Institutionalizing participatory, client-driven research and technology development in agriculture*

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Involving users or clients in research and development (Participatory R&D) is commonly promoted as a principle of successful innovation. Within industry, the client orientation of America's most-respected and productive companies has been well-publicized (Peters and Waterman, 1984), with the most avant-garde flexibly pouring out new products to meet varied customer needs (Stewart, 1992). Within agriculture, senior research managers, responsible for innovation, have highlighted "learning from and serving the users" as a basic tenet for achieving technical change in developing countries (Nickel, 1988), with the emphasis on research collaboration as well as end-product consultation. Yet while farmer participation in agricultural R&D is now perceived as an essential feature of sustainable agricultural innovation by environmentalists, socio-economists, and politicians — as well as agriculturalists (National Research Council, 1989; Bhatnagar and Williams, 1992), the capacity of formal research to collaborate with clients remains remarkably limited (refs?). The purpose of this paper is to briefly outline the main issues which need to be addressed if small farmers in low-income countries are to participate on a regular basis in the design and development of technical innovations in agriculture.

KEY FEATURES OF THE PARTICIPATORY R&D APPROACH

Participatory R&D has some unique characteristics which will affect its institutionalization in the agricultural sector.

First, it is **client-driven**. This means that farmers' (i.e. the principal clients) knowledge, needs, criteria, and preferences have weight in decisions about technical innovation. It also, more fundamentally, implies that farmers are actively involved in decision-making about innovation, not just at the very late point in time when adoption (or rejection) occurs, but early in the process when the agenda for research is set, when specific themes are proposed, and when design features are determined.

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Client-driven agendas are likely to differ markedly from those geared toward basic, long-term research. Clients have differing needs, specific to their own agronomic and socio-economic situation. Farmers, when themselves innovating, have always done so in a given locality with particular constraints and opportunities in mind. Addressing client needs means that the technology development process itself must be sufficiently decentralized to meet diverse farmers' goals and to allow for site-specific, local adaptation. Such **decentralized technology development**, the second major feature of participatory R&D, needs to be organized to promote and reinforce multiple sources of "horizontal" innovation (Biggs, 1986). The decentralized model contrasts starkly with the conventions of applied agricultural science which is organised around the general principle of a "pipeline" or centralised research capacity generating technology which is broadly adapted to a wide range of circumstances.

Decentralized client-driven technology development requires both applied research and farmers to perform new functions. First, decentralization suggests that the "pipeline" or transfer of technology model must give way to a client relationship which is highly interactive, evolving through time, and in which farmers participate early on in R&D. Such client involvement generates important feedback for the design of prototype-technology, which is tested, and adapted to fit local circumstances, and may stimulate further applied research in response to client specifications. Decentralizing towards an interactive model means that applied research must have a sharpened capacity to integrate feedback and modify research schedules in response to client critique.

A second change required by a decentralised model is for applied research itself to take a proactive role in anticipating diverse clients needs in the form of assuring many options, not only "on the shelves", but actually in the fields. National research programs and regional experiment stations no longer need to produce "finished" technologies or final recommendations. Instead, to facilitate decentralized technology development, researchers should think in terms of prototypes: these may encompass 1) technological components which can be combined and managed flexibly to meet a given situation and 2) a "menu" of potentially useful options to be screened, and perhaps modified. The notion of "prototype" in this sense implies exposing farmers both to *early technological designs* as well as a *diversity of technological designs*. To prescreen prototype designs, farmers can be brought directly onto experimental stations (Sperling, 1992), onto farm sites set up for the purpose (Scherr 1991), or simply exposed to a general technological model, outlined theoretically, rather than physically (Sumberg and Okali, 1989). By screening prototypes, farmers can select technological alternatives to be tested and adapted locally or they can project new ideas for further development.

Effective decentralization of testing is a task beyond most public sector research services and it is in this realm that farmer partners become key research partners. Testing of many different "menus" tailored to different preferences and localities sets the third major feature of participatory R&D: **the devolution to farmers of major responsibility for adaptive testing.** Farmers take the lead in organizing experimentation, evaluating results, and transmitting local recommendations. Such devolution potentially allows for increased scale of testing, better targeting of technology, and more realistic technology evaluation.

The fourth important feature of client-driven R&D in agriculture centers on **accountability sharing.** Those involved in research (state research/extension programs; NGO's; producer organizations; local communities; informal farmer groups) become liable for the relevance and quality of technology on offer. One of the biggest obstacles to institutionalizing participatory client-driven R&D in the public sector is that, presently, most agricultural research systems and their staff are not penalized for producing technologies which farmers cannot use. A necessary feature of client-driven or demand-led R&D is that clients must have the right to "buy into" (or "sell out of") a research program via their control over a significant proportion of resources needed for that program. Were the level of applied research resources tied to the impact obtained by adaptive research; and were that same adaptive research financed to a significant degree by farmer-controlled resources, then the necessary receptivity to client-demand in the research system could develop.

In brief, client-driven R&D requires that clients have a vote in setting research priorities as well as in the design of the final technological products. Further, clients should play key roles in allocating resources, and in evaluating the performance of research programs to ensure accountability. With rights go responsibilities, and responsibility in this context implies that farmers share the implementation of some of the adaptive research load as well as bear some of its costs. Only then is decentralization possible.

The next section of the paper discusses the issues involved in institutionalizing this approach.

ISSUES FOR INSTITUTIONALIZING PARTICIPATORY CLIENT-DRIVEN R&D

Creating client-driven agenda

In setting a client-driven agenda, one of the most commonly raised issues is how to reconcile the diverse, and often competing priorities and preferences of different client participants. Cattle ranchers will have different demands from nomadic pastoralists; women farmers have different priorities from men; commercial farmers differ from semi-subsistence producers. A nightmarish vision could be painted of literally thousands of different demands for localized research "menus" being articulated by participating farmers; and the question is posed "how can research systems respond to this?" .

One way to reconcile the often competing interests of the various groups might be to give them representation in the research arenas where decisions are continually being made: e.g. on the boards of national and international research institutes. Several options have been proposed: farmers could participate directly in planning exercises; on-farm researchers could act as proxies for farmers; or pre-planning meetings could be held in farming communities (Merrill-Sands and Collion 1993). Research agendas would thus be negotiated within a centrally-administered research system. However, the issue of taking the client seriously still hinges to a large degree on researcher "good will", with a healthy dose of interpretation as to clients' real wants/needs.

An example of the shortcomings of joint planning for creating a client-driven research agenda is the experience of OXFAM'S "Project Agro Foresterie (PAF)" in Burkina Faso. PAF initiated an annual process of government agency/peasant organization/NGO joint planning. Although this gives farmers an opportunity to provide feedback, joint planning has not changed the basic power relations which determine the research-extension agenda. The priorities in technology development are still set by agencies, and although there are farmer experiments, these do not reflect a client-led agenda (Gubbels, 1993). Another example of the weakness of interinstitutional planning and coordination as a mechanism for creating client-driven research agendas, is the experience with Research-Extension Liaison Units (RELUs) in Ecuador. Typically, RELUs have brought together a government research agency, the ministry of agriculture's extension program, development projects, local universities and farmer organizations in a committee. The mandate of a RELU includes research planning (identification of problems and potential solutions), coordination of research, training and extension. RELUs are intended to be a forum for feedback on farmers' problems. In practice, an evaluation found RELUs' joint planning did not address farmers' problems. The RELUs were sometimes able to address this function when an individual or institution, who asserted farmers' interests, took control of the committee or dominated it. The constitution of a joint planning process including farmer representation did not in itself lead to client-agendas being recognised in research plans or acted upon by the participating institutions (Bebbington, 1993:19–23).

A different mechanism for determining whose research priorities are given weight is one which places a significant proportion of the available resources for financing research under client control. This approach removes the need for centralised research planning by creating the means for client groups to contract applied research and so exert demand-pull on the research system. Instead of centralised planning, however, clear policy guidelines for priority setting and for monitoring quality of research are needed. Under such a scenario, the central question for research managers and policy makers moves away from "how to reconcile clients' competing priorities" to "what is the socially desirable allocation of funds among user groups for purposes of contracting research?".

The contract scenario poses a series of challenges: 1) how to identify which user groups should get a chunk of the financial pie (those most important to economic growth? those most needy? those with the highest political profile?). 2) how to develop the capacity for client groups to express demand as aggregates rather than as individuals? and 3) how to improve the effectiveness of existing organizations to represent the range of client needs. We already know cases where wealthier, or particularly export-oriented farmers in both developed and developing areas have been able to influence research budgets and effectively lobby for specific technologies (for the Netherlands, see Roling 1989a, for Zimbabwe,see Biggs 1989). Poor farmers, however, and particularly those less market-oriented, organize less easily, and "their real ability to say 'no' to a technology makes itself felt but erratically (Roling 1989b), i.e. who cares if they don't adopt? Organisations representing poor farmers are typically pressed to address issues of income generation, and input supply (including credit) to meet the short-run needs of their members. The research agenda generated by such organisations' immediate needs is not necessarily formulated to include long-run research issues, or to represent the interests of diverse socio-economic strata among their members. An example is the experience of the federations of Indian farmers in the province of Chimborazo in Ecuador, which in the late 1980's organised simple adaptive research services linked to their own farmer-to-farmer extension and input distribution programs. In the 1990's the ability of some communities and families to influence the concentration of these services in favored communities, the dramatic rise in costs of agrochemical inputs, and the absence of viable alternative technologies weakened the credibility of the federations with their member organisations which began to break away. Correspondingly, the ability of the federations to represent and negotiate a coherent client-driven agenda with research institutions was eroded (Bebbington, 1993:10-12).

One way for poor, unorganised farmers to exert influence on a national or regional research agenda might be for NGO's to act as "brokers" or intermediaries which represent farmers interests in joint planning as well as by their active role in adaptive research and technology development. A huge volume of action programs are in place, mostly NGO-sponsored, which have the intent of speaking for smaller farmers. Such organizations are scattered across regions, of variable composition and intent, often short-lived. Little systematic evaluation is available on their effectiveness in articulating their clients' demands for research (c.f. Bebbington and Thiele, 1993.)

While lauding their considerable strengths, several pioneering reviews suggest important limitations in relying on NGO's to voice poor farmers' research needs. Overview studies encompassing some forty NGO's in Latin America, Africa and Asia (Carroll 1992; Riddell and Robinson 1993) show NGO's which have limited capacity to work with the poorest groups tend to select themselves out of activities which demand time, risk, or other commitments. Further, NGOs' agenda for technology development may be as susceptible to being ideology-driven as client-driven. Promotion of organic or environmental issues and validation of ethnic origins and ideals have been prime areas of NGO advocacy, sometimes in spite of clients' priorities (Farrington et al., 1993). Kohl (1991) provides a telling example in the development of protected horticultural systems (PHS) in the Bolivian altiplano which started in the 1980's and was disseminated by over 50 NGO's by the end of 1990. These intensive cultivation systems were designed and promoted by NGO's. PHS projects suffered persistent technical difficulties; often the production was insufficient to pay off the producers' debts. Kohl attributes the technical problems to faulty design based on trial and error methods of technology development, and a failure by NGO's to test the technology adequately before launching demonstration and implementation (Kohl 1991:6-11). Moreover, producers were rarely involved in the design or planning of PHS; the technicians who promoted them were never accountable for the technical success of PHS; and there was no compensation for participants who were engaged in a technically-flawed enterprise. The PHS experience illustrates that grass-roots, NGO-based initiatives may be just as vulnerable to disarticulation from client interests as are public sector research entities.

In conclusion,

Decentralizing technology development: reorientations in research

For applied researchers, decentralizing technology development implies a basic change in the way technologies are developed. Rather than focussing on fine-tuning a limited number of products and then verifying them on selected farms, the scientist develops a larger range of prototypes which will be tested and may be modified to suit specific needs and circumstances. Such a re-orientation suggests that scientists working on experiment stations should have a relatively good idea of the broad range of client needs and constraints at the beginning of the technology development process. It also suggests that scientists have to be prepared to part with their technologies at a relatively earlier stage in their product development—before they have "the" answer. Client-driven R&D will demand considerable behavioral changes and perhaps even role reversals on the part of the various participants (Chambers, et al. 1989). Increased involvement of farmers in the initial screening of prototypes, however, should mean that relatively more of the technological shortcomings, as well as promising opportunities, are identified early. Several examples illustrate the approach.

Rwandan farmers have considerable experience in managing local bean diversity: some 550 varieties exist countrywide and farmers themselves adjust mixtures of some 20 varieties for specific soil types and crop associations (Scheidegger, 1993). Despite such dynamic diversity on-farm, the selection sequence of the Rwandan Agricultural Institute (ISAR), paralleling western models, sharply narrows the diversity of cultivars on offer: while some 200–300 entries are initially screened, only 2–5 enter on-farm trials—the sole entry point for client feedback. From 1988–1993, an experimental program sought to draw on farmer' experience early in the breeding process, when varietal options were still extensive. During Phase I, farmer varietal experts evaluated 15 bush bean cultivars in on-station trials 2–4 seasons before normal on-farm testing; they then chose cultivars for home experiments. On-station evaluations showed that women experts select along two sets of criteria, preference and performance variables, with many of the desired attributes not easily integrated in a formal breeding framework. On-farm trials suggested farmers were well able to target cultivars from station fields to their home plots. Farmer selections outperformed their checks with average production increases of up to 38%; breeder selections in the same region showed, on average, negative or insignificant production gains. The range of cultivars desired by farmers was revealing: the number adopted from the two-year phase, 21, matched the total number of varieties released by ISAR in the 25 years previous (Sperling et al., 1993). During Phase II of the program, participants screened a broader range of cultivars even earlier in the selection process: 80–100 entries in on-station trials 5–7 seasons before conventional on-farm testing. In subsequent on-farm trials, laid in community plots, farmers selected 26 different varieties for home testing during the first two seasons alone. The experiment highlights farmers' ability and eagerness to screen large numbers of varieties relatively early in the R&D process. It also suggests important possibilities with prototype screening: enhanced and diversified production on-farm, significant savings from reducing on-station research.

Another example suggests the advantages of prototype screening with more complex technologies. Rwandan farmers sought to intensify production in crowded highland valleys, where they were cultivating dryland crops on raised beds. Scientists most readily conjured up the model of the "sorjan" system, practiced by Indonesian farmers, whereby rice is grown in the drains between beds. Yet rather than pursue a "logical" idea wholesale, they discussed with farmers a range of technical and managerial options, which to that point had been only cursorily examined by formal research. For example, rice could be grown in paddies in any of the three principal seasons as well as in drains; or green manures and aquaculture might be integrated in various ways; farmers also were encouraged to propose alternatives. Self-organized groups of farmers ultimately decided which options they would try, when, and on what scale and innovation was stimulated by several methods, including regular visits among groups in nearby valleys. The results, after three years of researcher-farmer interaction, were surprising; all groups rapidly appropriated rice, achieving mean yields of 3-4 t/ha with few external inputs. Equally striking was the diversity of ways in which the groups integrated the crop. Some grew uniform crops of rice in paddies, others rotated rice with maize and sorghum, still others combined rice with sweet potato production and fish ponds. By collaborating with farmers early on, scientists avoided investing costly investments in ultimately unacceptable technologies, the "sorjan" being a case in point. Farmers felt that the limited space between their raised beds did not justify digging a canal, building a dam and sowing a seedbed. However, they were prepared to take a much larger step: many, including the poorest, turned all their valley land into paddies to accommodate a crop they had never before grown. Researchers elaborate: "...had we attempted to design the technology in isolation before taking it on-farm, it is unlikely we would have considered the method employed in several groups .... Building and then destroying raised beds is prodigiously demanding of labour when considered on a hectare basis, but appears acceptable to farmers who manage only a few hundred square meters" (Loevinsohn et al., in press).

In conclusion,

Decentralizing technology development:
Developing farmer capacity to lead adaptive research testing

Participatory, client-driven R & D also demands considerable changes in research at the farm level, among the clients themselves. Institutionalizing farmer participation involves developing a community-based adaptive research capacity, achieved by working with groups of farmers (rather than individuals) and with producer organizations. While the participation of farmer groups in localized R & D facilitates farmer-to-farmer training, and rapid transfer of information about innovations, it also presents a series of challenges. Above, we noted that firm contractual arrangements would help determine an agenda for action with specific client groups. But do researchers have the skills to work directly with groups? In devolving adaptive testing to farmers, are research systems committing themselves to working principally through intermediary organizations, e.g. NGOs— and with what consequences (see Thiele et al 1988)?

Perhaps a more fundamental question hinges on the quality of on-farm testing. An argument against devolution of adaptive research to farmers is that as farmer participation in managing in on-farm experimentation goes up, so the reliability of data from such experiments goes down (Baker, 1991). This question needs to be resolved empirically by comparing the reliability, cost and pay-off to farmers of experiments with varying degrees of farmer participation (Ashby 1986). It has important implications for cost-effectiveness. If farmer participation in on-farm testing must be supervised to ensure reliable recommendations, then it becomes a very expensive luxury.

The issue of on-farm testing and data interpretation might be addressed from two different perspectives. First, how can scientists get more rigorous or scientifically interpretable data out of participatory trials? When farmers are involved in trial design and management, resulting data sets tend to be heterogenous within and among locations. Such trials, while realistic of actual farming practices, can be difficult for researchers to analyze and interpret. Statistical procedures are currently being refined to address such heterogeneity (e.g. Heinrich and Masikara 1992, Pinney 1991) and scientists have an important role in furthering the range of methods for handling "non-conventional" data, that is, data which does not emerge from the "conventional", fully-controlled, identically replicated experiments. Evidence exists that farmer-designed and managed trials can be highly predictive of future farmer assessment and adoption (Sperling et al. 1993). The more technical flexibility scientists have in handling heterogenous data, the more they may be willing to acknowledge farmers as major partners in managing on-farm research.

This concern with the reliability and scientific rigor of participatory methodology can also be turned on its head. Instead of asking, "how can researchers better interpret farmer-conceived trials", we might ask: "how can farmers be taught to internalize and manage western scientific methods (that is, researcher-guided trials) so these clients can generate truly robust data." Following this logic, farmers, independently, could generate locally reliable and adoptable recommendations—to be promoted by the formal research system. Several experiences show that suitably trained farmers are well able to manage simple replicated on-farm trials, with researcher input required mainly for research design and statistical analysis. Farmers, can interpret comparisons among treatments and make plans for new comparisons based on previous trials (Ashby, 1990). A proliferation of such trials would involve considerable changes in the role of village level extensionists. Instead of teaching farmers about finished recommendations, village-level workers would train farmers in the essential principles of experimental methods (see Bunch 1982).

Of course, as a third option, researchers might reorient their expectations of what adaptive testing should bring. On-farm trials might be conceived as a means of stimulating farmer innovation, with varied elements, in diverse combinations (Loevinsohn et al.,in press). Because of expected variability in farmer testing strategies, collection of statistically reliable data may not be possible. Giving farmers free experimental rein, however, may result in the completion of more realistic, hence more predictive, experiments. Farmer qualitative assessment of promising options may be sufficient if sample sizes are sufficiently large and if researchers can help differentiate among various farmer clientele (Scherr 1991).

Under all scenarios, the key question remains as to the costs and benefits of devolving adaptive testing to farmers. To what extent can the costs of adaptive research be "externalized" by the formal research system (via devolution to farmers) and at what return in terms of technical innovation? An experimental project designed to train Colombian peasant farmers in on-farm experimentation procedures and to assess their capacity to take over major responsibility for trial management and data collection found that the time input to farm trials of technical personnel could be reduced by up to 50 percent, once farmers' were fully trained. On average sixty percent of trials for which farmers were responsible were statistically analysable in the first year of this project; by the end of the second year, as the input of technical personnel decreased, 100 percent of farmers' trials were statistically analysable. The change was due to the greater autonomy given to farmers in handling the purchase of inputs which facilitated timely planting, and reduced loss of experimental plots due to tardy financial management by extensionists. The project's findings suggest that significant economies could be obtained in public sector on-farm testing, given appropriate training and devolution of this activity to even semi-literate farmers. (Ashby, 1993).

Identifying organizational principles for accountability sharing

Probably the most challenging issue is how to institutionalize sharing of accountability for research. Contractual relationships which set priorities among client groups and research programs can also serve as a mechanism for performance evaluation and accountability. Several different ways of using contract relationships to ensure accountability are being tried.

One option is direct accountability. A Chinese example is a harsh one. Eighty per cent of Chinese are smallholders farming less than a half hectare and most use traditional farming practices. In 1985, the State Science and Technology Commission was launched to manage China's agricultural research, with the goal of obtaining 70 to 80 percent of all research put to use by farmers. By 1987 the Jiangsu Province (one of China's wealthiest) had established more than 50 contracts between its Academy of Agricultural Sciences and its farming and trading organizations. These contracts accounted for 10 percent of the Academy's income; payment is based strictly on results with a refund to the client if a research project fails. As a result the academy has speeded up the release of new varieties and the production of seed which it sells to farmers, thus providing income for research (Forestier-Walker, 1987). There are also cases where strong client control has shaped programs with impressive research results. For example, in the Ivory Coast, the cotton development agency, CIDT, and the research institute, IDESSA, jointly plan the annual research program, including the budget. All funds available to IDESSA for cotton-related research, operating costs for technology development and linkages, are directly tied to a cess on cotton revenues. Simply: "the more effective IDESSA is in meeting CIDT's technological needs, the greater financial resources its gets for research on cotton" (Eponou 1993:41). Over the last thirty years, cotton yields have more than tripled in the savannah zones. During the same period, gains in coffee and cocoa, subsectors with no client contract, have been insignficant (Eponou 1993, pp. 41 & 58).

Another option for creating accountability is for farmers' organizations to finance and administer adaptive research activities, thus "pulling in" the relevant research and expertise required by their members. Examples of farmer organizations which have had high levels of control over adaptive research and extension are those in Chimborazo, Ecuador referred to earlier in the paper. Farmer organization carry out simple field trials with agronomists hired by the organization, and technologies are adapted in members' fields. Results are extended to members through the organizations' meetings, training courses and sometimes by extension agents financed by the organization. Members' demand for public sector research is communicated in a variety of ways, varying from formal petition by the national organizations to informal client-patron relationships between farm-organization officials and state agency employees. While farmer organizations that control some adaptive research can act as a constituency which channels demand to research, their capacity to influence the independent allocation of resources to different items on the research agenda is weak (Bebbington 1991:9). Capacity to implement adaptive research does not automatically ensure that farmers' organizations can materially alter the accountability of research organizations for delivering useful results to farmers.

A third option for creating accountability is to institutionalise evaluation of the usefulness of research to clients through a third party. For example project evaluations by the NGO FUNDAGRO, Ecuador, recently have included farmer-beneficiaries in evaluating both the project and the implementing agencies. This role in evaluation has stimulated farmer organizations to demand increasing control over projects, and to actively work on articulating research and extension to meet their needs: One farmer organization (UCIG) established a strong input into the national agricultural research institute, INIAP, with respect to orienting on-farm research and seed production (Bebbington, 1993).

As a national system, Chile has made some of the greatest advances towards institutionalizing accountability through contractual relationships. In 1986, the Agricultural Research Institute (INIA) was transformed into a private corporation which established contractual relationships with NGO's and small farmers' organizations to close the gap between research, extension and particularly small farmers. In one case, a major NGO, the Agrarian Research Group (GIA) implemented the contractual relationship to involve local farmers in joint planning. Farmers are organised into Village-level Agricultural Committees of 15-40 members, which in turn belong to an umbrella organization. These committees define a technical program including on-farm experimentation, and the allocation of credit funds. One result has been that farmer-led experimentation is recognised in budgeting: in 1990 a credit line was being tested to support farmers' experimentation with new crops or technologies

(Berdegue 1990:20). Committees established in each agroecological area are responsible for setting up a Centre for Adaptation and Transfer of Technology (CATT), directed by a joint committee which includes representatives from local farmers' organisations. The CATT committee has the responsibility of defining on-farm research priorities and issuing recommendations. Each CATT has a budget to pay for research requested by the committee from INIA. The contractual relationship obliges INIA to involve farmers' representatives in the selection of sites for local CATT committees, and in the definition of the annual research program. As of 1990, over a dozen organisations of small farmers had set up their own technical programs, operating as private extension firms contracted to implement extension programs drawing on CATT-sponsored research (Berdegue 1990:13-16).

Although it is still too soon to evaluate the impact of Chile's contract system on rates of adoption by farmers, the evolution of the approach to include farmers' representatives not only in planning, but in the budgetary decisions, illustrates what is likely to be an important organisational principle for institutionalising accountability sharing in the future.

ISSUES FOR THE FUTURE

There are significant gains to be made by institutionalizing client-driven R&D in agriculture. Previous sections have suggested but some of these: more productive, diversified and stable production systems; a greater number and range of farmer partners/beneficiaries; important research savings both on-station and on-farm. Case material, drawn from many continents, also shows that many R&D efforts already in progress aim to enhance client participation and address some of the formidable research and institutional issues involved in doing so.

There remain, however, key areas of research yet to be explored to ensure that the risks of Participatory R&D are minimized and its benefits expanded. Three of special note are signalled below.

Prototype screening, as illustrated earlier, will demand that both scientists and farmers take on new roles and responsibilities. Scientists, in particular, may be challenged to think in technological terms which are both broader and more specific. Broadening is realized in the form of a diversity of options which scientist can proffer and in their conceptualizing of models and components, rather than of fine-tuned products. Greater specificity, however, will also be demanded as scientists clarify the realms of their specific comparative advantage vis-a-vis farmers. Certainly one major task lies in initially screening the wealth of exotic options: for example, importing new germplasm; sharing experiences from elsewhere. Equally, scientists will have a heightened responsibility for screening and anticipating dangers which farmers cannot "see"—with this task having to take place significantly earlier in the research sequence. Using germplasm again as the technological example, scientists early on in the selection might screen for disease-susceptible or anti-nutritional elements—traits which may be "invisible" to farmer. In the past, scientist reluctance to share technological screening has hinged on a perception that farmer exposure to unfinished products means exposure to greater levels of risk (see Pachico and Ashby 1983). This issue has to be directly pursued. What have been the risks of exposing farmers to prototypes? Are the risks greater with exotic elements and less with recombinations of existing or known elements/practices? How can research plan and compensate to minimize such risks?

The second issue emerges from the products of prototype screening. The decentralization of technology development and the subsequent release of many technologies on-farm has important implications for the structure of technology support institutions. For example, in most research systems, breeders search for a few widely-adapted cultivars to accommodate large-scale centralized seed production (Davis 1990). Client-driven selection programs, however, which cater to various needs and offering a diversity of cultivars, will demand the development of smaller-scale and more decentralized multiplication systems so as to guarantee farmers' continuing access to locally-selected products (Sperling, Scheidegger and Buruchara 1993). Do scientists have the skills to diagnose the participatory capacity of support systems? What particular features make a technology support structure able to accommodate client-driven research? How can "participation cost-effectively be enlarged to encompass work with government agencies or ministries which explores ways of making them more responsive?

The third issue is the perhaps the most challenging and suggests that some of the weaknesses of a strictly client-driven agenda need to be anticipated. While we take as our primary clients small farmers in low-income countries, we also recognize that other interest groups have valid needs. Farmers' research priorities, which are commonly short-term, need to be reconciled with the priority of other social interest groups whose agenda may center on longer-term, less immediately-tangible benefits: for example, consumers concerned about pesticide residues, or conservationists worried about biodiversity). This raises the issue that participatory client-driven R&D may cause an imbalance between location-specific adaptive research (what farmers are most likely to demand as first priority), applied research geared towards understanding general principles (what scientists might like to pursue) and research oriented towards sustainability concerns (what special lobbyists might advocate as top concern).

The desired balance among research programs is, of course, a policy decision: what amount of resources should go to long-term research vs. that with immediate pay-off to farmers. To the extent that responsibility for short-term adaptive on-farm testing is devolved to farmers, and they absorb some of the costs, public sector resources may be freed for other types of research. Even under such a scenario, however, several issues need to be explored.

> –What institutional arrangements can ensure that research will respond to questions not resolved by client-driven adaptive research and yet which block progress on-farm?
>
> –What is the return on investments in adaptive vs. applied research, including the return on research particularly aiming for sustainability?

While cumbersome, these issues are open to research. Varying organizational forms might be evaluated for their effectiveness in promoting both a client-driven and applied research agenda. Analyses could also focus on the allocation of resources for applied vs. adaptive research among beneficiary groups (including future generations) and on documenting their relative achievements. Scientists can have a critical role in providing information to guide what are essentially political decisions.

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