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9. ABSTRACT

Questions of appropriate technology are usually discussed in terms of economic and engineering decision-making. Questions of the social effects of technology are always present but are rarely given the sustained attention which they should be. Technology is insinuated into social and cultural situations. The local social and cultural organization affects the roles technologies have and how they are used. The decision-problem in appropriate technology is not how to satisfy lists of criteria of what appropriate technologies are or ought to be. It is a tradeoff problem in which judgments need to be made about costs and benefits, impacts and opportunities. In making those decisions, it is necessary to anticipate what the terms of the tradeoffs will be and to continue assessing the terms of the tradeoffs. One way to do this without sacrificing change is to compare intervention and explication strategies. The former seeks to minimize social effects, the latter tries to use them. External assistance can make a short-range contribution by providing the materials to enter a diffusion stream. In this kind of contribution, the assistance role is defined in relation to alternative forms of initiating and maintaining a diffusion stream. External assistance can make a long-range contribution by seeking to create an integrated professional community that can develop and maintain perspectives, standards and experience. In this kind of contribution, the role of assistance is then defined in relation to the joining together of alternative substantive (disciplinary) strands of the professional community.

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APPROPRIATE INSTITUTIONS FOR APPROPRIATE TECHNOLOGY:

A Framework for Analysis and Guidelines for AID Roles

A Consultancy Report Written for USAID
April 1976

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INTRODUCTION

What is appropriate technology? From some points of view it describes a category of particularly adaptive and ingenious technical choices that have been an attribute of rural areas and poorer countries for several decades. The current appropriate technology movement from this perspective is an attempt to acknowledge and encourage this sort of creativity and, through various approaches to exchanging information, an attempt to proliferate recognition that there is an alternative. Another perspective on appropriate technologies is that it represents a viable path to economic growth that it is especially suited to the resource limitations and endowments of poorer areas and offers an alternative to the unsatisfactory transfer of advanced technologies; and reliance on the trickling down of the benefits of advanced technology utilization to less advantaged sectors. The current appropriate technology movement from this vantage is an attempt to legitimize and elaborate the option, to incorporate it into the profiles of national planning, and, through various approaches to generating and diffusing "appropriate technologies," an effort to reduce unbalanced economic growth, and increase employment in areas with chronic shortages of resources necessary for more rapid growth under other alternatives.

This paper will argue that a distinction can be drawn among appropriate technologies that crosses between these two perspectives and which may provide a more useful basis for thinking in practical terms about the roles of appropriate technologies in social and economic change. It will then be argued that the basic problem for research and extension is to actively incorporate into planning a more complete

specification of the diffusion profile of anticipated and desired users. Processes to implement that inclusion are discussed and roles for effective allocation of AID resources identified.

Two types of appropriate technologies can be defined in relation to the problems uniquely addressed and the objectives and means characteristically offered. The two types are: product design and production technology.

The major problem addressed by product design appropriate technologies is the lack of access by low and moderate income producers and those in certain production (e.g., rice), service, or infrastructure (energy) functions to capital choices which can enhance output and return. In developing solutions to the problem of access sets of private and social objectives have been specified as objectives. The private goods to be maximized are increases in output and improvements to returns to labor. The social goods to be maximized are increases in output and conservation of critically short or maldistributed resources (cash, access to credit, fuel). Since the principal resource constraint is capital, --ranging from farmers lacking cash or credit to purchase equipment to the high foreign exchange costs of importing equipment, the preferred means to realize the objectives noted above is to substitute a smaller, simpler, more economical technology for high-cost capital.

The major problem addressed by production technology alternative technologies is the scarcity of perceived viable alternatives to capital expansion paths; paths which are typically labor displacing and

characterized by high per-worker and per-workplace investment. In developing solutions to the problem of marginally viable alternatives, the basic private goods to be maximized are increased or maintained output levels, returns to investment and market position. The principal social goods to be maximized are increased or maintained output and product quality and increased employment. The principal resource constraint is uncertainty about firm expansion paths which are not capital intensive. Uncertainty and risk can be attributed to several factors, including the desmonstration effects of comparable product output in industrialized societies, but a more basic set of factors is the perceived inconsistency between non-capital intensive paths and attempts to increase standardization, to enhance the predictability in estimating required inputs and attainable outputs, and to break critical input and output bottlenecks. In developing appropriate technology solutions to the problem of the uncertainty of alternatives to capital-intensive expansion, the preferred means is to reduce the uncertainty by substituting effective combinations of labor and capital to capital alone.

The next two sections will discuss the major "costs" which are typically confronted in evaluating alternative means within each of these two types of appropriate technologies, the major routes developed for trade-offs between objectives and costs, the problems of defining and locating appropriate target groups, and the principal derived or second generation problems of appropriate technology utilization. An outline of the argument for each type of appropriate technology is presented and then illustrated through discussion of problems of

agricultural development and rural industrialization. In Section III, the discussion is focused on the problem of identifying R and D functions. In Section IV, a set of roles for AID are identified which address both short and long run objectives concentrated on enhancing R and D effectiveness and appropriateness.

SECTION I: AN OUTLINE OF THE ARGUMENT

	Product Design	Production Technology
1. What are the major "costs" which are typically confronted in evaluating alternative means?	1. Labor may be displaced. 2. The skills and/or infrastructure required to effectively utilize the product may not be present or may be distributed in a fashion that is inconsistent with the group initially identified as lacking access.	1. Dislocations in work organization. These can arise from new demands on supervision, planning task organization, group rather than individual skills, etc. 2. Inefficiency, that is, maintenance or deterioration of quality control, standardization, and overall competitiveness. This will be particularly problematical in dual economies and/or economies just beginning import substitution emphases in the products and markets involved. 3. Increased administrative costs associated with recruitment and training and coping with the possibly increased likelihood of work interruptions.
-- What are the major routes for trade-offs between objectives and costs?	1. Specification of "acceptable" levels of labor displacement. 2. Specification of "acceptable" distortions in product diffusion. 3. Clearer link between the skills required and the labor markets that are to be reached.	1. Specification of "acceptable" levels of dislocation, inefficiency, and increased administrative costs. 2. Provision of alternative forms of labor subsidization and compensation. 3. Rationalization of industry involved to improve competitive position through product differentiation and sub-contracting.

	Product Design	Production Technology
	4. Provision of alternative employment opportunities. This route assumes that the costs have a spatial dimension which amounts to encouraging migration and/or invites providing new forms of employment at the origin or the destination.	4. Provision of various input and marketing facilities to reduce uncertainties and costs. This can proceed on a national basis through various forms of regulation, etc. or it can proceed on a local or regional basis through development of appropriate infrastructure.
	5. Provision of delivery and support structures which enhance the probability of effective diffusion and back up subsequent utilization. This ranges from direct concern with marketing to the organization of information services.	
2. The Diffusion Profile **A. How is the "target" group identified?**		
--Industry	1. Primarily in terms of output bottlenecks in activities already characterized by high labor input and/or low possibilities for additional labor input without reducing marginal return.	1. Primarily in terms of labor substitution possibilities (without output or return reduction).
--Size	1. The major criterion is access, low or non-access can be measured through cash income, but it can also be measured in terms of relationship to	1. Small and medium firms, usually defined in terms of number of actual workers, amount of investment, and with judged potential for expansion given market structure.

	Product Design	Production Technology
	existing formal and non-formal money markets given the cost of available technologies.	
--Location	1. The usual assumption is that end-users in addition to lacking sufficient resources to acquire existing technologies, do not even have real access to those technologies. This suggests that end-users will be found in concentrations. For rural industrialization or agricultural development, this means weakly developed or non-existent intermediate towns and market systems. The emphasis is therefore on the spatial aggregation of potential users.	1. The usual assumption is that firms will or do have access to markets, --for new labor, for supplies and outputs. When tied to rural industrialization, emphasis will be placed on market centers and firms located there The emphasis is therefore on assumed or required linkages.
--Special Group Characteristics	1. Most work has been in agriculture. Special attention is usually given to particular crops and/or particular tenure classes.	1. The focus of efforts is often on firms which have indigenous entrepreneurs. 2. Specific programs may be directed not at the firms directly but at particular groups of unemployed whose skills background, etc., are to be maximized.
B. How are "target" groups reached?		
—Organization	1. The Private Sector. Fabricators in the private sector often will do product production and will be involved in marketing.	1. Industrial extension, --usually tied to a managementand/or engineering capability.

	Product Design	Production Technology
	2. Marketing and production are often integral components of broader policies directed at the increase in production of some commodity. This can vary from subsidies to producers of the technology to subsidies to end-users to purchase the technology.	2. The Private Sector. This is less common, but private consultancies may play the same function. 3. Indirectly, through subsidy or compensation policies which alter incentive strategies for some "typical" target firm to move to labor-intensive expansion.
—"Style"	1. Extension work is generally couched in terms of recommendations. This results from two basic factors. First, products are designed for some typical commodity production function. They are increments to existing functions and as such, there is much less concern for particular adaptive stresses. Second, the assumption is that large numbers of end-users face virtually identical problems. Face-to-face meeting with each user is often not possible.	1. Extension work is generally diagnostic. This results from what is ultimately a firm by firm form of analysis, although referenced to industry production-functions and labor substitutabilities. Dualism and work organization characteristics require sometimes extensive modification of industry elasticities to each case. Appropriate Technology as reconfiguration yields firm-focused analysis.
C. What are the major problems which typically characterize efforts to reach "target" groups.	1. Inability to deal with all users often leads to focus on certain users; --but these may not be the target group. This problem is derived from emphasis on number of adopters.	1. Location of optimal firms can be expensive and uncertain. Reliance on existing sources of information (tax records, etc.) may exclude the very firms that are the target. A related problem is the inability in many cases to know whether the sample chosen is even representative of the target population.

	Product Design	Production Technology
	2. Some product design appropriate technologies require utilization patterns that differ from current production patterns. In agriculture, the typical example is a pump which requires a number of farmers to coordinate activities that were formerly conducted with significantly less coordination.	2. The emphasis on management and engigineering inputs may underestimate work organization related problems, --particularly quality control and standardization.
	3. Provision of follow-up in terms of materials (spare parts, service) and information is more difficult to institutionalize, particularly for low access groups.	3. Evaluation in terms of increased employment may skew firm selection to already expanding firms or lead to labor addition with very low marginal productivity.
D. What are the major routes to reduce problems in reaching "target" groups.	1. Organization of user cooperatives.	1. Designation of particular market centers or urban areas in addition to industry or size designations can provide more manageable parameters for firm selection.
	2. Assignment of diffusion functions to local-level planning on governmental institutions.	2. Organization of extension to reach marginal firms. This can vary from preliminary organization of firm associations to utilizing marketing structure as an entry point.
	3. More active utilization of existing private sector capabilities either through subsidies, etc. to local agribusiness sector and/or subsidies to users to create a more effective demand for complementary private investment in agribusiness.	

3. **What are the principal derived or second generation problems of appropriate technology utilization.**

Product Design

1. Intermediate technologies may be a link to a next level of capital choices. This will be true for end-users but more significantly for the agri-business and relevant private sectors for which more capital choices is their logical market expansion and for policies which encouraged by any successes may look for further capital possibilities. All of this can have serious employment and migration consequences.

2. Product design appropriate technologies may increase dependence on external markets for parts, servicing, etc., that may inject a major element of uncertainty.

3. For the types of economic activities typically covered by product design appropriate technologies, capital choices may represent irreversible alterations in production functions.

4. The relationship of particular technologies to established social patterns in which the activity is embedded may not become clear until after technology adaptation. This

Production Technology

1. Certain types of appropriate technologies, e.g., second-hand equipment, may only be short-run solutions to employment and expansion problems and they place firm in position of dealing with new and more difficult problems of equipment maintenance and repair.

2. Appropriate-technology capital-labor configurations may not be effective options for small and medium firm survivability in dual and import-substitution economies.

3. Increased employment may require control and coordinating functions that place significant stress on organizational operation. Task decomposition for example as part of a capital stretching strategy can lead to the necessity of compensatory incentives for old labor used to broader autonomy and complex management and planning functions to reduce the uncertainties of absorbing and coordinating new labor and new tasks.

4. The relationship between socio-technical systems within the firm, the emergent social properties of the firm within the community and assessments of labor substitutability often do not get recognition until stress has been placed on existing firm and firm-community organization.

Product Design

can take the form of dislocations in patterns of goal-setting, cooperation, labor recruitment, etc., and/or in recognition of patterns which are more or less critical for the effective utilization of technologies.

Production Technology

5. The reliance of particular labor expansion paths on local and regional infrastructure, --particularly labor markets, --and the fragility of those markets given broader changes in labor incentives. This is part of the larger problem of the assumptions about labor and output markets that often characterize production technology appropriate technology work. An example is the experience which has accompanied workplace dispersion approaches. Both markets and labor projections prove unreliable.

SECTION IIA: PRODUCT DESIGN

For low-income farmers, increases in output and/or improved returns to investment can be attained through a wide range of alterations in the role of technology in agricultural production functions. Mechanical seeders, dryers, threshers, tillers, pumps, and milling devices are only a few examples of equipment which, if properly introduced and utilized, can yield substantial income gains for the agricultural producer. It is frequently the case however that these items and other forms of agricultural equipment are available on the market at a price which exceeds the purchasing power of low-income groups and at a scale inappropriate for smaller parcels. Broader accessibility to these capital goods can only be achieved by reducing the cost of the equipment and/or enhancing the purchasing power of the end user. Equipment redesign frequently exists as a cost reducing alternative. Many agricultural devices are frequently imported and incorporate overly elaborate design characteristics. In-country modification of imported equipment or development of new models can yield substantive cost reductions through the application of simplified design requirements, the utilization of local materials, and/or the employment of low-wage labor in small-scale fabrication firms. Such cost reducing modifications can also yield significant savings of foreign exchange through decreased dependency on equipment imports.

While a wide range of product design are available to improve small farmer incomes, the question of "appropriateness" must be comprehended within a larger social context. In more conventional terms, the appropriateness of any one particular technology choice must include

some assessment of externalities or social opportunity costs (i.e., what may be good for the small farmer may or may not be consistent with the larger public good). Some candidate technologies may yield substantial gains without any significant concomitant social costs but the more common example is less benign. For example, the introduction of more efficient milling equipment may yield higher levels of rice output but at the same time exact a heavy price in the corresponding displacement of traditional methods of handpounding, a highly labor intensive operation. The result in social terms can be a sizeable loss of employment and income for the rural labor force.

The problem of assessing the appropriateness of a particular technology suggests that a range of trade offs are available to the decision maker in coping with the task of minimizing opportunity costs and that certain compensatory actions (public works projects, resettlement programs, etc.) to offset the costs in loss of income for displaced labor may be required.

The above example suggests that anticipating and calculating social repercussions of any technological change constitutes an integral component of any evaluation process to assess whether a particular product design is appropriate or inappropriate.

Another major component is the likelihood that the product will reach the desired target group. For example, even if measures are taken to reduce the cost of equipment, market outlets may be so distantly located as to prohibit the small and low-income farmers from getting real access to these products. In addition, market outlets may be unavailable for absorbing the expected production increased arising from the use of new equipment.

In brief, the choice of any particular product design will likely necessitate additional assessments of certain policy and organizational measures to assure that target groups are able to benefit from the proposed technical change. In many cases the process of assessment should illuminate significant relationships between the problem of product design and the kinds of institutional capabilities available for undertaking the tasks of securing its diffusion and adoption within a particular clientele group. Thus, proposed designs which contain moveable parts and attendant requirements for high-precision fabrication may entail a reliance upon larger scale manufacturing firms. While these firms, in contrast to smaller metal working industries, are able to produce more sophisticated designs they may not have established market outlets in more remote areas. In addition, these firms may enjoy the status of being shielded from normal competitive pricing by virtue of government allowances which provide assured access to credit and imported raw materials. These advantages may incline firms to price their products beyond the reach of lower income farmers.

In the first line production of a particular design, it may be necessary to overlook the above constraints and engage the services of larger fabricating firms. Larger firms are in a more secure position to invest more resources in distribution and marketing services. While the initial diffusion profile may be skewed in the direction of higher income groups in areas of close proximity to urban centers, the eventual entrance into the market of more competitive and perhaps smaller scale producers may give rise to a somewhat more equitable diffusion profile. These diffusion bottlenecks can also be partially removed by supplementary

policy actions in the provision of subsidies for producers or for the target clientele.

While the pattern of institutional involvement and diffusion profiles may be somewhat constrained when assessing the appropriateness of high precision product designs, the boundaries of choice are somewhat more elastic when considering the manufacture and marketing of less sophisticated designs. In those instances where product design requires less attention to precision and quality control, there is much greater prospect for embedding the proposed technical change within traditional patterns of market and production capabilities. Under these conditions small scale fabrication shops can assume a major role in the production and marketing of a new product design, a feature which likewise assures the provision of locally available back-up repair and maintenance services. The utilization of small firm manufacturing capacities also serves to generate second order employment and income effects in that their production functions are largely characterized by labor intensive methods with material inputs from local sources. While maximizing the role of the small farm sector may yield substantial gains with respect to the wider distribtuion of a new product and the generation of attendant spill over growth in a more decentralized fashion, it also places a heavy burden upon the industrial extension service in their efforts to introduce a new product line among a widely dispersed and extremely diverse array of small fabrication shops. An assessment of alternative policy and organizational measures for product diffusion would therefore entail some weighing of the short- and long-term costs and benefits of engaging the production and marketing capacities of the small firm sector.

In some cases, however, the particular dimensions of a proposed product design will require major organizational and institutional changes in order to secure its acceptance and effective utilization by the target group. This is especially the case in the diffusion of some so-called "indivisible" technologies, where the product design cannot be scaled down into smaller self contained units to meet the needs of individual small farmers. The appropriateness of these innovations, and more particularly their capital expense, can only be justified if the end users are organized to fully utilize the proposed design. The full dimensions of this problem are implied in both the acquisition and utilization of new product designs. Thus, the capital costs of some technical inputs exceeds the purchasing power of the individual farmer, a condition which necessitates a mutual sharing of saving and investment burdens among an aggregated clientele. A similar need for organized responses within the target group would also apply with respect to product utilization. The use of tubewells, tractors and other indivisible technologies may require a considerable degree of regulation and planning in the allocation of their services at peak demand periods, a condition which in turn entails significant modifications and indigenous social innovation in the collective organization and allocation of work patterns within villages.

In summary, the introduction of new product designs characterized by the need for group responses in the diffusion profile may require substantial and sustained extension programs to strengthen or establish new mechanisms of reciprocity and collaborative decision-making within the clientele group. It is often the case, however, that government

extension services and other auxiliary public agencies are unable to provide an adequate level of support for new organizational structures within village communities. New capital equipment consequently remains either under-utilized or falls under the control of groups not identified with the target clientele. Cumulative research on the establishment of agricultural cooperatives designed to assist low-income farmers indicates that in most developing areas control over these organizations and the benefits they provide eventually accrue to the more privileged and higher income groups within the rural sector. In summary, the appropriateness of a particular product design will need to be assessed with respect to the likely capacities for generating sustained organized responses within the target group in order to avoid unacceptable distortions in the diffusion profile.

Calculation of an initial cost-benefit estimate for a particular product design along with an attendant assessment of anticipated bottlenecks and distortions within the diffusion process needs to be supplemented by analysis of likely intended and unintended social and institutional implications of the extensive acceptance of a particular technological innovation. On the supply side of the equation, a widespread adoption profile will likely necessitate the increased provision of institutional services (spare parts distributors, maintenance and repair shops, credit facilities, etc.) in sustaining the optimum utilization of a particular product innovation. Likewise, on the demand side, the extensive adoption of a new product design will likely entail major increases in output and a larger marketable surplus. In the case of agricultural commodities characterized by low elasticities of demand,

substantial production increases at the aggregate level will result in price reductions and attendant income losses for small-scale producers. A downward price spiral of this kind would defeat the intent of a technological change designed to assist small farmers and would need to be mitigated by such compensatory actions as the introduction of a price support program, a measure which implies a more encompassing range of institutional services within the rual sector. The problem of initiating compensatory policies becomes even more complicated in the case of small-scale production of export commodities where producers are highly vulnerable to the cyclical fluctuations of supply and demand in world trading patterns.

Anticipating the secondary and tertiary effects of technological change assumes greater significance when seen from the perspective that a proposed product design innovation may foster increased producer dependency upon market services. Since most small farmers are without capital resources as a cushion against temporary vacillations in market performance, any adoption of a new product design which involves less insularity from market forces will pose high levels of uncertainty and risk for the small-scale producer. These vulnerabilities are magnified when new product designs enhance producer specialization in one or two commercial crops at the expense of abandoning traditional and more diversified cropping strategies for home consumption and sale. A temporary price decline under conditions of increased specialization can represent a substantial loss of income for some small producers and an attendant decline in their access to requisite consumption items within the larger market arena. This problem is further compounded if

product designs cannot be re-deployed or substituted for other production functions thereby preventing small farmers from engaging in compensatory actions in the pursuit of more profitable cropping strategies. Likewise, the widespread adoption of certain product designs may constrain a farmer from reverting to former production practices, a condition which would have serious repercussions given a sudden scarcity of complementary production factors or the demise of adequate technical services. Thus, intermittent or prolonged shortages of petrol and/or spare parts may make it prohibitively expensive to sustain the operation of a motorized tilling device but equally expensive and impossible to revert back to animal power, given their past replacement and increasing unavailability as an alternative production input.

Potential stresses and bottlenecks mentioned above increase geometrically under conditions where the successful diffusion and adoption of one product design leads distributors and consumers to seek new avenues of capital substitution and expansion for new or complementary production functions. In these instances, one or several technical innovations may unleash an accelerated pace of technological change which is both unanticipated and undesired when viewed from a larger perspective of the spill over effects and disruptions these engendered in patterns of cooperation, income distribution and labor allocation within village communities. Much of the contemporary literature in rural development is a chronicle of how proffered and well intended technical changes have triggered a chain of social and economic reactions which could neither be constrained by public policy or adequately accommodated within the larger social system. It would seem imperative therefore that the

proposed diffusion of a new product design would involve both projection of anticipated secondary and tertiary ramifications with respect to the existing social order and an assessment of the prospect of mounting an effective set of policies and administrative instrumentalities in coping with these changes.

SECTION IIB: PRODUCTION TECHNOLOGY

The concern for introducing appropriate changes in production technologies is very much associated with the problem of how to accelerate the transmission of growth opportunities to the rural sector and secondly the need for reducing capital expenditure costs per unit of increased employment. In the first instance, it is frequently the case that industrial growth patterns tend to cluster around larger urban areas where modern production processes characterized by capital intensity and high wage labor assume an important if not dominant role in shaping the larger configurations of investment and employment patterns within the national economy. At the same time, however, a spatial distribution of growth opportunities in favor of larger urban areas creates a corresponding loss of economic momentum in rural areas serving to further exacerbate intersectoral discrepancies in income and employment generation and accelerating the pace of rural to urban migration. One corrective action in overcoming this sectoral dualism and the attendant dysfunctional consequences in welfare and income disparities is to undertake a program of industrial dispersion whereby new production capacities are deliberately distributed and assimilated within the rural sector. The second concern for enhancing labor-capital ratios simply reflects the need for production technologies compatible with labor abundant and capital scarce resource endowments. In this situation, an industrial profile based upon capital intensive production technologies serves to exact a heavy price in social opportunity costs by making a scarce resource less available and underutilizing an abundant resource (labor).

The assessment of appropriate production technologies requires an understanding of the organization of production within identified target firms and the direction in which these production structures can be modified in order to attain both higher output and greater use of labor. A preference for descaling production technologies into smaller units reflects not only an effort to capitalize on the pre-existing pattern of traditional small-scale production units within the rural sector, and the attendant range of resources (capital, labor, and management) at their disposal, but the interest in small production units also reflects a concern to avoid the large resource investments for infrastructure improvement usually required in support of larger production units.

With small and medium firms as the identified target group an assessment is then in order with respect to the range of possible and appropriate changes in production technologies within these structural constraints. An initial analytical component would be the charting of likely expansion paths for smaller firms (market surveys), in order to establish probable opportunities for increased production, and/or improvements in existing product lines, or the adoption of new product lines. Once a new product design has been identified the next analytical phase would be an assessment of the range of alternative production technologies available for utilization in the production process. A final assessment would entail some calculations concerning the capacities of the target firms and society within which they are embedded to absorb and sustain a proposed range of technical innovations. In each step of this analysis, assessments concerning calculations of appropriateness

with respect to expansion paths, alternative production technologies and absorptive capacities, are made from the perspective of the cost and benefits a particular innovation will yield, and the various trade-offs available in optimizing some values without at the same time exceeding certain levels of specified stress or costs with respect to other priority concerns.

In many instances, assessments of expansion paths and the identification of candidate product designs constitute areas of analytic concern which link directly to the problem of selecting appropriate production technologies. Thus, new products containing high precision components and/or the requisite need for standardized parts will in turn most likely necessitate the adoption of production technologies which are relatively rigid in their factor requirements. In these instances the prospects may be somewhat limited with respect to moderating capital costs and expanding the scope for labor substitution. Constraints of this kind assume a more prominent role when new and complex product designs are in competition with products already imported from abroad or under production by capital intensive firms within the indigenous modern sector. Requiring and preserving a market position under these conditions will place great pressure upon small firms in maintaining high levels of quality control and efficiency in order to compete with established trade mark brands.

Assessments concerning the appropriateness of a particular expansion path and the choice of certain production processes require some evaluation of rural sector social structures and their capacity to absorb and sustain a proposed range of modifications in production processes, and similarly

some anticipatory projections of the secondary and tertiary social and economic repercussions likely to be generated by these changes. Studies of small and medium scale firms undergoing transition from simple to more complex production processes indicate that a wide range of problems and obstacles are encountered in adopting new patterns in the organization of work and management practices. It is frequently the case that traditional structures of work and authority are not openly responsive to changes associated with the introduction of more complex production technologies. In trying to anticipate probable sources of elasticity and rigidity in the relationships between technology and work organization and a larger set of cultural and social constraints, the primary assessment task becomes one of measuring the capacity of the target firms and community to support and sustain a proposed range of technology innovations and specifying both the acceptable levels of social stress and/or probable distortions in organization and production performance. Thus, in some instances, certain components of a proposed change in production technology might need to be discarded with perhaps some concomitant marginal declines in quality control and output, a cost judged acceptable however, given the benefits acquired in not having to sustain major remodifications in traditional work patterns. In other instances, certain production processes are likely to be more rigid in their technical and factor requirements, and consequently less amenable to redesign adjustments in achieving greater compatibility with traditional structures of authority and work organization.

Assessment of technology choices needs to include consideration of the probable secondary and tertiary costs involved in the adoption of

new production and organizational processes. In many instances, the requisite demands for social change accompanying the introduction of a new technology may be quite substantial and pose a high level of risk and uncertainty for many of the participants in the target audience. In other cases, new forms of work organization involving more structured and impersonal types of labor-management relations may have their replication and spill over effects in other parts of community life as attendant increases in labor mobility and higher levels of group conflict serve to undermine traditional patterns of affiliation and group solidarity. All of these tensions are magnified when the target groups are subject to the destabilizing influences of producing for high risk markets. Vulnerability to fluctuations in market demand along with likely irregularities in servicing more distant markets (transport bottlenecks, tariff impositions, etc.) can exact a heavy price in communities where traditional and diversified sources of employment and income have largely been supplanted by the performance of small industries dependent upon a wide range of decision-making structures far removed from their control. In these instances, policy and institutional measures designed to sustain and reinforce acceptable measures of community resilience and economic diversity may be in order where the assessment procedure reveals anticipated high levels of dislocation and stress attendant upon the introduction of new work and production processes.

Once the assessment process has encompassed a set of evaluations concerning appropriateness of a projected range of expansion paths, an examination of alternative production technologies, a profile of variations in absorptive capacities, and anticipated social changes associated with

the support of a particular technology innovation, the analysis should move to a concern for problems of diffusing and sustaining the innovations within the target firms and the identification of various institutional measures necessary to adequately perform this support function.

The first task in this exercise entails the identification of the target or candidate firms, a process which includes consideration of such criteria as firm potentials for high levels of labor-substitution with low concomitant expenditures for new capital investment, firm location in proximity to existing infrastructure and market services, and likely firm dispersion in areas of high labor or unemployment densities. Other variables could be added to these calculations and certain assessments would need to be made in terms of the trade-offs associated with alternative strategies for firm selection. It is possible for example that firms with high potentials for labor substitutability would not be located near required infrastructure services, or that firms with adequate market centers would not be located in spatial areas where policy measures intend to provide the major focus of economic assistance. In this latter case, where development targets are defined primarily in terms of spatial dimensions (an impoverished province or district) or group characteristics (low-income labors), it may be that the range and number of existing small and medium scale industries will be quite limited, and that major emphasis will have to be placed upon the development of new firms. In addition to new firm generation, in any of the above cases, compensatory or ancillary measures for such investments as infrastructure improvement or higher levels of expenditures

for capital outlay may have to be accepted as an additional cost factor in the attainment of a desired range of development benefits.

The assessment process for the selection of candidate target firms also needs to include consideration of appropriate assistance programs to introduce and sustain a proposed range of technical changes. Conventional definitions of industrial extension services usually limit the scope of services to engineering and management assistance, and while these capabilities may be adequate in situations where marginal modifications in production processes are in order, where more substantial changes are warranted with respect to firm production processes and workplace organization, a wider range of social science expertise would need to be made available in order to properly assess not only levels of managerial and technical elasticity, but more importantly to anticipate the range and thresholds of stress patterns under conditions of innovative change within the firm structure. The need for these analytical capacities is particularly important when the establishment of new firms requires some familiarity with social and psychological processes tied to the identification and development of new entrepreneurs.

The task of formulating a generalized development strategy for small and medium scale firms is somewhat encumbered by the fact that technical, managerial and organizational problems may vary widely from one firm to another, requiring that extension programs remain relatively responsive to the provision of a wide spectrum of assistance profiles. This flexibility in the diffusion of services is particularly important in cases where knowledge of existing firm structures is relatively limited, and where there is some risk that initial firm samples are not sufficiently

representative of conditions in the field. In these cases, a premature effort to design a generalized assistance program may result in the provision of inappropriate services and the omission of a more pertinent and vitally needed resource package.

The provision of extension services is only effective when complemented by a broader range of policy adjustments. In some instances the provision of subsidies or other compensatory measures would be warranted in order to reduce perceived risks and encourage new entrepreneurial ventures. In other instances, revisions in tariff structures and related tax measures may be necessary to generate appropriate expansion paths among target firms. Major policy reforms in support of small firms are particularly important in dual economies where modern sector industry plays a prominent role in shaping basic patterns of production and consumption within the larger national economy. Without some policy measures designed to reduce the frequently protected and privileged role of firms within the modern industrial sector and attendant actions to provide greater access and incentives to the more traditional small firm sector, the prospects for expanding employment would appear limited.

The assessment of appropriate policy actions and assistance programs in support of small firm expansion also requires some consideration of diffusion mechanisms and more explicitly an evaluation of alternative extension approaches. It is frequently the case that government organized industrial extension services will be used as the primary diffusion agent, with perhaps some participation from private sector consulting firms. Government extension services usually have an already established set of

branch and network offices in the target areas although these structures are frequently understaffed and their personnel poorly trained with respect to administering sophisticated extension programs. Thus, some form of supplementary assistance from either public or private sources is usually required to enhance skill and assessment capacities for the extension function.

Finally, under conditions where the supply of trained extension agents is limited, the problem of working with a large number of dispersed small firms may require some consideration of alternative extension processes in order to achieve a greater focus in the provision of engineering and managerial assistance. The establishment of demonstration plants and training centers, and the organization of target firms into production associations or the creation of other similar institutional arrangements may enable extension agents to more effectively transmit and sustain innovational changes within the recipient firms.

SECTION III: R AND D FUNCTIONS

The principal implication of our discussion for R and D is the complexity but importance of incorporating active concern for anticipated diffusion profiles into the R and D problem identification and project selection processes. Incorporation of anticipated diffusion profiles can be summarized as

1. Anticipating likely stresses that would be generated by particular products or process designs.
2. Making explicit the assumptions which constitute or support expectations of diffusion and "success."
3. Anticipating those stresses and/or altered conditions which can be expected to accompany diffusion or will be required to facilitate diffusion which cannot be adequately confronted through modification of the appropriate technology and which will require therefore
   a. specification of acceptable levels of stress and/or specification of altered conditions which may be less critical;
   b. specification of time or phasing expected;
   c. some attention to forms and costs of supplemental activities.

Incorporating Diffusion Profiles into Product Design R & D

Target groups (usually externally identified) or likely target groups (a specification which can be made internally) need to be analyzed in terms of

a. Hardware and software assumptions. This applies ot only to the end-user but to those support facilities or capacities critical for

equipment maintenance. The major hardware concerns are assumptions about inventories of or access to complementary or compatible equipment. This would range from fuel and other inputs where required to ownership of or access to tools for normal upkeep. Software assumptions can be placed in two groups: intra-process and extra-process. Intra-process software assumptions refer to characteristics of the process only which will be directly affected by the product design:

1. The major intra-process concern is: How interdependent are the various steps in the process affected? Where interdependence is very high, either technologically (output of one stage is input of another and the pace of the second is dependent on the first) or socially (limited labor allocated sequentially), the introduction of any modifications may have effects outside of or broader than might be expected from simple substitution.

2. The major extra-process concerns are: How socially and culturally embedded is the process? How difficult is it to distinguish organization of the process from organization of the extended family, village, etc.? Difficulties in distinctions will lead to problems of extension entry and complicates understanding of production and marketing orientation.

b. Relationships between alternative product designs and the organization and range of production technologies. In point a.,

hardware support assumptions applied to servicing and backup for a product already in the hands of an end-user. In this point, the reference is to the hardware and software assumptions attached to the production of particular product designs. Fabrication assumptions will be derived principally from two common appropriate technology criteria: low cost, maximize utilization of indigenous resources. The IRRI agricultural engineering shop provides an illustration. They have consistently sought to gear their agricultural equipment designs to the production capacities of firms in the countries where diffusion was expected. However, more generally, the specification of fabrication capacity can be done in a manner that spills over to production process appropriate technology (i.e., choose capacities in which fuller utilization will be associated with employment generation) or one that seeks capacities in terms of output scale and marketing attributes (i.e., choose capacities in which fuller utilization may be associated with lower cost). Another factor is the extent to which the relevant industry is location specific, and what the implications of that are for transportation and marketing (in other words, the more relevant question may be marketing rather than production capacities). A major question is whether the production industry is dualistic and if so, whether the distribution of management, and marketing skills may either preclude certain type firms from viable participation or whether participation would have to be subsidized through transfer payments, technical assistance, organization of marketing cooperatives, etc.

c. Assumed inventories of skills. This is true for user and producer. For the user, there is the problem of what skills are required to effectively utilize equipment and what learning costs are implied. This will often not be a source of significant stress and/or nonadoption or nonutilization, but is is important to address the question explicitly since

1. This in many ways is a core attribute of appropriate technologies, i.e., it does not place unusual stress on existing skills.

2. If relearning is required, then attention will need to be given to the organization and costs. Where extension facilities are not available in the private sector (e.g., agribusiness servicing) or public sector (appropriate extension services), then the feasibility of adapting other organizations (e.g., schools in rural areas, nonformal approaches, etc.) will have to be addressed. This point relates back to a.2. If the end-use process is socially and culturally embedded (e.g., organized around religious values and operated as a village activity) then the question of who are the actual users, what are existing mechanisms for skill transference, etc., may have to be understood to assess the feasibility of alternative learning approaches.

d. Estimation of likely process-skewing effects. The end-use process can be skewed or distorted through two broad classes of appropriate technology effects.

1. Reorganization of inputs. For a number of reasons, both economic (product designs which break output bottlenecks and yield greater marginal return to labor may lead to a reallocation of labor inputs) and social (people may want to be associated with a new product, to the extent of reallocating time even if the marginal returns to increased equipment-time are diminishing), the reallocation of labor and time may lead for example to increased specialization, to the subcontracting of formerly performed operations, etc. The question of whether these steps are good or not requires reference to broader questions referenced in point e. below but it is important to anticipate, weigh and assess likely changes.

2. Reorganization of outputs. For reasons similar to those discussed in d.1., equipment which breaks an input bottleneck may lead to specialization of outputs. Product focus will be good or bad, of course, in relation to broader market factors but the point of sections d.1. and d.2. is that skewing may occur and that particularly in somewhat fragile environments, skewing may be irreversible immersion into market viscissitudes that may prove problematical. This is most true for small-scale industrial enterprises but it is potentially true in agriculture as well. A portable dryer can encourage HYV planting and input investment on the assumption the product will be marketable, but it will probably lead to a broad range of labor-substituting input reallocations (technology for labor

e.g. pest and weed management through chemicals rather than hard labor). A hired tractor can facilitate better land preparation but it may encourage reduction of multiple cropping already practiced, and increased dependence on the market for home consumption.

e. Assessment of the durability of the current policy environment and its relationship to user incentives. Assessment of both the existing and prospective policy environments is an important element of any process of target group identification. It relates to the durability of particular problems, bottlenecks, incentives and represents a guage against which to assess not simply user costs (how long will a particular product design pay) but research and development costs (what contribution will a product design make to output, income, etc.). For example, a paddy rice dryer would be considerably less worthwhile if acceptable moisture-content levels were raised, if support rice prices increased enough to make even penalized moist rice a paying proposition. Another example is the current Direct Seeding Program in the Philippines. This is an approach to rice planting which seeks to make maximum use of average rainfall curves by direct seeding a rice crop before or at the start of a rainy season, harvesting in the height of the rainy season, and planting a second transplanted crop for harvest in a relatively dry period. Dryers will be necessary for the first crop. It is easy to imagine a number of plausible scenarios which would make the dryer a poor investment.

1. The investment forces a commitment to a pattern of land utilization that may accelerate nutrient depletion; thus requiring at the least, significant complementary investment in fertilizers.

2. Removal of adequate support levels, giving additional advantage to larger or locationally more well-placed producers, etc.

To illustrate how these types of questions might be incorporated into R & D project selection for product design a form of analysis we will call Likely Stress Points (LSP) will be utilized. This can be seen as a decision-making aide since the problem at base is one of determining needs, assessing possibilities, anticipating costs and stresses, evaluating alternative modifications and complementary activities, and then deciding that a particular design and a particular package of production, marketing, utilization and follow-up assumptions are appropriate. Figure 3-1 is an LSP for Product Design. The columns are defined by a major dimension of product design utilization; --the relation of the product to an existing process. Three types of relationships are noted. Variable means that the content of the function involved and the function as performed with the product is characterized by a broad range of empirical possibilities. This would apply in situations where a variety of outputs were being produced and the function involved (e.g. packaging) varied accordingly. Uniform means that the content of the function does not vary with output. Uniform functions would be found where there was specialization and finer divisions of labor.

FIGURE 3-1

PRODUCT DESIGN LIKELY STRESS POINTS

Product Design Utilization
The relation of the product to existing process:
The function is:
The product's translation of the function will be:

Process Social Embeddedness			NOVEL		UNIFORM		VARIABLE	
Current embeddedness is: Embeddedness assumed by new product will be:			IS	WILL BE	IS	WILL BE	IS	WILL BE
	LOW	IS						
		WILL BE						
	HIGH	IS						
		WILL BE						

Organization of Utilization: Increasing Indivisibilities

Process Transformation: Increasing Production Function Modifications

IN TERMS OF: regional market organization, group identifiability, follow up required and likely, etc.

Novel means that the function is not a well-established part of or well-integrated into the larger production process.

The rows are defined by a second dimension, the social embeddedness of the process. Two types are noted for discussion, low and high. Low embeddedness implies that the organization of the process is distinct from the organization of the community. The social effects problem will tend to be restricted to within firm people. High embeddedness implies that the organization of the process is closely intertwined with that of the community. In this situation, alternatives in process can be quickly translated into broader social change, which may or may not be problematical. The two dimensions form the core relationship. The question then is to assess

1. the implications of changes in one dimension for what may be required of or will be elicited from the other dimension;
2. the linkages between relationship 1. and major diffusion profile factors in terms of degrees of change which might be stress producing; complementarity and process assumptions which may not have been clear, leverage points for introducing and multiplying change or for modulating its intensity, etc.

An Illustration

Tugaya, a small town in the Southern Philippines is the major brassware manufacturing site in the country. The process is very labor intensive and highly embedded--being a community activity in which decison-making, skill transference are closely tied to broader cultural patterns

of leadership and socialization. A major output bottleneck is wastage due to lack of control over temperature in the brass-molding phase of the process. With the extension of electricity to Tugaya, a proposal is being made for several simple electric ovens which could maintain the uniform temperatures needed. The present heating method is variable, that is, it has wide variation in performance to accommodate a broad product mix and because of unpredictable components used in the heating process. The suggested product design would make that function uniform. Individuals are to be trained to operate these ovens and these individuals would be the target of periodic retraining as agents for communication of new brassware ideas.

The shift from variability to uniformity is a case of specialization that, in a highly embedded activity, will make unnecessary skills developed over time to predict and cope with variability. If that coping skill is relatively high in the apprenticeship and cultural scales of the community, what are the possibilities for non-acceptance unless a short-term approach to minimizing this obsolescence is developed? The attempt to select a set of individuals to operate the new ovens and to subsequently utilize them as extension contacts assumes a relatively low degree of embeddedness, i.e., these individuals can operate external relationships without jeopardizing internal ones. But if task roles and skill transference are closely linked to the distribution of authority and prestige, is it feasible to assume that individuals selected externally can function as desired or that individuals selected internally will be chosen on the basis of relevant criteria? A compromise is to expand the training to operate through the apprenticeship hierarchy; and to devote

additional emphasis to a variability area that has not been well developed: marketing.

This is a simple example, but it serves two purposes. First, it suggests the sequence of questions that need to be asked and relates those to a core relationship--in this instance the effect of a change in the relationship on certain other factors. Second, it provides further evidence of the multidisciplinary character of the appropriate technology problem.

Incorporating Diffusion Profiles into R & D for Production Process

Incorporation of a diffusion profile in this category of appropriate technology R and D is characterized by many of the same questions which pertained to product design--particularly a,c,d,e, and f. However, there are additional questions which derive from the direct reorganizing thrusts of appropriate technology for production process and from the predominant thrust to generate employment without losing market position; a different trade-off than that faced by appropriate technology for product design (increasing output capacity without incurring high fixed costs). Three major additional questions need to be addressed:

1. What are the optimal possibilities for labor expansion in sociotechnical terms? Economic analyses of the possibilities for labor substitution are couched in a form of analysis that is basically output-(and hence, returns) related. But the capital-labor substitutability research and the microeconomic recommendations which come from it need to be enriched through integration with sociotechnical "tracer" analysis. The latter examines the social

organization of particular technical processes with special emphasis on the interrelationship of production indivisibilities and interdependencies with control and management attributes. The combination of C/L analysis and tracer analysis would offer considerable potential for assessing the management feasibilities of alternative C/L paths and it would provide insight on the process distortions which may result from labor-capital substitutions at particular points. For example, C/L analysis which suggests that some capital stretching strategy such as shifts would expand employment, need to be assessed in terms of the coordinative requirements demanded by shift labor.

2. What are the interrelationships between firm and community, --particularly in terms of labor pools, labor recruitment, and skill transference? Expanded demand, particularly for any special set of skills can place stress on existing firm-community linkages. the feasibility and costs of going beyond existing labor markets can be very high--in economic terms (cost of developing new recruitment mechanisms), in technical terms (the problem of finding or developing skills required and the intermediate costs in terms of output quality, market deadlines, etc.) and in social terms (in terms of residential and occupational migrants as outsiders and the broader alienation costs vis-a-vis the community).

3. What are the interrelationships between the possibilities and problems in altering production processes and characteristics of the industry and region. The linkage to industry has been widely recognized and while in policy terms small or medium enterprises may be the focus of appropriate technologies, in more operational

terms, the question reduces to small or medium firms in industries presumed to have special labor elasticities and growth possibilities. The significance of dualism, a structural feature of many industries in developing countries, usually requires interpretation in light of the production functions which characterize a particular industry.

The role of regional structure has been recognized much less often, even though one of the more popular books in the appropriate technology field, Schumacher's Small is Beautiful devotes considerable attention to it. The viability of existing workplaces and the possibility for their expansion or dispersion can be related to several dimensions of regional organization:

a. The distribution of intermediate market centers. This factor is particularly true in rural areas. It suggests that for both efficient collection of inputs and viable marketing of outputs, growth possibilities will require certain minimal externalities and that externalities tend to be found in the collection of functions present in intermediate centers.

b. The linkages between regional settlements. Settlement size, in terms of functional diversity and for some products, in terms of market size, is only one dimension. A related but distinct dimension is the set of linkages which tie settlements into systems. These systems can be arrayed hierarchically as functional diversity is related to linkage diversity. The idealized pattern has been a neat ordering of overlapping service areas. But in most areas of the third world, this pattern is not found. Instead patterns which

reflect administrative and colonial demands are found and these place several stresses on the range of choices present in designating certain industries and classes of firms within those industries as suitable growth prospects through appropriate technology. Three patterns can be identified which yield special stresses.

1. The Primate City. The concentration of a nation's industrial, service and financial resources in a single major urban center is perhaps the most common and most serious problem pattern. While externalities are certainly present, they take the form of critical diseconomies. First of all, there may be too small a market to support the large number of sellers. Second, the possibilities for individual firm expansion through more labor-intensive production must be weighed against the social costs of strengthening any "pull" factors for rural-urban migration. Third, as the term primate implies, urban infrastructure may be so weakly developed outside the major center that the costs of reaching that market do not provide an effective alternative to the primate city domestic market, --a factor that strengthens primacy and leads to distortions in economic growth strategies as recent ILO missions have indicated.

2. The Extractive City. For many developing societies, the principal mechanism for participation in international trade is the export of unprocessed or partly processed local natural resources. The settlement pattern that typically accompanies this is one characterized by a port city connected to dispersed

smaller settlements. The system is organized to facilitate movement out rather than between and it is this factor which places limits on growth possibilities. The effective market for any of the dispersed collection points will be quite small. The port town will have limited production externalities, principally because it is mainly a transfer point. Most goods are imported and most functions will be service oriented. The real economic base of such a region is highly delicate. A crop disease, a fall in world prices, demand for the crop, a rise in shipping costs, --any of these factors can virtually put the region "out of business."

3. The Administrative Town. This is a pattern which makes sense as an approach to revenue collection, maintaining peace and order and other administrative objectives. Centers are developed to transmit higher level desires down and taxes up. They do not have significant local or indigenous functions and thus are not able to serve as effective catalyzers of economic relationships. While that does not preclude such relationships from developing, it can make the growth possibilities very limited by making access to distantly located administrative resources a critical necessity. For example, if credit allocation decisions and policies are made in Bangkok, what are the implications for small enterprise entrepreneurs in the Northeast who seek assistance in developing markets and hiring more people.

A significant dimension of these three patterns is that they all tend to deflect extension attention away from rural areas and from non-administrative

centers. Much of the recent discussion on labor migration (Todaro), for example, suggests that the probability of finding employment in an urban center relative to an origin area is a major factor in migration decisions. If that is so, then it follows from the high unemployment characteristic of cities that the major long-term growth possibilities and short-term need are outside the big city, the extractive port, and the administrative center. But, the patterns described briefly require that careful assessment be made of the assumptions defining target group selection in terms of short and long run costs, competition and complementary investments needed.

Figure 3-2 is a Likely Stress Points (LSP) diagram for incorporating diffusion profile concerns into Production Process R and D. The columns are defined in terms of the degree to which production must yield standardized output (borrowed from Woodward). Unit production will be outputs that are made to specification, made to order. The variability and often low volume for any single order, makes even simple forms of capital stretching, i.e., jigs and fixtures, uneconomical. Batch production is also production to varied specification, but the volume is sufficient to permit, to differing degrees, the devotion of certain equipment to the same function for long enough periods and large enough outputs to provide opportunities for a variety of capital stretching and labor absorbing strategies (jigs and fixtures, shifts). Continuous production in addition to representing continual production of the same outputs, --thus encouraging significant capital investments,-- is also characterized by a concomitant development: a high level of task decomposition for the application of capital investment that significantly increases the complexity

FIGURE 3-2

PRODUCTION TECHNOLOGY LIKELY STRESS POINTS

Process Interdependence
The Mode of Production:
Current Mode of Production is:
The Mode of Production will be:

		CONTINUOUS		BATCH		UNIT	
		IS	WILL BE	IS	WILL BE	IS	WILL BE
PERSONALISTIC	IS						
	WILL BE						
MECHANICAL	IS						
	WILL BE						

Workplace Organization:
Control System
Current control system is:
Control system assumed by new process will be:

Organization of Inputs: Increasing Specialization

Product Output: Increasing Standardization

IN TERMS OF: infrastructure assumptions and requirements, labor markets, degree and importance of dualistic industry structure, etc.

and interdependence attributes of the process. The rows are defined by the control systems characteristic of work places. Two types are noted. Personalistic control is a highly flexible form of control, adapted to varied outputs and to supervising not simply job performance, but skill transference. While such control systems may be highly centralized or decentralized, effective control tends to be fragmented across actual work-groups. It is the work-groups which allocate labor and define the overall task sequencing. Mechanical control is a form of control best suited to coordinate complex and highly specialized inputs into optimal patterns for output production. Control cannot be fragmented because particular stages are dependent on other stages.

These two dimensions form the core sociotechnical system relationship. The LSP proceeds through analysis of that system and its interrelationships to the diffusion profile factors discussed earlier.

An Illustration

The construction of wooden ships in eastern Indonesia is a process that has gone on unchanged for many generations. A group of artisans. organized in relation to a 20 year apprenticeship, contract themselves to an entrepreneur who has found a buyer and the raw materials. It is a system in which seasonal unemployment is high and in which supply lags behind demand; --the latter condition weakening the wood shipbuilding industry as a whole. The system is a unit process with highly personalistic control.

With expansion of demand for sailing ships and with the possibility for motorizing the ships to give them supplemental power, there are growth

possibilities that are constrained by two factors: 1) the present contracting system which leaves workers unemployed and 2) the skill transference process which is premised on the construction of one boat design only. To confront these problems, i.e., to meet demand and increase employment, the following proposals have been made:

1. Create a "shipyard" to which buyers would come rather than the complex system which currently links buyers and entrepreneurs.
2. Convert the organization of production from apprentice-focused work group--each capable of building a boat--to specialization focused work groups, --each capable of producing a particular boat part. Instead of the same group producing a boat from log to finished product, each boat would be worked on by different groups at different times. Specialization, in turn, would facilitate the introduction of appropriate technologies for wood curing, more precision in cutting, etc.
3. The control function would shift from apprentice-based to coordination derived from plans. The plans would represent the range of "models" possible with the components available.

These changes represent a number of assumptions about factors which would not be stress-producing; --assumptions which would need testing:

1. The creation of a stationary labor force will not displace the current mobile labor force.
2. The reduced need for long apprenticeship will not displace the current highly skilled labor force.

3. The increase in specialization will not stretch existing managerial capabilities and will not suffer from the absence of a process to replace existing master craftsmen.

4. The assumed expanding market will not be saturated or reduced by competition with other forms of ships and thus replace seasonal unemployment with no employment.

These assumptions do not include the problems of introducing change to begin with. The recommendation is to work through the entrepreneurs. However, since the entrepreneurs have only an indirect connection with actual production, that recommendation amounts to an usurpation of craftsmen functions by entrepreneurs or the training of new people entirely.

The reorganization is justified in order to meet a demand for a flexible product, to support an expanded demand for ships, and to facilitate the introduction of managerial process adjustments to improve product equality and precision and the addition of a motor to ship design. A number of trade off strategies could be explored to reduce the potential social dislocations and, it might be added, the unpredictable direction of change in ship quality and competitiveness.

1. A configuration for the addition of engine power could be explored which had narrower ramifications on overall ship design and construction.

2. A shipyard could be formed without sacrificing the existing work-group organization. The grounds for this tradeoff would be to alter labor recruitment rather than skill acquisition processes, limiting specialization to <u>new</u> functions (motor installation), and

seeking to incorporate improvements of existing functions into existing work organization (wood curing, rib measuring, etc.).

3. To prepare for a time when specialization would be unavoidable, a consolidated shipyard might be encouraged to take on other construction-related jobs.

R and D Functions Summarized

What should be clear by this time is that the problem of appropriate technology is highly multidisciplinary. The relative importance of particular questions will vary from case to case, but because we do not believe that it is possible to develop a small fixed set of questions to fit all situations, we conclude that a large number of questions must be held in readiness. The decision which questions to ask is the critical R and D function and while as will be explored below there are orgaizational answers to structuring proper question raising, there is no substitute for what those organizational alternatives seek to accomplish: the presence of a variety of viewpoints focused on defining and dealing with a particular problem.

There are three additional factors. First, R and D must be sensitized by an active link to relevant policy agencies and processes. In a policy environment unfavorable to subsidizing labor expansion, certain target groups may simply not be reached through technological inputs alone. In a policy environment encouraging survival of small-scale enterprises or rural industrialization, the feasibility of certain product design and production process appropriate technologies increases dramatically. Second, R and D must be sensitized by an active link to varying elements in the

relevant private sector. This is a delicate matter because in welfare terms, some elements may lose through broader industry reorganizations implied by some appropriate technologies, but it is also the case that in most situations the target group itself, if not the success of the target group, will come to rest on the private sector. Third, R and D needs exposure to unmediated feedback on its problem perceptions and alternative solutions and that implies some type of extension function.

SECTION IV: A ROLE FOR AID

AID can move in either or both of two broad directions. First, an emphasis can be placed on the short-run goals of enhancing the capabilities of indigenous institutions to work on appropriate technologies. Second, an emphasis can be placed on developing a multidisciplinary capacity independent of or in conjunction with the assets and liabilities of particular institutions.

The Short-Run: Enhancing Institutional Capabilities

Two approaches can be identified at the outset:

1. Arrangements can be developed to facilitate the distribution of goods produced in the U.S. This may have the advantage of leapfrogging certain R and D time, but it may necessitate even more R and D time to deal with the inappropriateness of such technologies.

2. An alternative would be encourage the development of adaptive research capabilities to reduce the inappropriateness of imported technologies. If that goal is complemented by some interest in developing or enhancing an indigenous capability to do adaptive research, various forms of technical assistance can be productive (e.g., Georgia Tech SSI work). This approach has a broad constituency in developing countries and capacities for adaptive research already exist or are being developed in a number of places. A variant of this approach that has considerable potential is the development of intermediate technology information networks, linking research institutes, universities and in some instance the private sectors in several countries (e.g. Technonet).

Given our own argument, alternative 1. would rarely seem appropriate unless the technologies were selected by and were the result of a thorough process of feasibility and assessment research. Alternative 2. is a reasonable strategy provided that its' most severe limitation can be overcome. It does not lend itself to the development of sustainable capabilities. This is because the needs for recognition of the benefits of this style of indigenous problem solving may not be well developed given the demonstration effect of used or obsolete Western technologies and because the resources typically provided by external assistance for institutional or program start-up are not complemented by local contributions and goal-setting early enough to enhance possibilities for local assumption of comparable responsibilites upon the termination of assistance. The latter point is quite complex because the performance criteria often used by external assistance organizations place greater emphasis on immediate input-output accounting and less on growing local capabilities which may not be reflected in immediate or high level output accomplishments.

However, alternative 2. can be improved by raising the questions: What are the advantages and diadvantages of varying types of institutions and what are their major needs to make them appropriate institutions? Table 4-1 suggests in outline form an answer to these two questions. There are two ways to summarize this table. The first is a distinction between diversifying the capabilities of institutions already working on appropriate technology questions and diversifying the functions of institutions with capabilities that fit appropriate technology questions but not currently being applied in that manner. Universities and private

TABLE 4-1

INSTITUTIONAL BALANCE SHEET

TYPE OF INSTITUTION	ASSETS	LIABILITIES	NEEDED TO BECOME AN APPROPRIATE INSTITUTION FOR APPROPRIATE TECHNOLOGY
Universities	Possess diverse resources; not accountable in narrow economic terms alone; Broad range of research is legitimate.	Relevance in terms of problem-oriented, action-research often not well established; resources may not permit an action focus; many competing demands for limited resources; better Universities usually concentrated in urban areas; organizational innovation very difficult.	Better links to policy and private sectors, development of internal evaluation criteria which support action research; access to broader resources.
Research Institutes	Possibility of specialization and well defined problem focus.	Often have little connection with application or utilization of research output; specialized focus may be too narrow; difficulties in surviving success, that is, knowing the limits of particular approaches.	Better links to extension and utilization evaluation; problem oriented rather than discipline oriented internal organization.
Extension Agencies	Often quite sensitized actual problems, needs and possibilities	Absence of R and D capability often results in misapplication or overuse of particular materials; internal performance criteria tend to reward performance in less complex situations	More direct and continuing links to R and D capabilitie revised performance criteria

TABLE 4-1(continued)

INSTITUTIONAL BALANCE SHEET

TYPE OF INSTITUTION	ASSETS	LIABILITIES	NEEDED TO BECOME AN APPROPRIATE INSTITUTION FOR APPROPRIATE TECHNOLOGY
Management Institutes	Focus on decision-making and risk is highly relevant; substantial continuity and coherence in programs.	Work is often characterized by no critical evidence for appropriateness of particular approaches and assumptions; non-performance typically blamed on 'culture';scope of what can be managed often overestimated;decision-making for appropriate technologies not well-developed;more marginal and embedded economic activities typically ignored.	Needs to be supplemented by alternative viewpoints; requires link to research and extension capabilities which deal constructively with inappropriate assumptions
Private Industry	Possibility of mobilizing resources often very high; many 'networks' for implementation already in place;economic considerations ensure a form of assumption testing.	Profit motivation may not address basic appropriate technology questions adequately; private industry operations complicated by dualism.	Needs links to public sector institutions to ensure public good and welfare objectives are being addressed.

industry in developing countries may be examples of the second. Research Institutes, Extension Agencies and Management Institutes may be illustrations of the first. A second form of summarization is to draw a distinction between effective approaches to a particular problem and developing capacities to engage a broad range of problems. Universities, extension agencies and private industry probably have the best potential for the second; research institutions and management institutions problably have the best potential for the first.

With these questions and distinctions in mind, a more effective allocation of technical assistance and other AID inputs becomes discernable. The category "Other AID Inputs" can be summarized as efforts to link existing capabilities in common efforts. This could involve programs ranging from support for the establishment of consortia (a relatively loose confederation of diverse institutions to work on a broad range of problems related to appropriate technologies) and task forces (the organization of several institutions into functional groups, with each group tackling a major component of the same appropriate technology problem) under the aegis of some key institutions to the consolidation of existing capabilities into some new institution. The major challenge for activities in the institution-building approach is to enhance indigenous problem-solving capabilities and to sustain those capabilities once developed. This may require the incorporation of representatives of common target groups into R and D planning, a step that will invite the kind of accountability necessary to ensure institutions stay on their toes. A major challenge for AID will be to avoid accountability for itself strictly in terms of the distribution of intermediate

technology hardware or even the creation of jobs through such hardware, but rather to become accountable in terms of contributing to the development of institutions that can weave together diverse capabilities in a focused fashion and continue to do that after AID leaves in a manner that defines a problem indigenously, i.e., it sees the problem from the point of view of the user and immediate benefactor aware that it is the social good which needs maximization and sees the problem from the point of view of those directly and indirectly affected aware that acceptance requires maximization of private goods.

The Long-Run: Enhancing Indigenous Problem-Solving Through Expanding Disciplinary Boundaries

This is a long-run objective, but it can be met through short- and long-run activities. The basic objective is to support the establishment of a field which might be called development technology. One pillar of the field would be basic technological and engineering skills. But several other pillars would together be given equal weight: the individual, the individual and work organization; work organization and the region; the individual, work organization and the region. A four-year sequence is presented for illustration in Table 4-2. Students each year would be involved in a problem seminar on appropriate technology which would progress from exercises involving uses of intermediate technologies and inventorying existing technologies to progressively more complex problem-solving. For undergraduates and/or for a graduate version of the same curriculum provision could be made for specialization in terms of:

TABLE 4-2

A DEVELOPMENT TECHNOLOGY CURRICULUM

	Year 1	Year 2	Year 3	Year 4
Focus:	The Individual	The individual and the organization	The organization and the region	The individual, the organization and the region
	Microeconomics* Social Science Research Methods* Psychology	Industrial Sociology* Macroeconomics Theories of Entrepreneurship Social Psychology	Regional Development Economic Geography Rural Sociology*	Industrial Economics Economic Anthropology Alternative Extension Approaches Alternative Evaluation Methodologies

TECHNOLOGY RELATED CURRICULUM

Continuing Seminar: Problems in Development Technology:

- -R and D Management
- -Action-Research
- -Diffusion of innovations
- -inventrying local technologies
- -etc.

*2 semesters

-- R and D management (problem identification, screening alternative solutions)

-- Appropriate technology extension and evaluation

-- Agricultural or industrial focus (with greater degree of specialization possible also)

-- Urban or rural development.

The same profile of curriculum inputs could be decomposed or recombined into modular training packages ranging from several months to a year each. With appropriate types of follow-up, this latter option could be fruitfully combined with alternative 2. in short-run objectives and serve as a "shakedown" for broader degree applications. Modules and curriculum should be implemented on a regional basis to ensure a reasonable degree of initial relevance and where possible on a national basis to increase possibilities for linkages to the policy and private sectors. An example of this latter course would be the establishment of regional centers for graduate education in development technology. The centers would be located at universities with the potential for meeting regional as well as national needs.

A Role for AID Summarized

Optimally, both the short- and long-run objectives need to be addressed. A way of conceptualizing a program which sought to do this is presented in Table 4-3 and Figure 4-1. The key words of this conceptualization are feasibility, institutionalization and continuity. Whatever is to be done must be feasible--for AID and for the institutions with which AID would work. The critical capacities which we have already

TABLE 4-3

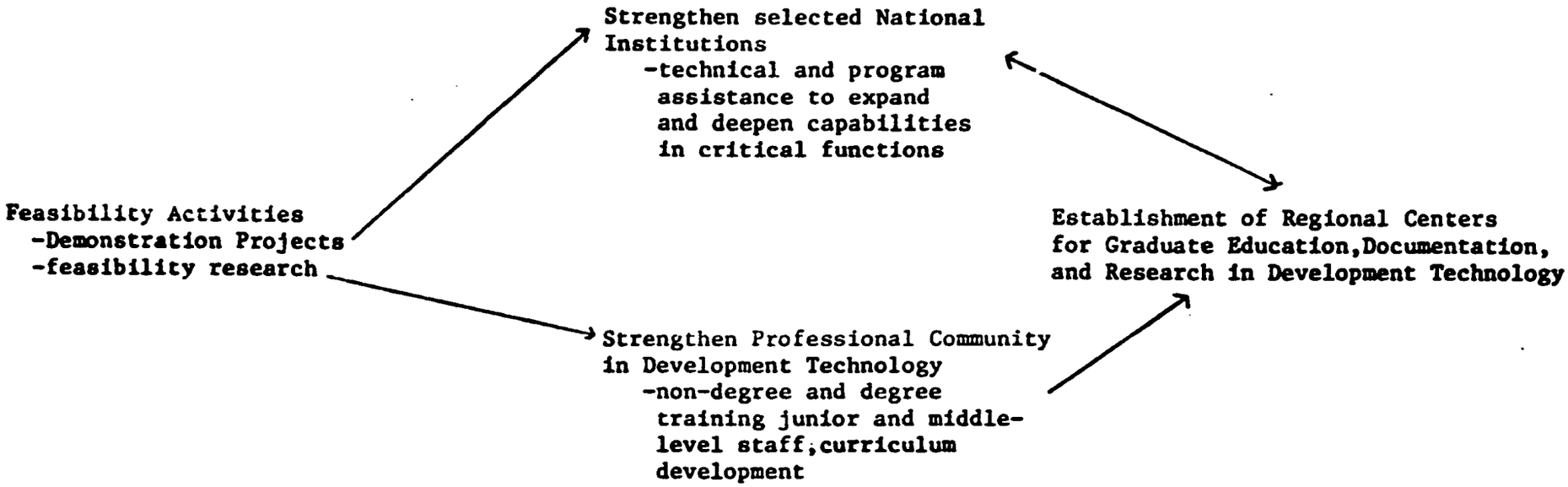
A ROLE FOR AID

Phase:

	FEASIBILITY	INSTITUTIONALIZATION	CONTINUITY
Broad Objective	Demonstrate the possibility of institutions doing multi-disciplinary work on appropriate technologies	Strengthen capabilities of selected institutions to do effective R and D and extension	Encourage development of a professional multidisciplinary community to evolve and maintain standards
Major AID Instruments	Technical assistance and grants for pilot and demonstration projects and feasibility research	Technical assistance and program grants to institutions; short-term training in U.S. and/or at specially assisted non-U.S. institutions	Educational grants for U.S. and/or indigenous training; Program grants and technical assistance where needed for curriculum development, testing, codification
Major Indigenous Institutions	Selected from Table 4-1 and appropriate public agencies	Selected from Table 4-1	Universities, Research Institutes

FIGURE 4-1

A FLOW CHART FOR THE GROWTH OF DEVELOPMENT TECHNOLOGY



discussed require two characteristics before any significant change in appropriate technology activity can be expected. One is the need to institutionalize capacities, to locate critical masses of capabilities in places where the likelihood of impact is highest. The second is the need to create and/or enhance the professional infrastructure which will guide the long-range course of this type of work and thus ensure that the learning process is a) cumulative and b) not restricted to individual experiences within a few institutions. In other words, it is the professional infrastructure which will provide continuity.

AID can begin with selected feasibility activities to demonstrate the possibilities of organizing for and programming around multidisciplinary approaches to technological R and D. AID can then embark on a carefully designed program to strengthen selected national institutions and prepare them for the assumption of regional roles as the professional manpower for regional institutions is created through non-degree training of junior and middle-level staff.

CONCLUSION

Most discussions of appropriate technology are cast in terms of economic and engineering decision-making. The question of social effects is always present but rarely given sustained attention. We have no quarrel with attention to economic and engineering decision-making, --only an objection to the tendency to disembody the decision-makers from the social milieu in which decisions are made or to pursue adequately the linkages between choices, decisions and social milieu. Those objections might be peripheral were it not for the social and cultural situations into which appropriate technologies are to be insinuated. In these situations, the category social effects is not even the whole story because what roles technologies will actually have and how they will actually be utilized will be an "effect" of local social and cultural organization.

We have tried to strike a middle but feasible ground between the biases of the existing mainstream and the biases of a more system-oriented view. We do not deny that change is often disruptive nor do we suggest that it be avoided because of that. Instead, we have tried to make three points.

1. The decision-problem in appropriate technology is not how to satisfy lists of eloquent and often inconsistent criteria of what appropriate technologies are or ought to be. The decision problem is a trade-off problem in which hard judgments need to be made about costs and benefits, impacts and opportunities.

2. In making those kinds of decisions, it is first necessary to anticipate as best as possible what the terms of trade-offs will

be and having made those decisions, it is even more important to continue assessing the terms of the trade-offs. One way to do all this without sacrificing change is to compare intervention and explication strategies. The former seeks to minimize social effects, the latter tries to utilize them.

3. External assistance can make a short-range contribution by providing the materials to enter a diffusion stream. The role of assistance is then defined in relation to alternative forms of initiating and maintaining a diffusion stream. External assistance can make a long-range contribution by going to the heart of the problem--it is currently one defined by multidisciplinary fields--and seeking to create an integrated professional community which can develop and maintain perspectives and standards, cumulate, evaluate and transmit experience. The role of assistance is then defined in relation to wedding alternative substantive strands.

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