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SUSTAINABLE TECHNOLOGY TRANSFER:

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By

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ABSTRACT

SUSTAINABLE TECHNOLOGY TRANSFER: AN ANALYSIS BASED ON CASES

By

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There is a growing concern on how to improve living conditions of people in developing countries, the majority of whom live in rural areas. The issue could be addressed from the perspective of sustainable technology transfer.

In this study sustainability of technology transfer was evaluated using five major variables. These were: (1) participation by users in planning and/or implementation of the technology transfer process, (2) the type of mechanism used for transfer, (3) the form of management and control, (4) use of resources, and (5) benefits to users.

The study adopted an approach based on theoretical and empirical literature and three cases involving technology transfer. These were: agroforestry, rural education and health care in Nepal, Paraguay and Senegal respectively. Field work, undertaken by World Neighbors for Nepal, and the United States Agency for International Development (USAID) for Paraguay and Senegal, provided data that was primarily qualitative.

Analysis of the data, using an interdisciplinary approach, showed that sustainability of the technologies considered was positively related to all five variables, which

were interrelated and reenforce each other. Participation was the most crucial variable.

The study also found no significant differences in the achievement of sustainability among the three cases despite diversity in the type of technologies they involved and location of the countries.

Specifically, sustainable technology transfer was found to be a viable strategy for achieving increased agricultural production and related activities as well as improved access to rural education and health care which constitute important components of rural development.

The importance of further research including in terms of longitudinal quantitative analyses was underscored. Methodology for evaluating sustainability of technology, presented in this study, can be used as an input for such undertaking.

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CHAPTER I

INTRODUCTION AND REVIEW OF BACKGROUND LITERATURE

1.1 Conceptualizations of Development and Technology

Conceptualizations of development based on measures such as increase in Gross National Product (GNP), and industrial output have been found to be inadequate. This was due to recognition that development differs from growth in that, unlike the latter, it involves both economic and non-economic changes [Oberle et al., 1978; Bryant et al., 1982; Lewis, 1984; Korten et al., 1984; Guy, 1987; and Meier, 1989]. The following characterization of the major development problems by Korten et al. (1984) reflects the above distinction: "... three central development challenges: poverty, environmental deterioration, and the empowerment of people through increased participation in the development process" (P.ix). These problems are intimately related, and any effort aimed at dealing with one in isolation from the others is not likely to be effective.

A similar change can also be observed in the conceptualization of technology. Approaches that considered technology as being primarily equipment and the processes that use of such equipment involve were predominant. As a result the concept of technology was made synonymous with technique,

and its application limited to few activities. This was found to be unsatisfactory and led to a broader conceptualization of technology.

The goal of this study is to answer some of the questions raised on the gap between technology transfer and its use for long term problem solving in developing countries. It adopted an approach based on theoretical and empirical literature and three cases involving transfer of technologies. The underlying premise of this study is that conditions of people in developing countries could be improved through sustainable technology transfer.

1.2 Organization of the Study

The rest of this chapter provides a review of background literature in terms of the engineering/technical and adoption-diffusion approaches to technology transfer. The salient issues that arise under each approach including the critique are examined with particular emphasis on developing countries. For instance, the central role accorded to individuals as unit of nalysis, and communication as a predominant aspect in the adoption-diffusion approach are brought out. General examples of regional and national technology transfer models are also illustrated.

Chapter two focuses on sustainability both in general and with specific reference to technology transfer. A distinction between technology transfer per se and sustainable

technology transfer is made. Five variables, that impinge on sustainability of technology transfer, are also identified from the literature.

Data sources, selection method and criteria, operational definitions of variables used in this study, as well as the hypothesis, which is based on variables derived from the literature on sustainability and technology transfer, are presented in chapter three.

In chapter four, the three cases are described and analyzed to establish the relative importance of the variables and test the hypothesis.

Chapter five presents a general methodology for evaluating sustainability of technology including in terms of longitudinal quantitative analyses. The aim here is to chart out possible ways for pursuing further research in this area.

The final chapter is a synthesis of the major elements of the study. It includes summary and conclusions, limitations of the study, and some aspects for further research.

The appendices provide general background information on each case discussed along with related activities.

1.3 The Technical/Engineering Approach

This approach, sometimes presented by combining engineering and economic aspects, emphasizes the importance of factors that lead to high profitability at the lowest

possible cost. It assumes that technology is neutral in its consequences. In support of the approach Jones (1971), David Livingston Institute of Overseas Development Studies (1975), and Evenson et al. (1978), among others, argue that where capacity to generate technologies is limited or non-existent, those developed in other economic or physical environments will be suitable. That is, they maintain technology can be readily transferred and used irrespective of differences that may exist in the economic, social, cultural and other aspects.

If the above argument is accepted, technology transfer becomes a matter of merely obtaining what largely consists of hardware and putting it in place. Whether or not this is a tenable position will be demonstrated in subsequent discussion. The context under which the engineering approach was introduced will however, be examined first.

Industrial activities in general, and manufacturing ones in particular, have provided the primary venue for promoting this approach. In the case of developing countries, it is best represented by the period of the 1960s and 1970s, referred to in the literature as the decade of growth. Industrialization was guided by a strategy of import substitution advocated, among others, by Hirschman (1958 and 1968), and Prebisch (1959).

Hirschman (1968) based his arguments on linkage effects both forward and backward. The former relates to a situation in which "every activity that does not by its nature cater

exclusively to final demands will induce attempts to utilize its outputs in some new activities" and the latter indicates that "every non-primary economic activity will induce attempts to supply through domestic production the inputs needed in that activity" (p. 100). He emphasized that such linkages are likely to be achieved better in industry than other sectors, including the rural sector.

Prebisch focused on the terms of trade between manufactured and primary goods which he argued favored the former. To mitigate the concomitant deficit in the balance of payments, he emphasized the importance of expanding production of manufactured goods by adopting a strategy of import substitution.

It is worth noting that import substitution involves two phases. The first phase is one of producing consumer goods generally under substantial protection [Corden, 1961 and 1971; Johnson, 1964; Balassa, 1970, and Grubel et al., 1971]. The second phase could involve production for export and/or development of intermediate and capital goods sector. Approaches to measuring performance of import substitution industrialization and some of the problems are among others discussed by Chenery (1960 and 1971), Steuer et al. (1965), Power (1966), Winston (1967), Lewis (1969), Desai (1969), and Bruton (1965, 1968 and 1970).

Examination of the above literature indicates that, for a number of reasons, achievement of the first phase was not

as impressive as hoped by many. Nevertheless, it performed by far better than the second phase in several developing countries. That is, realization of the second phase was distinctly difficult.

The import substitution strategy has, therefore, been sharply criticized both from the vantage point of long- term development and its consequences on specific issues, notably employment. The general criticism is based on the fact that such a strategy is not consonant with prevailing realities in developing countries and, hence, detracts attention away from the prepondrent rural sector in terms of overall development strategy, priorities, and investment [Nagamine, 1981; Chambers, 1983; Korten et al., 1984; El Ghonemy, 1984; Cernea, 1985, and Brundtland, 1985]. In most developing countries, the rural sector makes substantial contribution to employment, gross domestic product and exports. Accordingly, its performance will affect the tempo of change in the overall system.

Limited gains, especially of long-term nature, led to shift in emphasis towards the rural sector [Johnston et al., 1974; Axinn, 1978; Mellor, 1976 and 1986]. Along with such a shift, it became clear that the debate focusing on whether to choose between rural development and industrialization was no longer central. Rather the issue became one of how to harmonize and integrate the various activities in both sectors.

Specific criticism pertaining to employment consequences of import substitution is put in the context of excessive reliance on the use of imported machinery. This was encouraged by government policy support that gave rise to capital-intensive techniques of production. The relatively limited size of the industrial-manufacturing sector in such countries, however, imposed constraint on expansion possibilities of import substitution. Studies by Morawetz (1974), Stewart (1974), and White (1978), indicate a sluggish rate of growth in employment relative to investment and output in the industrial-manufacturing sector and sub-sectors. This points to the fact that technology and employment issues are intimately related and cannot be treated in isolation from each other.

An example of an approach using a model of technological development relating to agriculture in the U.S.A. and Japan is given by Hayami and Ruttan (1970). It is briefly discussed here because of its implication for the type of technology that should be enhanced in developing countries. The model is guided by factor endowment and their relative prices. Using data for the period 1880-1960, the authors show that land scarcity in Japan necessitated development of biological and chemical technologies while shortage of labor in the U.S.A. called for mechanical technologies that are labor-saving.

The corollary of the Hayami and Ruttan model implies

that, where prevailing factor endowments are not taken into account, resource use will not reflect relative scarcities and opportunity costs of alternative courses of action. It can therefore, be inferred that labor-intensive technologies should be promoted in developing countries where substantial labor supply exists.

The same conclusion also follows from one of the basic tenets of economic theory. which stipulates that the technology being adopted should enhance the productivity of other factors that are relatively abundant in supply. While efficiency cannot form a sufficient criterion alone, it is necessary when considered in conjunction with others as Goodman (1976), notes:

> The choice of technology to be generated and diffused must be intimately related to priority development objectives, balanced income distribution and more efficient use of locally available materials, but at the same time the technology must be socially acceptable.(p. 4)

Others including Dunn (1979), Riedjk (1982), and Sands (1986) have argued along similar line. A specific alterative that recognizes limitations of the import substitution strategy, and policies that go with it, is the small enterprises approach. It emphasizes that the operation of such enterprises should be integrated with various relevant activities, both in terms of input and output, thereby enhancing their performance and that of others. There has

been increasing empirical evidence showing substantial employment and income opportunities derived from such enterprises in developing countries [Liedholm, 1984; Liedholm et al., 1985 and 1987]. The relative efficiency of these enterprises in the use of the scarce factor, capital, in such countries compared to their large-scale counterparts has also been established [Byerlee et. al., 1983].

In addition to its neglect of employment, socio-cultural, ecological and other similar aspects, the engineering approach treats technology as being synonymous with technique. There is a fundamental distinction between the two. Technique refers to physical aspects of an activity that relate largely to the hardware and its mode of operation, such as the extent of labor and capital intensity involved in a given process. On the other hand, technology is a body of knowledge that is applied to production of diverse goods and services and is more than technique and hardware [Stewart et al., 1982]. A number of writers including Root (1968), Merrill (1968), and Glaser et al. (1983) have envisaged that the application of technology encompasses various activities such as social and organizational other than industry. Given this conceptualization, the engineering approach's presentation of technology and the implication that technology transfer is only related to the modern sector, in general, and industrial-manufacturing activities, in particular, is too limited to be useful for development planning [Abel et al., 1981; Ruddle et

al., 1983; and Derman et al., 1984].

Another assumption of the engineering approach is that no local technologies exist. Anthropological and related literature Moyes (1979), Brokensha et al. (1980) Molnar et al. (1983), Chambers (1983) and Redclift (1987) show that this assumption does not hold. They maintain that local technologies always exist in various forms and serve several purposes. Moyes (1979), writing on the nature of such technologies, notes: "... local technology consists of an extensive body of skills, an enormous amount of information and a strong element of experimentation" (p. 9).

It is acknowledgement of the existence of such technology and the underlying framework --economic, social and others-- that calls for a need to attach great importance both to the type of mechanism and speed of transfer. As Glaser et al. (1983) note:

> Technology has deeper anthropological meaning. It is a key element in culture, it determines the relationship of a community with its natural environment and is the most concrete expression of values ...it is both unfeasible and socially counterproductive simply to pass a veneer of technology onto indigenous culture. Hence transfers of technology require a high sensitivity to match technical resources congenially not only with social goals, but also with infrastructure or cultural/social foundations. (p. 338)

Over emphasis on transfer of physical hardware by the engineering approach did not give due weight to mechanisms of

technology transfer and the implications thereof. This represents yet another shortcoming of the approach.

1.4 The Adoption-Diffusion Approach

The literature in this area presents technology transfer from different disciplinary perspectives, such as Economics, Sociology, and Anthropology among others, with underlying assumptions and factors deemed important to each [Katz et al., 1962; and Rogers, 1983]. It is almost exclusively related to the rural sector, in general, and agriculture, in particular, and reflects the prevailing dominant view of the sixties that research should address constraints to adoption believed to be cultural in nature. This was also a period of the Green Revolution, when packages of technologies, of which the seed-fertilizer -irrigation example is a well known one, were developed. Adoption of such technologies at the time was considered necessary in that it was perceived to lay the basis for transition towards modernization.

Technology transfer in this approach was considered to be a process involving links between supplier(s) of given type(s) of technology, on the one hand, with intermediaries facilitating the transfer and users of the technology, on the other. Five broad levels of transfer can be distinguished. These are: international, national, regional, group and individual each of which is discussed below. It should be noted that while there are examples of the other levels of

transfer, a substantial body of the literature focuses on the individual level as a basis of analysis.

International technology transfer can take place through various arrangements made with businesses, bilateral and multilateral agreements. They can be at macro level as well as in terms of specific programmes and projects [Root, 1968; Hayami and Ruttan, 1971; Swannacknunn, 1978; and Odle, 1979].

An example of national transfer of technology is given in Figure 1.1. It suggests that local research can be combined with foreign technologies and used to enhance the diffusion process in a given country. Existence of close linkages between local research and foreign technologies is assumed. Nelson (1974) and Ranis (1972, 1978) have also called for a similar approach to promote local research by providing incentives.

A framework for regional transfer, illustrated in Figure 1.2, is dependent on the policy and other measures adopted at the national level. Such measures require not only planning for various sectors of the economy but also articulating the specific targets so that internal consistency and overall balance are achieved. The policy framework also has to encourage both local technological innovation, as well as securing from abroad technologies those that are likely to be conducive in promoting the country's long term development objectives. Apart from difference in scope between the national and regional models, the list of tasks involved in

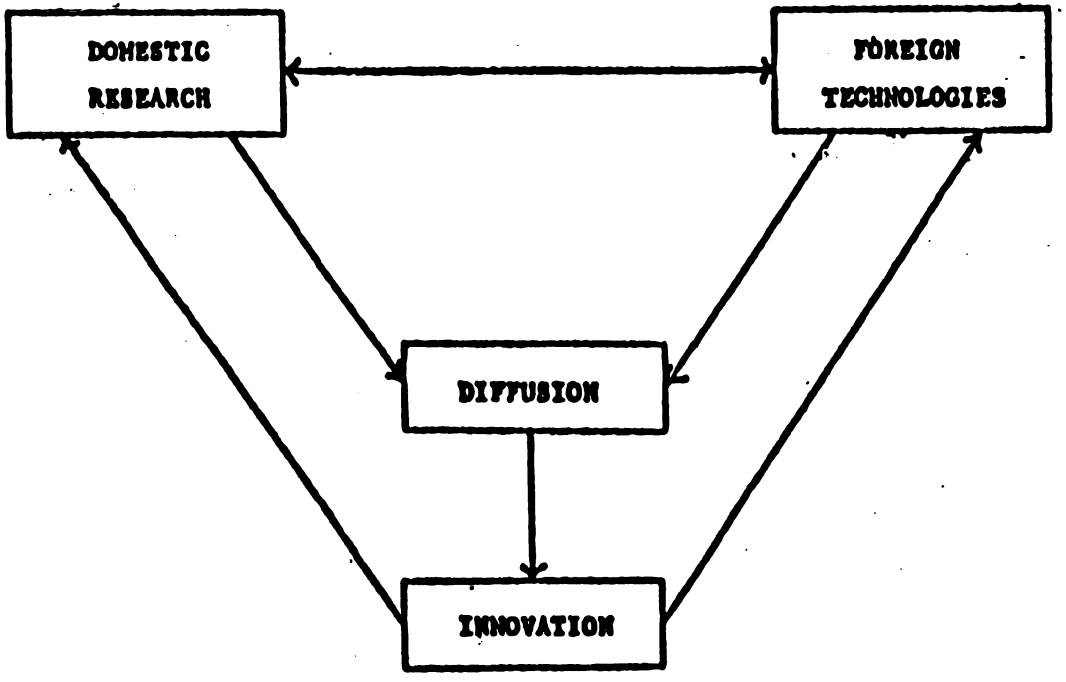

Figure 1.1 Illustration of Technology Transfer at a National Level.

Organization of American States-Inter-American Cultural Council, "Strategy for the Technological Development of Latin America," Part I, (Washington, D.C., 1969) 30.

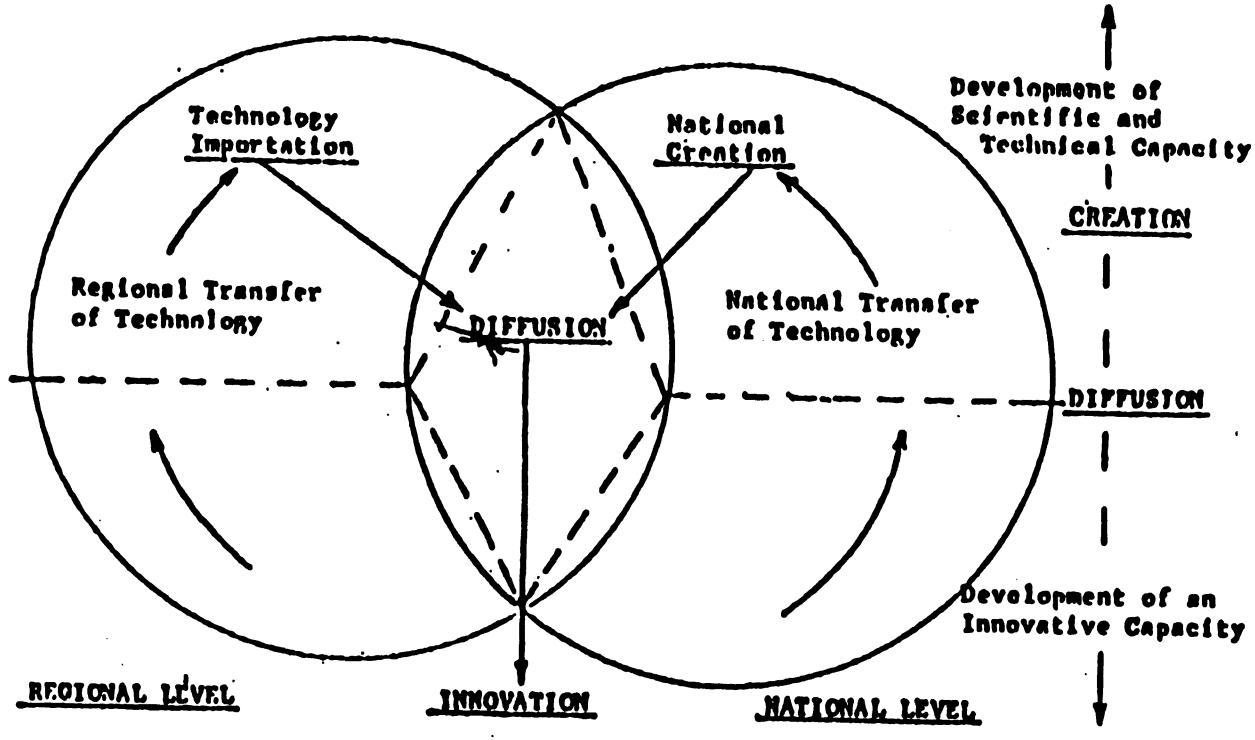

Figure 1.2 Illustration of Technology Transfer at a Regional Level.

Organization of American States-Inter-American Cultural Council, "Strategy for the Technological Development of Latin America," Part II, (Washington, D.C., 1969) 28.

both imply that coordination and communication are of paramount importance. This indicates that there is close linkage between the macro and micro levels and decision making should take such linkage into account.

The U.S.A. experience was among others, given by Wilkening (1958), Lionberger (1960), and Feller et al. (1984). Learner et al. (1967), Rogers et al. (1967), Baker (1987), Rivera et al. (1987), and Roling (1982, 1987 and 1988) provide similar account for developing countries. As will subsequently be shown coordination and especially communication, have also been central both to the group and individual adoption decision processes.

Rogers et al. (1971) provide a framework for group-level analysis shown in Figure 1.3, and define stimulation as:

> The sub-process in collective innovation decision-making at which someone becomes aware that a need exists for a certain innovation within a social system. The system or else is a system member who is oriented externally through social relationship with members of other systems. (p. 227)

Similarly, initiation is defined as:

> The sub-process in collective innovation decision-making by which the new idea receives increased attention by members of the social system and is further adapted to the needs of the system. Initiation may result from the activities of more than one individual.(p. 278)

and legitimation as:

> The sub-process in collective innovation decision making at which a collective

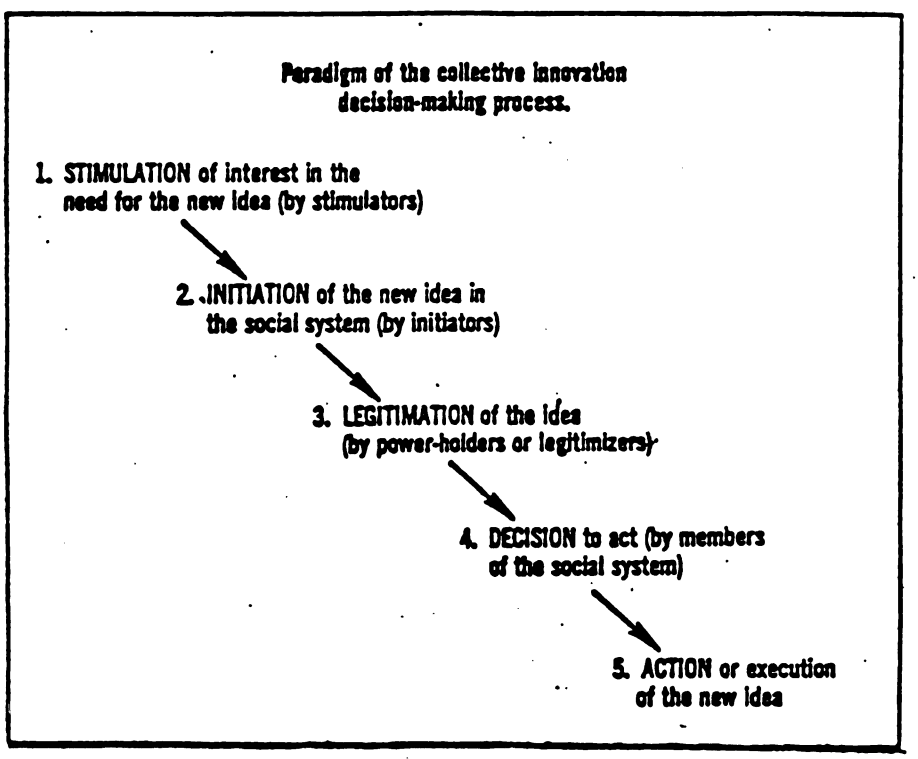

Figure 1.3 Paradigm of the Collective Innovation Decision Making Process.
Everett Rogers and Floyd Shoemaker, Communication of Innovations (New York: The Free Press, 1971) 276.

> innovation is approved or sanctioned by those who informally represent the social system in its norms and values and in the social power they possess... It may be possible for the initiators to proceed successfully without consulting the legitimizer in a social system.(p. 280)

A general presentation of the individual level analysis is given by Rogers et al. (1971) in Figure 1.4 and involves four stages. These are: knowledge, persuasion, decision, and confirmation. The first stage represents a phase of recognizing the existence of innovation and some understanding of its operation. The second and third stages involve formation of an attitude that will either lead to acceptance or rejection of the innovation. In the final stage, the individual has room to either solidify his acceptance decision or reverse it if new information indicates that acceptance is a wrong decision. Personality and socio-economic characteristics, as well as communication behavior, from the three major aspects that are considered central for adoption to take place.

Many early studies, a few examples of which will be discussed below, have specified several independent variables in relation to individual adoption, the dependent variable.

Fliegel (1967) and Hursch (1969) argued that adoption is dependent on the effort that a change agent makes in promoting innovation(s). Others including Rogers et al. (1969 and 1971) specifically maintained that it is the quality of the change

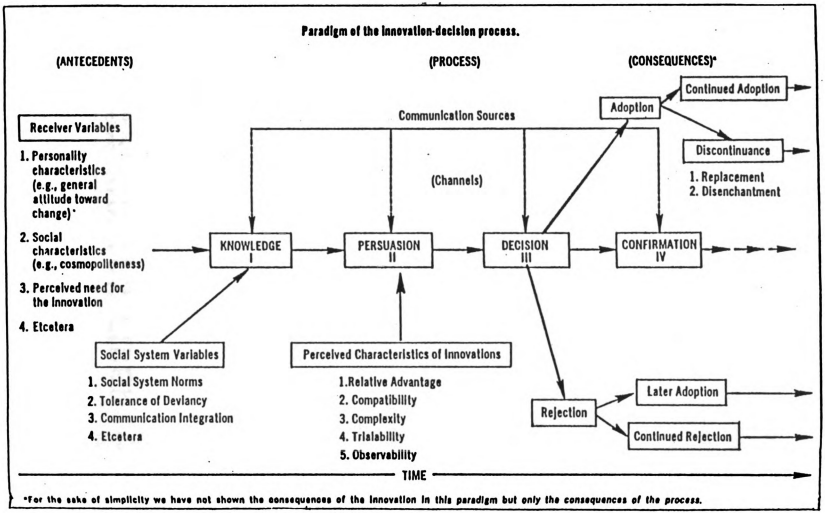

Figure 1.4 Paradigm of the Innovation - Decision Process.
Everett Rogers and Floyd Shoemaker, Communication of Innovations (New York: The Free Press, 1971) 102.

agent's link with individual adopters that is crucial in influencing their decision to adopt not merely the quantity of his effort. This was recognized to involve the overall attitude, and strategy of the change agent, including an understanding of the adopters' extant ways of doing things. According to Rogers et al. (1969):

> Essentially the agent serves as a communication linkage between clients and primary innovation source (this) relationship is characterized by reciprocity that each expects to exchange with the other. Communication is more effective when a higher degree of homophily is present. (pp. 193 and 194)

The above implies the need to enhance communication by non-coercive strategy to promote adoption.

Another commonly used independent variable is the degree to which individual adopters have access to, and are able to make use of services such as credit, marketing, and extension [Sprague, 1967; Gaud, 1968; and Jones, 1971].

The diffusion-adoption approach also accorded a central role to rationality and maximizing profits as the basis of individual decision making. Schultz (1964) has maintained that:

> Despite all that has been written to show that farmers in poor countries are subject to all manners of cultural restraints that make them unresponsive to normal economic incentives in accepting new agricultural factors, studies of observed lags in acceptance of particularly new agricultural factors show that these lags are explained satisfactorily by profitability. (p. 164)

Hopper (1965), Wharton (1966), Griliches (1969), Yotopoulos et al. (1976), and Schutjer et al. (1977) represent but a few of the writers in support of the above. Concepts of rationality and maximizing profits have however, been subject of intense debate both at theoretical and empirical levels. Among others, Lukes (1970), Horton et al. (1973), and Heiner (1983) have argued that rationality has to be perceived in relative rather than absolute sense. This means that it has to take into account the prevailing context, including diverse non-economic aspects and recognize the existence of risk and uncertainty.

For instance, there are various sources of risk and uncertainty in agriculture and related activities. They range from natural conditions, such as environmental, climatic variability (Welch, 1970; Gerhart, 1975) and fluctuations in earnings associated with them Just et al. (1983) to consequences arising from policies [Raske, 1977; Van Sant et al., 1985; Collins et al., 1986]. The latter can have effect in various forms including provision of infrastructural services or operating on production and pricing of inputs and outputs. The distinction between risk and uncertainty is a well known one of being able to assign a probabilistic weight to the former and unable to do so for the latter [Arrow et al., 1970; Sassone et al., 1978; and Hirsheifer, 1979].

Studies by Dillon et al. (1971), Canacian (1972), Gerhart (1975), and Roumasset (1976), among others, show that owing to consequences of the above factors, farmers tend to be risk-averse primarily to guard against their survival being threatened. Willingness to adopt is primarily dictated by prevailing circumstances. Omission of risk therefore, represents one of the major criticisms levelled against the maximization-approach.

Specifically, behavioral models were used to criticize the maximization approach and the assumptions on which they are based. Simon (1958, 1976, and 1979) particularly argued what obtains in practice is satisficing and not maximizing. This is due to bounded rationality indicated by limitations in resources including time and cognitive ability.

Gannon (1966) and Coughenour (1968) advance a broad criticism of the diffusion-adoption approach by pointing out that it does not recognize the complexities involved among various factors and interrelationships that exist between them.

Perrin et al. (1976), Andrew et al. (1982), and Ashby (1982) specifically argue the approach does not incorporate a number of important elements which Ashby (1982) summarizes as follows:

> ...diffusion research has been notably deficient in attention to the diverse physico-biological and social requirements of agricultural technologies and to variation in farming environments as

> factors in influencing peasant farmers' adoption behavior. One reason for this deficiency has been the assumption that new agricultural technologies were widely "adoptable" improvements on farmers' traditional technology. As a result, characteristics of different technologies have not been considered relevant data in explaining deference in adoption among farmers. (p. 235)

Being cognizant of such consequences there has for instance been increased emphasis on the farming systems research approach in which specific agro-climatic and related aspects are considered at the micro-level [Friedrich, 1986; Fresco et al., 1986; Flora et al., 1986; Axinn et al., 1987]. If this approach is applied, the technology developed and/or transferred is to be derived from field experience with farmers' participation, rather than from research centers without such experience. It also suggests that the agricultural extension system within which the change agent operates must not take a form of top down approach but rather a two-way learning process between the change agent and users of the technology [Rivera et al., 1987; Axinn 1988].

The modern/traditional dichotomy, which the diffusion approach makes, is misleading given the existence of diverse technologies in various countries that cannot be readily classified under the above categories.

Based on the assumption that institutional and other constraints are not significant, the role of incentives in individual adoption decision process was considered marginal.

This resulted in emphasizing the importance of communication in the diffusion-adoption approach [Roger et al. 1971]. Others, including Havens (1975), Schultz (1978), and Feder et al. (1985), underscored the need to deal with some of the constraints to adoption by using incentives. This implies that, if communication is to be an effective tool it is necessary to ensure that bottlenecks and distortions caused by various measures hindering adoption be minimized.

The discussion thus far shows that technology transfer being a multi-faceted process is not amenable to treatment merely in terms of engineering or communication issues by themselves. The case for considering it within the context of the total milieu has therefore become more broadly recognized.

CHAPTER II

SUSTAINABILITY

2.1 General Considerations

Sustainability is discussed in the literature at a general level as well as in terms of specific activities. The general approach has been used by Repetto (1986), Globlal Tomorrow Coalition (1987), and Gow (1988). Achievement of food-self-sufficiency, maintaining given environmental balance, curbing population growth, and transfer of technologies aimed at meeting users' needs provide examples of specific activities. Among others, works by Glaser et al. (1983), Douglas (1984), Edens et al. (1985), Dahlberg (1986), World commission on Environment and Development (1987), and Chambers (1988) pertain to one or more of these activities.

The essence of sustainability can be discerned from a broad definition given by Repetto (1986) which states that it is:

> ... a development strategy that manages all assets, natural resources, and human resources as well as financial and physical assets, for increasing long term wealth and well-being. Sustainable development, as a goal, rejects policies and practices that support current living standards by depleting the productive base, including natural resources. (p.15)

This indicates sustainability encompasses diverse

aspects that should be considered in addressing long term problems. Whether in terms of the general approach or its specific variants, sustainability implies capacity building which Fear et al. (1989) characterize as being:

> ... equivalent to the opportunity to enhance the sense of community in the locale... In the developmental sense, levels of community-ness vary with the extent to which people psychologically identify with the locale and aspire to strengthen its capacity to solve problems. (p. 79)

Not only does capacity building require mobilization of various inputs but also streamling their utilization. Planning, which has two phases, can play an important role in facilitating these tasks. The first phase of planning is one in which overall goals are laid out along with specific targets. The feasibility and internal consistency of such targets are usually worked out even if tentative, among others, taking into account resource requirements that can come in different forms -cash, in kind, as well as material inputs. The sources can be both local and external. Writing on this Fear et al. (1989) note:

> ... the concept of reliance on local resources and indigenous capacity is stressed again and again in community development literature. However, the notion of complementing these resources, when necessary, with outside resources and assistance is also emphasized. The developmental question that looms large is this: How is it possible to acquire, direct and control outside resources in ways that are consistent with local values and preferences? (pp. 77 and 78)

The total development effort typically has therefore, local and external components with the former coming from private and public bodies. The private component can be further considered in terms of individuals, communities, and organizations. Government support is usually extended through budgetary allocation earmarked from public funds. External input is generally phased out after a limited period of time. The critical question for sustainability is whether or not the overall effort and activities based on it can be durable especially when the external input is no longer available.

Implementation represents the second phase of planning in which stipulated targets are operationalized. Based on observations during this phase, feedbacks may be used to modify the initial targets thereby making the operation flexible.

A distinguishing feature of planning from the perspective of sustainability is the role played by those affected by various decisions. This marks a significant departure from earlier practice of planning in which participation from below was nominal [Gran, 1983; Conyers et al., 1984; Korten et al., 1984; Cernea, 1987; Chambers, 1986 and 1988; and Gow 1988].

The ultimate goal of participation is to promote empowerment of people to make them fully contribute to the development process since, "... development involves personal

transformations that can take place, only if individuals themselves are intimately part of the process- that is, if they shape it and are transformed by it." [White, 1987, p. 160].

Sustainability also requires that the planning process be comprehensive in scope given that decisions concerning various issues have inter-temporal and inter-generational implications [Hartwick et al., 1986; and Randall, 1987]. It should however, be noted that there are a number of problems that can be encountered in attempting to accommodate diverse and in some cases conflicting issues. The concept of trade off, based on the principle of opportunity cost, should be used to reconcile possible conflicts.

Within the above framework, sustainability can be further discussed by considering specific issues. Foremost among them are benefits -potential or actual- that accrue to people and accordingly affect the extent of their participation. Concern here is not only with existence of benefits but also continuty in their flow [Honadle et al., 1985; and Salmen, 1987].

The notion of benefits should be perceived broadly, and in social rather than private terms. This follows from the foregoing discussion of sustainability. Costs should also be treated alike and in conjunction with benefits to ensure that they are not excessive relative to the latter. Studies by Honadle et al. (1983) and Morss et al. (1985) show that the

absence of empowerment based on participation by users has resulted in many projects not showing any long term benefits.

Promoting both participation and continuous flow of benefits will require the existence of a decentralized system of operation. The degree of such decentralization can vary ranging from a regional to a local village/community level. In the context of sustainability, decentralization is not based on physical considerations such as a watershed but rather on people and how to assist them in addressing problems they are faced with. Chamber's (1988) observation is pertinent in this regard:

> ... sustainable resource exploitation, environmental conservation, and rural development are best served ... by starting with people - the very poor and the poor ... they are best served by secure and adequate livelihoods which allow and encourage them to take the long view in their use of resources and to maintain and improve their position. (p. 25)

Works by Bryant et al. (1984), Gow et al. (1985), and Uphoff (1986) among others, corroborate the importance of institution building and decentralization for promoting sustainability.

2.2 Sustainable Technology Transfer

Technology transfer has been discussed in various contexts, both at the micro and macro levels. It represents a process by which technologies already in existence are made

available to new users from outside or within a country. The technology is not new, since it has been used by others for some time. On the other hand, the concept of technology development involves creating new technology for the first time [Valdes et al., 1979; CIMMYT, 1980; Cooper, 1980; Dahlman et al., 1985; and Hyman, 1987].

A distinction between technology transfer which takes sustainability as a primary goal and one that is not concerned with it is an important one. Accordingly, in the case of the former technology transfer is a means to promote the goals of development and is not an end in itself. On the other hand, the objective of the latter is to make a particular technology operational with the aim of deriving the highest possible level of financial return. It is characterized by a centralized system of management and control [Axinn, 1972 and 1978; Feller et al., 1984; and FAO, 1985].

The above distinction can be illustrated by specifically focusing on literature pertaining to the three activities namely -- agroforestry, rural education and health care analyzed in chapter IV. Gregersen et al. (1987) writing on the case for agroforestry note:

> ... deforestation and poor land use... are repeated in all regions of the Third World. ...forestry widely integrated into land use improvement programs can reduce the severity of theses problems and actually solve them in some cases (p.8).

This indicates agroforestry can form the basis for achieving goals such as reduced soil erosion that have implication for long term development [Brundtland, 1985; Easter et al., 1986; and Davis et al., 1987].

In education there are three key issues of accessibility, financing, and relevance. A number of specific aspects including equity revolve around these. Given that an educational system is closely tied to organization and operation of existing institutions at national, regional and local levels, any educational reform should take into account the overall structure within which it is to be implemented. In the case of developing countries, where a large proportion of the population is found in the rural sector, the importance of educational reforms geared to develop skills relevant to this sector has been emphasized. Among others, this calls for redressing existing inequities, regarding access to educational services, between urban centres and rural areas [Axinn, 1972 and 1978; Coombs et al., 1973; Foster et al., 1973; Psacharopoulos, 1973; and UNESCO, 1984].

Health care has also been discussed in terms of various issues. Chambers (1979) argues that seasonal change has an important effect on health particularly in developing countries where facilities to deal with the problem are very limited. Bader (1979) among others, maintains that technology transfer in the health sector of such countries

has favored capital-intensive investments in large facilities, such as hospitals and laboratories. Only a very small proportion of people in many developing countries can have access to such facilities. This is due to distance and the poor system of transport, as well as inability to afford the relatively high cost of getting services notably by those living in the rural areas.

Khuner (1971), Griffith et al. (1971), Johnston (1977), Schultz et al. (1979), and Rifkin (1980) argue that the prevalence of disease, in general, and communicable ones, in particular, are impediments for development. To alleviate the problem Rich (1973) and Krishnan (1975), among others, have emphasized the need to promote technologies that can assist in meeting the health needs of the large proportion of the people. This requires examining whether or not the service is affordable to users and hence viable over the long-term. The issues of viability points to a need for users'participation in some aspects of its operation, such as covering part of the expenses to secure medical supplies, payment for community health workers, construction and maintenance of health facilities [Newel, 1975; Djukonovic et al., 1975; and De Ferranti, 1985].

Five variables emerge from the foregoing discussion of the literature on sustainability and technology transfer.

1) participation in planning and/or implementation of the technology transfer process by users forms the basis for

their empowerment. 2) Knowledge about the type of mechanism involved in the process of technology transfer represents one way by which to judge the extent of such empowerment. 3) The degree of decentralization in management and control by users of the technology has a number of ramifications for sustainability and represents another variable. 4) understanding effect(s) of technology transfer on utilization of various types of resources is essential when durability is a prime concern as is the case with sustainability. 5) Benefits to users -direct and indirect- represent specific indication of pay off that result from transfer of a particular technology.

The above closely related variables, operational definitions of which are given in chapter III, are used in this study to assess sustainability of technology.

CHAPTER III

DEFINITION OF VARIABLES, DATA SOURCES, AND HYPOTHESIS

3.1 Definitions of Variables

This study adopted an approach based on theoretical and empirical literature and three cases from developing countries involving technology transfer.

Review of literature was important in laying general framework for conceptualization of various key issues such as development, technology and technology transfer. Among other things, it clarified the need for a study on sustainable technology transfer given that achievements of past technology transfer efforts, in the developmental sense, were very limited.

Before discussing the rationale for selection of the three cases that provide sources of data and presenting the hypothesis, operational definitions of technology, technology transfer and variables used in this study are given. Glaser et al. (1983) define technology as:

> ...more than technique, that is more than science and engineering. It encompasses the totality of specialized means including those of management, administration and public policy, used to develop goods or services for human sustenance and comfort. (p. 338)

Adopting the above broad definition, technology in this study represents means employed to alleviate long term problem(s) faced by users in diverse activities.

Technology transfer in this study denotes a process by which technology from within or outside a country is made available to a community in a particular location. It is undertaken to fulfill developmental goals.

Participation, the first variable, reflects the role of users in planning and/or implementation of the technology transfer process. It is identified in this study in terms of staffing, cash and contributions in-kind from local areas. When all three forms of inputs are present, participation is considered high.

In Chapter II, a transfer mechanism involving intermediaries closely tied only to source(s) of the technology. This reflects one-way communication and the absence of participation by users and defined as a delivery system. In contrast, an acquisition system involves two-way communication based on users' needs. These features are used to identify the type of transfer mechanism, the second variable, of this study.

A third variable is decentralization in management and control. Decentralization represents the extent to which users are involved in management and control over operation of a technology. Cost-sharing and management by users at the local level are two indicators used in this study. They

reflect users' willingness to bear some of the financial, as well as non-financial responsibilities that the technology transfer may bring with it. When the presence of both is observed, decentralization is considered to be high while their absence shows lack of it.

Use of resources, the fourth variable, is identified by the extent to which the technology transfer process promotes greater utilization of abundant resources relative to scarce ones. For developing countries the former is made up of readily available resources such as labor and other material inputs while the latter represents those that are not.

Benefit(s) both direct and indirect to users represents the fifth variable. In this study direct benefits are identified by increased fodder production, access to education and health care services as a result of introducing agricultural, educational, and medical technologies respectively. Indirect benefits are those achieved due to linkage effects.

3.2 Data Sources

Over forty cases were examined as possible sources of data for this study. Using primarily, but not exclusively, study variables derived from review of the literature, as much data as could be obtained was gleaned from each and recorded. The data was largely qualitative. Three cases were ultimately selected. These were: agroforestry project

in Nepal[1], rural education development project in Paraguay[2] and primary health care project in Senegal[3]. There were a number of considerations in selecting the cases. First, they provided relatively more data. Given that technology transfer spans diverse activities, it was also important that such diversity be reflected in selecting the cases. Accordingly, the cases were mixed both in terms of region with one case each from Asia, Latin America and Africa as well as the type of technologies- agricultural, educational and medical. In addition, all three cases involve basic needs related activities, that have long term positive implications for developing countries. Selection of the cases was therefore, based on general as well as specific issues that relate to practical rather than theoretical considerations.

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[1] Tom Arens and Gopal Nakarmi, World Neighbors, South Asia Regional Office, "Baudha-Bahunipati Family Welfare Project: Its Income-Generation Activities with particular Reference to Agroforesry," A paper for presentation to the International Institute for Environment and Development's Conference on Sustainable Development, London, April 20-30, 1987.

[2] Ronald Nicholson, Henry L. Miles, Diane N. Johnson and Judith M. Titus, "US Aid to Education in Paraguay: The Rural Education Development Project," AID Project Impact Evaluation Report, No. 46, US AID June 1983.

[3] Abby L. Bloom, "Prospects for Primary Health Care in Africa: Another Look at the Sine Saloum Rural Health Project in Senegal," AID Evaluation Special Study, No. 20 US AID, April 1984.

Although details of the three cases are given in chapters IV and the Appendices, some of their major features are discussed here. Field work for the agroforestry project in Nepal was undertaken by staff of World Neighbors. This organization was one of the major sources providing financial and technical assistance for the project.

The original project focused on family planning, and agroforestry was only one component. As time went on, it became apparent that there were a number of specific and interrelated problems other than family planning. Baseline surveys were conducted to identify the nature and scope of such problems. The singling out of fodder as being a central problem led to data collection on the introduction, trial, and adoption of a new fodder tree called Ipil-Ipil.

Data collection for Paraguay involved a team that had a working knowledge of Spanish, was familiar with the project areas, and the country's school system. The team also used, the input of experts for making sociological studies in designing the questionnaires that formed the basis for field interviews. Teachers, directors, supervisors, regional education center personnel, students, parents, and Ministry of Education staff involved in various departments were covered by these interviews. Access to education, construction, and maintenance of educational facilities, relevance of curriculum, teaching material development and teacher training were the major issues addressed. The

interviews were supplemented by observations, including visits to schools and review of documents. Decentralized educational reform was aimed at redressing inequities between urban and rural areas as well as making education more relevant.

Phase one of the rural health project in Senegal was faced with a number of problems notably financial viability. Based on evaluation of the first phase by the USAID (1980) and the government of Senegal, the project was restructured and implemented.

3.3 Hypothesis

Based on theoretical constructs, empirical evidence, operational definitions of concepts and variables provided above as well as, the three cases to be analyzed in Chapter IV, this study is aimed at testing the hypothesis that technology transfer is sustainable when there is:

- participation by users in planning and/or implementation of the technology transfer process;
- acquisition type of technology transfer;
- greater use of the relatively abundant resources;
- decentralized management and control; and
- Benefits to users.

Given that sustainability is multidimensional,

involving not only the economic, social, and cultural aspects but also others such as physical and biological, an interdisciplinary approach to analysis is envisaged in this study. The variables also reflect this interdisciplinary feature as they represent elements from various disciplines.

Transfer of technologies in the three cases were each examined using the five variables and the results provide basis for assessing sustainability.

Methodology for evaluating sustainability of technology given in chapter V could be used for making analyses including longitudinal quantitative ones if the necessary data become available.

CHAPTER IV[1]

DESCRIPTION AND ANALYSES OF CASES

4.1 Agroforestry Project - Nepal

The Baudha-Bahunepati project which initially focused on family planning shifted its emphasis to agroforestry that was accompanied by introduction and dissemination of a technology.

The three major ecological zones of Nepal and the features associated with them are given in Appendix A. It will suffice here to provide some background on the type of land and related activities summarized by Arens et al. (1987):

> Generally in Nepal, wet land terraces are cleared of all trees and grass to maximize production of rice and wheat. Since this land is considered prime land, there are objections to planting trees and grass on wet land terrace faces... small, marginal farmers are generally the primary users of forest lands ...

The Majhi of the Bahunepati community, who first had access to the agroforestry based technology were, an example of small farmers indicated above. Implications of continued reliance on existing practice was recognized in that increased cultivation of forest land led to reduction in the amount of fodder available and, hence, decline in the number of animals possessed by farmers that provide manure and supplementary

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[1] This chapter draws significantly from [Arens et al., 1987; Nicholson et al., 1983; and Bloom, 1984].

source of income. Less manure availability for input in farms meant reduced level of agricultural production, while declining sale of livestock further lowered the already low incomes. These interrelated problems revolved around fodder and according to Arens et al. (1987):

> What was needed was a majic species which grew on terrace faces (roughly 25% of the country's cultivated land is unused terrace face), which could be cut to prevent shading, deep rooted to prevent competition with crops for moisture and nutrients, and multipurposed to provide fodder, green manure and fuelwood (p. 7).

To deal with the foregoing problems Arens et al. (1987) add the following goals, were envisaged:

- To increase agricultural productivity and family income of small farmers in particular.
- To increase community participation in program design, implementation, and sustaining management.
- To integrate project activities with other agencies and HMG for effective of available resources.
- To demonstrate the project's cost effectiveness... (pp. 3 and 4).

It can, therefore, be observed that efforts aimed at improving the community's well-being encompassed income-generating activities, rather than exclusively focusing on family planning. Specifically, since people in the area derive their livelihood from agriculture and related activities, promoting this sector's development was considered essential. Agroforestry was used to achieve this task.

An understanding of agroforestry as used in this study is given by Gregersen et al. (1987):

> Agroforestry has been defined in numerous ways. Simply stated, it is an agricultural technology that incorporates trees into annual and perennial cropping systems. The overall intent of agroforestry systems is to promote positive interactions among trees and crops to obtain better crop yields and sustain production using the limited resources available on a small farm. ...agroforestry has also become a viable option for LDC small farmers who need to improve and to sustain production without using high input technologies.(p. 31)

Before considering the specific technology involved in this project and its consequences, the role of various participants both external and domestic will be discussed. External assistance was provided by World Neighbors and Oxfam, in the form of financial and technical input for planning. By 1987 support by World Neighbors covered nineteen of the forty-four administrative areas in four districts [Arens, 1983, p. 3].

Local communities, played important roles in various aspects of the project's operation notably by donating land, participating in research, trial, demonstrations, and cost sharing in training, as well as extension of the technology. The government also provided some assistance for research and training. Planning from below characterized the project's program approach, with decentralization and flexibility forming the basis of its operation.

The particular technology was aimed at handling the major problem of chronic fodder shortage used to feed buffaloes. Arens et al. (1987) outline how introduction of a new fodder tree began:

> In 1977, a few Ipil-Ipil (Leucaena leucocephla) seeds of peruvian and giant varieties were obtained from the Philippines and sown in plastic bags. Innoculent came from soil around a tree planted some years before. ... the giant varieties out performed the peruvian strain in fodder yields. Seeds were collected from these trees and ... a small nursery was started in 1978 to produce seedlings for distribution to farmers... (p.8)

Writing on features that made Ipil-Ipil attractive over other varieties including local ones, Arens et al. note:

> The trees were prolific fodder producers and could be cut every 2 to 4 weeks during the monsoon, unlike most local trees that are cut seasonally, once a year. Ipil was well suited because it coppiced well and could be lopped low to the ground and cut regurarly. It is a vertical rooter and roots do not compete with crops. (pp. 9 and 10)

It can be discerned from the above that the new variety was suitable interms of physical-biological aspects as well as in its ability to address the basic problem the community was faced with.

The question that arises from the foregoing is the extent to which the new fodder tree has been grown by farmers in the project area and possibilities for disseminating it to other areas. Initial on farm trials involved a few selected farmers

to assess the suitability of the new variety using a nursery. The seedling showed eighty percent survival rate [Arens et al. 1987, p. 9]. This led to devising an extension scheme based on home nurseries primarily involving users both within and outside the project areas. Arens et al. (1987) write:

> Starting in 1980, "field days" were organized. Farmers in the same community, and those from other panchayats and districts were given a tour of farmer demonstrators ... and involved in field level discussions and sharing with Bahunipati farmers. ...farmers were followed up at least once a month to ensure they were successful and all the steps and practieces were being followed, from transplanting, spacing, manussing, weeding, protection, lopping, feeding practices etc. (p. 10)

Data by Arens et al. (1987) show that the impact of the new fodder tree among farmers, both in the project, and other areas was substantial. During 1978-1986, eighty-eight percent of households in the Majhi village planted the tree [p.12]. Outside the project area, Ipil-Ipil training and demonstration has reached twenty-three administrative areas. Community fodder nurseries, organized by local farmers, were developed in two other areas by 1986 [p. 17].

Owing to increased availability of fodder, veterinary facilities and the resulting animal upgrading, the number of livestock in the project area increased by forty percent, and earnings from its yearly sale rose by eighty-two percent between 1983 and 1986 [Arens et al., 1987, p. 5].

There were also other benefits due to the project. One

of them was increased community effort to avoid negative effects of environmental degradation. An illustration of this was: "Terraces have been stabilized by extensive planting of Ipil.. and soil erosion reduced" [Arens et al. 1987, p. 13]. Use of fuelwood from the Ipil_Ipil tree also meant that the high demand on forest resources and, hence, the extent of deforestation was reduced.

Arens et al. (1987) also note that "...planting and management practices were meshed with the farmers' cropping and labor practices" (p.9). This was an important factor in the transfer of the technology because users' participation accorded them a concrete opportunity to assess its potential benefits on the basis of which they decided to accept it.

An important indirect result in relation to family planning should be noted. With relative improvement in income and related benefits, family planning acceptance among villagers had risen by twenty-one percent between 1977 and 1986 [Arens et al., 1987, p.6]. This trend of family planning acceptance being preceded by economic and related changes was consistent with historical experience [Leibnstein, 1974; Perlman, 1981; and World Development Report, 1982].

Arens et al. (1987) further note:

> A national training program for 15 NGOs (under the auspices of the Social Services National Coordination Council) was conducted in Bahunipati's Majhi village in 1986 to assist other NGOs replicate and build on the "user group" concept successful in Bahunipati (p.8).

The above shows that the project also had broader impact in that it demonstrated the existence of common geeneral issues on the basis of which development can be promoted despite defferences in local circumstances.

Description and analysis of the project, based on the evidence presented, showed that participation was the major driving force. Specifically, it encompassed local farmers, including women, in all phases of its operation ranging from research about the technology to training and extension. Participation involved users both in planning and implementation of the project.

The mechanism of technology transfer was of the acquisition system type in this case. It is supported by the fact that demand for introducing the technology was derived from needs of users, based on studies in which problems of the community were clearly established.

There were a number of factors that accounted for achievement of decentralization in management and control. The whole process of experimenting with the new fodder tree evolved in the local areas, where the gravity of the fodder problem had been felt. Decentralized program management, use of staff from the local area, and regular follow-up facilitated adoption of the technology by farmers both in the project area and beyond.

Transfer of the technology also led to more use of relatively abundant resources in diverse forms such as, human

and material inputs.

Alleviation of fodder shortage was the major and foremost benefit realized by the community. Not only did it become available, but also on a continuous basis because the technology introduced made a year round harvest possible. Table 4.1 summarizes major features of the technology transfer in terms of concepts and variables of the study. Illustrations of community development activities that emerged as a result of extending the technology are discussed in Appendix A.

Since all five variables of this study are supported by analysis of the evidence, the agricultural technology involved was sustainable.

Table 4.1

Application of Concepts and Variables: Agroforestry Project - Nepal

Type of Technology Involved	Scope of the Project
Agricultural	District Level
specifically introduction of new fodder tree	covering forty eight administrative areas each with population of between 2000 and 9000 in five districts.

Indicators of Participation by Users
Local community participation in program design implementation, management and evaluation.
Farmers provided various types of local inputs for research, trial, training and extension of the new fodder tree.
Project staff were mostly from the local area.

Table 4.1 cont'd.

Type of Mechanism used for Transfer	
Acquisition	- Based on local initiatives.
Management and Control	
Decentralized with regular follow-up.	
Use of Resources	
Human	About 90 percent of extension staff was from the local areas. Farm families were used, among others, for planting seeds, and trial of fodder tree.
Material and Financial	Contributions- cost sharing by communities for various activities such as research training and extension.

Table 4.1 cont'd.

Benefits
The technology was adaptable to individual farm family condition and had social acceptability among farmers.
Empowerment of local people due to transfer and use of the technology.
Increased --- -fodder production -availability of manure for fertilizing fields -crop production -income from sale of animals -acceptance of family planning
Reduced forest depletion due to use of leaves from the new fodder tree as source of fuel.
Training of local personnel including farmers in various activities.
Coordination of project activities with government livestock, fodder and reforestation programs in the area.
The project demonstrated the importance of participatory approach and stimulated other related activities.

Source: Compiled from Arens et al., (1987).

4.2 Rural Education Development Project - Paraguay

The Rural Education Development Project in Paraguay was pursued within a framework of the country's development strategy. Nicholson et al. (1983), provide the following background:

> ... education and the overall development process within Paraguay began to evidence a new dynamism. ... a new approach to regional development stressed rural (areas) supported by integrated infrastructure investments. (Appendix B, p. B-1)

The above strategy had two major features. The first was emphasis on the rural sector, from which the majority of the country's population derives its livelihood. Use of a regional approach in setting educational program priorities represented the second feature. Figure 4.1 provides a map of Paraguay with some of the locations covered by the program.

In adopting region as a frame of reference, it is necessary to clarify the basis for it. One approach is based on use of physical factors such as a watershed, [Perloff et al. 1960] while another starts with people in a particular area and problems that they are faced with as key considerations [Nagamine, 1981]. It is in the latter category that the Rural Education Development Project in Paraguay, the particular problems of which are identified by Nicholson et al. (1983) below, falls:

> In 1970 Paraguay's education sector was characterized by inefficiency and inequitable access. ...the curriculum had become irrelevant. ...the facilities had

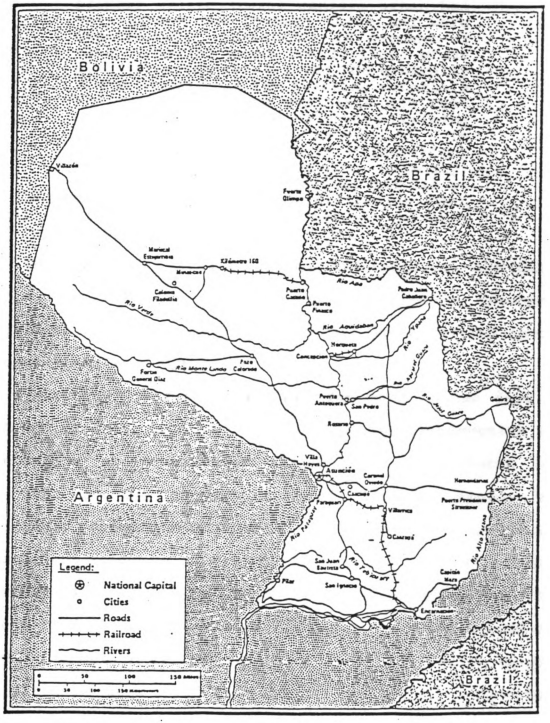

Figure 4.1 Map of Paraguay with Location of Regional Education Centres from Ronald Nicholson et al., (Washington, D.C., 1983) xi.

> become inadequate. ...only 20 percent of rural primary schools offered all six primary grades (rural schools often had only grades one through three and were overcrowded). Less than 18 percent of those entering grade one finished grade six (retention rate). The MOE generally acknowledged that few teaching materials and text books were available and that teachers had received inadequate training in the use of these materials. In addition, the MOE (Ministry of Education) had an inadequate planning capacity, received insufficient funding and had an overly centralized administration that did not respond to local needs. (Appendix B, pp. B-2 and B-3)

The problems revolve around implementing curriculum reform, provision of various inputs including teachers, facilities and other supplies, within a decentralized system of operation [Appendix B].

Community contributions that came both in the form of cash and in-kind, such as land and labor for construction and maintenance of educational facilities constituted one component of the domestic input. Another source was government support represented by Ministry of Education allocations amounting to $1.8 million during 1970-1976. USAID provided $4.2 million in loan and $300,000 in grants over the same period [Nicholson et al., 1983, p.5]. It emphasized the need to adopt a systems approach that integrated various activities, such as curriculum, textbook production, financing, administration and construction of schools to assist smooth implementation.

The USAID loan was used for building the following:

1. Two new Regional Educational Centers (RECs) and upgrading of one existing school complex to RECs status. Once completed, a network of seven RECs would reach 10,700 students and indirectly affect 140,000 additional students ... about one third of the student population in Paraguay.
2. A Superior Institute of Education (SIE) planned to provide improved secondary school teacher preparation.
3. One hundred twenty primary schools (grades one to six) to increase access and equity, especially for students from low-income families living in communities with the largest classroom deficits.
4. Four hundred eighty thousand copies of 19 books for grades four, five and six for rural areas [Nicholson et al., 1983, p. 5].

Establishment of Regional Education Centers, and The Superior Institute of Education were important in carrying out tasks envisaged by the educational reform. Activities of the Centers ranged from preschool to secondary and vocational education that imparted practical skills. Nicholson et al. (1983) specifically write that:

> They have a Corps of teaching, administrative and support personnel within each local unit. They use the new curricula in their schools and teacher training programs. They have become effective decentralized units of administration as well, with responsibility for teachers' salaries,

> construction, and budget allocations.(p. ix)

Table 4.2 provides data on enrollment in Regional Education Centers by level of education. It shows that Villarrica had increased enrollment for all three levels[1] while for the other three centers the increases did not include the primary level. This may be due to differences in priorities among the Centers, in general, and Villarrica's, command over relatively more resources than the others in particular. Enrollment in such Centers should be interpreted within the context that, in general, "...their primary role is to provide educational leadership; and community development in the ... areas where they are located" [Nicholson et al., 1983, p. 5]. Accordingly, enrollment data is but one of several indicators of their role.

The Superior Institute of Education was established to orient the system towards general education. Measures used to achieve this include teacher training and teaching material development. Enrollment by course at the Institute is summarized in Table 4.3 It shows that consistent with establishment of the Institute's goal, enrollment in specialized education declined significantly. In contrast, increased enrollment in teacher training reflects movement

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[1] Nicholson et al. (1983) indicate that primary schooling runs up to grade six while the basic level represents grades seven to nine. Practical-vocational oriented training such as humanities and commercial studies are offered at grades ten, eleven and twelve.

Table 4.2

Enrollment at Regional Education Centers

Regional Education Center	Primary		Basic		Humanities	
	1975	1979	1975	1979	1975	1979
San Lorenzo	712	570	360	428	233	397
Encarnacion	1053	939	694	648	325	559
Villarrica	672	716	329	350	187	213
Concepcion	765	674	611	702	324	438

Source: Ronald Nicholson et al. (1983): F-5.

Table 4.3

Superior Institute of Education, Enrollment by Course, 1970 and 1975.

	1970	1975
Teacher Training	120	276
Primary	-	140
Secondary	120	136
Specialization	84	12
Teacher Improvement	-	1307

Source: Ronald Nicholson et al. (1983): F-6.

towards general education.

There are a number of other positive impacts that have resulted from implementation of the project. Central to all of such impacts discussed below is change in curriculum at various levels of the educational system. Nicholas et al. (1983), note four steps that such change involved:

> First, before a school can initiate the curricula, teachers and directors must have at least 2 1/2 months of ... training in theory and practice.
> The second component requires a parent orientation program ... to introduce new concepts, strategies and programs.
> The third component requires a more comprehensive assessment of students;
> Fourth, curriculum technicians integrate new text book materials and innovative instructional practices into new curricula.(pp. 9 and 10)

Characteristic features of the new curriculum include participation by various groups, and its orientation towards meeting practical needs. In addition to the seven Regional Education Centers, the new curriculum was used both by public and private schools as Table 4.4 shows. The relatively greater use of it by public schools compared to private ones is due to the fact that the education reform and financing focused on "...qualitative and quantitative improvements for selected elements of the ...public school system" [Nicholson et al., 1983, Appendix B, p. B-2].

An important input for implementing the new curriculum was the increased number of teachers. This was promoted by building ten new teacher training institutes [Nicholson et

Table 4.4

Number of Secondary Schools Using New Curriculum, 1980

Department	Total	Sector	
		Public	Private
Capital	26	13	13
Concepcion	2	1	1
Cordillera	6	5	1
Guaira	3	1	2
Caaguazu	2	1	-
Itapua	1	1	-
Misiones	1	1	-
Paraguari	1	1	-
Alto Parana	1	1	-
Central	7	7	-
Neembucu	3	3	-
Amambay	1	-	1
Pdte. Hayes	3	-	3
Total	57	36	21

Source: Ronald Nicholson et al. (1983): F-3.

al., 1983, p. 7] and establishment of teachers certification program, as Table 4.5 illustrates that 84% of primary level teachers were certified by 1974. Women played important roles in the country's educational system in that they, "...comprise nearly 95% of teachers, and most of the school directors, district supervisors, Ministry of Education personnel, and department heads" [Nicholson et al, 1983, p.16].

Table 4.6 shows that enrollment both at the primary and secondary levels increased, with a relatively greater increase in the latter. The figures reflect some improvement in access to educational opportunities. This was important for students in rural areas since it enabled them to attend school while continuing to contribute towards family labor working on family farms.

The positive impact of introducing the new curriculum can also be illustrated by improvements in retention and graduation rates. For instance, they increased from 40% to 52% and 36% to 47% for secondary schools between 1964-1969 and 1974-1979 respectively [Nicholson et al., 1983, p. F-4].

Publication of educational material represents yet another indication of the degree to which the new curriculum was being put to use in practice. Table 4.7 shows that between 1972 and 1975, educational material published totalled 470,000. Prevalence of an overall gap between demand and supply in this regard was due to the fact that, ".. the MEO's budget is so inadequate that necessary instructional material

Table 4.5

Number of Primary Level Certified and Non-Certified Teachers, 1970-1974.

		Certified		Non-Certified	
Year	Total	Number	%	Number	%
1970	13,392	10,610	79	2,782	21
1972	14,114	11,705	83	2,409	17
1974	14,945	12,482	84	2,463	16

Source: Ronald Nicholson et al. (1983): F-8.

Table 4.6

Primary and Secondary Schools Enrollment, 1970 and 1975

	1970	1975
Primary Enrollment	424,179	460,000
Urban	201,041	193,000
Rural	223,138	273,000
Secondary Enrollment	55,777	75,425

Source: Ronald Nicholson et al. (1983): viii.

Table 4.7

Educational Material Published, 1972-1975

Year	Grade	Texts	Guides	Total
1972	first	80,000	5,000	85,000
1972	second	30,000	3,500	33,500
1972	third	25,000		25,000
1973	first	50,000		50,000
1973	second	30,000		30,000
1973	third		3,000	3,000
1974	first		10,000	10,000
1974	second		3,000	3,000
1975	first	64,200		64,200
1975	second	65,000	3,000	68,000
1975	third	90,000	9,000	99,000
Total		434,200	36,500	470,700

Source: Ronald Nicholson et al. (1983): F-9.

are in short supply" [Nicholson et al., 1983, p.x].

In terms of distribution, arrangement between educational institutions and the Internal Revenue Service made possible,

> ...selling text books in the regional tax offices located through out the interior of the country. ... 165 branch offices of the Internal Revenue Service, ...provide ready made outlets for text books [Nicholson, 1983, p. 12].

In addition, decentralized operation of the Regional Education Centers was instrumental in promoting use of educational material in their respective localities.

Data relating to students'achievement under the traditional and the new curriculum is given in Tables 4.8 and 4.9. Scores in the range of three to five represent a category of good to excellent[2]. A comparison of the three subject areas namely social life and communication; Nature, health and work; and mathematics showed scores of 74%, 80% and 78% under the traditional curriculum while the respective figures for the new curriculum were 80%, 90% and 89% [Nicholson et al., 1983, p. 15]. It can be concluded from the above that achievement test results improved with introduction of a more relevant curriculum.

While all tables thus far have provided data in terms of specific issues, Table 4.10, consolidates both general and particular phenomenon using concepts and variables of the

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[2] This classification is adopted by Nicholson et al. (1983) and not the author of this study.

Table 4.8

Results of Achievement Tests Given to Traditional Curricula Students in Senior High School

	Grade										Total	
	1		2		3		4		5			
Subject	#	%	#	%	#	%	#	%	#	%	#	%
Social Life and Communication	35	16.28	22	10.23	50	23.26	59	27.44	49	22.79	215	100
Nature, Health and work	24	11.01	19	8.72	43	19.72	63	28.90	69	31.65	218	100
Mathematics	20	9.17	28	12.84	50	22.94	71	32.57	49	22.48	218	100
Total	79	12.13	69	10.60	143	21.97	193	29.65	167	25.65	651	100

Source: Ronald Nicholson, et al. (1983): F-4.

Table 4.9

Results of Achievement Tests Given to New Curicula Students in Senior High School

	Grade										Total	
	1		2		3		4		5			
Subject	#	%	#	%	#	%	#	%	#	%	#	%
Social Life and Communication	15	8.02	23	12.30	37	19.79	42	22.46	70	37.43	187	100
Nature, Health and Work	8	4.23	11	5.82	27	14.29	60	31.75	83	43.91	189	100
Mathematics	6	3.16	15	7.89	31	16.32	56	29.47	82	43.16	190	100
Total	29	5.12	49	8.66	95	16.78	158	27.92	235	41.52	566	100

Source: Ronald Nicholson, et al. (1983): F-5

Table 4.10

Application of Concepts and Variables: Rural Education Development Program, Paraguay

Type of Technology Involved	Scope of the Project
Educational	Regional
In particular relating to curricula reform.	Aimed at establishing local regional educational centers that provide educational leadership and community development.
Indicators of Participation by Users.	
Participation by local communities in various areas including:	
Curriculum change.	
supply of a large number of personnel especially as teachers.	
mobilizing resources from the locality fund raising.	

Table 4.10 cont'd.

Type of Mechanism used for Transfer	
Acquisition	-Based on long term needs of communities.

Management and Control
Administrative responsibility shifted to local Regional Education Centers (RECs) that are: -decentralized -assisted in distributing teaching material. -in controlled teachers' salaries, construction and budget allocations.

Use of Resources	
Human Material Financial	contributions used for constructing, and maintaining educational facilities and similar tasks.

Table 4.10 cont.

Benefits
Introduction of new curriculum and relevant teaching materials and textbooks aimed at meeting practical needs.
Building of new schools in the rural areas improved access and equity.
Improved students' achievement.
Higher retention rates.
Empowerment of local people due to changes brought about by the educational reform.
School building design developed during the project's implementation is adaptable to different site conditions.

Source: Compiled from Ronald Nicholson et al. (1983).

study. The project was characterized by participation involving diverse groups--the communities in general, students, teachers, and educational institutions. Such participation included planning and implementation of curriculum reform. Since curriculum reform was based on assessment of the type of education provided relative to the needs of the communities, the technology transfer mechanism reflected this and hence it was an acquisition type.

Regional Education Centers, and units under them responsible for handling various tasks at local levels were also established. Their responsibilities include budget decisions and distribution of educational material thus illustrating implementation of decentralized management and control in practice.

Use of relatively abundant resources such as human and material inputs, contributed by communities, was enhanced. In addition, there were specific benefits realized including increased access to educational opportunities, improved students' achievement and retention rates.

Analysis of the evidence using the five study variables therefore, shows that the educational technology was sustainable.

4.3 Rural Health project - Senegal

This was a primary Health Care Project located in the Sine-Saloum region shown in Figure 4.2 It was introduced in 1977 to deal with the following problems (Bloom, 1984):

> Inadequate numbers of trained health and community development personnel. Exceedingly poor access to health care, due in part to insufficient numbers of health facilities, particularly health posts (the most accessible source of health care for the bulk of the region's population). Inadequate supplies of essential drugs and long delays in procurement. (p. 3)

Given the above it was stipulated that the project, "... establish a network of 600 village health posts staffed and supported by 1000 community level personnel throughout the region." [p. 3].

The project budget totalled $5,021,282 of which USAID provided $3.3 million in various forms ranging from equipment and medical supplies to training. The government of Senegal covered the balance. Five of the six provinces with a population of about 880,000 in Sine Saloum were to be reached over a period of four years [Bloom, 1984, p.4].

Although health facilities were set up in over 400 villages of the region, there remained important problems relating to financing and implementation [Bloom, 1984, p. 5]. Ability of the project to continue functioning was therefore, called to question. According to Bloom, 1984:

> ...village health facilities were not financially viable ... not recovering their operating costs (particularly the

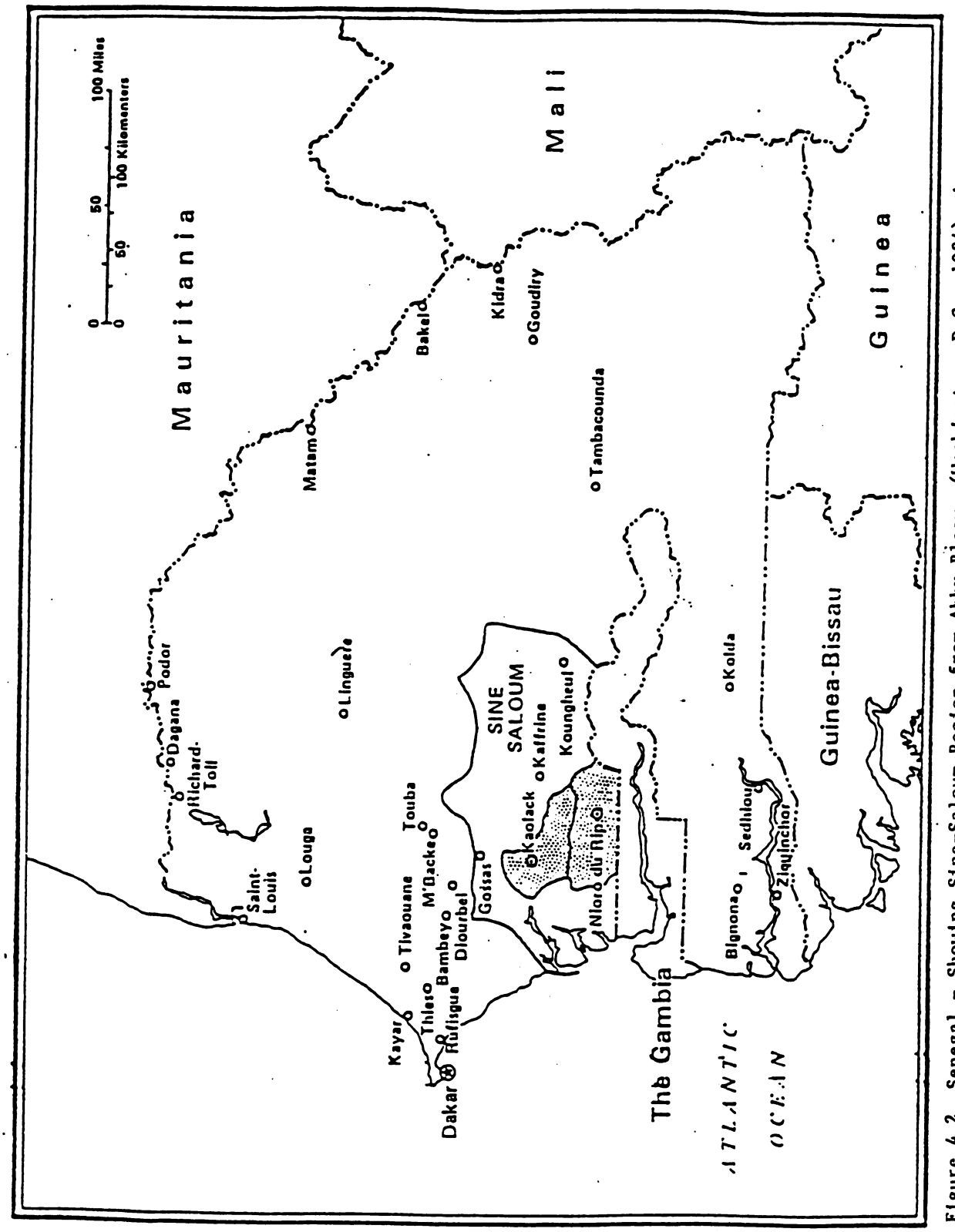

Figure 4.2 Senegal - Showing Sine-Saloum Region from Abby Bloom, (Washington, D.C., 1984) x1.

> cost of medicines), many had closed ... In addition, ... transport system could not cope with the new demands imposed by the PHC program.(p. ix)

These problems led to a need for revitalizing the project in late 1980 by concentrating on measures aimed at increasing community participation both in planning and implementation. A system of user fees, to address the project's financial viability, was established. Not only was this to cover costs of medicines, but also remuneration for services rendered by community health workers, and maintenance expenses of health facilities. Bloom (1984), provides specific features of the operation:

> All payments for drugs and fees for services ... are deposited in the village health committee treasury. ... in addition to ensuring that financial contributions are made, the village health committee ensures that, health workers are responsive to villagers' felt needs. Ensures that accurate financial records are kept, that stocks of medicines are replenished, and that funds are not diverted. Holds meetings to review ... management problems and village health problems. Selects village health worker candidates. (pp. 12 and 15)

The above indicates that community participation in practice was both diverse and significant.

Training of staff, in general, and those involved in village management committees, in particular was also promoted after 1980 "... to increase the villagers' understanding of the health program and their responsibilities of financing and managing village level activities" [Bloom, 1984, p. 9]. Women

played an important role in health services by participating as community health workers.

Domestic and external effort in construction and location of health facilities was streamlined to avoid their concentration in few locations. For instance, the major store for medicines was moved to facilitate distribution at village level. This was important given the overall goal of increasing access to primary health care with limited resources.

The need to maintain financial and health data both for planning and monitoring performance was also underscored (Bloom, 1984):

> An innovative, comprehensive survey to measure morbidity, mortality, nutritional status and knowledge, attitudes and practices to family planning was conducted in collaboration with the U. S. Center for Disease Control (CDC).(p. 7)

This indicates that in practice due weight was given to gathering information on important aspects of health care, illustrations of which are presented and discussed in Appendix C along with other background issues.

Introduction of a Primary Health Care (PHC) system to the region was made possible not only by use of field staff, such as community health workers, but also due to willingness by the communities to pay for the services they received. Their participation in executing different tasks was also essential. Given these features, the transfer mechanism

involved was an acquisition type.

Decentralized management and control was one of the distinguishing features of the project after 1980. It was manifested by jurisdiction of local health committees over collection and allocation of user fees. Use of relatively abundant resources was promoted as a result of the technology transfer. Services rendered by Community Health Workers, cost sharing through payment of user fees, use of local material and labor for constructing health care facilities provide concrete illustrations. Using concepts and variables of this study, salient issues pertaining to the project are summarized in Table 4.11.

Evaluation of the data using the five study variables, therefore, demonstrates that the medical technology providing primary rural health Care was sustainable.

Table 4.11

Application of Concepts and Variables: Rural Health Project - Senegal

Type of Technology Involved	Scope of the Project
Medical	Regional
specifically relating to rural primary health care	covers five provinces with about 20% of the country's total population

Indicators of Participation by Users
Active community development in the project's operation through village health committees including meetings to review village problems and encourage people to make use of health services. Community Health workers were predominantly from the localities.

Type of Mechanism used for Transfer Acquisition.
The project was based on meeting needs of users and had social acceptability as reflected by their willingness to share the cost of providing health services.

Table 4.11 cont'd.

Management and Control	
Decentralized -especially in the management of user fees- both in its collection and utilization at the village level, such as payment for village health workers.	
Use of Resources	
Human Material and Financial	Contributions by local communities for construction, maintenance of health facilities and provision of various activities

Table 4.11 cont.

Benefits
Availability of local primary health care services.
Local people were empowered as a result of transfer and use of the technology.
Training of health workers and village management committees.
Introduction of record-keeping on various aspects of health in the communities.

Source: Compiled from Abby Bloom, (1987).

CHAPTER V

METHODOLOGY FOR EVALUATING SUSTAINABILITY OF TECHNOLOGY

Evaluation is an effort aimed at promoting use of theory to guide practice and is a means by which to judge process(es) and effect(s) of an activity. Underscoring its crucial importance the UN (1985) notes:

> ...evaluation is now seen as an aid to learning ... as a tool of effective management of development activities in the short run and intermediate terms, and for strengthening management capabilities in the long term. ... (as well as)... making optimal use of limited resources and to lay greater emphasis on the quality of development efforts and their results [pp. 7 & 8].

The above indicates the need to build in evaluation at the beginning rather than leaving it until the end of an activity. Once devised for the initial stage it could easily be extended to other subsequent stages. Jequier (1983) observes that:

> ... risk also depends on social and cultural factors. Certain new technologies, because they are well tested, may have a very low technical and economic risk, but may ultimately fail completely because the social and cultural factors were neglected. (p. 16)

This reflects that social and cultural acceptability of a technology are crucial in assessing its sustainability. At the heart of the social and cultural factors lie issues

relating to human and institutional dimensions. These can be considered both at the macro and micro levels as well as in terms of measures undertaken by private and public bodies.

This chapter presents general methodology for evaluating sustainability of technology. It highlights what has been done in this study and can also serve as a basis for future work. Four major distinct but related phases, based on a synthesis of the literature and the three case studies, can be advanced. The phases are depicted in Figure 5.1 and discussed below.

Phase one involves devising the conceptual framework. It provides a general basis, for describing the process(es), identifying the major factors affecting the operation and determining intended consequences of a particular technology under study. When different conceptualizations of what is being studied exist, it is important that the framework adopted by a study and operational definitions thereof be made clear. This phase represents a general research tool and can be undertaken along with phase two.

Phase two is concerned with background information gathering on the locale that can be categorized into general and specific factors. Examples of general factors include social, cultural, economic, physical and biological. Participation, management and control, mechanism of technology transfer, use of resources and flow of benefits to users represent illustrations of specific factors.

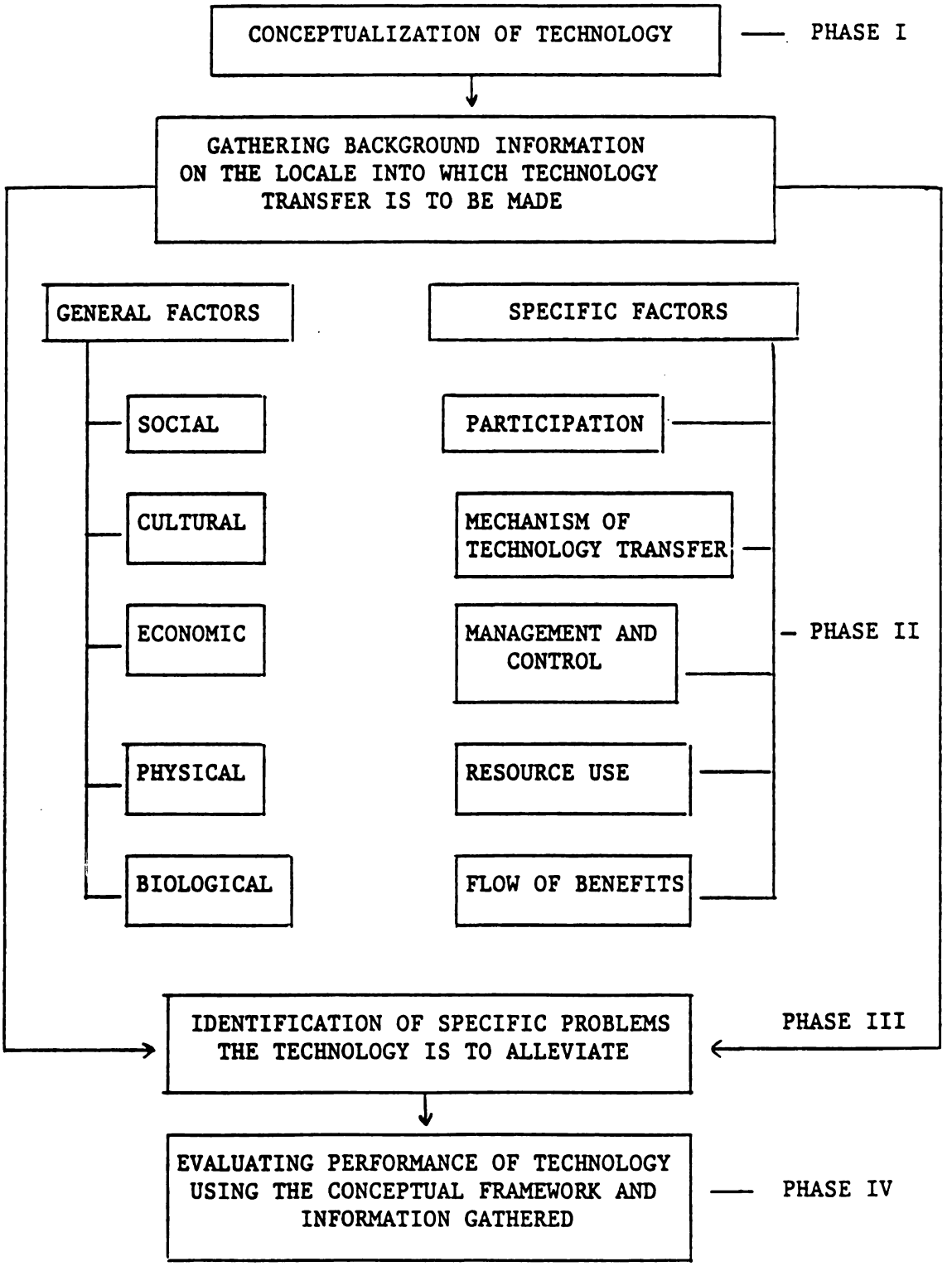

Figure 5.1 Framework for Evaluating Sustainability of Technology synthesized from the literature and the three cases.

The first step of the research strategy for phase two requires devising a questionnaire to generate preliminary information from a small proportion of potential users of the technology on an informal basis. This is a useful input for a more formal, structured and comprehensive questionnaire, both in its coverage of issues and the size of the population of users to be interviewed, that will be administered subsequently.

Formulating the questionnaire and the associated task of making budget estimates needed to undertake the research is the responsibility of the major researcher(s). Administering the questionnaire, whether on a small or large scale will, however, require use of assistants. Such assistants usually must have a minimum level of formal education, in addition to knowledge of the local language, culture and similar other community system(s). They should also be given some kind of training prior to beginning their assignment. It is during such training that objective(s) of the research, importance of the data to be collected, and interviewing procedure(s) including the schedule and approximate length of time to be spent in each interview session have to be fully explained. Equipped with good grasp of what they are expected to do, the research assistants should explain the same to potential users of the technology to get clear and pertinent answers.

The major researcher has to participate closely in the field work, to ensure reliability of information being

gathered by making first-hand observations about the locale.

There are two other possible sources of background information. The first is off-field interviewing of individuals and/or groups to obtain insight about the locale especially relating to general factors. Examining documents relevant to issue(s) under study represents the second source. Once the information gathering task is completed, what remain are coding, summarizing and storing it in a suitable form for conducting analysis.

Before proceeding to consider the issue of measurement in terms of specific indicators, it is in order to discuss broad approaches on which such measurements can be based. Direct quantitative measurement represents one approach. Dealing with indicators that readily lend themselves to such measurement using market price and physical quantities of inputs and outputs need not be dwelt upon. However, both theoretical and practical considerations that application of such measurement calls for should be properly taken into account as subsequent illustrations show.

In other circumstances, indirect methods of measurement have to be applied. The scalogram analysis provides one such method. It involves adding up elements, considered relevant to constitute components of the indicator at hand, for developing a composite index. The method requires that the elements be both undimensional and cumulative to form such an index [Blalock, 1968; Morrison, 1970; and Miller, 1983]. A

numerical scoring system, reflecting the relative importance of each element, should be utilized if the tools of statistic are to be employed in analyzing them. This is because for such analysis the scale used should be of the interval or ratio type.

Bennett et al. (1975) suggest another method to deal with the issue of measurement namely:

> ... to draw inferences through proxy or substitute measures. Proxy measures are short term indicators of long term program effects and are based on research tested relationships. These are relationships between: (a) the achievement of objectives at lower and higher levels within a phase...; or (b) the achievement of objectives within the earlier phase and a later phase... (p. 15).

They argue that the above method is particularly necessary for assessing long-term consequences of activities that cannot be observed over the short-term. This is based on the general premise that short and medium term trends in a given activity can be used to extrapolate future pattern. To apply this method it is necessary to have some historical data that can be used as a point of reference to evaluate the results obtained since actual magnitude of the factors being measured do not exist.

In cases where direct and indirect quantitative approaches to measurement discussed above are not feasible, qualitative approach has to be adopted [Collinson, 1979]. Use of categories such as high, medium and low to indicate

broad magnitudes in relative terms represents one form of the approach. These categories are usually established on the basis of responses received from potential users of the technology and/or examination of relevant documents(s) concerning various issues.

The distinction between qualitative and quantitative measurement is not based on lack of understanding of interrelationships among various issues being examined in one case as against the other but rather on differences in the relative specificity of findings.

Having set a general perspective on evaluation illustration of specific indicators will now be discussed. Financial and material contributions, that could come from local and external sources, are indicators of participation by individuals, communities as well as governments and non-government organizations. Where records for each exist, they can be used to quantify and assess implications of various levels of participation on sustainability overtime.

Knowledge about indicators, such as users beliefs, attitudes, and practices is important because sustainability of technology ultimately depends on users acceptance of it.

In terms of management, the extent of decentralization and its fit with the conditions in the locale represents another indicator. It can be analyzed by considering issues such as leadership and staffing at various levels of the technology transfer process including research,

demonstration/training and extension.

Some of the above indicators can be measured using the principle of opportunity cost. For instance, monetary estimates can be made for time spent working in managerial and other capacities with committees and associations in planning, decision making and implementation.

Implications of issues emanating from government policies and programs, such as tariff, subsidy, credit, tax, import, export and price policies should also be considered. The effects of these issues on sustainability of technology transfer are among others, reflected through input and output markets. Most of them can be quantified as discussion in chapter one shows. Likewise, activities of private sector institutions and their impact on sustainability of technology should be examined.

In general the question of which approach to use for measuring various indicators will have to be decided upon careful examination of each method's requirement(s) and the indicators' ability to meet them. One of the practical aspects that has to be considered is the nature of data likely to be obtained. From diverse examples given in this chapter, it can be discerned that there is scope to utilize the different approaches. That is, direct and indirect quantification, and qualitative measurement of different forms.

The degree of impact that the various general factors

will have on sustainability of technology depends on the specific nature of the technology being considered. For instance, when dealing with agricultural technologies, (Johnson, 1985; and Sfeir, 1986) physical and biological factors are crucial. In addition, particular issues such as availability of market, existing land and labor use practices, as well as farming systems also become more relevant. These can be better understood if considered in conjunction with evidence derived from research involving users of a particular technology in a locale, rather than independent of them.

Phase three delineates the specific research area with which a study is aimed to deal. This is done by spelling out the particular problems that are to be analyzed. Problems, especially of micro nature, are usually identified from information gathered in phase two within the context of the conceptual framework developed in phase one. Alleviating particular problem(s) at hand without at the same time generating new ones is the general underlying goal. Problems involving fodder production, rural education, and primary health care analyzed in this study are but three different examples.

In phase four, performance of the technology is evaluated using a set of criteria derived from relevant theoretical and empirical literature. The five specific factors indicated in Figure 5.1 provide examples of such criteria used in this study. For assessing sustainability of technology, such

factors should be considered in terms of the extent to which they enhance users' long-term goals and possibly that of the community within which they are located. Understanding implication(s) of a technology on utilization of scarce resources relative to abundant ones in the particular setting being analyzed is important.

Despite dysfunctional consequences that can arise from various sources due to risk and uncertainty, the task of evaluating intended results should be done as well as possible. This calls for exercising care both at a general level and in terms of specific technique(s). For instance, when there is interdependence among variables, use of regression analysis will not be satisfactory since multi-collinearity among the independent variables makes deriving sound coefficients using the least square method problematic. Other features of the regression model, such as its assumption of errors being associated only with the independent variables, should also be noted.

In cases where interdependence among variables exist techniques such as factor analysis, which envisages that no variable, dependent and independent alike, is error free, should be used [Scott, 1966]. It is defined by Harman (1965) as a multi-variate technique used to transform a large number of inter-correlated variables into non-correlated factors. The ultimate purpose of this exercise is to have an understanding of the entire collection of variables. The

technique has been applied at a general as well as particular levels with mixed results [Eysenck 1952, Adelman et al. 1971].

Major frameworks within which evaluation has been made using various specific techniques include, social impact assessment (FAO, 1981; Carley et al., 1984; and Derman et al., 1985), environmental impact assessment (Rau et al., 1980; McAllister, 1982; and Seneca et al., 1984) and economic impact assessment [Richardson, 1972; Greenberg, 1978; Barlow et al., 1979; and Bulmer, 1982]. Whichever framework and technique is utilized for evaluation, effort should be made to incorporate as much of the relevant factors as possible. Clarity should also be maintained given that the purpose of using one or more of the above is to gain an understanding of the activity being examined.

Specifically, care should be taken in making use of different techniques. For instance, when applying the cost benefit technique (Turvey et al., 1965; Maass, 1966; Sassone et al., 1986) it is important that there be no distortions of costs and benefits -direct and indirect alike- resulting in under or over estimation of them. Accordingly, distinction between private and social calculus should be made at the outset and the items to be included under each be carefully identified. Different formulations of cost-benefit equations each with underlying assumptions should also be examined for their suitability.

In choosing a discount rate, the implication of a

particular choice on inter-temporal and inter-generational aspects, both in terms of resource allocation and the distribution of the resulting benefits, should also be recognized. Deliberate *apriori* choice of low discount rate should, for instance, be avoided if limited resources are to be allocated competitively. Various types of trade-offs made should also be considered in terms of long-term consequences.

A general frame of reference for methodology to evaluate sustainability of technology is summarized below:

(1) The importance of participation by potential users of the technology, directly and indirectly, in research about the locale has to be recognized and utilized. That is, evaluation of sustainability of technology should begin with an understanding of the specific conditions users are faced with and their needs.

(2) Given that issues relating to sustainable technology transfer span diverse aspects, use of an inter-disciplinary approach is important for understanding them.

(3) Although sustainability should place primary focus on micro aspects especially as they relate to users of the technology, an understanding of macro issues is also important.

(4) Criteria for evaluation should not be those relating to characteristics of the technology *per se* but rather factors derived from research and considered to be crucial for achieving sustainability.

(5) Given that qualitative and quantitative analyses are complementary both should be done to reenforce each other if there are no constraints to do so.

In undertaking all of the above, there is choice in terms of the specific type of techniques to be used from existing body of knowledge but the suitability issue has to be carefully addressed in light of what is being analyzed. This is important because if the method utilized for a particular task at hand is wrong, the conclusions derived by using it cannot be correct.

The methodology and the underlying criteria discussed in this chapter can be applied to diverse technologies and are hence replicable.

CHAPTER VI

SUMMARY, FINDINGS, CONCLUSIONS, LIMITATIONS OF THE STUDY AND ASPECTS FOR FURTHER RESEARCH

6.1 Summary

This chapter presents some of the salient points of the study, the theme of which is Sustainability of Technology Transfer, in the form of summary, findings, conclusions, and limitations. Some areas for further research are also indicated.

The review of theoretical and empirical literature, in Chapters I and II, discussed technology transfer in terms of: (1) the engineering/technical, (2) the diffusion-adoption, and (3) the sustainability approaches. This was done to facilitate exposition and bring out some of the major contrasts between the different approaches on various issues, including conceptualization of technology itself.

The engineering/technical approach was shown to be based on the assumption of suitability of technologies notwithstanding differences in other aspects such as the environment, institutions and the social structure. It is almost exclusively discussed in terms of industry in general and manufacturing activities in particular. In this approach technology was perceived to be synonymous with technique and hence emphasis on physical hardware and its transmission from

one place to another whether within a country or among countries.

The diffusion-adoption approach was presented using different disciplinary perspectives and the assumptions that go with them. Economics, sociology, and anthropology based treatment of the approach were predominant. Providing package of inputs such as seed-fertilizer-irrigation to farmers was pursued as a primary goal. The technologies were typically generated from experiences at the International Research Centers, and assumed to be acceptable to farmers. Granted this assumption, it was argued that the key determinants for adoption of the technologies revolved around individual adopters' personal characteristics and the efficacy of communication between those effecting the technology transfer and the adopters.

One of the major challenges to this approach has been the basis for its assumption that technology derived at the International Research Centers will be readily accepted by users and given this whether mere focus on communication was of any utility by itself. Prevalence of ecological and farming systems differences among others, form the basis of the above challenge.

In recent years it has generally been recognized that preoccupation with technology transfer <u>per se</u> has not been able to address long term development problems. The need to reexamine the premises of such transfer has therefore, become

important. This necessarily means focusing on the issue of how to achieve sustainability. In contrast to the other two approaches, the sustainability approach emphasized that technology transfer represents a means for enhancing users participation and empowerment by involving them in the planning and/or implementation of the transfer process. It takes into account the economic, social, cultural, physical, biological and other aspects. In addition, it adopts a dynamic perspective considering inter-temporal and inter generational implications of decision making and is based on a comprehensive framework. The approach also supports the underlying theory which postulates that a technology making use of the relatively abundant resources relative to the scarce ones should be promoted.

Five variables identified from the literature on sustainability, were used in formulating the study hypothesis which states that technology transfer is sustainable when the following exist:

- participation by users in planning and/or implementation of the technology transfer process;
- acquisition type of technology transfer;
- greater use of the relatively abundant resources compared to scarce ones;
- decentralized management and control by users; and
- benefits to users.

From a total of forty cases examined three that provided

relatively more data were selected and used as sources. They were based on field experiences from Nepal, Paraguay, and Senegal conducted by staff from World Neighbors for the former and the USAID for Paraguay and Senegal. Each organization also made significant financial and/or technical support to the projects over limited time period.

The specific problem in the case of Nepal revolved around alleviating shortage of fodder supply faced by a local community. By using resources both from local and external sources, a technology that was able to satisfy the community's fodder needs on a continuous basis was introduced. In addition, a number of other community development activities, related to the fodder production, emerged. The project therefore, had linkage effects.

In Paraguay the negative consequences of irrelevant curriculum and access to educational opportunities especially for those living in the rural areas constituted major problems. The goal of the educational reform among others, was to address these problems.

Senegal's primary health care project was aimed at providing services to rural communities that do not have access to the few health facilities usually concentrated in urban areas.

Diversity of the cases regionally, sectorally, and in terms of the types of technologies -agricultural, educational, and medical- was important to evaluate whether or not

sustainability of technology was affected by it.

This study adopted a broad conceptualization of technology which recognizes that not only is it more than technique but is also applicable to diverse activities.

6.2 Findings and Conclusions

The following findings emerge from analysis of the data using the five study variables.

First, operation of all three cases were decentralized thereby facilitating the dual task of involving users in cost sharing of the projects' activities while at the same time putting management and control in their hands. Various types of Committees were the primary forms of organizations used in exercising such control. That is, through users' participation the technologies enhanced empowerment, and capacity building. The mechanism of technology transfer used in all three cases was therefore, of the acquisition system type. This is in contrast to the delivery system approach in which technology transfer merely represents a top-down mechanical process with no consideration of participation by users.

Second, increased use of the relatively abundant resources was characteristic of all three projects. This was found to hold both in the form of staffing, which included a sizeable proportion of women as well as material inputs from local sources.

Sustainable technology transfer was a viable strategy for achieving increased agricultural production and related activities as well as improved access to rural education and health care. This was due to positive effects of participation, acquisition type of technology transfer mechanism, decentralization in management and control, increased use of the relatively abundant resources and continuity in flow of benefits to users. These were interrelated and reenforced each other. Of these, participation was the crucial variable. The study also found no basic differences in the achievement of sustainability in all three cases despite diversity in the type of activities they involved and location of the countries. The findings support the study hypothesis.

6.3 Limitations of the Study and aspects for further Research:

Use of secondary and qualitative data represent two practical limitations of this study. It should however, be noted that the distinction between qualitative and quantitative analysis is not based on lack of understanding of interrelationships among issues being studied in one case as against the other but rather on differences in the relative specificity of findings. The methodology presented in chapter V can be used as an input for conducting further studies. Some illustrations of which are given below.

Identification and quantification of changes in various types of domestic and external inputs overtime and the consequences for sustainablity of technology provides one ground for further study.

Closely examining existing local organizations in terms of their development, strengths and contributions -direct and indirect- to sustainable technology transfer is also relevant.

Women in many rural societies including the three cases examined in this study make important contributions working in the fields and otherwise. Given this systematic analysis of conditions that will make maximum use of their effort for sustainablity of technology can be important.

possible linkage between micro and macro factors and their implications for sustainability of technology can constitute yet another aspect for further research. If necessary data become available, the methodology presented in chapter V can be used as an input for conducting further studies.

APPENDICES

APPENDIX A

Appendix A

NEPAL - GENERAL BACKGROUND, EMERGENCE OF RELATED ACTIVITIES AND EXTENSION OF THE TECHNOLOGY.

Nepal has over ninty percent of its population in the rural sector (Tull et al. 1987). It has three major ecological zones each with distinct characteristic features as Table A1 and Figure A show.

Table A1

Population, Cultivated and Forested area

Ecological zone	Altitude (M) above sea level	Gross Area ('000km^2)	Population 1984 (mill)	cultivated Area ('000Km^2)	Forested Area ('000Km^2)
Tarai	<500	24	7.1	15	9
Hill	500-4000	96	7.8	16	29
Mountain	>4000	21	1.4	neg.	neg.
Total		141	16.3	31	38

Source: Upadhyay, "Watershed Management in Nepal Under Conditions of Limited Data and Access," in K. Easter, et al. Watershed Resources Management: An Integrated Framework with Studies from Asia

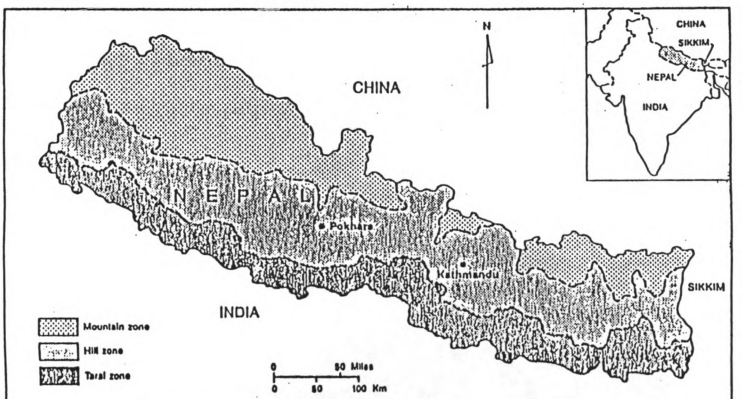

Figure A. Nepal's Three Major Zones from K. Easter, et al. (Boulder: West View Press, 1986) 176.

and the Pacific (1986): 178.

neg = negligible

Upadhyay (1986), summarizes some features of each zone as follows:

> The Tarai zone occupies about 17 percent of Nepal and is extension of the Indo-Gangentic plain. the zone contains about half of Nepal's cultivated land and slightly less than half of the population. ... the climate is sub-tropical. Land use is predominantly agricultural in the southern belt and there are forests on the southern slopes. The Hill zone .. climate is a temperate monsoon type with cool dry winters and warm wet summers. Half of the total population and 68 percent of the land area of Nepal are included within the zone. The zone has a complex system of high ridges, basins and steep slopes. Less than 5 percent of the zone is flat. Cultivation is done on bench terraces of varying standards, and in many areas terracing has gone beyond prudent levels. terraces have been established on lands too steep and fragile for cultivation under normal rainfall conditions. large numbers of livestock are past of the farming system. The forest type is predominantly temperate. .. intensive use of land, heavy grazing pressure, and a rapid rate of deforestation have been major contributing factors to increasing erosion in this zone. The mountain zone occupies 15 percent of Nepal's land area and has about 8 percent of the total population ...this zone is ... characterized by low rainfall and low temperature during much of the year... the short growing season, low rainfall, and fragile landscape have restricted intensive use of the land, although grazing pressure is relatively high. The typical alpine vegetation... is now disappearing because of heavy use as fuel wood. (pp. 178 & 179)

Differences in agroclimatic conditions in general and

access to fertile land in particular, therefore, make major difference in the livelihood of inhabitants. The agroforestry project stimulated two activities in the Majhi village - a small irrigation canal and a drinking water supply system. The first led to increased dry land cultivation thereby boosting food production and the latter made access to drinking water for Majhi households possible.

These activities illustrate that local communities can expand the range of services available to them through cost sharing. Table A2 provides cost data for four activities including the above two in Majhi village between 1978 and 1986. Components of the two broad categories of costs used in the Table were specified by Arens et al. (1987), as follows:

> ...Program Expenses (training, materials, equipment, transportation, rent, drugs, cost of stud animals), and staff costs (including allowances for the nurseryman, livestock assistant and extension staff, pro-rated administrative support, and ... consultant's costs. (p. 6)

It can be discerned from the above that program expenses are those allocated for fixed inputs while staff costs represent spending on variable inputs.

Although local participation in training and extension regarding Ipil-Ipil was substantial, Table A2 shows that staff cost exceeded program cost. This may largely be due to expenses incurred for research and consultancy personnel fees.

Drinking water and irrigation canal activities being

Table A2

Costs of Majhi Community Development Activities, 1978-1986 (in U.S. dollars).

Activity	Program cost	Staff cost
Ipil-Ipil	5312	8531
Livestock	3125	2375
Drinking water	820	100
Irrigation	475	250

Source: Arens et al., (1987): 7.

almost exclusively undertaken by the community did not involve cost for research and consultancy. On the other hand there was spending for purchase of equipment. The two put together resulted in program cost being greater than staff cost. The Table shows of the four activities, drinking water project had a relatively very low staff cost followed by irrigation. Extension of the technology and related activities for 1986 is given in Table A3. It indicates that over fifty percent of the total areas reached by the extension program fall under Ipil-Ipil training and demonstration activities while progress in other activities was slow. This is not a surprising result given that the primary activity was that of achieving self- sufficiency in fodder production.

Table A3

Extension of the Technology and Related Activities, 1986.

Activities	Number of Administrative Areas Covered
Animal upgrading	8
Ipil-Ipil training and demonstration	23
Drinking water supply systems	8
Irrigation Canals	2
Community fodder nurseries	2
Imported citrus trial	9

Source: Compiled from Tom Arens et al. (1987): 17.

APPENDIX B

Appendix B

PARAGUAY - BACKGROUND DATA

The Rural Education Development Program (REDP) was established in 1962 when operation of the Inter-American Cooperative educational service (SCIDE) came to an end. Nicholson et al. (1983) summarizing the background write:

> SCIDE made six major transition: (1) the technical-vocational school in Asuncian, (2) the San Lorenzp Rural Normal School (1956), (3) the in-service teacher training centers, (4) the preservice training programs (5) the curriculum and materials center (1957) in Asuncion, and (6) numerous new schools and classrooms. ...the Rural Education Development Project (REDP)... continued many of the programs begun by SCIDE. REDP's stated aims remained mearly identical to those of SCIDE: to reduce illiteracy in paraguay through an increase in normal schools, in-service teacher training, new school construction, development of instructional materials, and reorganization of the Ministry of Education (MEO).[PP. 2 and 3]

Table B1, provides general and education related data. It indicates among other things, that per pupil cost for primary and secondary levels increased substantially, with the primary level showing a relatively greater increase.

Illustration of per unit construction and furniture costs at the primary level for 1972 and 1973 are given in Table 2.

TABLE B1

Trends in Population Growth, Enrollment and Related Aspects, Selected Years, 1955-1979

ITEM	1955	1968	1970	1975	1979
Population (millions)	N.A	1.4	2.4	2.6	2.9
Gross National Product (GNP) (million guaranies, G)*	11,993	30,483	74,921	190,438	N.A
Per Capita (U.S. $)	N.A	N.A	305	320	404
Ministry of Education (MEC) (million guaranies, G)	124.9	352.8	1,388.4	2,709.9	5,626.6
MEC Budget as % of Total Budget	12.36	12.92	13.3	14.7	13.4
Population (7-14 yrs)	N.A	N.A	510,000	580,100	615,400
Primary Enrollment	254,118	330,000	424,179 (83)	460,000 (80)	504,000 (82)
Urban	N.A	196,000 (1966)	201,041	193,000	199,000
Rural	N.A	176,000 (1966)	223,138	273,000	305,000
Population (13-18 or 15-19)	N.A	N.A	332,500 (13-18)	262,381 (15-19) 1977	402,400 (13-18)
Secondary Enrollment	16,000	39,000	55,777	75,425	110,095
Pre Pupil Expenditures--Secondary	N.A	$32.71	$55	$96.85	N.A

Source: Ronald Nicholson et al. (1983): viii.

* G 126.00 = U.S. $1 (Fluctuating free market rate in 1971).
N.A = Not Available.

Table B2

Unit cost of Primary Schools: Construction, and furniture -1972 and 1973 - (in US dollars)

Data	construction/m^2	Furniture/m^2
9/12/72	35.21	13.04
10/31/72	42.29	12.91
2/28/73	58.13	28.20
4/4/73	68.98	12.90
7/25/73	76.96	16.65

Source: Ronald Nicholson et al., (1983): F-1.

Table B2 shows that construction costs approximately doubled while furniture cost increases were relatively modest. Given that local material was used in school construction, the large increases in cost may be attributed to other inputs especially imported ones.

APPENDIX C

Appendix C

SENEGAL - DEMOGRAPHIC AND HEALTH CARE BACKGROUND DATA

The primary health care project covers twelve percent of the country's land mass and about one fifth of the total population. It is considered to be one of the largest in the Sub-Saharan region [Bloom, 1983]. The major economic activity in Sine Saloum is agriculture with Millet and Peanuts being the two major crops grown in the region. Millet combined with other crops such as rice, cow peas and corn is the staple food crop while peanuts, one of the country's major exports is a cash crop with the region contributing about two thirds to export earnings Bloom (1983).

Table C1 provides data on health and related aspects both for Senegal and Sine Saloum. It shows that annual population growth rate and infant mortality rate are high for the project area compared to the country as a whole.

Table C2 provides data on major communicable disease prevalent in the Sine-Saloum region for the period 1979 and 1980. The Table indicates that Malaria, prevalent all year round, is not only top on the list but also showed an increase of about twenty-three percent in one year.

Number of deaths due to malaria by various age groups in

Table C1

Demographic and Related Data.

	Senegal	Sine-Saloum
Population (1982 est)	6,000,000	1,200,000
Land Area (Km)	197,000	23,620
Population Density (persons/km)	30.5	51
Crude Birth rate	48/1000	?
Crude Birth rate	23/1000	?
Annual population growth rate	2.8%	4.0%
Infant mortality rate (1979)	118/1000	118/1000
Mortality rate under 5 years	275/1000	286/1000
Life expectancy at birth	44	?
Fertility rate (1980)	7.1	?
Adult literacy rate	27.8%	?
Access to safe water	37.0%	?

Source: Abby Bloom, (1984): Table 1.

Table C2

Principal Communicable Diseases Sine-Saloum, 1979 and 1980

	1979	1980
Malaria	103,193	126,957
Gonococchal	5,910	4,061
Streptococchal Infections	4,946	12,638
Whooping Cough	4,321	4,028
Measeles	3,935	1,995
Schistosoomiasis	2,266	1,995
Chicken Pox	1,720	3,655
Flu	1,570	3,019
Mumps	1,482	1,705
Amoebiasis	-	2,978

Source: Abby Bloom (1984): Table 3.

Sine Saloum is given in Table C3. It shows that malaria is widespread among all age categories, although fatality arising from it is relatively high, among children aged one to four years.

The above are consequences reflecting combinations of factors including environmental conditions, lack of access to health services and poor nutritional intake both by adults and children Bloom (1984) notes:

> The overall nutritional status of Senegalese mothers and children is poor: low birth weight is a problem affecting 10 percent of all infants; one-quarter of pre-school children weigh less than 80 percent of the standard weight for age; anemia is common among both women and children; and a substantial portion of children aged 1-6 years receive less than 75 percent of their daily caloric requirements.(p.3)

It can therefore, be discerned that children are especially vulnerable to various types of disease.

Availability of medical personnel and facilities for the region in comparison with Senegal as a whole is given in Table C4. The data shows that they are limited particularly considering the relatively sizeable population of Sine-Saloum.

Table C3

Sine-Saloum Total Reported Deaths: Malaria Cases and Deaths by Age group, Reported by Health Facilities - 1979.

Age group	Malaria cases	Malaria deaths	% of total deaths due to Malaria	Total deaths
Under 1	12,764	11	1.7	635
1-4	23,508	42	24.9	169
5-14	27,481	33	17.8	185
15+	39,440	36	18.0	450

Source: Abby Bloom (1984): Table 4.

Table C4

Distribution of Medical Facilities and Personnel:

Sine-Saloum and the Nation Trend.

	Senegal	Sine-Saloum
Hospitals	12	1 (8%)
Hospital beds	35,323	268 (8%)
Health Centers (Dep't. Hospitals)	35	9 (26%)
Health Center Beds	787	103 (13%)
Material and child health centers	65	10 (15%)
Physicians	295	18 (6%)
Nurses	2,482	293 (12%)
Mid wives	381	25 (7%)
Population per physician	18,670	60,367
Population per Nurse child bearing age	2,219	3,708
Females per mid wife	3,447	10,392

Source: Abby Bloom (1984): Table 2.

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