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SUSTAINABLE AGRICULTURAL SYSTEMS

ISSUES FOR FARMING SYSTEMS[1]

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BACKGROUND

The development paradigm has shifted considerably in the last five years. Production of food is no longer the goal. The green revolution along with its associated high yield varieties and high input technology is being challenged and reevaluated.

The World Commission on Environment and Development (WCED) chaired by Mrs Gro Harlem Brundtland, Prime Minister of Norway, has made the following comments on the agricultural production systems developed in recent decades (WCED, 1987):

> The agricultural systems that have been built up over the past few decades have contributed greatly to the alleviation of hunger and the raising of living standards. They have served their purposes up to a point. But they were built for the purposes of a smaller, more fragmented world. New realities reveal their inherent contradictions. These realities require agricultural systems that focus as much attention on people as they do on technology, as much on resources as on production, as much on the long term as on the short term. Only such systems can meet the challenge of the future.

An Advisory Panel (chaired by Dr M S Swaminathan, former Director-General, IRRI) on Food Security, Agriculture, Forestry and Environment to the WCED in its report "Food 2000: Global Policies for Sustainable Agriculture" has stressed the need for preserving the resource base of agricultural production:

> Enduring food security will depend on a sustainable and productive resource base. The challenge facing governments and producers is to increase agricultural productivity and thus ensure food security, while enhancing the productive capacity of this natural resource base in a sustainable manner.

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The WCED Advisory Panel has stressed the importance of giving adequate attention to the sustainable livelihood security of the rural poor in order to protect and enhance the productive base of farming. They have explained three major reasons why sustainable livelihood security is basic to food security.

First, it is a precondition for a stable human population. The poor lack secure command over resources, expect some of their children to die and rationally have large families as a survival strategy. Their aim is to spread risks by diversifying their sources of food and cash with members in different activities and places, and to have sources of support in their old age. Only when livelihoods are secure, when children survive, and when assets like land, livestock or trees can be passed on to children, does it become rational to limit family size.

Second, secure resources and adequate livelihoods are prerequisites for good husbandry and sustainable management. Insecure tenure prompts quick exploitation with little concern for long-term degradation; secure long-term tenure encourages a long-term view and the investment of labour and funds in resource enhancement. The fact that poor peasants will hold on to their land even in the most distressing situations demonstrates the tenacious ability of the poor to take the long view with resources. But this is only possible with secure rights and when basic needs are met: the dispossessed and the starving cannot concern themselves with sustainability.

Third, sustainable livelihood security reverses destabilizing processes. Secured against a background of rural development, it eases rural to urban migration, thus reducing pressure on urban services and jobs, and weakens the demand for low food prices for the urban poor, thereby allowing incentive prices for rural food production. Increased crop production by the poor, where they are, with resources at their command improves their level of living and generates secondary employment. It reduces the need for food to be produced elsewhere and generally contributes to national economic development.

The most common term to describe these concepts is sustainability. TAC (1988) has recently addressed the implications of Sustainable Agricultural Production for International Agricultural Research. They suggested that sustainable agriculture should involve the successful management of resources for agriculture to satisfy changing human needs while maintaining or enhancing the quality of the environment and conserving natural resources. But sustainability should be treated as a dynamic concept, allowing for the changing needs of a steadily increasing global population. In the static sense, many traditional agricultural production systems were sustainable for centuries in terms of their ability to maintain a continuing, stable level of production. However, the needs and increasing aspirations of expanding numbers of people have forced changes in production practices that have imposed excessive demands on the natural resource base, making the modified farming systems unsustainable.

A recent meeting of some of the international research institutions not formally members of the CGIAR has further clarified the problem of sustainability (Annon, 1988). Three new challenges face us in agricultural development:

1. to safeguard and to sustain past increases in food production in order to feed the ever increasing global population. This requires sustaining the current resource base;

2. to improve the productivity of farming systems in less favoured environments; and,

3. to develop new production technologies that raise productivity but do not pollute and are sustainable.

In order to meet these challenges, a new and more encompassing research stategy must be developed. There is now considerable discussion within the national and international research communities to develop this new sustainable research agenda.

In this paper I will first discuss some of the recent developments in S E Asia (I have limited experience in South Asia but assume many of the issues are the same) in sustainable agriculture then make some suggestions how the Asian Rice Farming Systems Network can contribute to the development of the new research agenda that results in more sustainable farming patterns and component technologies.

REGIONAL IMPORTANCE

The issue of sustainability is very important in the South East Asian region. Concerns have been initiated by farmer groups and non-governmental organizations (NGO's) in the Philippines, Indonesia, Thailand and Malaysia. This initially was very much a negative attack on the green revolution and in the Philippines this was also part of the democratic movement. However, the last two years have seen considerable changes in official policies in all countries. There is now considerable support for policies in sustainable agriculture from governments, IRRI, other international research centres and regional organizations. For example, the South East Asian Pesticide Management and IPM Workshop, February 1987, sponsored by the Consortium for International Crop Protection and the Thailand Ministry of Agriculture and Cooperatives (which included representatives from UN, regional ministries of agriculture and chemical companies) recommended that "..... concerted efforts should be made by governments and pesticide industries to develop and promote Integrated Pest Management and called on governments to make a commitment to adopt IPM as their National Crop Protection policy."

The stress on sustainable agriculture is also shown by various donors (particularly GTZ, Ford, CIDA, SIDA, etc.) while many of the

International NGO's have had a long term commitment to this approach.

ISSUES OF SUSTAINABILITY

The issues of sustainability vary by country and environment. In this paper I will use the environmental classification used at the 1988 International Rice Research Conference, that is, by rice growing environment - irrigated lowland, rainfed lowland and upland. The importance of this classification as pointed out by a number of the papers presented at IRRC 88 is that the problems, solutions and methodologies are different for the various environments.

IRRIGATED LOWLAND

The rice bowls of Central Luzon in Philippines, Central Thailand and areas of Java have benefited the most from the Green Revolution and the new High Yield Varieties and associated technology. They are also the best examples of the environmental and social consequences of this technology and are in need of more sustainable technologies.

The areas in need of research in sustainable agriculture in irrigated environments are:

1) Overuse of agriculture chemicals
2) Sustainable pest management
3) Diversity
4) Soil sustainability

RAINFED LOWLAND

These environments particularily the unfavourable areas while low in stability eg., wide year to year variations in production because of variations in rainfall, can become much more sustainable.

The researchable areas in sustainable agriculture for rainfed environments are:

1) Low input soil improvement
2) Low input pest management
3) New cropping patterns before and after rice
4) Existing farmers strategies

UPLANDS

The uplands and highlands are the critical environments. The problems (but not solutions) are often obvious - eg., soil erosion; while in some upland farming systems where vegetables are grown, excess pesticide use is a major problem for applicators, consumers and downstream users. Sustainable systems are crucial in the uplands to avert environmental, social and political catastrophy. The insustainability of these areas threaten the other environments eg., deforestation on the slopes resulting in severe flooding in the plains during the rainy season and drought during the dry season.

The major researchable areas in sustainable agriculture for upland environments are:

1) Soil stabilization, maintenance and improvement
2) Traditional management systems
3) Low input pest management

RESEARCH ACTIVITIES

Sustainability cannot be studied in isolation but must become part of ongoing activities and networks. TAC (1988) states "consideration of sustainability should feature strongly in on-farm research. Sustainability should always be an evaluation criterion in the process for identifying, screening and adapting technological solutions to farmers' problems ..... The implications for applied research are clear. Just as it has become accepted that new technologies have labour, cash and management implications they will be important in the eyes of the farmers so they will also have implications for sustainability ..... These principles imply a continuing need for close contact with OFR through their involvement in networking arrangements with national research systems. They also have implications for the further development of training in OFR methodologies to ensure that evaluation of sustainability is adequately emphasized."

METHODOLOGY

1) Definition: The first problem is to define sustainability. Sustainability is not equal to stability. In ecological terms, sustainability is the ability of a system to maintain productivity when subjected to stress or perturbation. In other words, the wide fluctuations in rice yield (due to variable rainfall) in a rainfed environment like NE Thailand reflect low stability but not necessarily low sustainability. Whereas the steady decreased yields (caused by soil erosion) of continuously cropped corn (maize) fields on a steep slope in Northern Thailand indicates low sustainability. Sustainability can be measured but it is difficult and can only be done by time series data (unfortunately, after the fact). There is evidence from ecology that a high level of internal recycling and diversity increases stability.

There are now many meanings to agricultural sustainability. (Douglas, 1984; Altieri et al, 1984). There has, until recently, been little effort to quantify sustainability, but there is a body of knowledge in ecological theory which has relevance for agricultural systems. For example, one of the popular themes of ecosystem theory is the relationship between species diversity and system stability (Odum, 1971). In its simplest form, this theory suggested that simple systems with few species are less stable than more complex systems with a greater number of species. However, this theory has generated considerable arguments over (i) the methods of measuring diversity, (ii) the unit to measure, and (iii) the underlying mechanisms. The most recent consensus appears to be that increased diversity does not necessarily produce stability. It is, however, the connectances or linkages between species that are more important for system stability. (See Connell and Sousa, 1983; King and Pimm, 1983 and Margalef and Gutierrez, 1983 for examples of recent arguments.) Ecological theory does not help us much with the relationship between stability and sustainability. Although Holling (1973) uses the terms resistance and resilience both of which are properties of sustainability. Dover and Talbot (1987) give an excellent review of the ecological principles related to sustainability.

Conway (1985, 1987) identifies sustainability along with productivity, stability and equitability as systems properties that are useful in defining agroecosystems. Sustainability can be defined as the ability of a system to maintain its productivity when subject to stress or perturbation. Unfortunately, measurement is difficult and can often only be done retrospectively. Lack of sustainability may be indicated by declining productivity but, equally as experience suggests, collapse may come suddenly and without warning.

One of the appealing features of these systems properties are that they can be expressed in a number of parameters (e.g. kg, $, calories) which allows for an expression of biological, economic or nutritional factors. In addition there are various scales or hierarchies which have to be considered and the scales may vary with the parameters. Lowrance et al (1987) suggest agronomy sustainability can be measured at the field level, microeconomic sustainability is at the farm level, ecological sustainability could be at the watershed level and macroeconomic sustainability can be at the national or regional level.

At a recent IRRI meeting on the issue of sustainability an attempt led by Bob Herdt, Rockefeller Foundation, was made to further quantify productivity . This definition allowed for incorporation of elements of environmental, health and livelihood considerations by considering them as capital items and costing their depreciation. A recent paper (Lynam and Herdt, 1988) expand on this and point out clearly the areas needed for research.

The South East Asian University Agroecosystem Network (SUAN) (funded by the Ford Foundation with back-up support from East West Center, University of Hawaii and Gordon Conway, Imperial College, London) have also tried to produce an operational definition of sustainability. The proceedings of their recent meeting (Charoenwatana and Rambo, 1988) gives some examples of the practical application of sustainability.

The urgent need is for the development of an operational definition of sustainability so it can be used as a routine measure in farming systems research.

2) Farmer Participation: Issues of sustainability require further adjustments in Farming Systems Research. Many of the problems and indeed solutions are site specific. This is often viewed by component researchers as a problem. It is instead a challenge to further develop methodologies to deal with micro level problems and test possible solutions. The French-Thailand Farming Systems Project for example are using on-farm agronomic tools to carry out complex OFR research (Crozat and Chitapong, 1987; Sebillotte, 1987) instead of carrying it out on station. This approach is still considered too complex for wider application but the techniques could be simplified.

Many issues in sustainable agriculture research requires an extensive not intensive approach. Traditional fertilizer and pesticide research utilize an intensive approach at a few sites. The materials are applied at saturating levels which minimizes site to site variation by modifying the environment to make it more uniform thus allowing extrapolation over wide areas. However, for biological processes (i.e., BNF or biological pest management) the between site variability is usually much greater than within site variability, and so the conclusions are valid only for the sites studied. This problem is a familiar one in FSR where often one has to trade off intensive observations on a few sites for extensive observations dealing with a wide range of sites. The use of multilocation trials is a response to this. A similar sort of philosophy, i.e., of balancing and integrating extensive and intensive approaches, needs to be developed in research on sustainable agriculture problems.

We have to go one step further and that is to understand farmers as researcher and assist the farmer in his research (Lightfoot, 1986). As Patriquin (in let.) says " we should try as much as possible to put the research tools in the hands of the farmer... Ultimately, that is the only practical way to deal with natural variation on a one-to-one basis. It also merges research with development and accelerates the transfer of new technology to farmers."

We tend to think that farmers cannot do this research but long before there were plant breeding stations farmers were collecting and breeding. The best farmers have always been natural experimenters. Many traditional farming systems are far more sophisticated and complex than modern systems. There is now an increasing body of knowledge on "Participatory Research" which involves working closer with the farmer than traditional FSR. These approaches and methodologies (see Farrington, 1988; and ILEIA, 1986) can be incorporated into the various steps of FSR used by the ARFSN.

PEST MANAGEMENT

Chemical Pesticides: There is now considerable concern in the region about pesticde overuse. Rola (1988) has highlighted many of the hazard of pesticide use in the Philippines. She concludes that the preliminary results indicate both acute poisoning and chronic effects on the health of farmers (primarily economically active males). In spite of these effects, the farmers still continue to use pesticide as they feel it is the only viable crop protection method or they hire farm workers to spray pesticides on their rice fields (Adalla and Rola, 1986). Loevinsohn (1987) shows that the widespread use of pesticides by farmers on small holdings in Central Luzon was followed by a 27% increase in deaths among them from causes other than physical injury. Similar problems are becoming apparent in upland vegetable growing areas. In addition to the direct health effects there are indirect effects due to insecticide residues in human and animal feeds. There are also ecosystem effects (which have not been well documented in SE Asia): toxicity of aquatic organisms i.e., fish and frogs; loss of natural biocontrol agents; pest resistance (brown plant hopper in Indonesia is the most spectacular example).

The solutions are very complex and involve policy and political issues. The role of FSR in this process will be to assist in the development of alternative sustainable pest management technologies by:

1) carrying out OFR on possible solutions. OFR will be in conjunction with lab and station researchers working on botanical pesticides, biological and cultural controls, and IPM. This will be primarily in the irrigated areas but also in the upland vegetable areas with the objective of reducing and replacing current chemical pesticide usage. But equally as importantly,

2) identifying farmers practices, traditional knowledge, and attitudes then feeding this back to other researchers.

The above strategy assumes that pests are the problem and should be controlled, however, another approach is that pests are a symptom of a larger problem with the system. The solution therefore is to correct the fault in the system. This can be done by modifying soil fertility, increasing system diversity, synchronous planting, intercropping, spatial diversity, crop rotation (temporal diversity), increase natural pests and biological control and decrease the use of wide spectrum chemical control. This alternative pest management strategy is much more knowledge intensive than the chemical strategies they will replace. There will be a much greater need to determine farmers attitudes to pests, pest management and pest control decision making. In rainfed and upland environments farmers indigenous knowledge and practices will have to form the bases for the development of low input pest control strategies.

DIVERSIFICATION

One of the early achievements of cropping systems research in Asia has been to intensify and diversify cropping systems. The initial achievements were to add another cereal crop (rice or wheat) but recent efforts have been on adding upland crops (soybean in Sumatra and mungbean in northern Thailand). The earlier successes were primarily in irrigated or favourable rainfed environments. Recent research has clearly pointed out the lack of suitable cultivars for many of the unfavourable environments. This has led to increased breeding and selection for the harsh conditions of these environments (acid soil, drought and water logging).

The approach of developing new cropping patterns has not been successful in the uplands. The complexity of upland cropping patterns and the farmers decision-making process makes it difficult to do convential cropping systems research in this environment. It has, however, been more productive to examine wider problems eg., soil stabilization and test or develop new systems eg., contour farming.

SOIL SUSTAINABILITY

It is becoming apparent that the crop intensification has led to problems of maintaining soil fertility. Organic matter depletion, trace mineral deficiencies and decreased diversity of soil organisms are symptoms of decreasing sustainability. It is therefore very important to have long term studies of soil fertility in multiple cropping systems. For example, China is now using more chemical fertilizers and organic matter inputs are decreasing as the area of green manure is decreasing. It is also important to consider rotational cropping patterns that involve legumes in the system. As there is considerable evidence that the use of nitrogen fertilizer on legumes adversely affects nodulation, root development and nitrogen fixation, it is important to study soil nutrient recycling and availability and match crops and fertilization to these conditions. This requires that farming systems researchers and soil scientists work closely together.

There are many sources of bio-fertilizers that have potential in irrigated, rainfed or upland environments: BNF (legumes, blue green algae and azolla); manure and compost (however, composting is not appropriate in situations where there is a scarcity of organic matter and conflict between its use for fuel, feed and mulch. The solution is to increase the amount of organic matter rather than to produce compost); rhizobia and mycorrhizae (there are now considerable questions about the use of these potentially beneficial micro-organisms). The concensus is that breeding for promiscuous nodulation and promoting indigenous rhizobia strains are the best approaches for most crops. The promise that mycorrhiza offers under sterile control conditions have seldom been realized under field conditions for agricultural crops; green manures (their use is decreasing in China and they have not been widely used elsewhere in SE Asia) - the major questions are (i) how to fit them into farmers systems; (ii) what are farm level constraints (e.g. labour, cash, alternate land use) to their use; and (3) what are traditional practices?.

Contour farming/alley cropping appears to be a potential system for agriculture on slopping land as it offers the possibility of stabilizing slopes and decreasing soil erosion while at the same time increasing organic matter production for green manure, aninal feed and fuel wood. Systematic work has just started and considerably more information is needed on possible systems but, more importantly, constraints to farmers adoption.

FARMERS KNOWLEDGE AND CONSTRAINTS TO ADOPTION OF SUSTAINABILITY

This is a very important area for acceptance of sustainable technologies and requires increased knowledge of site level social and economic constraints. There are also macro level concerns related to subsidies, government policies, marketing channels, etc.

Particularily in the unfavourable rainfed and upland environments farmers have evolved many survival stategies which increase the stability and sustainability of their farming system. These strategies are not well understood but it is essential that new or improved systems build on this indigenous knowledge. This requires that site description be more detailed and social scientists' input will be needed on the FSR team.

Lightfoot et al (1987) give an example of the importance of land tenure and land security for acceptance of land conservation techniques. Where there is some security over land, shifting cultivators adopted long term solutions such as terracing and agroforestry techniques, however, when tenure and access to land are less secure they accept short term solutions of cover cropping which can accomplish the same aims. In many cases within the same barangay the technological solution will be different depending on the tenural status of the farmer.

CONCLUSION

The ARFSN is in the forefront of research in sustainability. There has been on going research on long-term cropping patterns, green manures and diversified cropping systems. The ARFSN has much to offer in future research on issues of sustainability. The first step is to operationalize a definition of sustainability that can be used to assess new components and farming patterns.

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