Role of Social Science Research in Cropping System Programs[1/]

by

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Introduction

Cropping system research programs are receiving increasing attention in international and national agricultural research programs as ways to increase production per unit of time. They are natural extensions of individual crop research programs and form a part of the basis for farming systems research being developed around the world. In discussing the role of social science research in these cropping system programs, some assumptions must be made.[3/] The first is that we are talking about cropping systems. Although the word "systems" has been used so widely in a variety of contexts it may be loosing its specificity in communications, it does provide important concepts to the reader. These include that systems research must be interested in the way definable parts of the systems add up to the whole. It must recognize that these parts are interdependent and that feedback mechanisms are present within the system

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3/ The author is an agricultural economist and not broadly trained in many other social sciences. Therefore, the discussion of the role of noneconomic social sciences may be somewhat inaccurate and/or restrictive. Social science is meant to include the disciplines of sociology, anthropology, political science, economics, and psychology.

such that the parts interact with one another to produce an outcome different then what would have occurred if they had been separated. These interactions in the system involve biological, physical, chemical, economic and human phenomena. Furthermore, these cropping systems are part of larger farming systems which must relate with social systems and institutional arrangements surrounding the farm. Therefore, cropping systems programs must be concerned with the behavior of an interrelated whole as well as the influence of outside systems and arrangements on the cropping system.

The second assumption is that the participants of this seminar are interested in applied research aimed at developing cropping systems that are adoptable by farmers that will increase their well being. In addition, the programs represented here will be involved (not necessarily in the lead role) in the process of extending the cropping systems developed to farmers.

The last assumption is that the process used in the development of improved adoptable cropping systems ought to include some social science inputs and that these inputs should be an integral part of the process. Hopefully why this should be and how it can happen will become more clear after study of this paper.

Purpose and organization of the paper

The strategy of this paper is to indicate the rationale for inclusion of social scientists into cropping systems programs by identifying important contributions they can make with brief comments as to how these contributions might be made. References to fuller discussions of some of these issues will be given. To do this, a brief discussion of the process most commonly recommended for use by cropping system programs will be given. Then, potential contributions of social scientists in each step of this process will be discussed. Finally, some general observations with respect to how multi-disciplinary work might be more effectively encouraged in cropping systems programs will be given in the summary section.

Steps Recommended for an Applied Cropping System Research Program

In order to identify important contributions that can be made by social scientists, a brief description of the strategy recommended in developing cropping system programs is necessary. Even a brief look at the current literature on cropping systems programs reveals a common agreement on the process that ought to be undertaken to develop improved adoptable cropping systems for farmers. The names attached to the individual steps and the specific aspects assigned to certain steps often vary, but the concepts are amazingly similar among the reports given of various programs.[4/] The general rationale for this recommended process is that cropping systems that are developed based on the

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4/ The major reason for this is that many of the accessible program reports come through the international agricultural research centers. They have formal and nonformal networks through which common philosophies are developed and communicated.

environment the farmers must function within are more likely to be adopted. In addition, to make a positive break from traditional cropping systems requires informed, tested changes be introduced to minimize possible undersirable consequences.

Analysis of farmers' situations and actions - step 1.

This step involves the inventory and analysis of factors that influence what farmers do and how and why they do it. This activity may also be used to develop base line data from which technology induced changes that occur can be measured. The results of this analysis are used to define what lines of research might be more advantageous to pursue in terms of the ability and inclination of the farmers to adopt new technology.

Design of technology - step 2.

As the farmer's working environment is analysed and what he does and how and why he does it becomes better undrestood, new cropping system technology design can begin. Component elements of crop technology are developed and/or assembled, tested and combined into potential cropping systems that reflect the synthesis of information gathered in the previous step. These cropping systems being designed are to reflect the determinants (conditions difficult to change) of the environment while incorporating changes that can be adopted to develop technology that holds promise of demonstrating superior performance over traditional systems.

On-farm testing and evaluation - step 3.

This third step involves taking systems judged to be feasible and productive to farm plots for further testing and evaluation. Since the previous step is usually accomplished in experimentally controlled conditions, the results of the design stage need to be verified and expanded using farmers' fields, reactions, and sometimes their management. The literature reflects some divergence in the specific objectives of this step. In some cases, farmers are asked to manage specified cropping systems and these results are compared to their traditional systems. In other examples, on-farm testing is divided into component trials closely guided by researchers and subsequent farmer managed trials based on the results of the on-farm component research trials. Measures to determine the constraints experienced by the farmers and initial impressions of the impact of adoption on the farm and village are also usually made in this step. Some programs include analysis of these consequences on more aggregated levels also. Initial analyses may also be made at this stage on the types of programs that meed to be developed by enabling institutions to insure that the requirements for the adoption of the new technology are met.

Extension and evaluation - step 4.

As cropping systems are tested and shown to be compatible with the farmer's situation as well as substantially more profitable and/or stable than the traditional systems, they may be extended over wider areas. The program leadership for this step is usually with extension agencies although the research program has a vital role to play. More complete studies can be made on the constraints to and consequences of the adoption of the new technology during this phase.

Relationship among the steps

This process is not purely sequential nor does it always flow in one direction. The steps:

(1) overlap in that more than one should be undertaken at one time;

(2) interact in an iterative way such that results in one step may require going back to redo parts of previous steps.

An example of this interaction would be the situation where farm level testing showed the farmer could not manage the mew cropping system properly because of commitments he had to other farm or nonfarm enterprises. This might entail further analysis of his environment (step 1) and redesign of new systens (step 2).

Role of Social Science Research in this Process

The amount of literature devoted to reporting social science research on cropping systems is still small while reports that discuss what should be done and why is growing rather rapidly. The lack of balance between social science and agricultural science[5/] research on cropping systems in Thailand is evidenced by the larger number of papers and participants at this seminar oriented toward agricultural science activities. In order to discuss the role of social scientists in the process briefly discussed in the previous section, the potential contributions will be discussed by steps.

Analysis of Farmers' Situations and Actions

The words used to label this step were chosen carefully to reflect concepts that are important to defining the rationale for this activity. Analysis is used to reflect the need to understand the farmers' situation rather than just to describe the elements making up the environment. The lack of an adequate understanding of the factors which determine what the farner does and how and why he does it often linits our ability to define relevant applied research. "Situations" was used to denote the range of factors that influence farmers' decisions and actions. These factors are associated with (1) his family and community; (2) the institutions that provide him with information, services, resouces and opportunities to sell his products; and (3) the quantity and quality of resources he commands. The assertion here is that useful cropping systems research must start from an analysis of the existing locale specific environments for which the program has responsibility. In some programs this step is used to define a baseline measurement of certain criteria that will be subsequently remeasured to identify the consequences of certain changes through time.

5/ Agricultural science is meant to include the areas of plant breeding, plant pathology, entomology, agronomy, soils, food science, animal science, and agricultural engineering.

Data collection planning

Since many social scientists are trained in data gathering techniques, they can contribute to the design and implementation of surveys and case studies. Before starting to gather data is it vital to define the focus of the project in terms of geographical regions or type of farmers or resource defined areas. For example, a program might be oriented to developing cropping systems for small farmers (and "small farmers" should be defined) in rainfed areas of a certain region within the country. The process of gathering data should be oriented toward describing and analyzing that population. It is also important to specify the use to be made of the data, how this work fits into the overall program, and the specific objectives of the cropping systems research program and this data gathering activity (see (1) for a more complete discussion of this).

Three types of studies may be meeded in this phase. The first would be a general survey to gain as complete a picture as possible about what farmers are doing and what conditions surround the farmer. The second type would be a specific study of fewer farmers to gain as complete an understanding as possible with respect to why they do things as they do. The third type of study would be a baseline survey to be used as a basis for subsequent remeasure to evaluate changes over time. Some of these purposes could be combined into one effort such as the baseline could be based on the farmers selected for indepth study.

If there is adequate secondary data available on this population, certain characteristics of the area and farmers could be defined in terms of frequency distributions. For example, suppose the cropping system program had a geographical focus. Within that area, secondary data would be used to delineate frequencies of farm size groups, cropping system types, irrigation access, soil types and distances of villages from urban areas. Then, the sample survey could be stratified to reflect the modal values of these characteristics. This procedure would tend to give one a more accurate sample of certain characteristics important in defining what the environment of the population is (see (12) for a more complete discussion of this procedure). Even if the secondary data or resources are not available to do this, some attempt should be made to see that the sample survey is representative of the area of concern.

Since the amount of relevant information that could be collected to better understand farmers' situations and actions is large and varied, some classifications as to importance and procedures for measurement are helpful. The first class could be delineated by the degree of difficulty the farmer or research program would have to change the values of certain variables. If the variable would be very difficult to change, cropping system development would have to consider it as a determinant (27). Rainfall distributions and farmers' ability to read would be examples. The variables that would be more easily changed such as nitrogen levels in soils can be varied in designing new technology. Availability of credit might fall between these two extremes.

Other useful distinctions relate to the procedure required to collect the data. If the event occurs once or infrequently during a year, questions related to the value of these variables need to be asked at only one time-single point estimates. If the event occurs frequently, questions may need to be asked several times during the year - continuous estimates. Examples of single point estimates would be the amount of a crop sold or quantity of storage available on the farm. Variables requiring more continuous measurement would be the amount of labor devoted to certain crops or rainfall received during the year.

Another distinction relating to measurement procedures is the likelihood of the respondent to remember quantities of activities. Farmers usually "register" such information as the time water becomes available or how much of a certain crop he sold. He does not tend to remember as clearly how much labor he used to accomplish certain tasks. Therefore, in general, single point registered data should have low measurement errors if the information carfully gathered. For data classified in the continous nonregistered class (e.g. labor use allocation), frequent interviewing must be done to ensure the data accurately reflects what actually happens. References (5) and (13) have more detail on these classifications and their utility.

The last classification relates to the need to set priorities on what is to be collected and how much accuracy is desired. This partially depends on whether the study is a general survey of an area, a specific case study or a baseline measurement. Fortunately, Banta (1) has discussed these problems well and provided a framework that will be useful to follow.[6/]

Data analysis

The variables to be measured could be classified as those relating to the environment, resources, activities, and needs of farmers. Appendix table 1 gives examples of the specific data that would be obtained and a classification for each of the criteria previously discussed.

This analysis phase includes more than a simple tabulation of the data presented in appendix table 1, it requires a diagnosis of the constraints facing farmers and an understanding of what they do and why. Social and physical scientists will have to cooperate in this endeavor but the comments here will be reserved largely to the role of the social scientists in this process.

For the environmental class, social scientists would need to establish the public policy (if any) on the output pricing of crops, input pricing of important factors of production such as fertilizer, seeds, labor and/or credit or proposed production or other special purpose campaigns (see (15) for a more detailed discussion). These policies can have a major impact on the profitability of various enterprises or activities through time and hence should be considered

6/ Since I have freely deviated at places from his specific ideas, one should not interpret this section as an accurate reflection of his concepts.

in designing new technology. A by-product of this step is that it provides a basis for judging the benefits and costs at the farm level of these policies. The data on policies toward agricultural associations and extension work would give useful indications on the problems to be faced in the extension of new technology and the prospects of farmer groups being able to become effective in credit provision, input supply and/or output marketing.

Sociologists and anthropologists would be useful participants in defining the social data suggested in IC. They have developed ways of measuring the influences of tradition on the way things are done as well as defining family structures and their influence on future labor availability and roles of males and females in various activities. Migration patterns can effect and is affected by multiple cropping systems (see (26)). Age structure is important in determining available labor through time as well as the number of economically productive people versus those that are too young or old to work (called dependability ratio). This ratio should be calculated on an individual family basis rather than the traditional Western concept.

The economic environment analysis should reflect the ability of people and goods to move in and out of the area as well as what facilities are present for possible storage of produce. This latter point is important in determining whetber farmers would have an ability to hold certain crops to be sold during higher price periods. Often the best time, in terms of physical productivity, to grow certain crops within a system is also when the crop is widely grown and hence is harvested at lower prices. Tenures and credit arrangements are part of the set of variables that determine the way in which gains from new technology are distributed. Tenure data should reflect not only land owner, tenant, part tenant, and landless labor proportions, but also how the costs and production are shared by crop, how people get access to land to rent and what informal sanctions are involved in continuing tenure arrangements. The credit information should include calculating the real cost of credit (28), sources of loans, how people get access to these sources, and limits on its use. The level of living can be measured from data collected elsewhere in terms of cash income, food consumed, housing quantity and quality, and other consumer items present in the household. This measurement is especially important if the analysis is to be used as a baseline.

Resources and their allocation form the central concern for cropping system research. Land ownership and use pattern distributions would result from the data collected under II A. These variables are also important in determining who might gain from new technology as well as how land ownership and use might change as a result of the adoption of new technology. Surprisingly, many surveys do not include land values as part of the data collected. However, this is one of the variables that may change significantly with the introduction of new technology and, given certain policies, may be the resource that "captures" much of the benefits. Parcel size helps in defining the limits of certain equipment development as well as understanding criteria used by farmer's to decide land allocation to various crops. The measures of various physical and chemical characteristics of the land and solar radiation is best done by the physical scientists and will not be discussed further except to comment that they are extremely important in determining cripping systems. The type of irrigation and amounts typically available through time to the area being studied is of utmost importance. This data may be available through irrigation associations or goverment agencies. It should be collected for several years to observe the variability in amount and timing. How the distribution of water is decided upon would be a part of this effort and is the topic of substantial sociology work.

Labor availability, use, and wages should be identified by sex; hired or family; and full or part time helpers by crop and other activities. This data is also noted in III A 3, III B 2, III C, and III E 5. The profile of labor use for cropping activities during the year should be compared to the profile in other major activities of the family. This gives one an indication of the true slack periods for labor use as contrasted to the labor use patterns in the cropping activities only. Questions relative to labor use in nonfarm activities should also be asked to determine the opportunity cost of using more labor at certain times in the cropping system. One way of doing this is to ask family members every two weeks whether they sought non-farm employment. If they did, one would need to ask how many days did they want to work and how many days were they successful in finding work. Then the wage they received would be multiplied by the probability of finding employment to arrive at the opportunity cost of labor for that two week period (see (20) for more details on this procedure).

Power availability and cost gives an indication of the flexibility farmers have to perform certain tasks by using relatively more labor versus more power. If quite low power/land ratios are found, cropping system development might initially be more labor intensive with some effort spent on encouraging small equipment development. The flow of operating capital data is helpful in diagnosing problems involved in investing in material inputs or larger capital items. Income time profiles combined with essential expenditure time profiles would assist in the determination of the amount of money available at particular times for investments that might be required by new cropping system technology. Of course the level of debt and savings is also helpful in making kind of diagnosis (see (13) for a discussion on the prlblems of getting this information).

The availability, quality and cost of material inputs such as fertilizer, pesticides, seeds, and herbicides are important factors in determining constraints faced by farmers. A spatial analysis by geographers or other social scientists to indicate time, distance, and cost of reaching supply points would give a deeper understanding of the availability of these inputs and their real cost to the farmers. Output marketing characteristics should reflect the products that have been traded, the reliability of the market, if farmers receive quality price differentials, what practices are involved in exchange, and how farmers obtain price information. Farm level prices over time should also be collected as many secondary data sources reflect wholesale prices. A full discussion of these variables is included in Aree Wiboonpongse's paper at this seminar. An analysis of price trends through time is helpful in indicating which commodities may become more competitive through time. Data on the average variation of prices within the year assists in determining the potential profitability of developing certain varieties that can be harvested at certain times to take advantage of higher price periods. Correlation of prices among crops being considered in the program help indicate if crop diversification would be expected to decrease price risks substantially. If the prices of possible alternative crops are highly positively correlated with each other and traditional crops, crop diversification cannot be expected to decrease this risk a great deal. Some information should by gathered on the capacity and utilization of the input and output marketing system as multiple cropping development is likely to affect these substantially. If there are substantial processing firms in the areas processing schedules should also be known.

Farmers' management practices affect their cropping systems' performances significantly. These practices result partly from farmers' attitudes toward change, risk, and debt; their pereeptions of crop characteristics and new technology as well as the priorities they have for themselves and their families. It is difficult to measure, interpret and verify data collected on these factors. Psychologists and sociologists have developed some measures and techniques that seem to be relevant for these concerns. Iresons' study (11) would be a specific example that is instructive to review for cropping systems programs. He sought to identify and rank criteria used by farmers in selecting crops, then identify these characteristics of crops as perceived by farmers and verify the relationship between the decision criteria, crop characteristics, and crop choices actually made by farmers. The identification and measurement of the relative importance of social and economic factors affecting cropping intensity was also attempted. In this effort, attitudes toward risk, new technology and the outside world were measured and integrated into a model. These data should be collected and analyzed to give a feeling for what farmers think are important criteria for choosing crops, and how they perceive these characteristics for the crops they know. Some of this knowledge can be gained from spending time with farmers in informal discussions about their farm business.

The cropping system is a part of a larger set of activities that require time and resources from the household. Many of these resources can be easily transfered among activities in which the household participates. To estimate the amount and cost of resources that are or could be allocated to a cropping system requires knowledge of these alternative activities. These include family area upkeep, community commitments, and nonfarm activities. Analysis of the nonfarm labor data was discussed in the previous section. All income sources should be identified to be able to understand financial resources available for investment.

The livestock enterprise is almost always integrated with cropping activities. It is important to understand how these enterprises relate to each other in terms of : competition for cash, land, and labor; and complementarity with respect to soil fertility and crops and by products consumed. Values of this complementary aspect should be measured because changes in cropping systems will likely affect these relationships substantially, expecially, if crop residues change from appropriate animal food to nonedible residues. A simple two enterprise budget is useful to initially analyze the input and output relationships between crops and livestodk as they exist on the farms.

An analysis of the cropping systems present on the farms forms the heart of this step. All cropping areas should be identified by crop and variety. An understanding of the characteristics of local varieties in terms of growing season, residue yields, tolerance to water and drought stress is extremely important. The agricultural scientists should further define these factors. Sequence of crops by plots is important not only in defining current systems, but also in correlating soil and other characteristics with the farmer's crop choices. Again, agricultural scientists should take leadership in defining the specific data to be collected on the variables in III F. Economists ought to participate in placing, for each crop and system, appropriate costs to resources (land, labor, equipment and supplies) and values to output sold, consumed, and by-products utilized. To obtain reasonable estimates of these continuous variables will require collecting data at different points in time. If enough observations are available, production function estimates by crops can be made to determine contributions of various resources to the output of particular crops. Labor can be disaggregated into land preparation, care of crop, and harvesting classes to see if labor use is optimal among these various activities. Profit function analysis can also be done to judge if farmers are efficiently allocating resources according to price differences as well as technical factors (see (23) for a good discussion of this method and its usefulness). Returns of these existing systems can be determined and compared among crops and systems by calculating the following:

(1) net income with and without labor costs included;

(2) returns per unit of land;

(3) returns per hour of labor;

(4) returns per unit of cash investment; and

(5) returns for any input that seems to be limiting such as water, or labor at a certain time

These alternative measures give one a perspective for the benefits farmers receive from the current systems. They will also enable one to compare the new systems with the existing ones on a number of criteria rather than just yield or net income.

Other important measures involve determining the stability and adaptability for crops and systems. Stability refers to the variability, in terms of yields or net incomes, of a crop or system in one environment over time. Adaptability refers to the variability of yields or net incomes of crops or systems at one point in time over various locations. Stability has obvious importance to farmers and researchers while adaptability is more important to research programs involved in a number of different environments. If there is diversity in environments sampled in this step, it could be useful to derive adaptability coefficients for various crops and systems. This could be done by comparing coefficients of variation of yields among crops at different locations.

Stability has important implications for cropping system programs as it is a factor in determining risk. Measures of stability for the current crops and systems would be usdful for comparison with new technology as it is being adopted. If secondary time series data is available, stability measures can be developed from these. One suggested method of doing this to calculate coefficients of variance of yields for one crop in the same location between two time intervals to see if its yield stability was increasing or decreasing. Coefficients of variation of yields (the percent variation from their means) could indicate the relative variance among crops in the same location over time. If secondary data is not available, this could also be done by asking farmers their judgments about the yield variation of certain crops. These measures would give one a comparative feeling for the yield risks among crops. The same procedure could be done to calculate price variations faced by farmers by using secondary data. If sophisticated analysis is possible, yield and price probability distributions can be sampled using Monte Carlo techniques to arrive at a gross returns distribution from which typical eash costs can be subtracted to determine the probability distribution of adjusted net returns. These distributions by crops could be compared among crops using means and variance comparison tests. Farmers will in general prefer an alternative if it has an equal mean for net income and lower variance than other options or if it has the same variance and a higher mean than other alternatives.

Another risk criteria is the expected value of the loss function. This is the amount of loss expected if yields and/or prices are so low as to not cover the cash costs of the crop activity. Farmers subjective judgments about the probability of obtaining certain yields could be obtained and compared with prices he receives and cash input costs he has to see how much he might expect to lose if his gross returns were not adequate to cover his cash costs. This value is in monetary units and can be compared among crops and systems. A related analysis would be to plot a net income frequency distribution for each crop and system among farmers. This would entail choosing net income intervals on the horizontal axis and percentage of occurance on the vertical axis. These distributions could be "added up" to cumulative distributions to show the percentage of times crops or systems had returns of at least certain net income levels. Of course means and variances could be calculated and compared. References (18) and (28) can be consulted for more details on the subject of risk and its measurement.

The last class of variables to consider has been labeled as needs. Information on sources of carbohydrates and proteins (whether purchased or grown on the farm) has important implications for the impact of changing the content of cropping systems. Taste also plays an important role in determining the acceptability of new varieties particularly for rice. The amount and timing of cash requirements for consumption items is important: (1) to judge available investment funds (as discussed previously); (2) to have baseline measures to see what effects increased incomes had on these items, and (3) to have a basis to compare the use of credit to purchase these goods over time.

Economic anthropologists have done several studies that focus on understanding why farmers do as they do. These social scientists advice and/or participation particularly in specific indepth case studies may be valuable (see (6) for examples).

The large amount of data mentioned in this discussion and outlined in Appendix table 1 should be considered with respect to the objective of the cropping system program. Therefore, certain priorties can be established as to desire for obtaining them and accuracy needed. Some of the information can be obtained by one point in time surveys while others require more continuous measurements. A sample classification is included in table 1 to illustrate how these variables might be organized. Each program staff would have to do this classification based on their own objectives and assessments. Reference (2) gives detailed instructions of how these measurement might be taken.

Design of Technology

With a better understanding of the situation the farmer faces and why he operates in certain ways, the design of new cropping systems can be more effective in developing technology that can and will be adopted by the farmer. These systems can be designed to use certain resources more fully, be compatible with the farmers activities and needs, and reflect his preferences for certain qualities. Some may feel all these qualifications limit the area for research so severly that nothing can be done. There is validity in this criticism. Some judgment is required to determine what conditions can be changed in the experimental process. This illustrates the usefulness of classifying conditions or variables as to the difficulty of changing them (see Appendix table 1). Certain conditions or variables may have already been classified as quite difficult to change (determinants) and these should be considered as fixed in the short run.

The design of new technology is a creative process that is difficult to characterize. The social scientist should be involved in deciding the contents and process of this step in an ex ante way rather than being an evaluator in an ex post fashion. Economists can assist in narrowing down the options to be actually tried in design to those most promising so research resources are not spent on components which are not feasible because of obvious problems with profitability or lack of resources. This can be done by comparing farmer costs and expected benefits of implementing the proposed change and the requirement the change would place on his management ability. The first comparison could be done using partial budgeting with realistic assumptions about yields the farmer might obtain. In this analysis, farmer costs for implementing the proposed change would include the direct cost (seeds, fertilizer, insecticides) and opportunity costs of diverting certain resources such as labor from other activities. The complexity of change would describe the changes in management required to move from traditional to the newer cropping systems (see (4) for a detailed description of this type of study). In general, higher expected net gain alternatives would be preferable to pursue compared to lower net gain alternatives if they involve equal management complexity. Or, if alternatives have equal expected net gains, the one with less management complexities should be pursued. Economists can also suggest opportunities that exist in the form of underutilized labor at certain times or higher output prices that may occur during certain seasons. If labor peak use of the new systems can be changed from peak seasons of traditional systems, the economic cost of labor would be lower (see (21)). This is one of the reasons data on opportunity cost of labor through time was important to obtain in the analysis step.

Another way to assist in the research search process is to develop models which help in determining which of the many theoretically possible systems should be investigated further. These models could also assist in estimating the size of effects and interaction of specific factors within the cropping system whose action cannot be readily determined by direct measures. Certain systems science techniques can be utilyzed to simulate different moisture regimes and probability of climatic patterns that could be combined with certain input requirements, socioeconomic conditions and output price levels to help define feasible systems. This kind of effort requires reliable and relevant data, appropriate theoretical concepts, competent personnel, and adequate computer facilities. While these prerequisites may not be present in many programs, this method has large potential for saving substantial labor and other resources versus investing in individual research programs for separate environments. References (25) and (17) are helpful understanding this potential using climatic analysis and system science techniques in general.

As components are tested and integrated into systems, economists should be involved in evaluating these new systems relative to several criteria. These would include:

(1) net gain/hectare

(2) returns to cash investment, land, and labor or particular limiting resources

(3) cash cost requirements

(4) stability of resource use (particularly labor) over time

(5) compatibility with the input and output market structure.

These criteria should be compatible with farmer preferences and with criteria to be utilized in the farm testing step. Forms used to record, organize, and analyze economic evaluation of systems design at the Multiple Cropping Project at Chiang Mai University are given in appendix table 2 through 4. Individual programs will have to devise their own, depending on research design and resources available to utilize in this process.

Some special problems arise in economic evaluation of cropping systems versus single crops. One of these is the costing of certain practices that have carry over effects to following crops. For example, making beds for planting one crop may actually be a partial cost to the following crop if the beds are reused for that crop. An individual crop evaluation would show the first (second) crop with higher (lower) costs than were appropriate. The same problem occurs with fertility interactions of crops following legumes. Should the legumes gross value be increased to account for this input furnished to the following crop? The answer is yes, but to accurately measure this contribution is difficult. These examples indicate that cropping systems' evaluation is more complicated than single crop accounting.

On-farm Testing

The technology designed in experimental plots rarely can be taken directly to farmers without further testing in the farm environment. The criteria to use in deciding which systems can be taken to the farm includes the confidence researchers have in the technical feasibility and the judgment that the systems are economically productive and fit within farmers' resource and institutional constraints.

This step can be divided into two phases - on-farm testing with research personnel management and farmer testing.

The on-farm research management trials are usually conducted to test various combinations of practices on cropping system performance. This may include research designs to analyze, for example, the effects of different insect management strategies, tillage practices, fertility levels, and variety differences. This would entail six treatments - one with new recommendations, another with all practice and the other four by dropping individually the new recommendation and adding the farmer practice. The factors chosen to vary should be onces that farmers are able to change as well. Suggested designs for this kind of experiment are given in (7). At this stage, the areas to be utilized for these tests should be large enough to gather reasonably accurate information on labor use. The minimum size is thought to be at least ½ rai. Economic records should be kept on the lbor, equipment, and supplies used by time period as well as the value of production. Of course data on soil type, rainfall, etc. should be defined by the agricultural scientists. The results of the tests would be calculated for each treatment as :

(1) net incomes per rai with and without costing labor

(2) returns to land, labor and cash expenditures

(3) resource use profiles through time

These results would allow one to judge the relative net income of each of the treatments and their associated cash requirements. This comparison might indicate that certain treatments, while having slightly higher net incomes, require far higher cash costs. Therefore, farmers might be more likely to choose the lower cash costs alternative and accept the slightly lower net income that it entails (see (8)). If some yield variance could be estimated the expected value of a loss could be assigned to these alternatives as discussed previously.

It is at this point in the testing process that partial budgeting becomes a useful tool. For each treatment of the experiment one can determine the average yield of the replications and their gross benefits. Then, variable costs (both money and opportunity cost) can be assigned and subtracted from the gross benefits to arrive at the net benefits of each treatment. If there was not charge made in the variable costs for the cost of capital, these net benefits can be calculated as a return to investment capital. If this calculated rate of return to capital is below the real interest rates the farmer must pay, then we can safely conclude that farmers will not consider this alternative. However, if the rate of return to invested capital in several alternatives is above the real interest rate, how much higher would it have to be to be attractive to farmers? They know that in some years these rates of return will not come about because of variance in yields and/or prices. One estimate (19) is that farmers require about 20 percent higher returns than the direct cost of capital. This is commonly called the risk premium. The following calculations are an example :

Farmer borrows for fertilizer	=	1,000 baht
interest on loan for 6 months (12%/yr)	=	60 baht
service charge and other expenses to get loan	=	50 baht
Total real cost of capital	=	11 %
risk premium	=	20 %
Minimum return to capital the farmer must have to invest in the alternative	=	31 %

Another way to analyze the risk involved in the different treatments is to take the worst two results from each treatment. This assumes that there are several experiments with the same treatments. A calculation of the net benefits (or losses) of each would reveal how much farmers might expect if their experience was similar to the worst of the experiments. This is similar to the expected loss concept discussed in step 1. It may turn out that some of the highest net gain treatments also have the most disastrous effects if certain things happen. However, some alternatives may have high net gains and relatively harmless worst cases. These are likely to be quite attractive alternatives to farmers. Anyone involved in economic analysis of on-farm testing should study reference (19) carefully.

The returns to resources and their use profiles would be useful in deciding shether certain limiting factors were productively used or required during times of high use on other activities on the farm.

Farmer testing of new cropping systems provides a better perspective of the performance of new systems compared to each other and with traditional systems, of farmers' ability to manage these new systems, and of the possible constraints certain institutions may place on adoption. At this level of testing the areas on which farmers test the systems should be large enough to provide a reasonable assessment ot the problems of operating these systems. Subsidies and gifts of inputs should be avoided if possible. Certain guarantees may need to be made to elicit cooperation. Participants may have to be selected to obtain a distribution of farm size, soil type, access to water or other important criteria. The same data should be recorded at frequent intervals as described above in the on-farm research management trials. It would also be preferable to record the labor use of the participant in all his activities while he is testing the new system. Notes should also be kept on the difficulty of selling products and obtaining inputs at required times. If adequate information is not available on traditional cropping systems management and performance, selected samples of these should be surveyed as well. In summary, this step might involve the following procedure.

(1) It must be decided what characteristics are desirable to include in the design, such as farm size classes, different proportions of time the family works on the farm, income classes, soil differences, access to water, etc. The proportion of participants selected in each class of the characteristics could be taken to reflect what was found in the general survey taken in step 1.

(2) Farmer participants should be selected who will commit a significant part of their farm to growing a new system recommended

by the research program.

(3) Resource use and productivity in the new system as the farmer manages it must be recorded as well as the difficulty of selling products and obtaining inputs at required times. The participant farmers' labor and operating capital use in all activities during the time of testing the new systems could also be recorded.

(4) Information referred to in (3) must be recorded for farmer s growing traditional systems and not testing the new systems. The experience of the village program of the Multiple Cropping Project at Chiang Mai is that farmers testing the new systems adopt many of the recommendations on their traditional systems being grown on other parts of the farm. Therefore, they do not constitute a good sample for observing traditional patterns.

The data resulting from this procedure would allow one to make several kinds of analysis. First, comparisons of net incomes and returns to resources among new systems and between new and traditional systems can be made as the farmers managed them. Resource use profiles could be compared between new and traditional systems to observe possible resource constraints at different times of the year shen the new and traditional systems are managed at the same time. If nonfarm employment is prevalent in the area, one could compare returns to labor in the new system to see if they were competitive with labor value in nonfarm work at different times in the year. The actual management complexity of these systems could be judged from the participants experience. Those particular aspects of management that were not implemented should be analyzed in further design and testing research. If the farmer testing program were spread over different environments, adaptability coefficients could be calculated. These would give indications as to how adaptable the new systems were to different environments when managed by farmers. The implications of these coefficients would be the need for more or less specific environment testing on various systems and hence how widespread they might be included in extension programs.

Stability coefficients for net income of systems through time could be derived if the farmer testing occurred over a number of years. The sources of variance of the net income could be separated into price and yield variation. Further analysis of significant yield variations would also need to be done.

Again it would be instructive to compare the new systems and traditional systems with respect to not only average net incomes but also the variance within each system. Comparisons of the two worst outcomes for each system might also reveal the expected disastrous results.

Preliminary judgments regarding the ability of the input and output marketing systems to support the new systems could also be made. The data collected in this stage would also form a basis from which estimates of the benefits of changing the infrastructure could be derived. For example, if sprayers and insecticides were not available to farmers, an estimate of their value could be made from data collected in the on-farm trials. This estimate would be useful in determining the possible benefits of supplying these inputs and what the timing and level of demand might be. Other examples for credit, small equipment or market outlets for new products could also be cited. These kinds of analyses would be useful in formulating extension program requirements.

Depending on the design for these farmer testing trials, other analysis could be done. If there were different farm sizes, income levels, or tenure arrangements represented by the participants, the differences in experience and results should be considered. Questions would include the following: Were there differences among classes in returns to various factors of production and why? How were the costs and returns distributed among landlord and tenant for the new systems as contrasted to the traditional systems? Were there different experiences in getting access to inputs such as seed and credit?

Further social science research at this stage could include obtaining participant farmers reactions to the systems they tested as to how they felt the systems met their needs and non-participants reactions to what they observed with respect to the new systems. Comparative characteristics of the farmers who did and not volunteer to participate in the testing program could be useful in sharpening extension strategies for the next stage. Information flows about the new technology could also be analyzed in this step. Analysis of how much information the non-participants received about the new technology and how they obtained that information would also be helpful.

Extension personnel should be involved in this step so they can become familiar with the new technology. This kind of training would be quite valuable to prepare them for the extension of this technology on a wider scale.

Extension and evaluation

As the new cropping system technology is validated by farmer testing, extension programs should be planned. While the leadership role in defining and implementing these programs may rest with institutions other the cropping system research group, the research people have important contributions to make. These contributions can be divided into two categories, preprogram planning and further evaluation of the technology adoption process. Social scientists have important roles to play in both these categories.

The preprogram planning aspect would include training of extension workers and developing requirements that need to be met by enabling and service institutions if the technology is to be adopted. Much of the training of extension workers would involve agricultural scientists and these topics will not be discussed further. Social science training should include helping extension workers gain skills at analyzing farmer and community situations. This could include survey techniques, communication skills, extension strategies, and farm management analysis. Although farm management training is very important in effective extension work, it is often neglected in training programs for extension workers. While not all extension personnel at the farm level need to be farm management experts, they do need an appreciation for role farm budgeting analysis can play in helping farmers decide about alternatives. This training could include preparing enterprise and partial budgets, family income and expenditure plans, and intermediate farm plans (3-5 year perspective). This kind of training and work would need to be supported by some farm management extension specialists at a higher level. The analyses discussed in the farmer testing section with respect to information flows and characteristics of farmers willing to test the new technology could help in this training program relative to extension strategies. Extension departments in ministries and universities should be able to provide instructors for the subjects related to extension strategies while sociologists, psychologists, and communications specialists would be helpful in the other areas.

The formulation of institutional support required for successful extension of new cropping system technology requires inter-institutional cooperation. The role of the social scientist involves assisting in estimating the level and timing of requirements that must be furnished as the new systems are extended. In cropping system technology extension, the timing of input and marketing services are even more important than in single crop programs. With information derived from farmer testing regarding input requirements and timing, this larger programming task will be based on more accurate information. The specific content of this process will vary among programs, but some common elements are likely to exist. First is the requirement for water as to amount, time, and place if the program is operating in an irrigated area. Changing the water distribution pattern may be difficult as it is probably oriented to serving the traditional systems (note data classification in appendix table 1). A second example would be credit. If the systems require quick turn over in crops, credit may have to be provided in a more timely way. Data collected and analyzed in step 1 and 3 on farm household income, expenses and cropping systems would be a basis for this analysis. Similar examples could be given for seed, fertilizer and other inputs. Output market concerns would need to be considered especially if new or minor crops were to be involved or if the production of certain commodities requiring substantial processing or handling wer to be increased.

The second category of this step includes further evaluation of technology by analyzing the adoption process. Fortunately, there is a large amount of literature on this broad topic (see (24) and (22) for a review of constraints to adoption studies). Basically, these research efforts have been oriented toward understanding the adoption process itself, factors constraining the process, and consequences of adopting the technology. Since the development of this cropping technology was oriented to production of technology that fit farmers preferences, resources and hard to change constraints, the implementation will face fewer constraints and be wider spread than otherwise. A small multidisciplinary research team of an agricultural scientist, economist, and sociologist and/or psychologist should carefully design a study in an area where extension efforts are to be made to monitor the progress, problems and impacts of these efforts. Similar measurements and designs as discussed in step 1 and the farmer testing program should be made before and during the extension effort (see (10) for an example of this kind of project on new rice technology). The question is not simply if the new technology is adopted or not as there are varying degrees of adoption and different parts of new technology. Therefore, in monitoring this process, it is important to define the parts of the new technology (new varieties and fertility levels, different land preparation techniques etc.) and the degree to which it is adopted (percentage of area, proportion of parts adopted, and frequency over time). The information regarding the particular aspects that have and have not been adopted is important with respect to understanding constraints. If, for example, some aspects are almost always not adopted while the adoption of other parts is much more variable, the first set of aspects may be considered unproductive by farmers or pervasive institutional constraints that prevent them from geing implemented may not have been removed. For those parts of new technology that have been adopted by some farmers and not others, further analysis as to the characteristics of those that have and have not should be done. In this research we are not so interested in simply identifying characteristics of farmers associated with technology adoption as we are at understanding more precisely <u>what</u> those barriers are. It may be smaller farmers and/or tenants do not have as easy access to some inputs as larger landowners. Or, location variables may explain the variance in that certain services are not reaching some areas. See (8) for an interesting example of research on constraints to rice yields. If there are certain important categories of farmers that have not adopted the technology, their situations should be analyzed as to why and work could begin on developing systems that are more relevant to them.

Consequences of the new technology should be measured with respect to the effects on production, incomes, employment and their distribution as well as on nutrition and use of inputs. If these studies continue over time, impressions regarding the variability in incomes can also be made. Specific questions would involve the effects on the level and structure of employment and its relation to equipment use changes since employment problems are of increasing concern now. The distribution of benefits among income classes and land ownership categories with respect to size, and owner, tenant, and landless laborer groups are also important to know to judge the "desirability" of the new technology from a policy viewpoint. The capital accumulation process needs to be monitored as well to estimate the size of gains and the ways they are utilized in terns of increased farm investment, nonfarm investment, and/or consumer goods. Since multiple cropping is already being "advertised" by the popular press (9) as a revolution in increasing production and equity, the documentation of its effects on these variables must be made so future policy can be based on what actually is occurring rather than on wishful thinking (see (14) for general discussion on these issues).

Wider effects on employment and income in industries buying outputs from farmers and supplying them with inputs and consumer goods can be estimated. Ex post measures of the returns to investment in the research program can be made from the baseline data developed in step 1 and the results of the extension program (see (15) for a discussion of techniques that can be used).

SUMMARY

Successful development and implementation of new cropping system technology requires that social and agricultural scientists work closely together. How this might be brought about involves several principles. Among them are:

(1) similar levels of experience and competence among social and agricultural scientists;

(2) representation of the disciplines concerned in the process of conceptualizing the program objectives and methods and setting policy;

(3) dissemination of information on the program's progress to all concerned;

(4) joint briefing sessions for visitors;

(5) an open attitude about the contributions of other disciplines; and

(6) compatible personalities.

That we must work together should be no surprise. Farmers have to "put it all together" and we can help by cooperating in the development and evaluation of cropping systems. One of the sub-disciplines that is a key to this integration-farm management-needs to be emphasized in the research and training programs.

Figure 1 gives a summary view of the research process that can be employed in cropping systems research programs along with the general contributions social scientists can make in each of the steps. The role then of social scientists can be summarized to be one of

(1) helping to understand the rationale of traditional farming practices and constraints on productivity,

(2) assisting in designing research on systems that will make them more easily adopted,

(3) evaluating potential systems as to their likelihood of adoption,

(4) estimating the requirements of new systems with respect to institutions relating to the farmer,

(5) helping to understand constraints on adoption, and

(6) estimating the consequences of the technology as it is adopted.

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Appendix

Table 1. Example of Classification of Data Needs

(see the end of this table for explanations of scales and headings)

Classification	Variable characteristics			Relative Importance of Data		
	change difficulty	frequency of measurement	ability to remember	Baseline	General	Specific
I. Environment						
A. Public policy						
1. Output and input prices	1	SP	R	3	3	3
2. Number of extension workers and training	1	SP	R	2	2	3
3. Ag. associations	1	SP	R	3	3	3
4. Production or other special purpose campaigns	1	C	R	1	1	1
B. Physical						
1. Topography	1	SP	R	1	1	1
2. altitude	1	SP	R	2	2	2
3. rainfall						
a. pattern	1	C	R	1	1	1
b. temperature	1	C	R	1	1	1
4. temperature	1	C	R	1	1	1
5. soil classification	1	SP	R	1	1	1
C. Social						
1. traditions	1	SP	R	3	3	2
2. community size	1	SP	R	1	1	2
3. community organizations	1	SP	R	1	1	1
4. education	1	SP	R	1	1	1
5. migration	1	C	R	2	4	4
6. community facilities	1	SP	R	1	1	1
7. family structure						
age	1	SP	R	1	2	1
sex	1	SP	R	1	2	1
relationship	1	SP	R	3	5	3
D. Economic						
1. roads	1	SP	R	3	3	2
2. transportation	1	SP	R	3	3	2
3. tenure arrangements	1	C	R	1	2	1
4. level of living	1	C	R	1	4	1
5. storage capacity	2	SP	R	1	2	1
6. credit arrangements	2	C	R	1	2	1

Classification	Variable characteristics			Relative Importance of Data		
	change diffi-culty	frequen-cy of measure-ment	ability to remem ber	Baseline	General	Specific
II. Resource s						
A. Land						
1. area	1	SP	R	1	2	1
2. value	1	SP	R	1	2	1
3. parcel size	1	SP	R	2	1	1
4. various physical and chemical measures	1	SP	NR	2	1	1
B. Irrigation						
1. type	1	SP	R	1	1	1
2. amount available through time	2	C	R	1	1	1
C. Solar radiation measured in various	1	C	R	1	1	1
D. Labor available						
1. family	3	SP	R	1	2	1
2. hired	3	SP	NR	1	2	1
3. wages in casn and/or kind	3	SP	R	1	2	1
E. Power						
1. animal number and value	3	SP	R	1	1	1
2. machine type and cost	3	SP	R	1	1	1
3. service facilities	1	SP	R	1	2	1
F. Operating capital						
1. cash flow	3	C	R	1	1	1
2. credit and debt amount and cost	3	C	R	1	2	1
3. savings	3	C	R	1	2	1
G. Material inputs (e.g.fertilizer pesticides, seeds etc.)						
1. cost	1	C	R	1	1	1
2. availability	2	C	R	1	1	1
3. reliability	2	SP	R	1	2	1
H. Output markets						
1. products purchased	2	C	R	1	1	1
2. product grading	2	C	R	1	1	1
3. prices padi	1	C	R	1	1	1
4. buying practices	2	SP	R	1	4	1
5. information supplied	2	SP	R	2	4	2
6. reliability	1	C	R	2	2	1
I. Management						
1. attitudes toward change	2	SP	R	3	3	1
2. attitudes toward risk	2	SP	R	3	3	1
3. priorities	1	SP	R	2	2	1
4. information sources	3	SP	R	2	2	1
5. trust of outside people	1	SP	R	3	4	1
6. attitudes toward debt	2	SP	R	2	2	1
III. Activities						
A. Family resource requirements						
1. Land-House and Yard area	1	SP	R	3	3	3
2. Water	1	SP	NR	2	3	3
3. Labor time	2	C	NR	2	2	1

Classification	Variable characteristics: change diffi culty	frequen- cy of measure ment	ability to remem- ber	Relative Importance of Data: Baseline	General	Specific
B. Community commitments						
1 . tax	2	SP	R	2	2	1
2. labor by family member	2	C	NR	2	2	1
3. cash	2	C	R	2	2	1
C.. Non-farm economic activities						
1. time by family member	3	C	NR	1	1	1
2. wages	1	SP	R	1	1	1
3. amount earned by family member	3	C	R	1	1	1
4. type of occupation	3	SP	R	2	3	1
5. attempts to do off farm work over time	3	C	R	1	2	1
D. Other income sources	3	SP	R	1	3	2
E. Livestock - for each type						
1. cash requiremen t	3	C	NR	2	2	1
2. land requirement	1	SP	R	2	2	1
3. crop requirement	2	C	NR	2	2	1
4. by-product requirement	3	C	NR	2	2	1
5.. labor requirement	1	C	NR	2	2	1
6. production and value	3	SP	R	1	2	1
7. sales and consumption	3	SP	R	1	2	1
F. Cropping system						
1. area by crop and variety	3	SP	R	1	1	1
2. sequence of crops by variety	3	SP	R	1	1	1
3. weed management	3	C	NR	1	1	1
4 . insect management	3	c	NR	1	1	1
5. disease management	3	C	NR	1	1	1
6. physical soil management	3	C	NR	1	1	1
7. chemical soil management	3	C	NR	1	1	1
8. water management	3	C	NR	1	1	1
9. harvest management	3	SP	NR	1	1	1
costs should be attached to each of the above for labor equipment and supplies used.						
crop calender	3	SP	R	1	1	1
system calender	3	SP	R	1	1	1
IV. Needs						
A. food						
1.. amount and source by family	1	C	NR	1	1	1
2. taste preferences of home produced food	2	SP	R	1	2	1
3.. amount purchased versus grown	3	C	NR	1	2	1
B. Consumer items-expenditure						
11.housing	3	SP	R	2	3	2
2. clothing	3	C	NR	2	3	2
3. transportation	3	C	NR	2	3	2
4. education	3	SP	R	2	3	2
5. health care	2	C	NR	2	3	2
6. other expenses	3	C	NR	2	3	2
C. Social acceptance						
2. norms of nation	1	SP	R	4	3	1
2. norms of community	1	SP	R	4	3	1

Classification	Variable characteristics			Relative Importance Data		
	change difficulty	frequency of measurement	ability to remember	Baseline	General	Specific
D. Stability						
1. income	1	SP	R	2	2	2
2. food production	1	SP	R	2	2	2
E. Improvement						
1. income	1	SP	R	2	4	2
2. community services	1	SP	R	2	4	2
3. food production	1	SP	R	2	4	2
4. consumer items		SP	R	2	4	2

The change difficulty scale refers to the ability of the farmer or research program to change the values of the variables.

1 - most difficult to change
2 - moderately difficult
3 - least difficult

The frequency of measurement scale refers to the need to measure a variable once (SP) or several times (C) during a year to obtain accurate data.

The ability to remember scale refers to the likelihood of a respondent remembering accurately (R) or not (NR).

The relative importance to data scale refers to the need to obtain certain levels of accuracy.

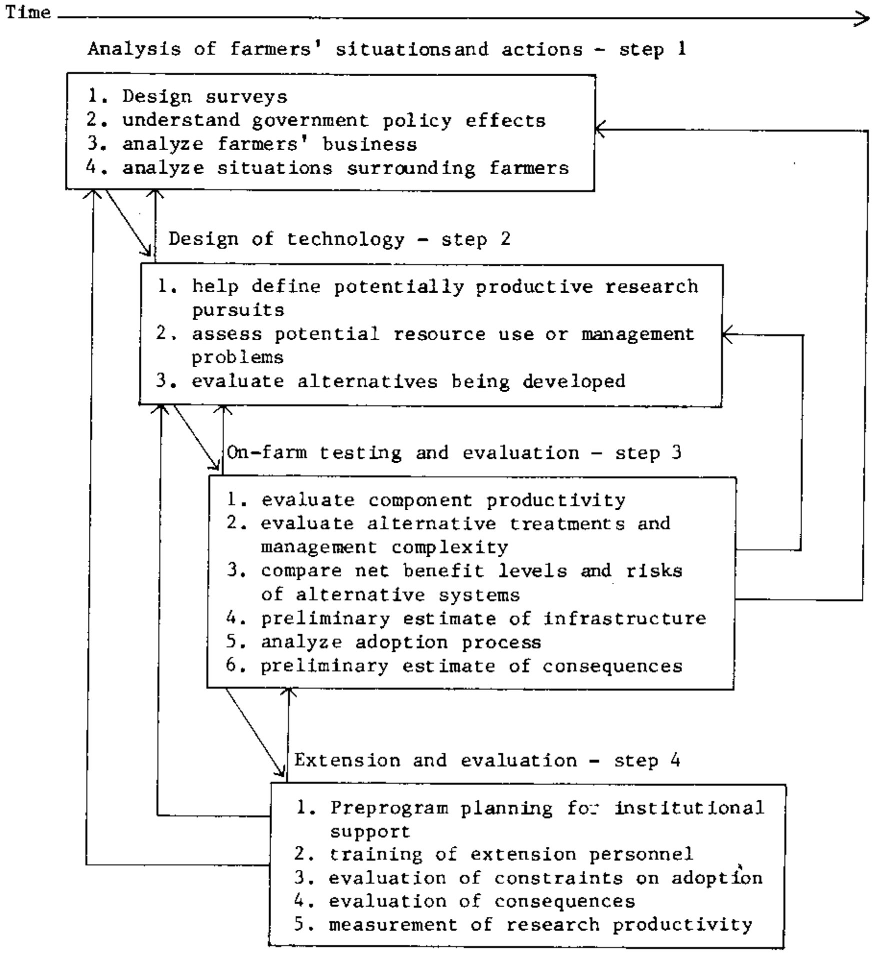
1 - must have accurate information
2 - should have accurate information
3 - should have general information
4 - helpful to have some information

A baseline study is used to measure certain variables so that later measurement will allow comparisons over time.

A general study is to provide researchers with knowledge of characteristics of farmers and their environment over the area of concern of the cropping systems programs.

A specific study refers to case studies of certain farmers to better understand why they do as they do.

Figure 1. Cropping System Research Program Process and General Contr... of Social Scientists [1]



[1] These steps overlap in time and results in later steps may require going back to previous steps for further analysis.