PERSPECTIVES FOR IMPROVING THE APPROPRIATENESS OF TECHNOLOGIES GENERATED FOR CARIBBEAN AGRICULTURE

CHARLES DOUGLAS, WILLARD PHILLIPS and CALIXTE GEORGE
(Caribbean Agricultural Research & Development Institute, St. Lucia and Trinidad)

ABSTRACT

The issues of appropriate technology are discussed within the broad framework of agricultural development. Three leading Models concerned with the role of agriculture in economic development are reviewed to determine their relevance to the Caribbean. It is concluded that, aspects of all the models had varying degrees of relevance to the Caribbean but were not comprehensive enough for Caribbean realities. Despite dissatisfaction with the generalities of the Models we identified a fundamental role for appropriate technology in rural development.

Perspectives relating to the appropriateness of Technology are discussed in the context of the receiving environment, the nature of the technology and the process by which the technology is generated. It was concluded that the circumstances of the large-farm sector were sufficiently different from that of the small-farm sector so that both the nature of the technology and the process of generation for each sector should be different.

The farming systems approach is considered to provide the most useful insights for developing appropriate technology for specific target groups of farmers. The systems Framework is used to indicate the role of socio-economic analysis in developing appropriate technology.

INTRODUCTION

The general problem of agricultural development in the Caribbean is the sustenance of a rate of growth in the sector that allows for a *'balanced'* expansion of the regional economies. This rate of growth should simultaneously ensure that the sector make a strong contribution to increased rural incomes, food security, employment, foreign exchange earnings and improved environmental stability.

The capacity of the regional agricultural sector to contribute to the attainment of these goals is considered to be circumscribed by a range of factors. These include: first, the absence of an overall policy to create the necessary harmony between agriculture and other sectors both nationally and regionally; second, structural rigidities related to resource ownership, organization, utilization and support infrastructures, and third technical problems related to either inappropriate technology or mechanisms for transfer.

This paper is devoted to issues associated with appropriate technologies, their identification, design, generation and transfer. In this connection the hypothesis is presented that despite the various constraints to agricultural development, progress will to a large measure, depend on appropriate technology.

In the first section we summarise three leading models that have been postulated to explain the role of agriculture in economic development, and by extension the small farmer problem. In the second section, a conceptual framework related to the demand for and supply of agricultural technology is discussed. Issues of appropriateness of new technology for Caribbean Agriculture are examined in the third Section. The role of socio-economic analysis in the development of appropriate technology is explored in the fourth Section. Finally, some implications of our analysis are identified.

THEORETICAL FRAMEWORK FOR ECONOMIC GROWTH AND DEVELOPMENT

In an attempt to place the issue of appropriate technology in the broader framework of agricultural development we examine three leading models that have been postulated in relation to the role of agriculture in economic development.

These are:

1. The Dual Economy Model (Jorgenson, 1969)
2. The Poor but Efficient Model (Schultz, 1964; Johnston and Mellor, 1961); and
3. Unequal Exchange between the Centre and the Periphery (de Janvry, 1975).

The Dual Economy Model

The main feature of this model is a modern industrial and/or plantation sector and a backward small farm sector coexisting. The modern sectors are characterised by a high level of market orientation and technology. Conversely the backward small farm sector is seen as highly subsistence in orientation, and utilizing very low levels of technology, and archaic social organisation. An increase in the rate of technological change, increased capital investment in agriculture or a fall in population growth rates are seen as options for the small-farm sector. With economic growth over-time the backward sector is expected to disappear.

The Poor but Efficient Model

For this model small farmers are seen as operating in a relatively static technological, economic and cultural environment to which they are well adjusted and within which they operate as rational economic men. Schultz argues that given their circumstances, a feasible escape from their 'poor but efficient state' is to provide them with profitable new technology. Johnston and Mellor (1961) share a similar view, they argue that there are compelling considerations which suggest that the most practical and economical approach is to enhance the efficiency of the existing agricultural economy through the introduction of modern technology on a broad front!

Unequal Exchange Between the Centre and the Periphery

In this model it is postulated that the continued impoverishment of the small farmer is crucial for the extraction of surplus value from the underdeveloped periphery to the centre. The solution to the small farmer problem is considered to require drastic changes in the political power structure and distribution of productive resources.

Relevance of these Models to the Caribbean

The provision of new technology is a major component of the first two models. According to the Schultz's model agricultural research is required to change the existing production functions of farmers, given that they use their existing resources efficiently. Beckford (1972) argues that this model is inappropriate for the Caribbean because structural factors create sectoral inefficiencies in resource allocation. The real danger, Beckford argues, is that this model may provide decision makers with a false justification for ignoring the need for structural changes in agriculture.

It should be noted that the suggestion is advanced that emphasis on new technology as a strategy is a politically inhert mechanism in order to subvert, avoid or delay the need for fundamental changes in the Unequal Exchange between the Centre and the Periphery model (Arcia et al, 1981).

The Unequal Exchange between the Centre and the Periphery model appears to provide a reasonable explanation of the small farmer problem. In addition this model appears useful in that it is recognised that small farmers operate in a highly restrictive environment, and that their potential to adopt new technologies is closely linked to the institutional framework within which they operate. De Janvry (1979) provides an excellent analysis of the irrelevance of the first two Models to Third World development problems. His arguments are quite appropriate to the Caribbean situation.

While we do not consider the Dual Economy or the Poor but Efficient model as providing an appropriate agricultural development framework for solving the Caribbean small farmer problem, we see an important role for new technology in improving their economic situation. This is true particularly if the technology and the transfer systems are appropriate.

THE DEMAND AND SUPPLY OF NEW TECHNOLOGY IN CARIBBEAN AGRICULTURE

The concept of inducement and diffusion of technological change provides a useful framework for understanding the factors which influence the demand for and the supply of technical change (Figure 1). In this model the demand for and supply of new technology is conceptualised as a circular cumulative process.

The pay-off matrix is hypothesised as the key determinant of the demand for and the supply of technology. Both the demand for and supply of technology is constrained or promoted by the socio-economic structure on the one hand, and the political and administrative structure on the other.

Each social group such as the plantation sector, commercial, semi-commercial and subsistence farmers exert differential pressure on the political and administrative system to undertake or not to undertake research into specific areas depending on the pay-off each group expects. The relative social status of the group determines how respective demands get translated into resource allocation for particular types of research.

The research results are filtered through the socio-economic systems and produce specific pay-offs for different social groups who can capture and utilize it. These pay-offs are determined largely by (1) the physical characteristics of the innovation in terms of its capacity to raise yield or reduce cost of production; (2) the extent of the diffusion of the innovation, which is influenced by agro-climatic factors, social and institutional conditions; including: land tenure, access to credit, transportation, markets, etc, and (3) prices which determine its relative profitability.

The pay-offs, induce additional demands for new research and the process is repeated. The model is incomplete in policy mechanism which establishes research priorities. The rationale being that the demand of the disadvantaged social groups would not get translated into action because of their limited social power. In addition types of research which may have a high pay-off for individual groups may not necessarily be in harmony with national development objectives.

THE APPROPRIATENESS OF NEW TECHNOLOGIES FOR CARIBBEAN AGRICULTURE

Attempts to establish elements which define appropriateness of new technology must be guided primarily by the idea of relevance to specific social groups. That is new technology must be designed to be consistent with the agro-climatic and socio-economic attributes of some identifiable target group. In the Caribbean context such target groups can be either small-scale farm-households or the large-farm sector.

Appropriateness of technology can best be evaluated in terms of:

1. the receiving agro-climatic and socio-economic environment;
2. the nature of the technology; and
3. the approach used to generate the technology.

The Agro-Climatic and Socio-Economic Environment

A principal identifying characteristic of Caribbean agriculture is the dualism between large and small-scale farms. The salient features of this dualism is adequately covered by various authors (Beckford, 1972; Hope, 1981; Coke and Gomes, 1984; Persaud, 1988). These features include: First, dualism in resource endowment and organisation. The plantation system is characterised by large-scale units of production, hired labour, substantial levels of mechanisation, production enterprises which are largely monoculture and destined almost exclusively for export markets. These plantations, although numerically unimportant, control the prime agricultural land, have priority access to credit, irrigation water, highly trained management, research, transport and marketing infrastructures.

In contrast, the small-scale sector, which is numerically the dominant group, is typified by extremely low levels of resource endowment. These farms on average are less than 1 hectare, frequently of hillside land with shallow, eroded, relatively infertile soils. These farm units rely largely on family labour and other indigenously owned resources. The predominant tools are still the cutlass, hoe, hand fork, pick-axe and spade. Commonly several crops are grown with multi-cropping and mixed cropping widely practiced. Livestock are also reared to satisfy a range of objectives.

Educational levels on these small-scale farms are relatively low and so it is uncommon to find farmers who maintain reliable farm records.

These small-farm systems are relatively complex in comparison to the plantations. For example, on the plantations it is easy to identify the manager or a clearly defined decision making hierarchy. Such is often not the case on small farms where multiperson decisions are the rule.

The major implications of this dualistic situation are: first, because of resource endowment and resource organization the nature of the technology which is appropriate for the plantations would be largely inappropriate for the small-scale sector. Second, the approach which may be suitable for generating new technology for the plantation sector would have to be different from that for the small-farm sector. Third, agriculture tends to be very demanding of public services, and per capita cost of these services tend to be high both in small states and on highly dispersed small-farm units. In the case of expenditure on research, returns are expected to be higher the wider the area over which resulting innovations can be used. For example, economies of scale were achieved through regional research efforts in banana and sugar cane. This experience may have relevance for research associated with domestic food-crops and livestock. Fourthly, the differences in man/land ratios, labour, and structural rigidities are likely to be major factors distinguishing the appropriateness of technologies for the large and small farm sectors.

The Nature of the Technology

Agriculture technologies possess salient features which determine the ease or difficulty with which they can be captured and utilized by different categories of people. Consequently, the nature of the technology, whether mechanical, biological or chemical influences social relations and the distribution of benefits.

Byerlee and Polanco (1986) have proposed five characteristics of technologies which determine their relative attractiveness to different farm circumstances. These include:

(a) profitability
(b) riskiness
(c) divisibility or initial capital requirements
(d) complexity and
(e) availability.

Profitability may be very important to farmers who are profit maximizers (e.g. commercial farmers), whereas risk minimization may be of greater significance to semi-commercial or subsistence farmers. The divisibility of a technical innovation may determine the capacity of different groups to capture and utilize it. For example, large commercial farmers may be more attracted to a capital using innovation (e.g. tractors) which minimizes dependence on hired labour. Conversely, small-scale farmers are likely to be attracted to innovations which are land augmenting and labour using (e.g. high yielding varieties). Complex technologies are more likely to be adopted by farmers with high levels of education and management, while simple technologies which require minimal changes in current practices may be more attractive to small-scale farmers. Availability of inputs may be the single most important aspect of a technology which determines its adoption. In this context, availability does not simply imply the presence of the input, but the capacity of different groups to capture and utilize it.

Technologies may also be considered in terms of "packages " involving various components. Levels of these components are related to the above five characteristics. The input level of these components can be grouped as low,intermediate and high. This range of input levels may be important for different groups of farmers in terms of resources.

The characteristics of profitability, riskiness, divisibility, complexity, and availability are useful criteria of appropriateness only at the micro-level. Coke and Gomes (1979) and Sundguist, Menz and Neumeyer (1982) have proposed some useful criteria which are applicable to macro-level evaluation. These include the extent to which the technology contributes to:

(a) attainment of national or regional objectives i.e. social utility;
(b) efficient utilization of land, labour, capital, human skills, energy, etc.
(c) the reduction in the incidence of malnutrition;
(d) the reduction in adverse environmental externalities (e.g. soil erosion, and chemical pollution);
(e) the reduction in unemployment directly or indirectly;
(f) reduction in capital requirements, riskiness and increased cash flow performance;
(g) the avoidance of waste;
(h) increased flexibility for adjusting to changes;
(i) avoiding the need for sophisticated management;
(j) the creation of greater intersectoral linkages, and
(k) reduced dependence on foreign exchange requirements for the procurement of inputs.

In light of the various factors which need to be considered to determine the appropriateness of technology, a methodology is clearly required. An approach towards the development of such a methodology is considered in the following sections.

Approaches for Generating Appropriate New Technology

The two approaches for generating technology in the Caribbean are the (a) Commodity or Traditional disciplinary mode, and (b) the Farming Systems Research mode.

The Commodity Approach

In the late seventies, the commodity or traditional approach dominated agricultural research in the Caribbean. Up to the early sixties this approach focused essentially on the quantitatively most important products: sugar, banana, cocoa, citrus, coconuts and livestock. With this approach the above crop or livestock systems were identified for modification based on pre-determined objectives such as increased yields, resistance to pests and diseases, etc.

Substantial technical knowledge was accumulated with respect to these commodities. Both large and small farms benefitted from this knowledge, although it can be successfully argued that the former benefitted more because of economies of scale.

The neoclassical logic of this approach was that by assigning research to the most quantitatively important commodities, productive efficiency could be increased, and economic benefits would be distributed equitably between different groups in society. This neoclassical paradigm assumes that:

(1) farms are homogenous profit maximizers;
(2) there are perfect markets for the products;
(3) perfect information;
(4) almost perfect factor mobility; and
(5) product prices will express the values of the products to society.

In the Caribbean Scenario these assumptions were violated. Consequently, the commodity approach suffered from two types of inefficiencies (Trigo, Pinerio and Chapman, 1982):

(a) the possibility of biases for assigning research priorities based on arbitrary decisions rather than their contribution to development. In this regard development should be interpreted in its broadest context to include equity and efficiency considerations;
(b) the generation of technologies which because of their unadaptability to specific production conditions of the potential users, are not incorporated into the productive process.

As a result of this approach, small-scale farmers with limited resources and negotiating capacity remained disadvantaged. Recognition that these small-scale producers were not fully integrated into the mainstream of agricultural economic activities, led to some emphasis, still along commodity lines, to some research in root, cereals, legumes and vegetable crops in the sixties. However, the research results were not adopted. Starting in the late seventies the Caribbean Agricultural Research and Development Institute (CARDI), the Ministries of Agriculture in CARICOM member countries and the University of the West Indies adopted the systems approach.

The Farming Systems Approach

The systems approach has been particularly popular for research aimed at the small-scale farm-households. This popularity is based on the logic that these small-scale farm households exhibit a series of production conditions that make it difficult for them to adopt technology which was generated without taking into account their agro-climatic and socio-economic circumstances. (Trigo, Pineiro and Chapman, 1981; Garrett, 1986).

A systems approach implies not being reductionist, but examining the complexity of the problem situation using the ideas of organized complexity (Checkland, 1986). In an agricultural context a systems approach recognises that agricultural activities involve groups of interacting components which function as a unit and each component is capable of reacting as a whole to external stimuli (e.g. Becht, 1974; Spedding,1979).

The main features that distinguish the farming systems approach are that it is :

(a) holistic in outlook;
(b) both multi-and interdisciplinary and involves the coordinated use of surveys, on-farm trials and on - station experiments;
(c) focused on problems of identified and relatively homogenous groups of farmers;
(d) very much an applied problem-solving approach to research which is ongoing and includes evaluation and impact assessment as part of its procedure;
(e) based on farmer participation with emphasis on bottom-up communication and recognition of the farm-household as the key actor;
(f) requires participation from non-research agencies, because it is recognised that technology is just one of the problems of farm-households;
(g) ensures effective links to, and influences basic research;
(h) dynamic,action-oriented and adaptive in that tentative solutions to identified problems are tested and modified,

redesigned or rejected on the basis of accumulated knowledge, understanding and experience is assessed by the extent to which it leads to the development of socially desirable technologies that are readily adopted by its specified group of target farm-households.

The above analysis indicates that the results of commodity or traditional research may not be adopted because: farmers cannot perceive the relevance of the research results as solutions to their problems. Furthermore, the research may have been misdirected because the researchers misinterpreted the farmers' situation through lack of understanding of his desires, perceptions especially risk, and constraints.

In contrast, the farming systems approach through its emphasis on understanding farmer circumstances is more likely to give weight to the need of the farmer and society at large.

Despite the fact that traditional research over emphasises biological potential and priorities may have been set by governments or researchers (Scobie and Posada, 1976), there has been successful commodity research. Thus it can be argued that researchers must have had an appreciation and understanding of the farming systems relevant to their work (Dillon and Anderson, 1984).

It seems fair to conclude that the traditional or commodity approach is but a part of the broader methodology of farming systems approach. In fact the systems approach, although relatively new, has already made inroads towards convincing traditional or commodity researchers that this is so (Cohan, 1980).

THE ROLE OF SOCIO-ECONOMIC ANALYSES IN THE DEVELOPMENT OF APPROPRIATE TECHNOLOGIES

In this section we examine the role of socio-economic analyses in the identification, design, generation and transfer of appropriate technologies for Caribbean small farm-households. The framework for our discussion is the CARDI Farming Systems Research and Development Methodology which is depicted in Figure 2. The Methodology has been described by George and Hart (1985), and is not repeated here. Instead we indicate the role of (a) ex-ante analysis in the first two phases: descriptive and design of alternatives; and (b) ex-post analysis in the latter two phases: testing and transfer.

Ex-Ante Analysis

The first role of ex-ante analysis in the descriptive phase of the methodology is to ensure that research conducted is relevant to some specified target group(s). This can be achieved with social scientists working closely with other disciplines in the selection and characterisation of target area(s). To begin, let us assume that a choice must be made between a number of competing areas. Socio-economic disciplines can contribute by their involvement in selecting and using a set of indicators representing technical, agro-climatic and socio-economic variables. These variables can be used in a weighted criteria model to select the area(s) for research (Douglas, 1990).

Once the working area is selected it must be characterised to identify homogenous groups of farmers or recommendation domains (Byerlee et al, 1980). The identification of homogenous groups of farmers enables (a) the selection of representative farms from each group for future on-farm experimentation or other farm-level studies; and (b) allows findings from these representative farms to be extrapolated to the group from which they were selected.

At this stage the point should be made that there is a wide range of multivariate statistical and quasi-statistical tools that can be used for characterisation or classification of farm systems within target areas. These include principal components, discriminant analysis, and several clustering algorithms, some of which have been applied at IICA and at CARDI (Cohan, 1980; Douglas,1989).

The second contribution ex-ante analysis can make at the descriptive stage is to provide for each homogenous group an understanding of the current farm technology and how it relates to farm-households': (a) objectives or goals, (b) resources and how they are organized; (c) decisions in relation to trade-offs between production and consumption; (d) the agro-climatic, and (e) socio-economic environment.

This information can be used to construct conceptual or resource flow models, showing the interactions of the farming systems with resources, inputs, outputs, consumption, markets, etc. (Bogahawatte, 1984). Third, the information, in two, can be used as a guide to determine major constraints and possible alternatives to improve the farm system or a particular production system.

As depicted in Figure 2, the socio-economic disciplines can contribute substantially in the descriptive or diagnostic phase by participating in Reconnaissance Studies, Specific Problems Surveys, Island Studies, Farm Studies, On-Farm Production Systems Analyses or Field Station Studies to generate required information.

For the Design of Alternatives, knowledge gained, in one, two and three above is used to design alternatives that will conform to farmers circumstances.

During the Design of Alternatives, socio-economic disciplines can utilise a number of hypotheses: First, for homogenous groups operating under very dry conditions, drought resistant varieties will be very relevant, whereas a technology with increased demand for labour (family or hired) during period of full employment will be inappropriate. Second, in groups with low land/man ratios the general thrust should be towards land augmenting rather than labour-saving technologies. Third, alternatives with a high probability of being adopted will be those that involve:

(a) Minimal changes in current practices or those that are minimally disruptive for the system.
(b) Under surplus family labour conditions, technology which increases land productivity, and output quantity and quality will be preferred. Whereas with scarcity of family labour and unused land the best option will be technologies which increase productivity of labour.
(c) The maintenance of the diversity of both crop and live-stock production systems are preferred to those that decrease diversity, and
(d) Technologies that are divisible are most suitable for poor-resource farmers.

These simple hypotheses, among others, will assist in screening possible technological alternatives. In addition, socio-economic disciplines can apply fairly subjective analysis, or intuition to arrive at likely probabilities of (a) net benefits for each alternative at the enterprise levels, and (b) of research success, and relate this success to the size of the population that could benefit. This could allow research priorities to be established.

Our discussion on ex-ante analysis is summarised in Figure 3. This framework also provides the basis for our ex-post analysis.

Ex-Post Analysis

In most farming systems research programmes, the testing phase involves comparison of both the existing farmer technology and the alternatives being evaluated. At both the on-farm testing and the on-farm validation stages the following techniques can be employed:

(a) Partial budgeting;
(b) Cost Structure Comparison;
(c) Comparison of resource use;
(d) Dominance analysis; and
(e) Mathematical Programming.

The first four techniques are considered as partial, because they relate only at the enterprise level, while the fifth technique is employed at the whole-farm level.

Whole-farm models are particularly attractive since they allow alternative technologies to be evaluated in the context of the response of the whole-farm or prediction (simulation) of their effects on the farm-system if they are transferred.

In addition, the sociologist can conduct studies to identify factors associated with adoption of recommended farm practices, such studies may provide useful and appropriate transfer approaches.

A further and more complicated aspect of socio-economic involvement is assessment of the impact of technology at the aggregate or Macro-level.

In the previous section we listed a range of criteria against which the appropriateness of new technologies may be measured at the Macro-level. These criteria of appropriateness must also be related to the objectives of the specific technical alternatives being recommended. This is necessary, since no single technical recommendation will satisfy all the stated evaluation criteria. The objective of the technical recommendation will, therefore, inform the criteria against which it must be measured and the choice of suitable methodological approach.

Anderson and Parton (1983) have reviewed a range of ex-post methods suitable for macro-level assessment of new technology. These, in order of increasing sophistication and data requirements, are: rules of thumb, scoring models, production functions, mathematical programming models and benefit cost approaches.

Regardless of the model used for ex-post macro-level assessment of new technology it is clear that the socio-economic team will have to be very creative in overcoming the problems of model specifications, aggregation biases and data requirements. Another related challenge is the question of price effects resulting from technology related shifts in the supply of farm output. Clearly supply and demand elasticities will be required for relevant markets to determine price effects on adoption or non-adoption of recommended technology.

CONCLUSIONS

The importance of the agricultural sector in the overall process of economic development in the region was recognized. In view of the numerical dominance of small low-resource farmers in the population, it was questioned whether sustained agricultural development was feasible without their active participation. The problems of the small farmer were, therefore, seen to be relevant not only to agricultural development, in particular, but also to regional development in general.

In an attempt to place the issues of appropriate technology in the broader framework of agricultural development, three models concerned with the role of agriculture in economic development were reviewed. Arising explicitly or implicity from this review was the need for an appropriate theory of rural change and economic development specifically addressing Caribbean realities. This is, therefore, the first challenge to which economists and other social scientists must contribute their perspectives.

Despite our dissatisfaction with the generalities of the Models reviewed, we identified a fundamental role for appropriate technology in the process of rural development in the Caribbean. Against this background, we identified a framework which is suitable for analysing both the demand and supply of technology for Caribbean agriculture.

In developing our perspectives relating to the appropriateness of new technologies for the Caribbean, we couched the issues in the context of

(a) the agro-climatic and socio-economic circumstances of the receiving environments;
(b) the nature and characteristics of new technologies; and
(c) the process by which the new technologies are generated.

On the basis of observed dualities between the large and small-scale sectors of Caribbean agriculture, specifically in terms of resource endowment, organization and utilization, we conclude that different technologies would be appropriate for different components of the duality.

Our examination of the nature of technologies indicated that, in general, technologies suitable for the large-farm systems would largely be inappropriate for small farming systems. The basis for his conclusion is that relative factor scarcities in both sectors i.e labour in the large-farm sector and land in the small-farm sector should induce a search for technical innovations to conserve scarce factors. In addition, differences in education, farming objectives (e.g. profit maximization versus minimization of risk), access to resources, markets, etc would influence the kind of innovations (e.g. labour-intensive, capital-savings versus capital-intensive, labour-savings) which are required.

The analysis related to the process by which appropriate technology is generated led to the conclusion that (a) the commodity mode best served the interest of the large-farm sector given the greater degree of homogeneity in this sector (e.g. monoculture sugar and banana production for essentially protected markets). Conversely the arguments for farming systems mode is very persuasive in the context of small-scale farm-households.

Moreover, the commodity approach was seen to fit into the broader framework of a farming systems research mode. The farming systems mode was concluded to provide useful insights for the identification and design, generation and transfer of appropriate new technologies for specific target groups of farmers. Some implicit problems are however outstanding for the implementation of the systems mode. This represents a challenge for the organization of national and regional research systems. However, given a genuine interest for, and commitment to small farmer development, this problem should not be insurmountable. In fact a start has been made by CARDI, UWI and some Ministries of Agriculture.

The Systems framework was used to indicate the role of socio-economic analysis in the identification, design, generation and transfer of appropriate technology. Assessment at the micro-level was concluded to be fairly straight-forward given the portfolio of tools available to the socio-economic disciplines. However, the assessment of the appropriateness of technologies at the aggregate level was seen presenting some challenges. This challenge is particularly evident in the context of the impact assessment of research results in terms of achievements of national objectives. This will require a high degree of creativity on the part of socio-economic disciplines.

REFERENCES

Anderson, J.R. and Parton, K.A. (1983), Techniques for guiding the allocation of resources among rural research projects: the state of the arts, *Promethus* 1 (1), 180-201.

Arcia, G. Johnson, S.R. and Sanders, J.H. (1981), Policy Implications from the Bean Technology Experiments and Small Farm Decision Modelling, CIAT, Report No.6, Columbia.

Becht, G. (1974), Systems Theory, the key to Holism and Reductionism, *Bioscience* 24 (10), 579-96.

Beckford, G. (1969), Towards an Appropriate Theoretical Framework for Agricultural Development Planning and Policy, *Social and Economic Studies,* 17 (3), 233-42.

Bogahawatte, C. (1984), Evaluating Crop-livestock-based Farming Systems: A village level study in the Dry Zone Rainfed District of Sri Lanka, *Agricultural Systems,* 14, 199-212.

Byerlee, D. and de Polanco, E.H. (1986), Farmers step-wise adoption of Technological Packages: Evidence from the Mexican Attiplano, *American Journal of Agricultural Economics*, 68, 519-27.

Checkland, P.B. (1981), Rethinking a systems approach, *Journal of Applied Systems Analysis* 8, 3-14.

Cohan, H.E. (1980), Diagnosis Methods in Farm Systems Research; In J. Servant and A. Pinchinat (eds), Proceedings of the Caribbean Seminar on Farming Systems Research Methodology, Guadeloupe, May 4-8, 1980.

Coke, L.B. and Gomes, P.I. (1979), Critical Analysis of Agricultural Research and Development Institutions and their Activities, *Social and Economic Studies* 28 (March), 97-138.

Coke, L.B. and Gomes, P.I., (1984), The Agricultural Sector in L.B. Coke, P.I. Gomes and A.M. Gajraj (eds), *Caribbean Technology Policy Studies,* Institute of Social and Economic Research, University of the West Indies, Mona, 7-79.

De Janvry, A. (1975a), The Political Economy of Rural Development in Latin America: An Interpretation, *American Journal of Agricultural Economics* 57, 490-99

De Janvry, A., (1975b), The Organisation and Productivity of National Research Systems, ADC/RTN Conference on Resource Allocation in National and International Agricultural Research, Airlie House, Virginia, January 26-29, 1975

De Janvry, A., (1979), Nature of Rural Development Programmes: Implications for Technology design, In A. Valdes, G.M. Scobie, and J.L. Dillon (eds), *Economics and the Design of Small Farmer Technology,*Iowa State University Press, Ames, 179-194.

Dept. of Agricultural and Applied Economics: Agricultural Production Technologies, Staff Paper P82-5, University of Minnesota, St. Paul, USA.

Dillon J.L. and Anderson, J.R. (1984), Concept and 'Practice of Farming Systems Research. In J.V. Mertin (ed), Proceedings of ACIAR Consultation on Agricultural Research in East Africa, ACIAR, Canberra.

Douglas, C. (1989), Farm Systems Classification in the Eastern Caribbean: Concepts and Methodology, Paper presented to the 3rd Meeting of Network of Investigation Methodology in Farming Systems Research, Bogota, August 4-14, 1989.

Douglas, C. (1990), Farming Systems Research Project: Final Report, Caribbean Agricultural Research and Development Institute, St. Lucia.

Garrett, P. (1986), Social Stratification and Multiple Enterprises: Some implications for Farming Systems Research, Journal of Royal Studies 2, 209-20.

George, C. and Hart, R. (1985), The CARDI Methodology in A. Bory, V. de Reynal and F. Rosaz (eds), Proceedings of Seminar on Caribbean Farming Systems and Alternatives for Development, Martinique, May 9-11, 1985.

Hope, K.R. (1981), Agriculture and Economic Development in the Caribbean, *Food Policy,* (November) 1981.

Johnston, B. and Mellor, J.W., (1961), The Role of Agriculture in Economic Development, *American Economic Review,* 51, 566-93.

Jorgenson, D.W. (1969), The Role of Agriculture in Economic Development: Classical Versus Neoclassical Models of Growth, In: C.R. Warton (ed), *Subsistence Agriculture and Economic Development,* Chicago, Aldine.

Mellor, J.W. (1967), Towards a Theory of Agricultural Development, In H.M. Southworth and B.F. Johnson (eds), *Agricultural Development and Economic Growth,* Ithaca, N.Y., Cornell University Press, USA.

Persaud, B. (1988), Agricultural Problems of Small States with special reference to Commonwealth Caribbean Countries, *Agricultural Administration and Extension* 29, 35-51.

Schultz, T.W. (1964), *Transforming Traditional Agriculture*, New Haven, Yale University Press.

Scobie, G. and Posada, R.T. (1976), The Impact and Political Economy of Technological Change in Agriculture: the Case of Rice in Columbia, CIAT, Columbia.

Spedding, C.R.W. (1979), An introduction to Agricultural Systems, Applied Science Publishers, London, 15-32.

Sundquist, W.B., Menz, K.M. and Neumeyer, C.F. (1982), Technology Assessment as a Framework of Analysis for Agricultural Production Technologies, Dept. of Agri. and Applied Econ., Staff Paper P 82-5, Univ. of Minnesota, St. Paul, USA.

Trigo, E.J., Pineiro, M.E. and Chapman, J.A. (1982), Assigning Priorities to Agricultural Research: a critical evaluation of the use of Programmes by Product-line and Production Systems, *Agricultural Administration,* 11 (2), 23-33.

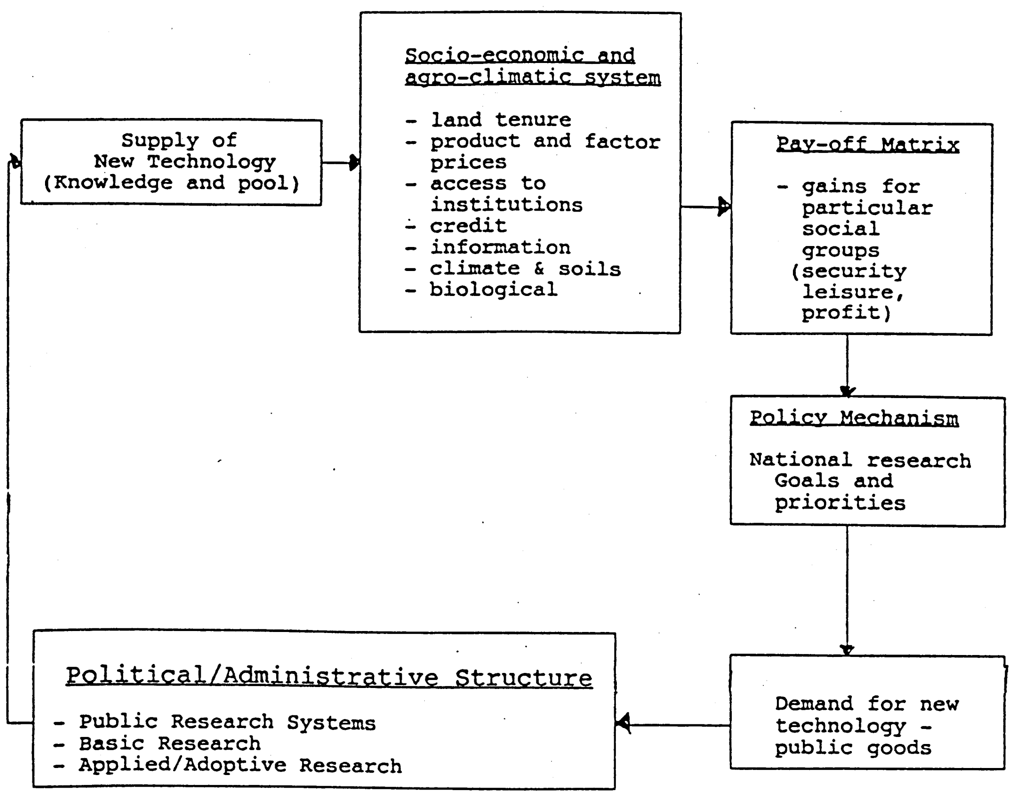
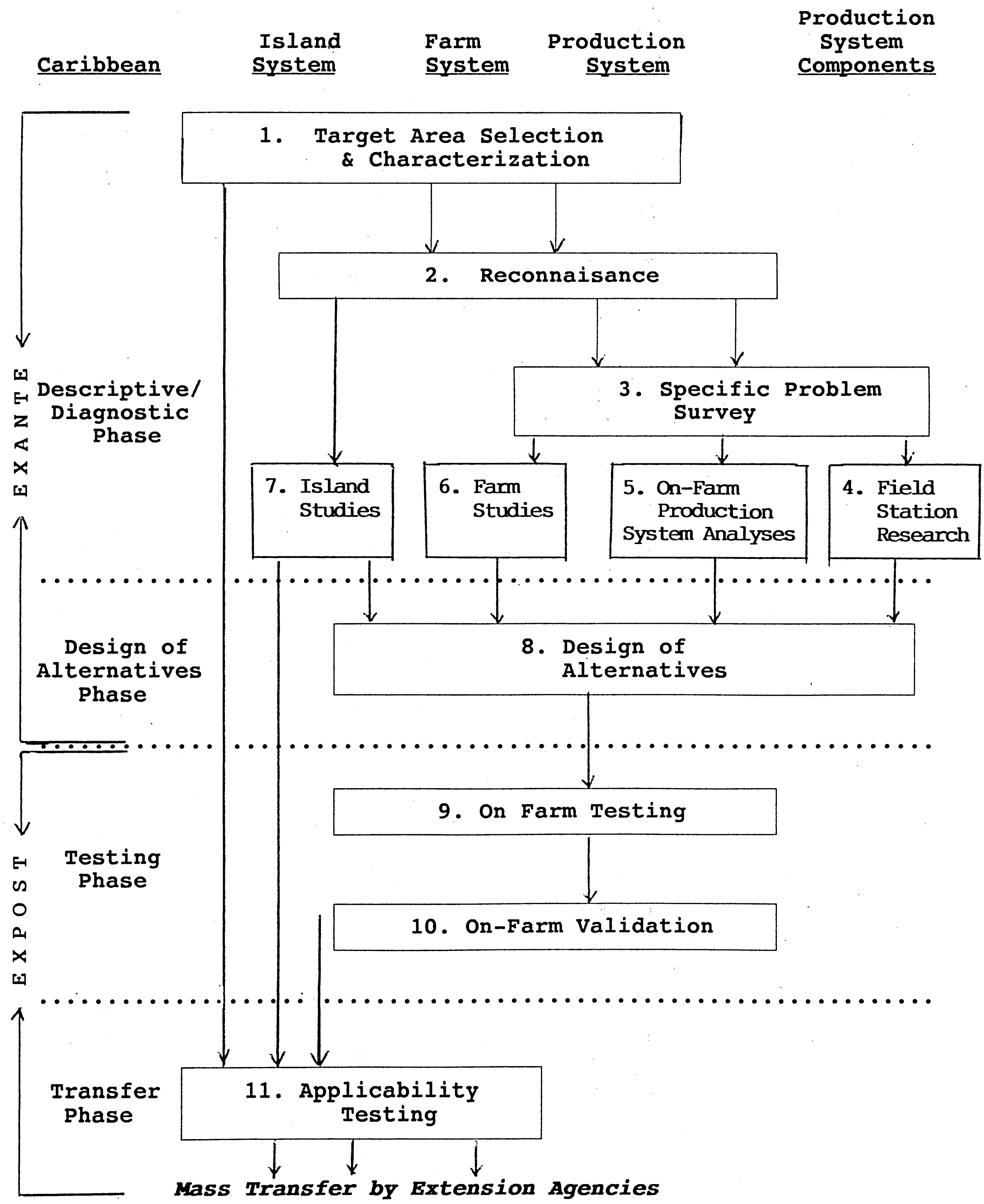


FIGURE 1: INDUCED INNOVATION MODEL OF DEMAND FOR AND SUPPLY OF TECHNOLOGY

FIGURE 2. CARDI'S FARMING SYSTEMS RESEARCH AND DEVELOPMENT METHODOLOGY



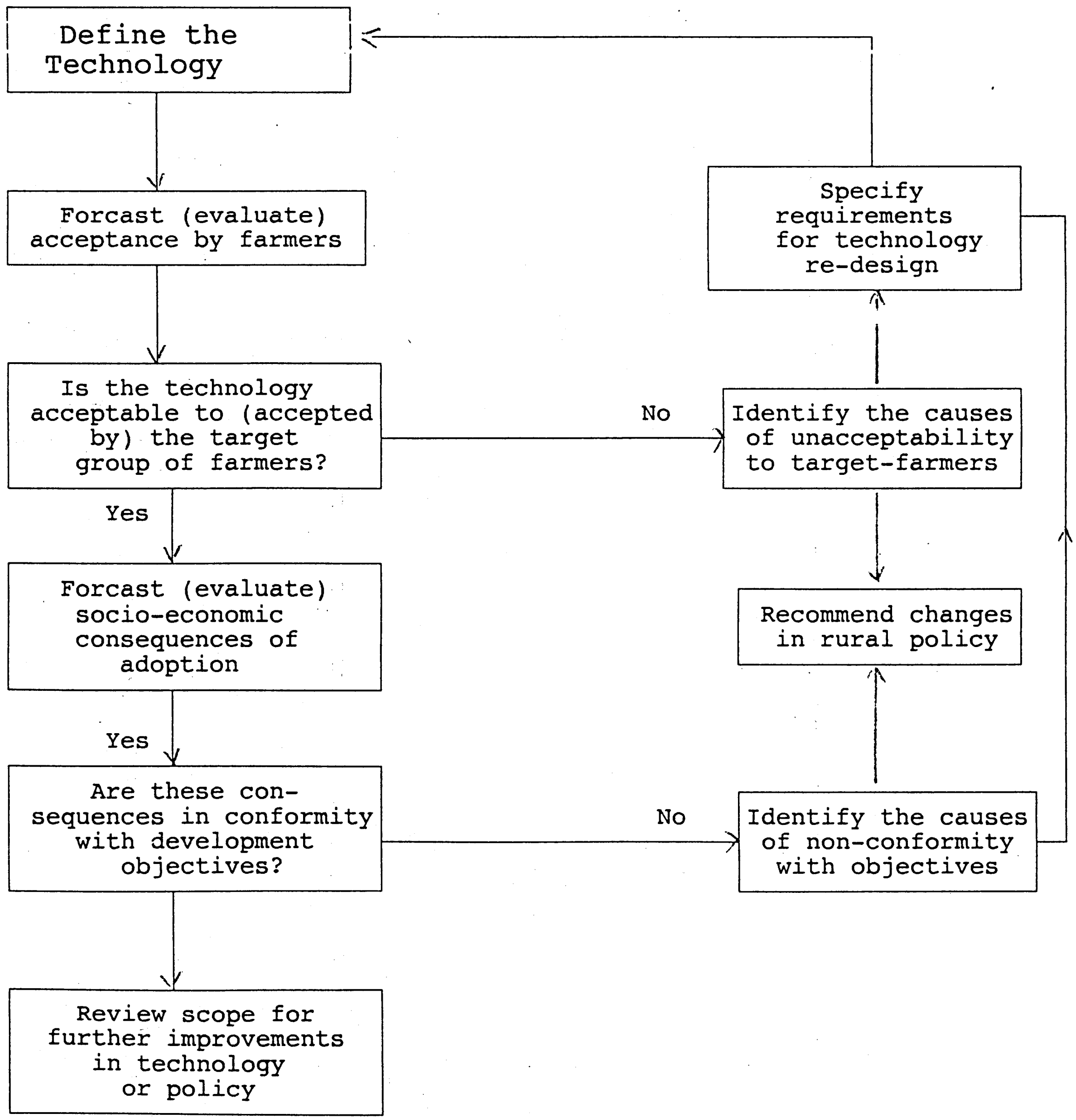


FIGURE 3: FRAMEWORK FOR EXANTE AND EXPOST ANALYSIS OF TECHNOLOGY