the developed societies, and this similarity is continuously enhanced by the process just described.*

In the traditional sector, on the other hand, the problem area is different from that of the

modern sector, and consequently the assumptions of the R and D system cannot be applied to the solution of its problem. It is an essentially non-explored area and there is no set of paradigms which could form the basic framework to direct the efforts of the R and D systems. Without that frame of reference, hunger or illiteracy, for instance, are not problems from a scientific point of view; they are only facts. *They become scientific or technological problems only when their social, economic and psychosocial parameters and variables are unambiguously defined.* The consequence, which is widely known, is that the traditional sector exerts very little explicit demand on the R and D system of the underdeveloped countries.

This statement does not contradict the fact that the R and D system performs some research on the problems of the traditional sector that results in the introduction of a few modern technologies. The important point, however, is that in most cases the research is made on the implicit assumption that the criteria applied to the modern sector are also valid for the traditional sector. This necessarily results in a piecemeal approach that induces the introduction of some 'modern' technologies, without taking into account the overall social effects.

### (b) *The stages of the methodology*

It is clear from the above that the main problem of the R and D system of developing countries is the lack of an endogenously generated set of assumptions or paradigms that can serve as the basic framework to develop technologies appropriate to their own needs and aspirations. It is also obvious that those countries cannot build such a framework through the same long process that acted in the past in the now industrialized societies.

In recent years, and in relation to that problem, there has appeared an abundant literature on 'recipes' for the type of technologies the developing countries should generate. It is universally said – to give just one example – that those technologies should be labour-intensive. It is true that in a country with structural underemployment the overall technological development should increase employment, but this does not mean that *all technologies* should be labour-intensive.

In our view, the specific type of technology a country or a region should adopt cannot be determined by *a priori* prescriptions; *it should emerge from the very process of generating it.* Consequently, the only solution for the developing countries is to devise a methodology of research that, while generating the required technologies, contributes at the same time to building up the systems of assumption which we have referred to previously.

In what follows we present a general outline of a methodology to generate appropriate technologies for rural areas. The reasons why we have selected the rural areas are the following:

(a) For the majority of developing countries the most pressing problems are in the rural areas. Besides, as they have more 'technological specificity' than the urban areas they exert, at least in principle, more potential demand on appropriate technologies.
(b) Mainly by improving the condition of the rural areas, and by creating in them the roots of a new style of development, it will be possible to close finally the gap between the so-called 'modern' and 'traditional' sectors by the building up of a new integrated society.
(c) *The basic principles* involved in the generation of technologies for rural areas are also valid for the whole society, although the mechanisms for their implementation could be somewhat different.

Two of the essential elements of the proposed methodology are the utilization of local knowledge, and the participation of the local people in the whole process. Therefore, before describing the various phases of the methodology, we will refer to those two points.

#### (i) *Local knowledge*

We prefer to use the term 'local' instead of 'traditional' because the knowledge of any social group is composed of a mix of traditional knowledge – in the sense basically of old, of unknown origin, and 'modern' knowledge, in a chronological sense – stemming from the need to adapt continuously to changing ecological and socio-economic conditions.[10]

For many scientists the use of local knowledge appears as a novelty of very doubtful usefulness. They forget that in the most advanced countries of the western world, besides science-based technology, a lot of 'traditional' technology is being used. In almost every field of economic activity – building (the brick was in use in the most ancient cities of the Indus Valley), carpentry, metallurgy, textile industry, ceramics, liquors, cooking etc. – technologies based on traditional empirical knowledge coexist with the most sophisticated science-based technologies. We must remember that common people have had to solve their problems in their

own way much before modern science was born.

In the rural areas of developing countries the utilization of local empirical knowledge is more important still than in modern sectors of those countries, or than in the advanced societies. This is particularly clear in the case of ecological conditions, which are so important for economies based mainly on agricultural production. Most underdeveloped countries are located in the tropical or subtropical areas, in natural environments that have been scarcely studied by the modern R and D systems. The local populations, on the other hand, have had to develop through long experience methods and technologies of production compatible with the physical environment, as a condition for survival. The analysis of those technologies, and of the knowledge contained in them, is the best shortcut to know environmental conditions which otherwise would take a long time to understand.[11]

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 in concrete specific technologies, *in 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, that is not one of the remarkable characteristics of the R and D system's connection with traditional knowledge.

(ii) *Local participation*

The recognition of the importance of people's participation in development programmes is not only based 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 time and again that many development plans in every field have failed because the opinion of the people involved was not taken sufficiently into account.

In the advanced countries, and in the modern or rich sector of developing countries, people have a degree of participation in the generation of the technologies that will affect them. This participation is implemented through a complex indirect mechanism that normally ensures the acceptability of new technologies even before they reach the potential users. For instance, no enterprise will try to commercialize a new product unless a market survey has been performed. Besides, the scientists and technicians who produce the technologies belong to the same milieu as the consumers, so they share their preferences and aspirations; applying the terminology we used when referring to the R and D systems, they share the same set of paradigms.

In the rural areas of developing countries, on the other hand, those mechanisms of participation are almost completely lacking; moreover, the scientists and technicians of the R and D systems belong to a different economic and cultural milieu, so they lack an adequate frame of reference as to which type of technology is best suited for the needs and conditions of the rural people.

The need for the participation of the peasants to develop technologies for the rural areas is also evident considering what we have said about local knowledge. The local population is the depository of the traditional empirical knowledge – including, besides the environment and concrete technological solutions, the socio-economic and cultural characteristics of the community – which can only be transmitted through an active interchange between scientists and the local people.

One of the obstacles that peasants have in identifying and posing clearly 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 that obstacle, 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. The participation of the local population in the process of creation of the technologies will contribute to generating the skills required for their use and production.

However, and despite the growing literature on the subject, there is still a great resistance to the participation of the peasants in development plans, and in the generation of technology. The main reasons given for the hesitation to fully accept peasant participation are that peasants are conservatives and tend to reject anything new, and that they are ignorant and cannot understand modern knowledge and approaches. However, when the reasons for the rejection of specific technologies by the rural people have been seriously studied, it has been found that normally this attitude is based on solid rational ground. In most cases the resistance to adopting

new technologies is based on the fact 'that the adoption of technological innovations cannot be taken in isolation from other factors such as land tenure, social organization and cultural values. The literature on the subject provides many examples of cases where "rational" innovations have been rejected by farmers because of one, or a combination, of these various factors, and not because of any "irrational behaviour" or an abstract "traditionalism" which some authors purport to find among peasants.'[12]

As for the 'ignorance' of the peasants, the point is not how cultivated they are from the point of view of general education, but how much they know about the specific productive activities in which they are involved. On this matter it is obvious that they have a clear advantage over most urban workers. The latter participate normally in a very small segment of the process of production, and have very little idea of the implications of even their own work. The farmers, on the contrary, have to know the whole cycle of production and are, for the most part, entrepreneurs and labour simultaneously.

(iii) *The stages of the methodology*

In what follows we will describe briefly the main stages of the proposed methodology. It is obvious that these steps do not constitute a strict sequence, as they will greatly overlap in time. The main task – to build up a set of comprehensive, valid assumptions or paradigms – constitutes a dialectic process. A few initial assumptions will form the framework for the definition of technologies, but the experience in their building and application will revert to the assumptions to modify, enlarge or complete them.

The steps of the methodology are as follows.

*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 that can be identified 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" . . .'.[13] As is well known, in many cases the solution of a technological problem depends more on issues of political, social and economic power, 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 these mistakes is that the involved organizations 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 Figure 2).

The first step of the process is to identify the poor sector of the population. As is well known, in many projects intended for improving the lot of the poorer sectors of the community, the final results was just the opposite: due to the lack of adequate socio-economic studies and local participation, the projects mostly benefited the richer sector of the peasants.[14]

Through the interaction with the peasants the problems of the community will be identified. It is important to remember that in any community there is a whole hierarchy of problem situations. The first one is what can be called 'The Problem Situation': it arises as a consequence of the type of insertion of the community in a global socio-economic and political system at the national level. In most cases the type of problems posed at this level cannot be solved by technological means.

Typical examples of this kind of problem are those related to the structure of land property, that can only be solved through a radical land reform; or the price changes of exportable products determined by international trade.

At a lower level in the hierarchy problems appear that, although related to the overall problem situation, vary widely their degree of control by the socio-economic and political context.

The problems identified are broadly divided into two classes: those without an R and D component, and those with an R and D component. The first ones are not the concern of the R and D systems, and consequently are left out of the picture.

An example of the first kind of problem – which is frequent in the rural areas of Mexico, for instance – is the case where more appropriate technologies do not substantially improve

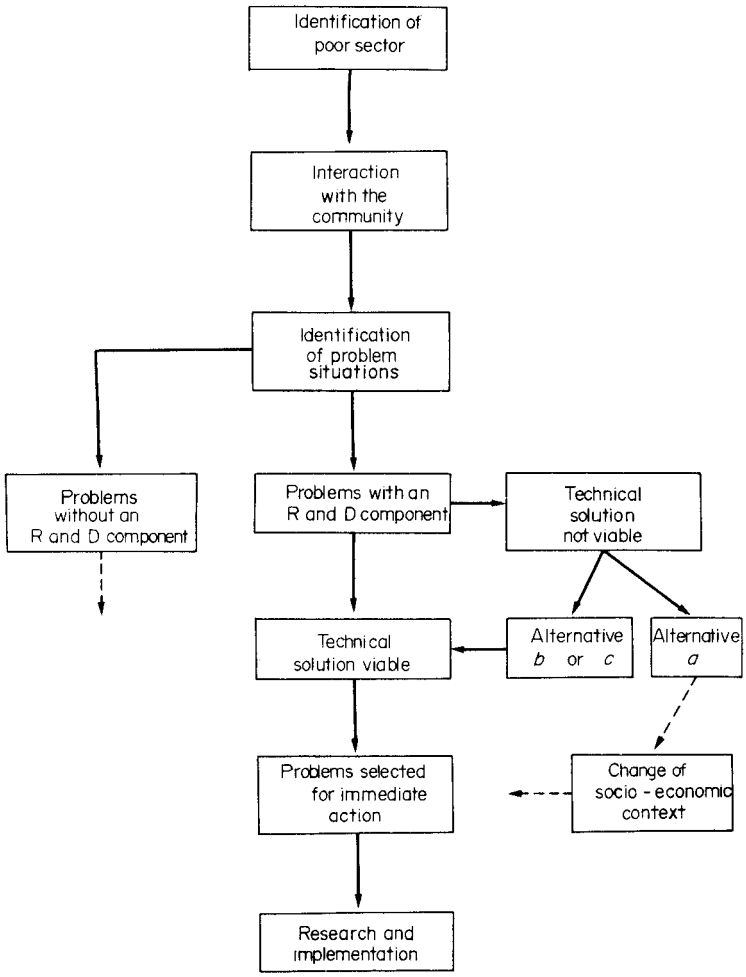


Figure 2.

the peasant's condition, because the middlemen and money lenders take all or most of the added profits.

The problems with an R and D component are divided into two categories: those in which the technical solution is not presently viable owing to socio-economic or political constraints; and those for which a technical solution is viable.

In the first category three alternatives are possible: (a) to leave the problem aside until a change in the socio-economic conditions allows them to tackle the technological component; (b) to find a technological alternative to bypass the socio-economic constraints; (c) to use the solution of the technological problem to overcome the socio-economic constraints. An example based on the MAYA report on the Henequen region of the Yucatan, Mexico, can be used to illustrate the three alternatives which we are referring to.[15]

The henequen is cultivated to use its fibre, which is extracted by mechanical means. As a by-product of the process a large amount of bagasse (solid waste) is obtained. The bagasse can be spread in a layer of a thickness of about 35 cm, and used as high fertility artificial soil to grow vegetables. However, a great deal of research is still needed to control pests and plant diseases, as there is not enough experience with the behaviour of this artificial soil in relation to those factors. The peasants, however, do not want to support the research because, owing to the fact that the vegetable market is monopolized in the region, they have problems in selling their small present production, they feel they

will be unable to market an output several times larger, despite the fact that there is still a sizable unsatisfied regional demand.

In this case the three alternatives mentioned can be exemplified as follows:

(a) To wait until the market conditions change. This is the alternative adopted by the peasants at present.
(b) A technological alternative to bypass the market constraint, could be to carry out research to identify some other crop which is both suitable for the artificial soil and which has an open market.
(c) To solve the technological problem in the expectation that increased production will oblige the local authorities to reconsider the situation of the market, or destroy the monopoly by the intervention of other economic interests. This option obviously involves a calculated risk.

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.

The next stage will be research and implementation of the solutions.

The central point in relation to the socio-economic study is that if there has been effective interaction with the peasants, the results obtained through the process just described should be essentially coincident with the interpretation of the socio-economic analysis. On the other hand, the preliminary results of the socio-economic analysis play an important role in helping the scientists to understand the problems of the community, to identify the poor sector, and to appreciate the importance of the technological factors involved in the problems. At the same time the information gathered in the continuous interaction with the peasants serves to correct and enrich the socio-economic study.

As an illustrative example of the application of the first and main stage of the methodology, we will briefly describe the procedure followed by the Ethiopian team in the project sponsored jointly by the United Nations University and the International Development Research Centre, Canada.[16]

The first task of the project teams was to identify the peasant organizations – formal or informal – that best represent the interests of the community. In the case of Ethiopia this was easy as after the 1974 revolution the rural population is organized in peasant associations, with democratically elected authorities, which have a high degree of autonomy in all matters concerning the activities and welfare of the population. To structure the contact between peasants and scientists, a committee in charge of the project was established composed of five representatives of the R and D organization involved in the project, and five members of the peasant association, including its local leader.

The identification of problems was carried out as follows: after a first discussion between the project leader and the chairman of the peasant association and other elected colleagues, a subcommittee of the peasant association composed of nine peasant leaders was established to continue the discussions. Several sessions of dialogue between them and the project leader were then used to define the problems constraining development as the peasants saw them in terms that scientists understood. In other words, the problems were documented as comprehended by the scientists in their definition by the peasants.

Using the scientists' conception of rural problems that constrain development modified to accommodate what was known of the peasants' conception of the problems, a questionnaire was prepared and distributed to all household heads. The categories of important problems that were identified through the questionnaire and the dialogue were essentially the same.

The identification of traditional solutions was accomplished through dialogue, as it was considered that a question of such a generalized nature is difficult to handle in a questionnaire.

The problems constraining rural development and their traditional solutions, as seen by the nine peasants of the subcommittee and as recorded by the project leader, were discussed informally with farmers and scientists. Finally they were discussed and assessed and their technological alternatives reviewed over an intensive 2-day meeting in which the participants were 18 farmers, one administrator from the district administration of the project area, and 29 scientists from the various R and D institutions of the country.

The final result was the identification of 18 major problems – with their traditional solutions and technological alternatives – which included soil erosion and fertility, swamps, forestry, animal pests, insect crop pests, weeds, plant and animal diseases, drinking water etc. For some problems it was found that the traditional technologies were adequate or only needed some upgrading by applying the re-

sources of modern science, and in others it was determined that new technologies were required.

An interesting example of the first case is soil erosion on steep slopes. The traditional solutions include planting vegetation on the hillsides as well as terracing the land and damming the gullies. Technologically these traditional solutions are sound and there is no need for alternative technologies. The causes for the lack of the wide use of these solutions lay in the lack of peasant organization, and the strengthening of the farmers associations should soon solve the problem. An example of the second case comes from forestry. Addis Ababa depends on *Eucaliptus globulus* for its energy for home consumption; for this reason, landowners during the pre-revolutionary period planted much of the red soil of the region with that tree. The farmers claim that *E. globulus* makes it impossible to grow crops in its vicinity, and even grazing grass is greatly impoverished. Vegetational and microbiological studies have corroborated this claim. As *E. globulus* is a new phenomenon in Ethiopia there are no traditional solutions, and therefore the solution has to come from the modern R and D system.

Finally, the procedure for the identification of technological problems that we have just outlined should be seen as a continuous process; the same interaction between peasants and scientists will continue during the next stage of design and implementation of the final technological solutions.

*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 is one required in any scientific research into a new area: to ask the very basic questions referring to 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 it is necessary to start by rejecting, as far as possible, any preconception or prejudice about the nature of the multiple needs (social, economic, psychosocial) it has to satisfy.

It seems obvious that this kind of question is always asked when a technology is being developed. The real point is that in the customary work of the R and D systems the answers seem to be generally obvious, for reasons already examined: the scientist is working with problems that belong to his own economic, social and cultural background so he has the tendency 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.

A typical example of the mistakes to which this approach can lead is posed by the housing problem. Technologists tend to believe that, given the precarious situation of the peasants, they will be content with any house that offers them a reasonable degree of climatic protection, and a minimum of modern sanitary conditions. The result is that in many cases, to the disappointment of the well-meaning technologists, the peasants prefer to live in their own poor dwellings rather than in the supposedly better new ones. The cause is that a house, besides giving climatic and sanitary protection, has several other roles to fulfil: social, economic, cultural and psychosocial.

An interesting illustration of the above was given to the author about 4 yr ago by a group of scientists of the Indian Institute of Science in Bangalore. A government-sponsored housing development project built a village in the area to resettle peasants living in nearby very poor dwellings. However, the peasants were unwilling to inhabit the new settlement, despite its evident superiority – from the point of view of climatic protection, sanitary conditions etc. – over their traditional houses.

A careful study of the situation showed that the seemingly irrational or 'conservative' attitude of the peasants was actually based on sound socio-economic grounds, as can be demonstrated by the two following findings:

(a) The new houses were built in parallel rows, to facilitate circulation, and wiring in case the electrical public network were to reach the village. In the old village the houses are built in clusters, around open spaces which are the locus of the social activity of the community. In this way the villagers, especially women, can talk and have social interchange with their neighbours, taking care at the same time of their domestic duties. The new spatial distribution of the houses disrupted the whole social life of the community.

(b) In the layout of the new village the animals used for labour – mostly oxen – were kept relatively far from the houses, on the assumption that people prefer not to have those beasts in their backyards. However, for a peasant Indian family those animals are among their most precious possessions, and

so they want to have them under their continuous care and surveillance. It is easy to see that a previous careful analysis – based on the identification of the 'problem situation' – of the functions that the new technology had to fulfil, would have avoided an expensive failure.

*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 one being developed. In some instances, it will be found that no idea worth being used is embodied in the traditional technologies.

An interesting example of a valuable idea contained in a traditional technology is given by 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 one of the important problems of the rural areas.

*Stage* 4

A general survey of the natural resources of the area should be carried out.

The most important concept to adhere to in this stage is that there is not such a 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. So 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 which will be the frame of reference for the final step to developing 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.

In finally building the technology, all possible solutions that fit the technological space should be considered. As is well known, 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.

It is obvious that 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 adaptation 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, it will probably be a problem 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 characteristics that the technology should have are determined. The *endogenous* is 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

1. V. V. Bhatt, *Development Problem, Strategy and Technology Choice: Sarovaya and Socialist Approaches in India* (World Bank, Development Economics Department, 1978), p. 3.

2. Charan Singh, *India Economic Policy: The Gandhian Blueprint* (New Delhi: Vikas, 1978), p. 53 (quoted by V. V. Bhatt, *op. cit*).

3. UNEP, *A Conceptual Framework for Environmentally Sound and Appropriate Technologies*, Report of the Expert Meeting held at Nairobi, 1–4 December 1975.

4. *ibid.*

5. Some of the best known of these lists are: UNEP, *Institutions and Individuals Active in Environmentally Sound and Appropriate Technologies* (Nairobi: May 1978); Canadian Hunger Foundation and Brace Research Institution, *A Handbook on Appropriate Technology, C4: Groups Involved in Appropriate Technology Development* (Ottawa: 1976); ILO *Technologies for Basic Needs, Institutions Dealing with Appropriate Technologies* (Geneva: 1978). Other organizations that have also published lists are: the Commonwealth Secretariat (UK); TRANET (Transnational Network for Appropriate Technologies, ISA); ITDG (Intermediate Technology Development Group Limited, London); and the National Science Foundation, USA.

6. See, for instance, A. K. Reddy, 'National, subregional and regional appropriate technology institutions, a preliminary assessement', Prepared for an *Expert Meeting on International Action for Appropriate Technology* (Geneva: December 1977); A. O. Herrera, 'Research and development systems in rural setting, background of the project', *United Nations University* (Tokyo: 1978), pp. 42–70; P. Cunnington, *Disadvantagement of the Poor Farmer in India Through Technology and Extension: The Need for Change* (Agricultural Extension and Rural Development Centre, Reading University, UK: 1976); E. M. Szekely, 'La generación de tecnologia para el desarrollo rural: principales corrientes en México', *Seminario sobre Tecnología y Desarrollo ENEP* (Cuautitlán, México: UNAM, 1977); D. Barking, 'Desarrollo regional y reorganización campesina. La Chontalpa como reflejo del gran problema agrario mexicano', *Comercio Exterior*, Vol. 27, No. 12 (México: 1977), p. 17; M. Howes, 'The uses of indigenous technical knowledge in development', *Workshop on Indigenous Technical Knowledge* (IDS, University of Sussex, April 1978).

7. See, for instance, A. K. Reddy, *op. cit.*

8. This methodology was developed by the author in 1974 at the Science Policy Research Unit, University of Sussex. It is now being applied in a research project being sponsored jointly by the United Nations University and the International Development Research Centre, Canada (IDRC). The author wishes to thank Drs. Purita Festin, Miguel Szekely, Taghi Farvar and Tewolde Egziabher for their useful criticisms and suggestions.

9. See among others, F. H. Cardoso and E. Faletto, *Dependencia y Desarrollo en América Latina* (México: Siglo XXI, 1971); C. Furtado, *Development and Underdevelopment* (Berkeley: University of California Press, 1964); O. Sunkel and E. Fuenzalida, 'The transnationalization of capitalism and national development' (IDS, University of Sussex, 1977).

10. A. W. Johnson, 'Individuality and experimentation in traditional agriculture', *Human Ecology*, Vol. 1, No. 2 (September 1972); C. B. Knight, *Economy and Change* (New York: Academic Press, 1974); M. Howes, 'The uses of indigenous technical knowledge in development', *Workshop on Indigenous Technical Knowledge* (IDS, University of Sussex, April 1978); R. L. Sampson, 'The motor pump: a case study of innovation and development', *Oxford Economic Papers*, Vol. 21, No. 1 (March 1969).

11. See, for instance, K. Ruddle and R. Chesterfield, 'Change perceived as man-made hazard in rural development', *Environment, Development and Change*, Vol. 7, No. 3 (1976); D. W. Norman, 'Rationalizing mixed cropping under indigenous conditions: the example of Northern Nigeria', *Samary Research Bulletin* 232 (Zaria, Nigeria: Institute for Agricultural Research, Samary, Ahmadu University); R. A. Rappaport, 'The flow of energy in an agricultural society', *Scientific American*, Vol. 225, No. 3 (1971); D. G. R. Belshaw, 'Taking indigenous technology seriously: the case of inter-cropping system in East Africa', *Workshop on the Uses of Indigenous Technical Knowledge*, (IDS, University of Sussex, April 1978); P. Richards, 'Community environmental knowledge in rural development', *Workshop on the Use of Indigenous Technical Knowledge* (IDS, University of Sussex, April 1978); M. U. Ghozurike, 'Ecological balance in tropical agriculture', *Geographical Review*, Vol. 61, No. 4 (1971); A. Fanitran and O. Areola, 'The concept of resources and resource utilization among local communities in Western State, Nigeria' *African Environment*, Vol. 2, No. 3 (1976); H. C. Conklin, 'Hanunoo agricultura: a report on an integral system of shifting cultivation in the Philippines', *FAO Forestry Development Paper*, No. 12 (Rome: 1957); D. Barker *et al.*, 'The utility of the Nigerian peasant farmer's knowledge in the monitoring of agricultural resources: a general report', Monitoring and Assessment Centre, Scientific Committee on Problems of the Environment, International Council of Scientific Unions, *MARC Report* No. 4 (1977).

12. R. Stavenhagen, 'Basic needs, peasants and the strategy for rural developments', *Another Development, Approaches and Strategies* (Uppsala, Sweden: Dag Hammarskjold Foundation, 1977), p. 43. See also among others: R. Traitler, 'People's participation in development', in *Structures of Captivity and Lines of Liberation* (Montreux: 1974); A. O. Herrera, 'Social determinants of science policy in Latin America' in Charles Cooper (ed.), *Science, Technology and Development* (London: Frank Cass, 1973), p. 25.

13. 'About the need for a new approach to the generation of technology for rural development', (México: Instituto de Estudios para el Desarrollo Rural, MAYA, A.C., 1977), p. 2.

14. See, for instance, P. J. Cunnington, *op. cit.*; M. Szekely, *op. cit.*; D. Barking, *op. cit.*

15. *Reporte sobre la Zona Henequenera* (México: MAYA, A.C., 1978).

16. Extracted from *Participation of a Rural Community in the Identification of Technological Problems*, Ethiopian Team, UNU R and D System in Rural Areas.