Evolution of Concepts and Approaches of Systems-Oriented, Farmer Participatory Agricultural Research

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Abstract

Systems-oriented, farmer participatory agricultural research came to the forefront in the early 1980s in response to limitations of Green Revolution technology-driven approaches for small-scale producers in marginal environments. Farming Systems Research has emphasized both systems orientation and farmer participation. However, these two concepts are distinct. Systems exist at multiple levels nested within one another. On-farm research may focus on single crops, cropping systems, production systems, or farming systems. Farming systems research is participatory in setting research agendas and evaluating results, but experimentation is largely researcher-managed, with consultative modes predominating over collaborative and collegial modes. Participatory research developed in the 1990s has strengthened collegial farmer participation and replaces the technology transfer paradigm with a self-directed learning paradigm. It may involve single components or production systems. New production systems may also be developed by researchers without direct farmer participation. However, farmers rarely change immediately to new production systems. Systems change through accumulation of incremental changes over time is more congruent with farmer behavior. With increased transition from semi-commercial, subsistence-based agriculture to global market-based agriculture, new linkages increase participation by non-farmers, non-governmental actors become key partners, and the focus of change can become an entire regional system.

Introduction

Systems-oriented, farmer-participatory agricultural research came to the forefront of agricultural development methodologies in the early 1980s. Similar approaches that had initially developed independently during the 1970s in Asia, Latin America, and Africa were synthesized in the early 1980s under the term *Farming Systems Research (FSR)*. FSR was a response to limitations of *Green Revolution* technology-driven approaches for small-scale producers in marginal environments. From its initiation, FSR emphasized both systems orientation and farmer participation. However, these two methodological concepts are distinct and not obligatorily linked. In the 1990s, FSR researchers placed increasing emphasis on participation. Newer umbrella terms such as *Participatory Rural Assessment (PRA)* and *Participatory Research* became predominant, with the term FSR often encompassed within them.

In Japan, Farming Systems Research is used as an English equivalent for the Japanese term *Comprehensive Research (Sôgô Kenkyû)*. Comprehensive Research is a major thrust of JIRCAS' collaborative research programs. Its focus is on developing new farming systems. In the international farming systems research literature, this approach is termed New Farming Systems Development (Merrill-Sands, 1985;

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Simmonds, 1985). While participation is not excluded by definition, in practice it has not been a characteristic of most Comprehensive Research, and doubts have been expressed as to the value and necessity of farmer participation in research.

This paper reviews the development of FSR and Participatory Research approaches, describes the concepts of systems and participation, provides a brief historical background and some current examples of Comprehensive Research, examines the assumptions underlying New Farming Systems Development and their implications for participation, and concludes with suggestions for a future approach integrating participation into New Farming Systems Development. The objective of the paper is to stimulate discussion during and following the Symposium aimed at the identification of conditions when systems approaches and farmer participation are needed, determination of the relationships between basic, applied, adaptive, and client-led research, and clarification of the roles of formal scientific research, client-led research, and extension.

Origins of farming systems research

In the 1970s, several approaches emphasizing both systems and farmer participation developed independently in Asia, Latin America, and Africa (Caldwell, 1994a). In Asia, origins can be traced back to *multiple cropping* research in rice-based systems which began initially on-station in the late 1960s at the International Rice Research Institute (IRRI), Philippines. Then, as new rice production technology went into farmers' fields, it did not always perform as expected from station results, even in the irrigated lowlands (Plucknett, 1980). In upland areas without controlled irrigation in countries such as Thailand and Indonesia, the Green Revolution package approach of production recommendations had to be further adapted to even more diverse conditions. Methodologies for on-farm experimentation on cropping patterns and rice-based farming systems for site-specific conditions developed in response (Gomez, 1977). These methodologies took a systems approach to encompass other activities interacting with rice production, and a participatory approach to insure that the resulting technology would be compatible with farmer management objectives and constraints.

In both Africa and Latin America, the Centro Internacional de Mejoramiento de Maiz y Trigo (CIMMYT, International Maize and Wheat Improvement Center) developed and tested methods for identifying priorities for on-farm trials and for economic evaluation of trial results (Byerlee *et al.*, 1980). In Latin America, the Instituto de Ciencia y Tecnologia Agricoles (ICTA) developed a rapid team appraisal approach, called *sondeo*, or "sounding out" (Hildebrand, 1981). These approaches sought to involve farmers in identifying priority research needs and carrying out adaptive on-farm research on those needs. Hart (1982) and McDowell and Hildebrand (1980) developed farming systems concepts based on the farm as systems of crops, livestock, and the farm household mutually interacting among themselves and in a hierarchy of systems.

These diverse approaches were synthesized in the early 1980s, under the term *Farming Systems Research (FSR)* (Gilbert *et al.*, 1980). The book, "Farming Systems Research and Development" (Shaner *et al.*, 1982) became a standard reference in the 1980s. The global Farming Farming Systems Support Project (FSSP) used the term *Farming Systems Research / Extension (FSR/E)* (Caldwell *et al.*, 1997; Frankenberger *et al.*, 1997). Both FSR and FSR/E were used in the international symposium series that began in 1981 and led to the formation in 1988 of the *Association for Farming Systems Research and Extension (AFSRE)*. AFSRE explicitly emphasized participation, presenting itself as an "international society organized to promote the development and dissemination of methods and results of participatory on-farm research and extension" (AFSRE, 1990). In 1998, AFSRE adopted a more broad-based name for the association, *International Farming Systems Association (IFSA)*.

Systems and participation

Although the two concepts of systems orientation and farmer participation have both been characteristics of FSR, these two concepts are distinct. At the same time, however, they are linked. As a general rule, the greater the level of systems complexity, the greater the specificity of the system (because many different combinations of multiple elements are possible), and the greater the need for farmer participation to determine where and how to make changes that improve the overall functioning of the system.

Systems exist at multiple levels nested within one another. Production of a given crop 1 on a given farm may be represented as a system encompassing the crop plants, soil and water, and weeds, insects, and diseases (Fig. 1, lowest level). When individual disciplines that study each of these components are combined into a commodity program, such research can be seen as systems research at the level of a crop agro-ecosystem. The objective of *commodity research* is usually to maximize productivity of the crop, or in some

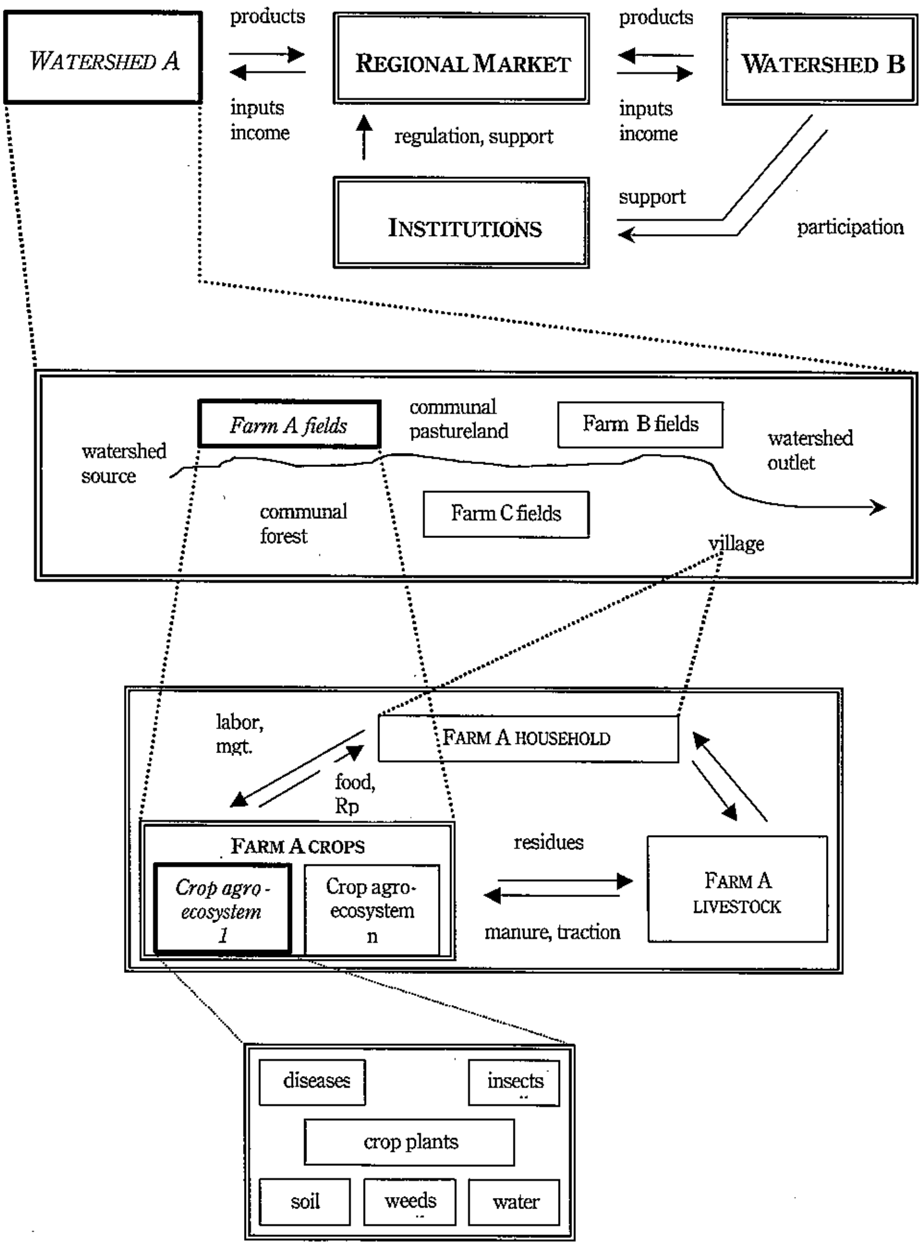

Fig. 1 A hierarchy of systems (inspired by Hart, 1982)

cases to improve the sustainability of the *crop agro-ecosystem.*

At the next level from the bottom in Fig. 1, the components of a given farm are viewed as a system. These components are crops, livestock, and the farm household. The different components interact with one another through the flow of products from one component that becomes inputs into another component. When a group of farms have similar systems, they are treated as a farming systems type, or domain in FSR terminology. The objective of research focused on a domain is to maximize achievement of the goals of the farm household. This is the level that FSR has traditionally worked at. Research carried out on representative farms belonging to a common *domain* may focus on a single crop agro-ecosystem, the cropping system formed by all the crops, the production system combining crops and livestock, or the entire farming system as a whole, including the household and its non-farm as well as farm production and consumption activities. In all cases, however, even if only one part of the system is the focus of research change, or *intervention* in FSR terminology, evaluation of results takes into account the response of the system as a whole.

Farms of one or more domains in a given area typically share a common resource base mediated by land topography and water movement. This resource base can be studied as a *watershed* (Fig. 1, third level from bottom). The farms in a given watershed may belong to one or more villages, depending on population density, size of the watershed, and social living patterns. At this level, fields belonging to different farms can interact with one another; fields, forests, and grazing land may interact; and the farm households interact among one another in decisions and customs regarding the use of shared resources. *Agro-ecosystems analysis,* as described in Conway (1994) functions at this level.

Finally, within a given region, such as a district or province, farms belonging to several watersheds are linked through regional markets and institutions (Fig. 1, top level). Economic analysis may be conducted at this level, biological research may be carried out on-station with the objective of developing a new farming system for the region, and potential wider impact in a region of on-farm research for a given domain may be considered, but on-farm research programs are usually not explicitly designed with the region as the unit of analysis, or for comparison of different interventions in different but similar regions.

The concept of participation was developed initially at the level of the farming system (Fig. 1, second from bottom). FSR focused on systems at this level is managed by small-scale farm households. Particularly in the developing world, but also in less advantaged parts of the developed world, such farm households typically have multiple objectives: *security, continuity,* and *identity,* as well as the objectives of *productivity* and *profit* more familiar to larger-scale agriculture managed purely on a business basis (Reijntjes *et al.*, 1992). In making decisions, farm households balance these different objectives, through strategies that include diversification, especially intercropping but also sequential multiple cropping and toposequence *diversification; recycling* of materials such as crop residues and fish and animal wastes; and extensification as well as intensification. These strategies can conflict, as for example in "soil mining" where short-term productivity places long-term security at risk (van der Pol, 1992). The particular mixture of strategies depends on site-specific environmental, economic, and socio-cultural conditions. The more complex the system, the greater the need for farmer participation to assess the effects on farm household objectives.

Merrill-Sands *et al.* (1989) discuss four types of participation: *contract* (researchers using farmers' land or services, usually on a payment basis, with no active participation by the farmers in the research); *consultative* (researchers consulting with farmers on needs, analogous to a doctor consulting with a patient, designing and testing solutions, and then consulting again with farmers on evaluation of the solution); *collaborative* (farmer knowledge included in the research design, and research designed, implemented, and monitored together); and *collegiate* (farmers carry out research on their own, with researchers providing information and services in response to farmers' requests). In a study of FSR projects in the 1980s, two-thirds used the consultative mode, while only one-third used a collaborative mode (Merrill-Sands *et al.*, 1991). The collegial mode was not characteristic of FSR in the 1980s.

Participatory research

In the early 1990s, in FSR symposia in Asia and North America, Chambers (1991, 1993) presented results of research using a collegiate approach, under the name of Participatory Research, and suggested that a paradigm and methodological shift away from both conventional technology transfer and FSR models of agricultural technology development to a self-directed learning paradigm could yield radically improved results. The first step in the new approach was the development of problem identification techniques based on visual sharing of information and analysis among farmers, called *Participatory Rural Assessment (PRA)*. PRA built on earlier *Rapid Rural Appraisal (RRA)* techniques for *diagnosis*, but used visual diagramming by farmers in place of oral question-and-answer interviewing. No longer was diagnosis a survey conducted by researchers on or with farmers, but an activity performed by farmers themselves. PRA rapidly became a mainstay of FSR and similar programs. When experimentation followed, it might involve single components (such as participatory selection or breeding) or entire production systems (such as those described in Lightfoot *et al.*, 1993), depending on farmers' priorities, interests, and resources. Formal designs and statistical assessment were replaced by farmer self-evaluation and adoption as criteria for measurement of achievement of objectives.

Comprehensive research

The initial concept of Comprehensive Research, or *Sôgô Kenkyû*, in Japan dates back to the 1940s (Caldwell, 1994a; Caldwell, 1994b; Iwasaki, 1952). Entirely analogous to FSR system concepts at the second lowest level of Fig. 1, it treated the farm as a management system of people, crops, and animals. This conceptual development was followed by a national program of on-farm trials at 389 sites between 1952 and 1962, termed the *einoshiken* program. After that period, Comprehensive Research was largely forgotten, as agriculture in Japan became more technical and commercial. However, in the 1990s, in response to changing economic conditions resulting primarily from liberalization of markets for agricultural products, Comprehensive Research was begun again in the National Agricultural Research system. Here, its focus was on the development of new systems that would be competitive in the face of global competition.

Comprehensive research outside Japan carried out by JIRCAS has largely followed this model also. Its objective is to develop new production systems to solve fundamental constraints for a region by "constructing a farming system" for the region. The long-term goal is improvement of the regional system (top level of Fig. 1). However, in practical terms, the research usually focuses on constructing a model production system linking crops, animals, fish, and in some cases also forestry, (second and third levels of Fig. 1). In Northeast Thailand, these linkages are weak in existing rainfed farming systems, so "constructing a farming system" for this region means research on use of residues from existing and new crops as animal feed and animal wastes as organic amendments (Kabaki, 2000). Potentially, these linkages may be built across farms of different types (dairy vs. crop-based). In terms of the classification of Simmonds (1985) and Merrill-Sands (1985), "comprehensive research" corresponds to New Farming Systems Development.

In this model of New Farming Systems Development, as predicted by Merrill-Sands (1985), farmer participation is not a significant feature. The research is carried out primarily on-station, or secondarily on land rented from farmers. Participation is generally limited to contract participation.

Indonesia's Agricultural Institutes for Technology Assessment are taking a New Farming Systems Development approach on-farm. On-farm trials in a lowland rice area in Bandung Province compared four systems, starting with farmers' rice production (model 0), improving rice production technology and adding in progression corn (in model 1), fish (in model 2), and finally cattle (in model 3), ending up in model 3 with a new system combining all of the above components (personal observation and personal communication, Aup Pahrudin, lowland rice regional team, Lembang Assessment Institute for Agricultural Technology (AIAT), Garut, Indonesia, September 2000). Here, farmer participation is more consultative in nature, incorporating PRA techniques at the beginning, but carrying out experimentation as in traditional FSR.

Assumptions of new farming systems development

Several key assumptions underlie the New Farming Systems Development approach. Each of these assumptions has implications for participation.

The first assumption is that existing systems are operating at the limit of what farmers can do, and that scientific research is needed to provide new options. This assumption is congruent with Shultz' "efficient but poor" hypothesis (1964), and is also supported out by the scarcity of success of community development efforts of the 1950s (Ruttan, 1975).

This assumption may not be equally valid, however, when farmers are presented with new alternatives for overcoming the limits of their current system. Farmers may have ideas different from researchers on which components to introduce change to first, and how to test and evaluate alternatives to their current systems. Farmers estimate the performance of an alternative based on empirical knowledge of management of the system over many years. Researchers estimate performance based on experimentation with one or a few components only, under experiment station conditions where other conditions are usually placed at optimum levels, supplemented by short-term observation and survey data of existing systems. Farmer participation in New Farming Systems Development could help direct the development of model systems.

A closely related assumption is that farmers will generally identify either short-term problems or very broad problems that go beyond agricultural research, like low prices for products. Working on short-term problems, leading to incremental change, will not remove the fundamental limits of existing systems. Those limits can be overcome only through ideas and techniques that are beyond farmer experience, that can come only from scientific knowledge and study. *Incrementalism* will not achieve a fundamental transition, hence the need to "construct" new farming systems based on information and perspectives not available to farmers.

Figure 2 depicts the research strategy of New Farming Systems Development. Technical needs assessment indicates the research potential of new farming systems at a much higher level than the

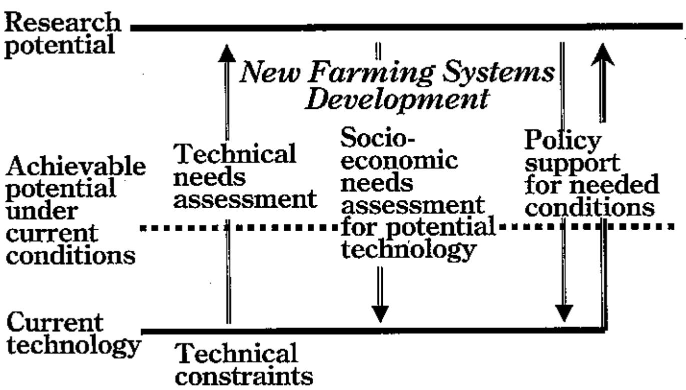

Fig. 2 Strategies and conditions for agricultural technology change

achievable potential under currrent conditions. The potential impact of incrementalism is seen as limited to an increase to the level of the dotted line ("achievable potential under current conditions").

With adequate time and sustained support, however, there is evidence from India (personal communication, Dr. V. Singh, International Rice Research Institute, September 2000) and Sri Lanka (personal communication, Dr. Alan Early, Agency for Agricultural Research and Development, September 2000) that incrementalism can result in fundamental transition of systems if sustained over at least 10 years. In Fig. 3, incrementalism is shown as exceeding current potential and gradually approaching the potential sought by New Farming Systems Development.

Much of the perceived failure of incrementalism may be due to the unwillingness of donors and administrators to make a long-term commitment necessary for incrementalism to succeed in this way, due to the need to show rapid results in administrative and financial systems based on annual review, annual funding, and assignments of two to at most five years. These short-term limitations of formal research and administrative systems are summarized by Chambers (1997).

Another assumption underlying the focus on New Systems Development involves the concept of the division of labor between international and national research centers, including JIRCAS, and regional agricultural research and extension systems (RARES). The mandate of national and international research centers is to conduct strategic research aimed at developing models for the future (top level of research potential in Fig. 2). Solving immediate problems of existing systems, and adapting technology produced by research, are seen as jobs of local institutions belonging to RARES. Using a medical analogy, solving such problems is viewed as being akin to the work of a family doctor, necessary to meet immediate needs, but not capable of overcoming fundamental problems that require basic medical research and the more advanced knowledge of specialists. In this concept, international and national agricultural research centers can be seen as being analogous to medical research centers, such as those working on cancer or AIDS.

However, international and national centers may have an important role to play in methods for the development of systems integration of new solutions. Again continuing the medical analogy, new drugs are tested outside the laboratory before they are recommended to the general public. On-farm research can be seen as analogous to testing of new agricultural technology outside the experiment station. The scientific soundness of induction from experiments at one or a few experiment stations to extension to thousands of potential users without an intervening step of testing with potential users is as uncertain as taking a new drug from the laboratory directly to the pharmacy counter without intermediate user testing.

If new seeds are analogous to a new drug, new production technology can be seen to be analogous to rehabilitation. Research on rehabilitation can only be performed in cooperation with patients, and patients can provide input into the improvement of the rehabilitation process. Moreover, such rehabilitation is most successful when patients themselves are involved in the design of the program.

In New Farming Systems Development, the role of socio-economic research is opposite to that of FSR, as predicted by Merrill-Sands (1985). New Farming Systems Development first seeks to determine what are the biophysical constraints on higher performance and sustainability, and what technologies can remove those constraints (Fig.2). Socio-economic research contributes by gathering information about the socio-economic context of current systems and the consequences of biological and physical constraints. Later, when biological research has constructed a new farming system that overcomes those biological and physical constraints, socio-economic research helps to determine the economic and institutional conditions needed for the new production system to be economically viable. This leads to policy recommendation (Fig. 2). In theory, if government implements policies that will create the needed socio-economic conditions, adoption should follow as a natural consequence.

FSR proceeds in the opposite sequence. FSR has traditionally taken the economic and institutional environment as given, and sought to determine what biophysical research on farmer priorities is feasible within the limits of that environment. FSR has assumed that over time, research can lead to a higher level. However, when policy support is needed, and how to introduce it, have not been well worked out in FSR, and remain an issue (Baker, 1993; Baker, 1998) (Fig. 3).

In New Farming Systems Development, farmer participation is seen as a part of extension, and "on-farm research" viewed as verification or demonstration. Participation and on-farm trials are tools for showing farmers the advantages and potential of the results of new technology or new production systems developed by biological research. In essence, farmer participation means farmer learning, learning about the new farming systems constructed by research, and learning how to use the technologies that make the new systems advantageous.

This approach is also based on assumptions about what farmers themselves want from research. The assumption is that farmers want answers, not participation. Farmers do not have the time, funds, or interest to work on developing answers; that is what farmers expect research to do. In this view, if research does a good job of providing useful answers, and the information reaches farmers, they will use those answers.

However, this view is not necessarily congruent with the behavior and thinking of farmers today. Farmers are more educated, and want to be more than the "objects" of surveys, contracts, or proposals for verification of researcher-developed technology. They demand a role in setting research agendas, are gathering information and trying out new alternatives on their own, such as circling a potato field with plants that support beneficial insects, and want to be regularly involved in the monitoring and assessment of station-based research (personal communication, three farmer-leaders, Pangalengan, Indonesia, September 2000). Farmers have requested that adaptive research focus on their priorities, and not be just a verification of technology coming from station researchers, leading the adaptive research institute to add a second experiment (personal communication, Mexy, Lembang AIAT, Indonesia, September 2000). Farmers want basic and applied formal scientific research to be defined by problems that they identify but cannot solve on their own through client-led on-farm research, and they want to be in control of adaptive on-farm research using new alternatives coming from the formal research system.

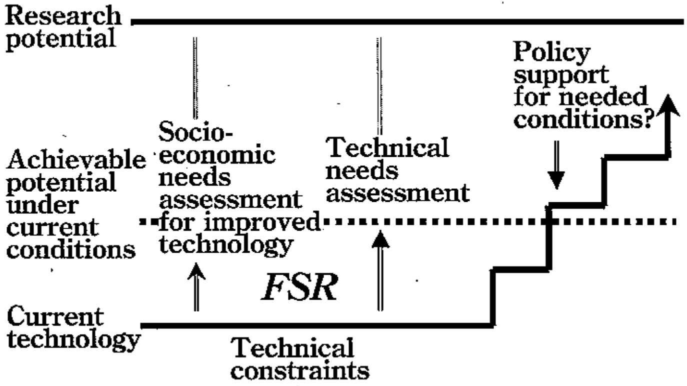

Fig. 3 Incremental agricultural technology change

Conclusions: Towards a participatory approach to new farming systems development

Three conditions must be met for the New Farming Systems Development model to work: farmers' access to information on the new system, their willingness and ability to take the risk of such a change, and policy support to make the change feasible. Providing information has traditionally been the mandate of extension, although information technology is making this more directly available to farmers without direct extension mediation. Here, this concluding section will focus on the last two conditions.

The willingness of farmers to make a total change to a new production system is a questionable condition. Change of systems through accumulation of incremental changes in component technologies over time is more congruent with farmer behavior, as Chambers (1997) summarizes from various experiences. The stepwise incremental increase of Fig. 3 may need to be superimposed on Fig. 2 in place of the direct arrow up to the level of research potential.

Farmer participation may have a key role to play at this point, not in the sense of extension, but in the sense of determining what is the best sequence of change to the new model system. In a participatory approach to New Farming Systems Development, multiple change components would be presented to farmers, with farmers given the choice of where to begin substitution. This approach would give insight into farmer change behavior and priorities. Monitoring of farmer systems with new components would also assess the effects of change.

An example of how such an approach might work is illustrated for Northeast Thailand (Caldwell, 2000). In the Northeast Thailand comprehensive project, technologies involving alley cropping, organic matter incorporation, no-till cultivation, and introduction of wet season corn and dry season forage crops have been developed over the past five years (Kabaki, 2000). These technologies could be combined into two mini-packages, one for soil conservation and the other for crop-livestock integration (Fig. 4). The mini-packages could then be tested both on-station and on-farm (Fig. 5).

In Fig. 5, the current farming system is at the far left. The next set of three clear vertical rectangles to the immediate right represents component research to date. The upper clear rectangle contains the mini-package of new soil conservation technologies, consisting of three linked triangles representing alley cropping, organic matter incorporation, and no-till cultivation, together with current technology, represented by a single triangle. The lower clear rectangle similarly contains a mini-package of new crop-livestock integration technologies, consisting of two linked diamonds representing corn and forage crops, together with current technology and other alternative technology, shown as single diamonds. The central clear rectangle represents

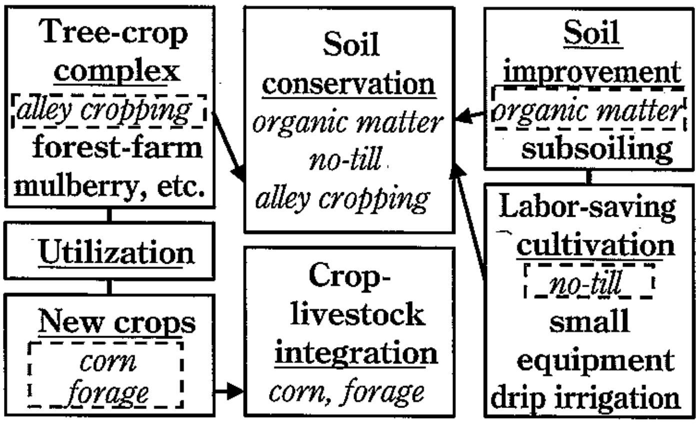

Fig. 4 Component technologies and mini-packages for Northeast Thailand

other areas of research.

Both New Farming Systems Development and incremental development proceed simultaneously to the right. The large clear rectangle to the immediate right of the three component research rectangles, labeled "R," represents a researcher-managed, on-station experiment in which all new components are combined into an optimum future model system. Parallel to this experiment, in on-farm research, following the participatory research principle of offering options, farmers would choose from the two mini-packages. Farmer 1, for example, might choose only the crop-livestock integration mini-package, Farmer 3 only the soil improvement mini-package, and Farmer 2 both. The environmental and management conditions of cooperating farmers would be monitored, to determine the conditions necessary for the successful incorporation of the mini-packages into a new system. If the results of these tests were favorable, an improved farming system with the two mini-packages could be offered to extension, resulting in the presentation to other farmers of similar systems and management. At a later point, farmers might then gradually incorporate other components, moving closer to the goal of the model new system.

Policy support for change is also a difficult condition. The cost of total change to the highest level of performance is usually beyond the means of most farmers, and perceived as too risky even for farmers who have or can obtain the needed resources. Risk involves not simply return to the higher investment required, but risk of potential loss of security of livelihood. When national governments do not have the resources to support the costs of changes, more emphasis may need to be placed on incremental change within the limitations of current socio-economic conditions.

The alternative is research to determine how to generate the income needed to support more radical change to new farming systems. The transition from semi-commercial, subsistence-based agriculture to global market-based agriculture opens up new opportunities for generating such new income. At the same time, research at this level, the highest in the system hierarchy of Fig. 1, requires participation by non-farmers, non-governmental actors become key partners, and the focus of change becomes an entire regional system. Methods to introduce, test, and assess change at this level have yet to be developed. Yet change at this level is necessary to provide the income flows in global market-based agriculture needed to pay for sustained, incremental change that can result in the fundamental transition sought by New Farming Systems Development. Change is made by farmers, at the lowest two levels of the systems hierarchy of Fig. 1, but they will undertake change only if they see that conditions for change are beneficial to them. The challenge for participatory research for New Farming Systems Development is to involve stakeholders, farmer and non-farmer, in research at the regional level (top level of Fig. 1) for the development of mechanisms that can

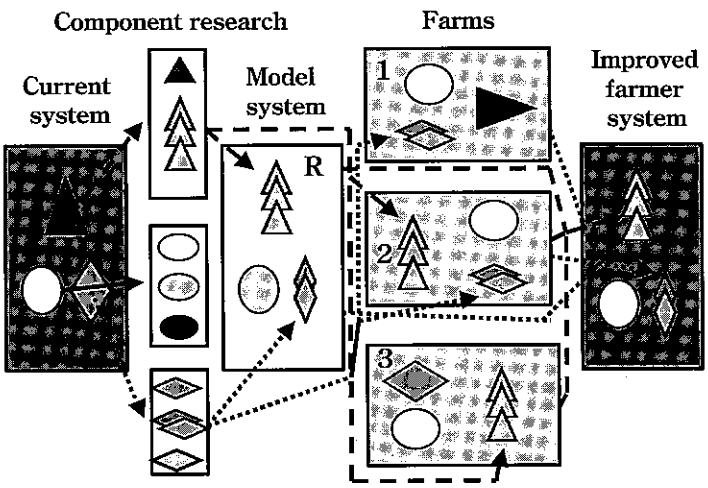

Fig. 5 Testing of two mini-packages

provide the income flow to enable farmers to make the individual changes at the lowest levels of the systems hierarchy of Fig. 1 that cumulatively across the region and across time will result in fundamental transition to higher levels of performance, income, and well-being.

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