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LONG-TERM VS. SHORT-TERM ECONOMIC AND RESOURCE CONSIDERATIONS IN FARMING SYSTEMS RESEARCH

BY

Dr. Sam H. Johnson III

Assistant Professor

Department of Agricultural Economics

University of Illinois

at Urbana - Champaign

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Abstract

Farming system research (FSR) is presently being promoted as a more appropriate research tool for agricultural development in LDC's. However, FSR has tended to concentrate on rapid, short-term gains. Data from Northern Thailand are used to demonstrate that increased yields do not necessarily ensure sustainability over time. Agroecosystems analysis combined with FSR can facilitate development of long-term sustainable technologies.

Long-Term vs. Short-Term Economic and Resource Considerations in Farming Systems Research

Traditional agricultural research has concentrated primarily on improving productivity (average net return to investments of land, labor, capital and management) with relatively little emphasis on stability (variability about mean productivity over time and space) and sustainability (long-term productivity). In less developed countries (LDC's) technologies developed by this research have often been more appropriate to larger, better endowed farmers and those agricultural firms producing for export and less relevant to smaller farmers that can least afford instability and declines in long-term productivity. Dissatisfaction with the results of these research strategies to solve problems of small farmers in LDC's has led to the development of more holistic research methodologies. Such approaches, popularly known as farming systems research (FSR), have evolved to strengthen linkages between farmers and researchers and to emphasize research under actual farm conditions.

As agriculture evolves from monocropped traditional practices to double and triple cropped farming systems, interactions become more complex. These intensified systems often include time-lags giving rise to the possibility of unforeseen systemic effects which may not exhibit themselves during the initial flush of increased productivity, but may later reduce the potential productivity of the entire system. Conventional research approaches have, in general, failed to address these longer term considerations. FSR potentially could encompass these concerns, as it takes a wider systems approach, but as currently practiced, particularly at the International Agricultural Research Centers (IARC's), has failed to consider questions of long-term sustainability as well as productivity. Unless a systemic approach capable of longer term concerns is adopted in the research and technology development stage, unforeseen effects may manifest themselves after large scale farmer adoption leading to widespread and serious damage.

The purpose of this paper is to demonstrate that research tools that concentrate on productivity and ignore stability and sustainability do not serve the needs of small farmers. Field results from Northern Thailand are used to document the necessity to consider long-term as well as short-term economic and environmental impacts.

Farming Systems Research

There are almost as many definitions of FSR as there are advocates (Shaner, Philips and Schmehl, 1982). Recognizing this fact, the Technical Advisory Committee (TAC) of the Consultative Group on International Agricultural Research (CGIAR) attempted to define FSR as part of their review of FSR at the IARC's (CGIAR-TAC 1978). TAC's definition of FSR; "research (including training), which is conducted with a recognition and focus toward the interdependencies and interrelationships that exist among elements of the farm system, designed to facilitate the generation and testing of improved technology" emphasizes relevance to the objectives of the CGIAR, (i.e., to research benefitting the majority of farmers in low-income countries and on commodities representing important sources of food for the developing countries).

When actually viewed in the field most FSR programs at the IARC's are an attempt to develop agricultural production technology that is more relevant to the needs of small farmers. FSR approaches have been encouraged by IARC staff because conventional experiment station type research has too often fostered technologies that were not consistent with the circumstance of small farmers. In contrast, FSR identifies the farming family as the central unit in the research process by directly involving them in the descriptive and testing stages (Gilbert, Norman and Winch, 1980).

Despite the recognized existence of complex systems interactions in FSR, there is a major methodological question of how important systems analysis is to FSR in its applied research context. In fact, Shaner (1983) argues that FSR has made little use of analytical tools of systems analysis and, consequently, applied or on-farm research might be a better term for the present approach than FSR. Methodological problems associated with analyzing complex systems, reinforced by the technical crop research mandates of the IARC's and the need to implement FSR programs within the bounds of limited financial and human resources of national programs, have tended to reduce the range of variables actually studied. Thus, FSR researchers usually focus on a few priority problems which offer potential for rapid increases in productivity (Byerlee, Harrington and Winkelmann, 1982). This approach does not include an effective mechanism to determine if these increases are sustainable over time. In fact, Bernsten and Herdt 1981) explicitly state FSR omits identification of changes in the agricultural environment stemming from management practices.

An alternative technique that explicitly recognizes the importance of long-term stability of environmental systems is ecosystems analysis (Evans, 1956). From the study of natural ecosystems it was a relatively short step, conceptually to the agroecosystem (Spedding, 1979). By definition an agroecosystem is: an ecological system partly modified by man to produce food, fiber, or other agricultural products. The transition from natural ecosystem to agroecosystem, however, involves several significant changes. The system is more clearly defined as man creates the boundaries. Similarly, the number of natural or biological components are reduced and important interactions are modified an regulated by man. Yet, the inclusion of man in the system including his cultural and economic activities, reintroduces considerable complexity but of a different nature. It is this rich, new complexity and the type of system properties these generate that makes analysis difficult (Conway, 1981).

Agroecosystems tend to occur in a hierarchial arrangement of subsystems where separate crop and livestock enterprises all interact with one another in a complex manner (See Figure 1). Those dynamic interactions bring about properties which are only apparent at a higher level system namely the farm. Both interactions within any level of the hierarchy and interactions between factors at different levels in the hierarchy give rise to system properties and must therefore be considered in relation to the performance of the entire system (Craig, et. al., 1981).

Land Resource Base

Most FSR programs at the IARC's are designed to adapt, evaluate and assist in the dissemination of new technologies that will substantially increase net income of farmers. This generally results in synthesizing sequences of crops and fertilizer practices to fit the local environment and the needs of farmers (Zandstra, et. al., 1981). These types of studies are important but, as presentely practiced by FSR researchers, they fail to ensure that the new technologies will not result in long term negative effects on the environment or even the social system. Considering the farmer and his needs as part of an agroecosystem, such concepts as risk, stability, resilience and durability become more important than concentrating solely on short-term productivity problems. From a long-term standpoint of particular interest are those properties of the system that result from dynamic interactions among the components such that the system as a whole may react differently from what would be expected from a consideration of individual components. In the following paragraphs these points are illustrated using dynamic reactions in soils that potentially may occur as a result of changes in cropping systems.

Soil Acidity

Soil acidity tends to develop relatively rapidly when tropical soils with low cation exchange capacities are cultivated. The system is complex but in well aerated soils aluminum toxicities often develop by reaction with other soil constituents. However, in systems where the soils are periodically flooded, reactions with iron and manganese tend to decrease the acidity and bring iron and manganese into solution in their reduced forms. As the soils are flooded the process has its own feedback as the reduced acidity tends to limit the manganese and iron in solution. The general result is that soils that are flooded are usually not particularly acid but rapidly become acid in dry periods (Figure 2). Given this situation, soils subjected to multiple cropping systems in which one of the crops is flooded paddy rice can be expected to acidify in a stepwise fashion over time, the pH increasing under rice and decreasing under the non-flooded crop (Reuss, 1979).

The level of acidity at which the system stabilizes is a function of soil properties, cropping systems and management practices such as fertilization. As the system acidifies, problems of manganese toxicity, lack of nodulation on legumes, and so on can be expected. Fertilization, particularly with nitrogen fertilizers such as ammonium sulphate, has been demonstrated to intensify the process by inhibiting the ability of soil organisms to nitrify the ammonium (Olson, 1972).

Environmental Changes

Data illustrating long-term environmental changes resulting from adoption of intensified farming practices are difficult to obtain and document. This data problem has tended to restrict long-term environmental studies particularly for small farms in LDCs. One case in which a significant amount of long-term information is available is the Chiang Mai Valley in Northern Thailand where the Multiple Cropping Project (MCP) at Chiang Mai University has been studying farming systems since 1968 (Multiple Cropping Project, 1974). Research results from this Valley can be used to demonstrate that environmental implications of changes in farming systems are important and must be given equal status with attempts to increase productivity.

Multiple cropping is not new in the Chiang Mai Valley, but was practiced on a small scale until the mid-1960's. With the completion of two large public irrigation projects and significant improvements in traditional irrigation systems, complemented by the availability of high yielding crop cultivars, better transportation and improved markets, cropping intensity has increased rapidly. Since 1968 intensity in the Valley has increased from less than 120 percent to over 165 percent in 1980. As this increase has resulted primarily from an intensification of land use rather than an extension of land under production, data from the Valley provide an opportunity to study effects of long-term changes in productivity, stability and sustainability.

The availability of irrigation water made it feasible to multiple crop large areas of the Valley bottom land. Using new high yielding varieties (HYV's) and chemical fertilizer, yields could be doubled in some areas and increased by more than half in almost all areas. Data from farmers fields in Chiang Mai Valley demonstrates this point (Table 1). With this type of response there seemed to be ample justification for a rapid adoption of new HYV's. Extension personnel and other crop specialists encouraged farmers to adopt these new farming practices although there was little information concerning interactions between these new management practices, including heavy doses of chemical fertilizer (primarily ammonium sulphate), and farmers' cultivation practices on other crops.

Long-term data from intensively cultivated fields indicate that under multiple cropped conditions these increases in productivity are not sustainable (Figure 3). After increasing yields from 4 tons/ha. in 1969 to 6.4 tons/ha. in 1971, yields steadily declined so that by 1977 they were again at 1969 levels. The coefficient of variation (CV) for the yield data, which has increased from 15 percent in 1969 to 30 percent in 1978, dramatically demonstrates that rice production with HYV's in these intensively cropped fields is unstable. This is in spite of consistently high levels of inputs (80-100 kg. Nitrogen/ha.) for the past decade. In contrast, fields in extension trials following recommended management practices are harvesting an average of 6 tons/ha. However, most of these extension fields are newly multiple cropped fields having only been intensively cropped for one or, at most, two years.

This instability appears to be related to rapid changes in soil pH both within the year and across years. Cropping patterns have a strong influence on the changes. From an original pH of about 6.5 in 1968, pH dropped to less 4.0 after three years of intensive multiple cropping. Since 1971, it has been necessary to use lime on intensively farmed areas in order to keep the soil from becoming too acid, but this has not brought yields back up, although it may have prevented further declines. In addition to problems with rice crops, falling yields have also been apparent in other crops. In some areas of the Valley soybean yields have declined from 2 tons/ha. to yields of less than a ton. Yields in some areas have become so poor that farmers have ceased to grow a second crop following rice (Loneragan, 1980 (Appendix I)).

Translating these yield fluctuations into income figures for the average farmer in the Valley is complicated by the fact that it is difficult to determine the total area affected. In addition, once farmers realize there is a problem they usually change their crop rotation or leave land fallow. Valley wide surveys were made in 1972-73 by MCP staff and again in the same villages in 1977-78 by MCP staff for the World Bank. Data from these surveys, which included crop cutting, indicate that overall rice yields are increasing, primarily due to cultivation of new land, but that they are less stable (Table 2). With the increasing intensity in the Valley, combined with the use of higher levels of fertilizer, it is quite likely that Valley rice yields in multiple cropped fields are in the process of following the same trend as the intensified areas plotted in Figure 1.

To illustrate what these trends mean in terms of income effects, Table 3 includes data from a 1969 representative mono-cropped field compared to a 1977 representative double-cropped field. Rice yields and production technologies represent an aggregate average drawn from a continuously monitored sample of intensively cropped fields. Soybean yields and production costs are drawn from a sub-sample of these same fields. Yields of these rice fields are indicated by points A and B, respectively, on Figure 1 while production costs and soybean production figures are drawn from 1969 and 1977 surveys of intensively cropped areas in the Valley. In intensively cropped fields, by 1977 farmers were forced to apply much higher fertilizer levels in order to keep yields from declining further. From income calculations presented in Table 3 it is apparent that in current dollars returns to labor and management per year are better with two crops. However, when 1969 prices and 1969 costs are used to calculate 1977 returns two crops do not provide higher net returns to labor and management. When annual net returns are divided by the days of unpaid family labor and management, the return to family labor and management falls from $2.38 to $1.19 per day. Thus, the two crop system results in reduced real wages for family labor and management. If, on the other hand, rice yields can be maintained at 6.5 tons/ha., total annual returns (in current dollars) increase to $422/ha. and returns attributable to family labor and management (using 1969 prices) increase to $2.53 per day. The first example illustrates that farmers in intensive areas are presently working longer hours and involved in higher level management for lower returns per hour. As off-farm employment opportunities have increased significantly in the Valley over the past decade the opportunity cost for labor has risen rapidly. Thus, contrary to claims of crop scientists and extension agents, farmers have not necessarily become better off by multiple cropping. Unfortunately, in some of the intensively cropped areas farmers are now in a situation where they cannot increase yields further; yet, if they reduce fertilizer and other chemical inputs yields will decline rapidly.

Future Directions of FSR

Traditional agricultural research concentrates on short-term productivity increases for a single crop. FSR, as currently practiced, while considering more farm level resources also tends to concentrate on short-term productivity gains. However, as demonstrated in the previous section, short-term gains do not guarantee stability or long-term sustainability. Intensification entails increased levels of inputs which leads to changes in farming systems, including chemical and structural changes in the land resource base. These changes are dynamic and in tropical areas tend to occur faster than in more temperate climates. The challenge is for agricultural scientists to anticipate the direction of these changes and be prepared with technologies to help farmers as the changes start to restrict output. This argues that instead of down playing the word "systems" in FSR, scientists must emphasize the dynamics of the farm system. Agroecosystems analysis has such a focus and therefore appears to have a role in FSR especially when long-term sustainability is given equal importance with short-term productivity gains.

Table 1. Responses to Nitrogen Fertilizers

	Yields (Metric Tons/ha.)			
	Level of Nitrogen Fertilizer (kg. N/ha)			
Variety	0	30	60	120
Traditional	4.55	4.59	4.73	--
HYV	4.63	--	6.16	6.43

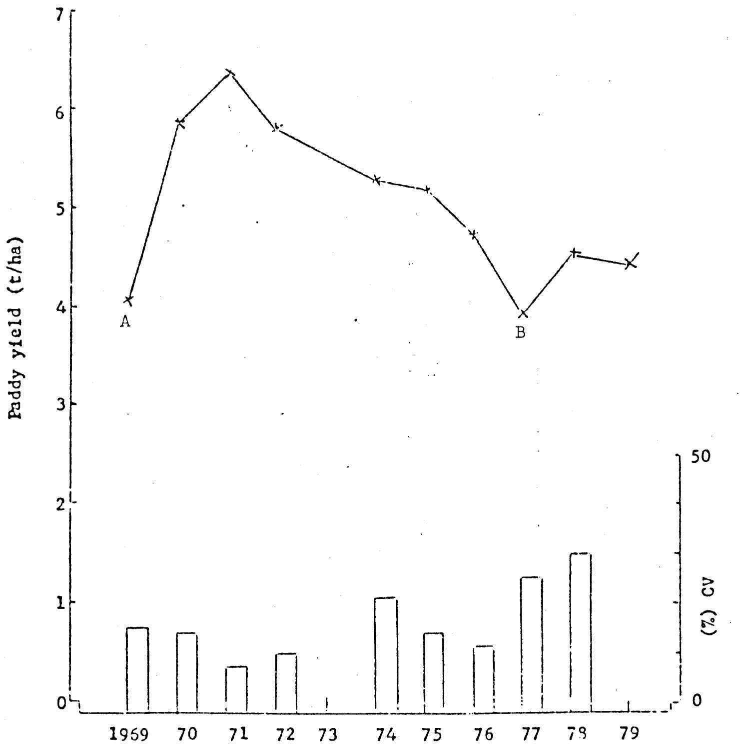
Source: Rerkasem and Gypmantasiri

Table 2. Changes in Average Rice Yields from 22 Villages in Chiang Mai Valley

	Fertilizer Use (kg/ha.)	Average Yield (kg/ha.)	Coefficient of Variation	Number of Cases
1972	20[1]	3063[1]	27%[1]	484[1]
1977	35	3750[2]	41%[2]	385[2]

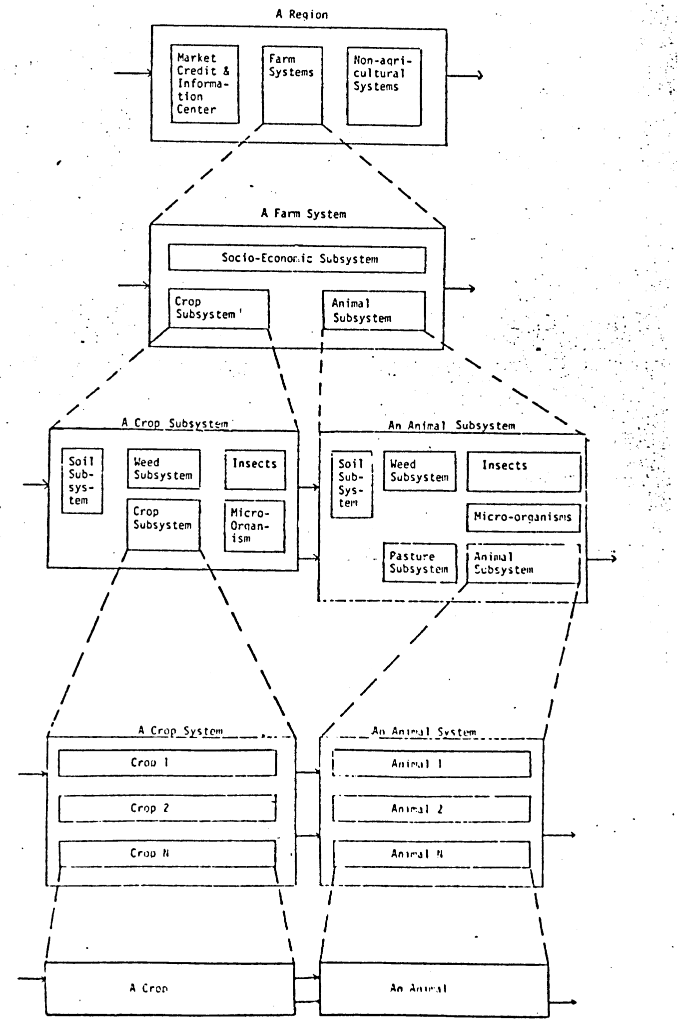
1 Tongsiri, Benchavan, Pichit Lertamrab and Alan R. Thodey, p. 169.
2 World Bank provided data tapes.

Figure 3. Rice yield in intensive cropping systems, each point mean from 16 plots.



Source: Rerkasem, 1980

Fig. 1. Hierarchical relationship between agricultural systems.



Source: Hart, 1982

Figure 2. Negative Feedback Loop Resulting from Nitrogen Soil Moisture Interactions.

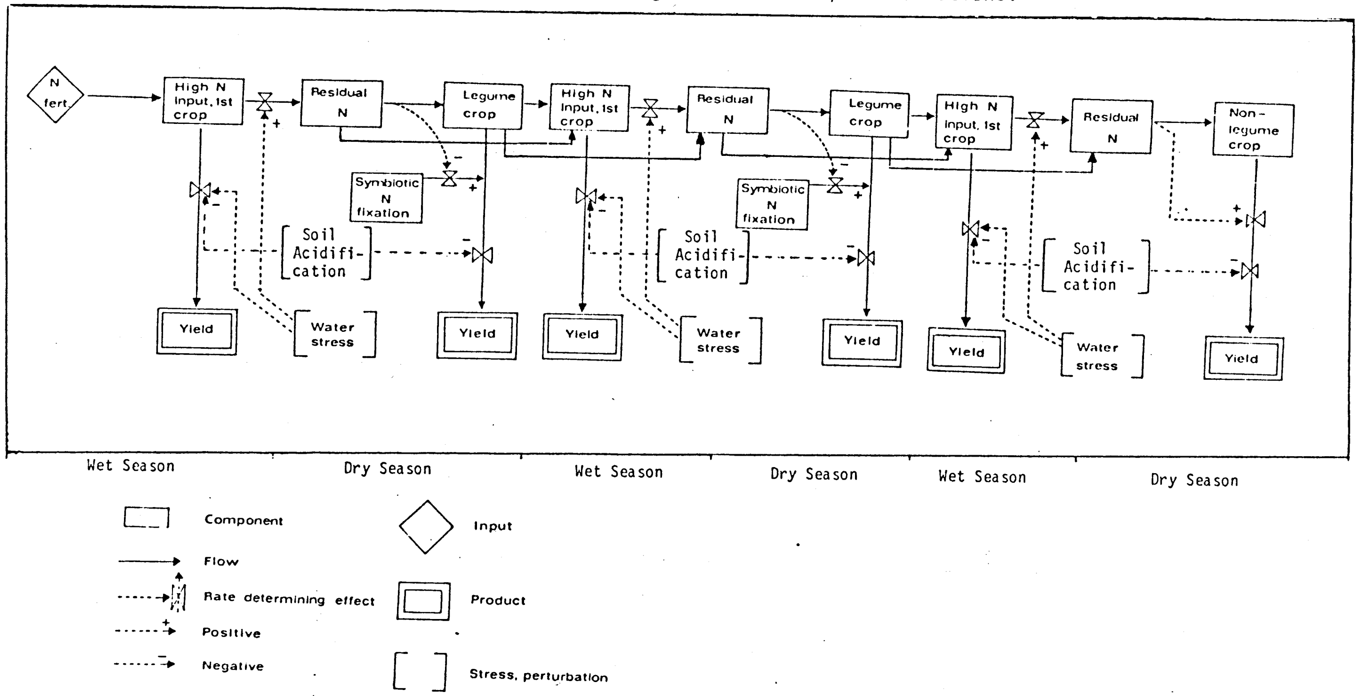


Table 3. Net Returns - 1969 vs. 1977 ($/ha.)

Year	Yield (kg/ha) Rice	Yield (kg/ha) Soybean	Price Rice[1]	$/kg. Soybean[1]	Gross Return ($/ha) Rice	Gross Return ($/ha) Soybean	Costs ($/ha) Rice	Costs ($/ha) Soybean	Net Returns to Labor & Mgt. ($/ha) Rice	Net Returns to Labor & Mgt. ($/ha) Soybean	Total ($/ha)
1969	4000	--	.055	--	220.00	--	79.00[2]	--	141.00	--	141.00
1977	4000	1316	.092 (.055)	.27 (.10)	355.00 (132.00)	245.00 (106.00)	286.00[3] (125.00)	245.00[3] (106.00)	82.00 (95.00)	110.00 (26.00)	192.00 (121.00)

(   ) Converted to 1969 prices.

[1] Wiboonpongse, Aree and Earl D. Kellogg.
[2] Thody, Alan R.
[3] Gypmantasiri, Phrek, et. al.

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