Institutionalization of Technology Development

David W. Norman

Abstract

Institutionalization of technology development is now a much more complex process than it was 30 years ago when the farming systems approach began to be popularized in low-income countries. The institutionalization of the approach occurred primarily in government-financed agricultural research systems that were almost wholly focused on technology development. During the last decade or so, structural adjustment programs and globalization of the world economy have had, and are continuing to have, a profound influence on many facets relating to technology development. These include its focus and the evaluation criteria used, the proliferation of funding sources and stakeholders, the need for those responsible for initiating, supporting and implementing technological research to be willing to be inclusive in terms of stakeholders, the need for empowerment/participation of the clients/beneficiaries in the whole research process, the blurring of the boundary between research and development, etc. Although many of these changes/trends are desirable, they tend to complicate issues relating to research management, design and implementation, and assessment, dissemination and adoption of the technologies that result. A brief overview of how these issues are dealt with presently, and, as a result, the challenges that need to be addressed, provide the main focus of this paper.

Introduction

It would have been a much easier task to write this paper 30 or even 15 to 20 years ago than it is today. During that period, major paradigm shifts have occurred in low-income countries not only in terms of those responsible for technology development, but also in approaches to, and accountability for, its development. Table 1 is an attempt to document in a very summarized form some of the very dramatic changes that have taken place. Three time periods are depicted, the early days coinciding with the Green Revolution (the 1970s), the days when the farming systems approach was most popular (the early 1980s), and the present day which is influenced so much by structural adjustment and globalization of the world economy. The changes that have occurred have had a very profound impact on the way that most of the issues I have been asked to consider have been addressed over the last 30 years. Since space does not permit detailed discussion on these changes, I will concentrate on the current situation. However, because there continues to be an evolution in the approach rather than a definitive, generally accepted, way in which some of the issues are currently addressed, some still relate to a great extent to those developed in the heyday of the farming systems approach. Before, however, looking at how the issues considered in this paper are currently dealt with, a cursory look at Table 1 indicates why technology development is a much more complex process at the present time, complicating the issue of its institutionalization in any formal sense. In this connection, pertinent points arising out of it, that relate to discussion later in the paper, are the following:

Professor, Department of Agricultural Economics, Kansas State University, Manhattan, Kansas, 66506, USA
(e-mail: dnorman@agecon.ku.edu).

Table 1 Changes in issues relating to technology development over time in low-income countries

Characteristic	Early 1970s	1980-85	Present time
Institutions mainly responsible for technology development:			
Sector	Public	Public plus farmers	Public and private including farmers
Number	Few	Few	More
Research emphasis: Direction	Top-down	Bottom-up	Bottom-up
Origin	Supply-driven	Demand-driven	Demand-driven
Perspective	Reductionist	Systems with supportive reductionist	Systems with supportive reductionist
Research funding	Reasonable	Reasonable especially for systems work	Increasingly limited/competitive
Decisions on, and responsibility for:			
Research prioritization	Mainly by research, some government	Research, government, plus farmers	Research, farmers, public and private sector developmental stakeholders
Research location (target area/groups)	Research plus government (policy)	Research, farmers, public sector developmental stakeholders	Research, farmers, public sector developmental stakeholders
Research and experimental strategy	Research	Research plus farmers	Research plus farmers
Research orientation/accountability with respect to:			
Farmers	Least	More	Greatest
Other stakeholders	Minor	Some	Major
Farmer involvement:			
Relationship with research[a]	Research extractive (isolated)	Consultative/collaborative	Collaborative/collegial
Problem/opportunity identification	Little	More	More
Designing/evaluating solutions/opportunities	Little	More	More
Disseminating promising results	Little	Some	More
Other stakeholder influence on research	Little	Some	More and increasing
Focus of research:			
Type	Strategic/applied	Applied/adaptive	Increasingly adaptive
Objective	Production	Production/equitability	Production/equitability (including sustainability)
Recommendations:			
Production environment considerations	Mainly physical (technical)	Physical and human (socio-economic)	Physical and human
Type	Few/ "blanket"	More/ "basket of options"	More/ "basket of options"
Approval process:			
Criteria importance: Researcher	Very high	High	Some
Farmer	Little	Some	More including other stakeholders
Sustainability	Little	Little	More
Importance of formal recommendations	Very	Somewhat	Less/spontaneous diffusion more acceptable
Segmentation of research/dissemination/ adoption continuum	Very	Somewhat	Decreasing

a. The papers given by Caldwell and McArthur at this symposium define the terms used in this row and develop the theme further.

- The numbers and types of institutions/groups responsible for developing technologies have increased and now include those in the private sector, both profit (i.e., commercial) and non-profit (e.g., non-governmental organizations (NGOs)).
- There has been increasing recognition of the need to incorporate farmers in the technological research process for the following reasons:
  * Many technologies developed have never been adopted, particularly those developed for poorer, more heterogeneous production (i.e., physical and socio-economic) environments (i.e., non-Green Revolution areas),
  * Increasing appreciation of farmer skills in terms of their ability to operate and survive in complex heterogeneous production environments,
  * Increasing recognition that farmers are experimenters in their own right and that instead of being passive ex post recipients of "developed" technologies they can play a constructive proactive ex ante role in helping identify, develop, approve and even disseminate relevant appropriate technologies,
  * The rapid evolution of participatory type methodologies (i.e., particularly in the 1990s) that help researchers (and also other stakeholders) work with farmers, that not only enable elicitation and systematization, and sometimes even quantification, of qualitative types of farm and farmer-related information, but greatly improve farmers' input into the technology development process itself,
- The relative isolation and insulation of researchers, especially in publicly funded research institutions, have diminished, resulting in increased accountability, because of:
  * Progressive evolution towards a seamless research-dissemination-adoption continuum,
  * Increased empowerment of farmers (i.e., see above),
  * The proliferation of agriculture-related stakeholders mainly because of the increased involvement of the private sector.
- Increasingly constrained financial resources (i.e., from government and donor sources) for public sector research institutions, and the demands for greater accountability (i.e., usually evaluated in terms of improvements in farmer productivity, and hence hopefully welfare, in a relatively short time frame) are resulting in:
  * Introduction of competitive research grant initiatives by some agencies (e.g., the World Bank),
  * Multiple sources of research funds often with specific conditions attached,
  * In the interest of achieving tangible results in a reasonably short time frame, a trend towards focusing to a greater extent on more "downstream" research (i.e., adaptive with some applied), sometimes at the expense of an appropriate systems orientation.

In general, apart from some aspects of the last issue relating to funding and accountability, the trends described above can be viewed as desirable, since increased inclusiveness of researchers, empowerment of farmers, and increased influence of agricultural development stakeholders, are collectively, likely to result in increased efficiency in creating a range of relevant sustainable technologies that can be adopted by different types of farmers and their families. However, it is also obvious that, in the quest for relevancy, efficiency, equitability, and sustainability, the institutionalization of technology development has become a much more complex process.

With these trends in mind, I now turn to the specific issues I have been asked to address in this paper, trying to evaluate them in the context and realities of the present day rather than simply in terms of the "conventional wisdom" of the farming systems approach that prevailed in the 1980s. Accordingly, after considering some of the issues relating to research design, implementation, and assessment of research results and their dissemination, I complete the paper with a short discussion on the types of research and a concluding comment. However, in dealing with these issues it is important to note that there is not universal adoption or even acceptance of all the factors discussed. Thus, I have tried to provide my own assessment of what, currently, is generally practiced or the trend that is taking place. Very useful references dealing with different aspects of the subject matter discussed in this paper are the proceedings of the recent biannual meetings of the International Farming Systems Association (IFSA), formerly the Association of Farming Systems Research and Extension (AFSRE), held in France, Sri Lanka, and South Africa, and the recently published book edited by Collinson (2000).

Research design

The demand-driven and participatory philosophy with reference to technology development obviously means that the prospective beneficiaries (i.e., mainly farmers) should play significant roles not only in determining, but also implementing, the technology research agenda. However, because of the large numbers of farmers, in relation to the limited resources of research-based institutions, particularly in countries with a great deal of diversity in terms of farming systems (i.e., reflecting the outcome of physical and human endowments and their interaction), difficult decisions have to be made as to which farmers and locations on which to focus research. This target area selection is often influenced by a number of interacting influences such as political considerations, the vociferousness of the local populace and/or their supporters, concerns about potential payoff from research, equitability and/or poverty, the seriousness of the problems (e.g., soil degradation, plant disease problem), the numbers of individuals potentially impacted, the importance of the area as far as the economy is concerned (e.g., providing food for the population, earning foreign exchange), etc. Collinson and Lightfoot (2000, p. 410) suggest an eminently rational approach to target area selection and the types of research to be done (i.e., discussed later in the paper), but in reality such logical criteria often receive less consideration than some of the influences just listed.

Characterization of the potential target areas is important not only in terms of helping in determining the general types of research initiatives that are likely to be relevant but also in helping to give an idea of the numbers of farmers and their families that are likely to be helped from such initiatives if they are successful. For both purposes, characterization of the production environment in terms of both physical (i.e., natural) and human (i.e., socio-economic) factors, and their interaction, is important. Unfortunately information on physical factors (i.e., climate and soils) is generally much more readily available and acceptable to technical scientists than human factors (e.g., population density, market access, ethnic origin, size of family, labor availability) although the recent evolution of Geographical Information System (GIS) techniques is likely to make the reconciliation between the two easier and more acceptable.[1] Identifying the numbers of farmers and their families that are likely to benefit from initiatives in a particular target area is an important consideration in determining whether to work on a particular issue. This is because the farming system, participatory approaches advocated in this paper necessitate working with small numbers of farmers representative of many more. Thus the issue of ensuring a multiplier impact from such focused research initiatives through the potential scaling-up effect (i.e., adoption of the results by other farming families) is an important consideration when research resources are very limited.

Following target area selection, the next critically important issue requiring resolution is to decide on

[1] Increasing appreciation for the close linkage between environmental degradation and poverty as a result of increasing numbers of people trying to eke a living out of a limited and fragile ecological base has reinforced the need to consider the interaction of the physical and human variables. The importance of this interaction is further exemplified by the recent ecoregional initiatives by the CGIAR institutions in partnership with NARS and other stakeholders, in which both sets of variables are considered. IITA has, for example, explicitly considered market access and population density as primary contributors to intensification of farming systems (Weber, 1996).

research priorities. Experience over time has shown that a critical ingredient in ensuring the successful acceptance and adoption of a new technology — or for that matter any new idea — is "ownership" on the part of all stakeholders. This is best achieved through encouraging the involvement of all stakeholders (i.e., farmers[2], researchers, and representative developmental "actors" such as communicators and support system providers (e.g., extension, policy makers, NGOs and private dealers)) in the process of planning, or at least approving, the research program, and to the extent possible, in its implementation (see next section). With the general move, in many countries, towards decentralization of developmental and research initiatives, regional/district-based stakeholder committees/councils are becoming popular as a means to coordinate local research/developmental activities, thus contributing to the trend towards a seamless research-development continuum. These, and farmer groups (i.e., once again, see the next section), provide appropriate fora for planning/approving the research program.[3] Although the major clients, namely the farmers, usually play the most important role in initial problem diagnosis and prioritization, increasingly the other stakeholders are viewed as playing significant roles in assessing their potential appropriateness, and in identifying potentially appropriate solutions and opportunities (i.e., the possibility of doing something that was not possible before, usually as the result of an exogenous or external change (e.g., improved market access, development of a market for a new crop)). As a result, stakeholder analysis is becoming an important component of the farming systems lexicon in helping to reconcile differing perspectives and helping reach a consensus on the priorities to be pursued. However, using farmers to help in initially diagnosing and prioritizing problems and solutions is sometimes criticized. Commonly raised criticisms and how they are increasingly being taken into account are as follows:

- Farmers very close to the subsistence level of living are likely to articulate short-term felt needs, the solutions to which will help ensure short-term survival, possibly at the expense of long-term sustainability. However, in the last decade, participatory techniques have been developed that can help farmers in transforming a foreseen problem into a felt problem (Woruba in Norman, Umar *et al.*, 1995), therefore moving it up the farmers' priority ladder. Good examples of this are the agroecological and aquaculture work of Lightfoot and colleagues (for example, see Lightfoot and Noble (1999)) and the integrated soil fertility work of Defoer and colleagues (Defoer and Budelman, 2000).
- Many of the felt needs or problems of farmers tend to require developmental rather than research initiatives for their solution. However, the development of fora referred to above that include representatives of both research and developmental stakeholders potentially enables such developmental needs to be addressed by the appropriate stakeholder.
- Any solutions proposed by farmers in response to their felt needs will be very limited and will be based on their own knowledge and experience. Once again, the fora mentioned above, provide a means of accessing and assessing solutions from outside (e.g., from other farmers, research stations, commercial sources, and increasingly from the Internet), thus greatly increasing the range of potential solutions from which selections can be made.

Stakeholder analysis is therefore very important in rationalizing research priorities and in deciding on the relevant potential solutions and/or opportunities to be evaluated. In contributing to this assessment/evaluation process, developmental stakeholders can also take into consideration that successful evaluation of the solutions

[2] It is important to note that farmers are not homogeneous in terms of access to resources (i.e., quantity and quality), attributes, goal(s) and of course gender. This means that there may well be some differentiation in terms of ascertaining problems, ranking priorities, and/or relative appropriateness of solutions. Therefore, farmers representing different "strata" or, in farming systems parlance, potentially different research or recommendation domains, need to be consulted (Norman, Worman *et al.*, 1995).

[3] For publicly funded research institutes, this is sometimes handled partly or in whole by a research program committee, once again, increasingly consisting of representatives of all the stakeholders.

and/or opportunities will be complemented by the support systems required for their adoption.[4] Substantial numbers of techniques now exist for systematically ranking and prioritizing problems and solutions, many of which appear in the documents cited in this paper.

Research implementation

During the research design stage, decisions also need to be made with respect to the degree to which farmers are to be involved in the research implementation process. Once again, the extent to which farmers, and for that matter, other stakeholders, feel "ownership," and commitment to accepting and using the results, is conditioned by the degree to which they are involved in implementing and, perhaps for other stakeholders, monitoring the research program. The conventional wisdom has generally been that the degree to which they are involved is determined to a great extent by the objective of the research protocol. For example, where there is a need to ascertain the cause-effect relationships between biophysical associated variables (i.e., treatments in a trial), researcher-managed and implemented trials (i.e., RMRI) of the type found on research stations are likely to be most appropriate.[5] However, such trials are likely to have more of an applied rather than adaptive research flavor. The latter is the primary focus of the farming systems approach, and as such involves research protocols that require direct farmer involvement — thereby involving interaction between physical and human variables — either in terms of providing labor (i.e., research-managed and farmer-implemented (RMFI) or, preferably, management as well (i.e., farmer-managed and implemented (FMFI) trials) (Norman, Worman *et al.*, 1995). Obviously the most relevant evaluation of technologies, as far as farmers are concerned in terms of their potential acceptance and adoption, occurs at the FMFI level.[6] However, in recent years there has also been a trend towards encouraging farmers to be involved at the more "upstream end" of the research spectrum (i.e., the RMRI level). This has sometimes only taken the form of seeking farmers' opinions and ideas on the potential treatments to be included in RMRI type trials (e.g., water harvesting-related trials in Kenya (Mellis in Sutherland, 1999) and Botswana (Heinrich *et al.*, 1990)). However, in recent years there has also been a trend to more direct involvement by farmers, for example, in participatory plant breeding programs (Sperling *et al.*, 1993), and in designing/implementing strategies that address ecological sustainability-related issues in which farmers in conjunction with outsiders (e.g., researchers and/or development specialists) use participatory approaches to examine trends in the flow of soil nutrients on their farms, and with this as a base, design and implement strategies that ensure and perhaps even improve the ecological sustainability of their farms in the future (Defoer and Budelman, 2000; Lightfoot and Noble, 1999).[7]

Farmer groups (i.e., both formal and informal) have become a very common and popular focal point for planning/designing, implementing and monitoring field trials, organizing farmer field days to publicize the

[4] Although beyond the scope of this paper, such stakeholder analysis also permits the possibility of assessing the felt needs of farmers that require initiatives that are purely developmental in orientation. Also, as a result, it also permits identification and implementation of other ways of improving the productivity and welfare of farmers and their families beyond those that are purely technologically oriented (e.g., local value-added processing, developing new enterprises).

[5] If the non-experimental physical variables (e.g., inherent soil fertility, weed complexes) are likely to be important in determining the cause-effect relationships, then farming systems advocates recommend that these trials are implemented on-farm with the non-experimental variables reflecting those faced by farmers (Norman, Worman *et al.*, 1995).

[6] However, in the move from RMRI to FMFI some scientists feel uncomfortable, since experimental designs have to be simplified, validity of and reliance on statistical techniques decreases, *ceteris paribus* conditions become more problematical, and replication occurs across farms.

[7] A number of CGIAR institutions, as well as national institutions and others have played leading roles in these types of initiatives (e.g., ICRISAT and CIAT in participatory plant breeding, ICRAF in agroforestry, and ICLARM in nutrient resource-flows). See the paper given by McArthur at this symposium for some information on these types of initiatives.

trials, and for facilitating interaction between and among stakeholders including farmer-to-farmer interaction. Substantial amounts of information on their advantages and functioning, and ways of organizing and operating them is available in the literature (FAO 1993; Norman, Worman *et al.*, 1995).[8] Farmer groups usually meet on a regular basis, to discuss research plans and implementation-related issues, and to evaluate results. They also, as just indicated, provide a convenient and efficient forum for researchers (i.e., both on-farm and station-based) and other stakeholders, particularly extension staff, to interact with each other and with farmers. In some countries, the extension service has developed even closer relationships with research institutions, in being responsible for the day-to-day supervision of on-farm research in their areas. Linkages and communication between farming system researchers, and on-station researchers,[9] extension staff and other developmental stakeholders (e.g., NGO and commercial sector representatives) are nurtured in one or more of the following ways: farmer group meetings and field days, stakeholder meetings at the district/regional level, and research planning and review meetings at the research institute level which increasingly include representatives of the different stakeholders (e.g., Tanzania, Kenya).

Assessment of research results and their dissemination

As a result of experiences relating to the lack of adoption of many technologies thought to be appropriate and relevant, the popularization of the farming systems approach, the trend towards increased incorporation of farmers in the research process, and recently increasing concerns about sustainability, criteria for evaluating technologies have become more complicated. Evaluation techniques now increasingly used include not only those that are formal in nature but also those that are more informal in nature. The former tend to rely on quantitative and objective (i.e., cardinal) types of data in emphasizing technical and economic aspects. Such information is important in providing convincing evidence to other researchers, and to planners and extension/development agency staff. Farmers involved in the trials usually make informal evaluations and thus tend to rely to a much greater extent on qualitative and subjective information of a more ordinal nature. These evaluations may be based on a large number of criteria that are weighted differently and are difficult to determine.

Evaluation criteria are further complicated by the fact that what is good for the farmer and his/her family may not be good for society as a whole. Therefore proposed changes need to be evaluated at these two levels. Details on these are given elsewhere (Norman, Umar *et al.*, 1995) but very briefly they involve:

● At the individual farmer level, assessing whether farmers would be:

* *Able to change* These are to a great extent quantifiable criteria and involve evaluating whether the technology is technically feasible, financially viable/reliable, and socially acceptable. Technical feasibility involves assessing the technologies under farm conditions (i.e., preferably at the FMFI level), sometimes involves the use of adaptability (i.e., formerly called modified stability) analysis to assess robustness across different production environments, and assessing feasibility and compatibility with respect to the resources and skills possessed by farmers, and compatibility with the support system that is likely to be available (e.g., market access, availability of the necessary purchased inputs). Economic analysis involves assessing returns in terms of the most limiting factor

[8] An important issue with reference to farmer groups is to avoid too much heterogeneity (i.e., farmers from different economic or social strata, mixing men and women) particularly if this inhibits active participation on the part of some members.

[9] Increasingly, however, the territorial boundaries between these two types of researchers are disappearing with all researchers expected to have a systems perspective, and to spend some time in on-farm research (Kenya, Tanzania). Although justifiable concerns have often been raised about the weak linkages between farming systems and station-based researchers, integrating them in this way undoubtedly potentially has some major disadvantages (Norman and Matlon, 2000).

(e.g., per unit of land when land is the most limiting input, per unit of labor put in during the labor bottleneck period when agriculture is very seasonal in nature and labor is most limiting). Types of economic analyses commonly used are cash flows, gross margins, budgeting, and risk analysis.

* *Willing to change.* These criteria are largely qualitative in nature and can be based on a large number of criteria. Participatory rural appraisal (PRA) techniques such as matrix ranking and scoring can be very useful in assessing and evaluating them.

● At the society level, equitability- related issues become important. This is considered in two ways:

* *Equitability within generations* Within households this involves assessing whether the proposed change will help or decrease equitability. For example, adoption of a technology may require more work on the part of women, thus increasing their workload, with little in the way of additional benefits accruing to them. Therefore gender analysis (Feldstein and Jiggins, 1994) becomes an important tool in assessing the potential benefit/value and equitability of a technology. Equitability between households also needs evaluation to assess that a technology suitable for one group of farmers does potentially not have a negative impact on the livelihood/welfare of farmers in another group.[10]
* *Equitability between generations* This in essence relates to sustainability in ensuring that the land remains productive for future generations to use.[11] The new approach to soil conservation, advocated by FAO, which embraces participatory principles, emphasizes, whenever possible, preventing soil degradation/erosion (i.e., preventative treatment) rather than the much more expensive approach of treating it once it has developed (i.e., curative treatment) (Norman and Douglas, 1994). This involves piggybacking ecological sustainability onto productivity. In essence this means assessing technologies in terms of their potential impact on ecological sustainability with preference given to those that improve both short-run productivity and long-term sustainability, and not supporting those that positively influence short-run productivity at the expense of long-run sustainability.

The beneficiaries as far as promising technologies are concerned, can be considered in two groups:

● The direct beneficiaries, the farmers and their families, who adopt and directly benefit from the technologies. For them, as indicated above, qualitative types of assessment are likely to be important in their decision to adopt. In addition, all other things being equal, the greater the flexibility there is in the management and application of the technology (i.e., so-called plasticity (Collinson and Lightfoot, 2000)), the greater is the likelihood of adoption by larger numbers of farmers operating in different production environments (i.e., human but also perhaps also even in physical factors).[12] Thus in addition to targeting information (i.e., indicating under what physical and socio-economic conditions the technology would be most appropriately applied) there is considerable merit in researchers, in collaboration and consultation with farmers and other stakeholders, developing conditional information (i.e., indicating how the technology might be applied in circumstances that deviate from the ideal)[13]

[10] In farming systems parlance these, in essence, are farmers in different recommendation domains, a stratification that can arise because of differences in command over economic resources, power, status, etc.

[11] Two other aspects of sustainability that are increasingly being considered, but which are not considered in this paper, are financial and social.

[12] Introducing new technologies (i.e., inputs, products and/or practices) into farmers' farming systems requires that compromises be made, in order that they fit. Thus there is now less support for final precise recommendations based on a prescribed and usually idealized technical management, which years ago used to be the typical output of many research stations.

[13] Adoption of this philosophy also means that for technological packages, a stepwise approach to its adoption is also often developed and advocated. Also in the same spirit, and in recognition of the heterogeneous production environments, there is a trend towards offering a range of technologies to farmers rather than the "blanket" (i.e., one technology fits all) technology approach that used to be commonly used.

(Norman, Worman *et al.*, 1995).

- The indirect beneficiaries, extension and developmental stakeholders (i.e., including planners), who have some responsibility in disseminating/promoting the technologies to, and supporting their adoption by, farmers and their families. To gain the necessary support and resources for such commitment often requires some form of formal recommendation, particularly on the part of publicly funded institutions/organizations. In recent years, decentralization of research and the proliferation of on-farm research involving much closer interaction with farmers have, in many countries, resulted in formal recommendation committees no longer being very effective or even operational. In the case of single component, divisible technologies (e.g., an appealing open-pollinated variety), this is likely to pose no problem, since it is likely to be diffused spontaneously via farmer-based networks. However, for those requiring support (e.g., hybrid seed production) or a learning element (e.g., a technology package containing both product and practice components, such as is usually the case in agroforestry-related initiatives) formal recommendations are likely to be important (Norman, 1998) even if the agency responsible for producing/distributing the inputs, and disseminating the necessary information, is in the private sector (e.g., commercial firm and/or NGO). Given the current trend towards decentralization of research, formal recommendations are likely to have another important function, in helping to improve the potential for scaling-up or multiplying the return from the research effort through encouraging adoption in other areas with analogous production environments.[14]

The research spectrum and institutionalizing technology development

Conventionally a research institution is ideally envisioned to conduct three types of research, namely strategic, applied and adaptive (i.e., on-farm participatory) research, which are complementary to each other and are necessary for a self-sustaining technology development program. Generally strategic and applied research concentrates almost completely on biophysical type research, with the socio-economic content becoming much more dominant at the "downstream" end or the adaptive end of the research continuum. Limited research resources have effectively excluded most low-income country institutions from engaging in strategic types of research,[15] while some have suggested that smaller countries, particularly those with diverse agroecologies, should focus almost solely on adaptive research, depending on technologies developed through applied research programs in other countries/institutions and/or developed in the increasingly popular regionally based programs (Lightfoot and Collinson, 2000). Because of increasingly limited research support in the public sector and the imperative to demonstrate impact, this move to greater emphasis on adaptive research is becoming increasingly apparent.[16] It is also apparent that in many low-income countries, this trend plus the proliferation of funding sources and the emergence of research-oriented initiatives in the private sector are reducing the coherence and control, and the nature of, the research programs, particularly in publicly funded research systems. It is obvious that the strategic, applied and adaptive research needs to

[14] Caldwell in another paper at this symposium further develops another significant issue in applying the farming systems approach, namely looking at systems at different levels (i.e., from the farm to the region) which also relates to the scaling-up issue.

[15] This type is generally perceived to be a comparative advantage of the CGIAR system, and high-income country- based institutions, including perhaps JIRCAS. However, even in the CGIAR system the imperative of producing tangible results and demonstrating impact in a reasonably short time period appears to be pushing their research programs further downstream than would be optimal.

[16] Incidentally, based on a six-country case study by Gilbert (2000), concerns that on-farm research is more expensive than station-based research are unfounded.

continue being replenished at the strategic/applied end of the pipeline, but given current trends, there is some uncertainty that this will continue to be the case. In addition some concerns have been raised about the use of competitive research funds — which are becoming increasingly common — in certain situations and circumstances (Farrington, 2000; Gill and Carney, 1999). It is also recognized that it is imperative that funding for public sector research (and for that matter extension) continues, particularly where natural resource management problems are severe, where most farmers have small farms and other very limited resources, and where the institutional and physical infrastructure is not favorable for private sector involvement. Unfortunately, at this stage, it is difficult to foresee the degree to which publicly funded research institutions and the systems perspective will remain intact (Farrington, 2000), although some appear reasonably optimistic about the prospects (Collinson and Lightfoot, 2000). However, whatever happens, survival is likely to require an even more demand-driven philosophy in order for research to be responsive to the needs of the clients (Gilbert, personal communication). Research-related initiatives by the commercial private sector obviously will generally continue to focus on relatively large farm operations involving marketable commodities usually requiring the purchase of external inputs.

Thus currently there is some uncertainty about the ways in which technology development will be institutionalized in the future. What is obvious, however, is that developing and sustaining linkages will be extremely important in ensuring connections between the three main types of research, avoiding duplication and overlap between public and privately funded research initiatives and institutions, and ensuring that the outcome of such endeavors produces useful results through linkages with agricultural development stakeholders including farmers.

Concluding comment - whither farmer participation and JIRCAS?

As I have indicated in the paper, there has been, in the last two decades or so, a paradigm shift in the approach to agricultural research which has resulted in major changes in the ways in which research is planned, prioritized, implemented, evaluated and disseminated. This shift towards greater participation — some would say empowerment — of farmers is consistent with trends that increasingly are considered desirable in society as a whole, such as decentralization, good governance, and democratization. A number of case studies have demonstrated increased productivity, improved sustainability, and greater equity in distribution of benefits, as a result of changes in the research approach reflecting this paradigm shift (e.g., Sperling *et al.*, 1993; Norman, 2000).[17] However, the conditions under which a research approach based on this paradigm shift is most likely to result in tangible impacts on the productivity and welfare of farmers and their families have not yet been fully determined. In evaluating its value and contribution, it is important to bear in mind that the "top-down" approach has often been unsuccessful particularly when applied to relatively unfavorable and heterogeneous (i.e., complex) production environments. Also the approach being implemented in so many parts of the world is still evolving methodologically, and is process-driven. As such it is dependent on the resources and skills available for its implementation, and contributions and efficient functioning of the other stakeholders who contribute to the agricultural development process. Availability of these process inputs, in fact, is the condition for the approach to yield the results so that it has a comparative advantage in producing more appropriate and equitable technologies. When the results of a participatory approach are sought, assessment and strengthening of these conditions must be built into the research plan for the process'

[17] Certainly a systematic study documenting the impact of farmer participatory approaches would be highly desirable at the present time. The paper given by McArthur at this symposium gives some qualitative information on the value of farming systems/participatory approaches.

to work.

What about JIRCAS and the role it might play in the institutionalization of technology development in low-income countries? I approach this issue with some trepidation since I am an outsider and know very little about your institution. Please excuse me if my comments are misguided due to inadequate understanding. As I understand it, the major focus of much of JIRCAS's program is what is called comprehensive research, which is analogous to what has been termed by Simmonds and Merrill-Sands (1986) as new farming systems development (NFSD). NFSD, in the sense used by Merrill-Sands, is concerned with biophysical type variables and therefore constitutes a type of strategic or, at the most, the "upstream" end of applied research.[18] As such it is a valid type of research, especially for production environments where farmers are close to fully exploiting the biophysical potential. However, I believe that it should not be viewed as a substitute for the type of farmer participatory research I have discussed in this paper, which focuses on the adaptive and "downstream" end of applied research. Rather I see the two types of approaches as being complementary to each other. As a research institution supported by a high-income country, JIRCAS certainly has a role to play in NFSD type research. However, I also believe that as a major research institution devoted to helping low-income countries, JIRCAS can also play a significant leadership role in developing and disseminating the more "downstream" adaptive research approach particularly in research systems in low-income countries that have less favorable and heterogeneous production environments under their jurisdiction, where incremental change may be the only type of change that farmers are willing to risk trying, and where there are likely to be returns from incremental changes in technologies.

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[18] CGIAR institutions have undertaken such types of NFSD (e.g., the alley cropping/farming work by IITA and the vertisol/watershed soil management type work by ICRISAT).

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