AN EFFICIENT INTERDISCIPINARY METHODOLOGY FOR DESIGNING AND TESTING TECHNOLOGY, INFRASTRUCTURE AND POLICY TO BENEFIT POOR AND DIVERSE SMALLHOLDERS IN VARIABLE CONDITIONS IN DEVELOPING COUNTRIES

Peter E. Hildebrand

CONTENTS

Cover photo: One of the ICTA technicians with a farmer in her farmer-managed trial in the highlands of Guatemala, ca 1977.

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Peter E. Hildebrand[1]

INTRODUCTION

Following the creation of the Agricultural Extension Service in the United States nearly a century ago, the model of moving technology from national or state experiment stations to the extension services and then to farmers was followed successfully for nearly 60 years. Particularly following WWII, efforts were made to identify "progressive farmers," those who benefited from new policies and improved infrastructure and were able to adopt the technology being created by this process. Horse traction was rapidly replaced by tractors particularly during the war. Farm size increased rapidly and the number of farms declined as the "laggards," who were not the "innovators" (Rogers, 1983) were fast disappearing from the farm scene and were relatively easily merged into the non-farm economy as the term "get big or get out" was often heard.

Without going into the reasons why the "bigger is better" concept is not wholly appropriate even for industrial countries, it became obvious early in the 1970s that it was not effective for the Third World where the large majority of people were small farmers and the majority were not being served by the trickle down strategy (Whyte, 1981 and 1986) nor able to take advantage of new policies and infrastructure. In the Third World, as opposed to the industrialized countries, little capacity is available to employ persons forced from agriculture into urban areas where crime and violence are increasingly common. Employment needs to be maintained and productivity and income increased on small, resource-poor farms in order for growth to take place and to reduce hunger. Even the gains made by small farms in the Third World with Green Revolution technology were achieved only by those with the best resource bases, a limited minority. The technology did not trickle down from them to other small farmers who did not have the advantages of the better resource base. As it became apparent that all farmers in a community were not part of the same "social system," it was realized that the progressive farmer strategy coupled with the failed trickledown theory did not work. Other approaches were needed.

Research on technology diffusion was able to show *ex post* what characteristics were related to "Innovators" (Hildebrand and Partenheimer, 1958), but were unable to provide *ex ante* suggestions for effective intervention strategies for the non adopters. And the progressive farmer strategy coupled with the trickle down concept fails when the farm population is not

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homogeneous, but highly heterogeneous, the usual situation in developing countries. "Laggards" and "Innovators," originally considered to be members of the same social system simply because they lived in the same community, region or country, are very different farmers, with different environments, resource situations and household composition.

Much of the research carried out in the United States, as well as in other countries, both developed and undeveloped, has been presumed to be scale neutral (Carter et al. 1981). It was thought by the researchers that it would produce and be adoptable equally on large and small farms. However, it will be argued in the next section that the majority of the research and planning that is conceived as scale neutral is, in fact, not scale neutral and is strongly biased toward large-scale commercial agriculture and against small, limited-resource family farms (Hildebrand, 1986).

Even though millions of farmers were bypassed because of the use of the progressive farmer/trickle down philosophy, this strategy, in a modified form, can be used for "categories of farmers who have been carefully identified as homogeneous and with innovations that have been developed to suit the characteristics of those homogeneous categories" (Röling, 1988 p. 71). Röling uses the term "target categories" that is similar to a combination of "recommendation" and "diffusion" domains (Wotowiec et al. 1988) found in the farming systems literature.

William Easterly (2006) discusses what he calls the "planners" versus the "searchers." The former envision great ideas for broad adoption of technology, policies and infrastructure while the searchers get on the ground and work from the bottom up. Kristjanson et al. (2009) focus on the gaps that exist between knowledge produced by researchers and action taken by decision-makers at all levels, from farmers to extension agents. Since the early 1970s, new searcher methodologies have been developed and improved for working with the abundance of *household and environmental diversity* found in limited-resource farming systems. During the 1970s, independent activities were being carried out by farmer-oriented researchers in the search for methodologies to provide improved technologies appropriate for and acceptable to the limited resource farmers in several developing countries (Gostyla and Whyte, 1980; Whyte, 1982; Collinson, 2000). Most of these have been termed "Farming Systems Research" or "Farming Systems Research-Extension" (FSRE) methodologies.

This document presents a combination of several of these procedures created and tested over a period of four decades that provides an efficient interdisciplinary methodology for testing and designing technology, infrastructure and/or policy *to benefit poor and diverse smallholders in variable environmental conditions* in developing countries, conditions anathema to most researchers and planners. However, there are many projects and programs underway at the current[2] time to reach this audience with improved technology, infrastructure and policy, all of which could benefit from using some or all of the methods discussed here. The multidisciplinary methodology combines a rapid appraisal or Sondeo, farmer managed on-farm trials, farm enterprise records, an index of acceptability of technology being tested, ethnographic linear programming or ELP, and modified stability analysis later called adaptability analysis.

[2] Some of these include the Sasakawa program, the Millenium projects, and those of several IARCs.

It is hoped that this document will provide some guidance to teams involved in the on-going and new programs of research and extension for diverse limited resource famers in Africa, Latin America and Asia as well as those making policy and infrastructure decisions for these conditions.

Sondeo

You are in a country and have a mission to reduce poverty and food security, and improve the livelihoods of small farmers who live in widely diverse situations throughout the country. You choose or are assigned a region within which to work and are provided with a multidisciplinary team of persons from both sexes and from agricultural and social sciences. The region is too diverse to consider as a whole so the first step is to identify one or more livelihood systems[3] within which to concentrate the team's efforts. The most rapid and effective method is by means of a Sondeo (Reiche et al. 1976; Duarte et al. 1977a; Duarte 1977b; Hildebrand, 1981). This should take place preferably during one or two weeks in the slack season prior to work beginning for the new season so the team can complete its work and be in the field when the farmers begin their land preparation and/or planting.

On-farm, farmer-managed trials

Assuming that there are some ideas for technologies that might fit the conditions of the persons in your livelihood system, begin some on-farm trials (Hildebrand, 1984; Hildebrand and Poey, 1985; Stroup et al. 1993). These should be farmer-managed and not run by members of your team. Also the farmers should expect to pay for any cash expenses involved. If it is seed then this can be returned after harvest. The plot size should not be large and there is no need to replicate plots on each farm (see Adaptability Analysis, below), but preferably you will have at least 12 farmers conducting the trials. Simple modifications to what the farmers are already doing are best to test and no more than a couple different treatments should be included. The team members should visit the trials often and discuss with the farmers how they feel about the changes that are incorporated. And, of course, team members must be there for harvest, otherwise the farmers might just harvest the plots with the rest of the field and the team members would not know what the results were. Of course, the farmers may already have decided to use the technology the following year or to reject it as not practical, but for its purposes of analysis, the team usually needs yield estimates.

The year following the on-farm trials, an additional measure becomes available—an *Index of Acceptability* (Chinchilla and Hildebrand, 1979; Hildebrand and Poey, 1985). This is not a test of how many farmers "adopted" the technology (the usual criterion for innovators), but

[3] A *livelihood system* is comprised of all the activities available to all the farm households in that system from which to choose their household *livelihood strategies* to earn their living. Farmers who can chose other activities not available to the farmers in the first livelihood system belong to another livelihood system.

rather a *test of a quality and usefulness of the technology as viewed by the farmers, themselves*. This is calculated the year following the trial and after the farmers on whose land the trials were conducted have had an opportunity to use it on their own.

Farm enterprise records

To improve on the information already collected and to improve the ELP models as validation proceeds (see below), farm enterprise records (Hildebrand, 1979a; Hildebrand 1982) are easily incorporated in the methodology. Even if these farmers do not keep records, by visiting them every two weeks (should already be happening) they can remember quite accurately what they have done, who did it, how long it took, and what, if any, inputs were used. In Guatemala, sometimes the children kept the records with adult input. But with frequent visits the information can be very acceptable and better than obtaining it by distant recall via surveys.

Ethnographic linear programming

This is the most recently developed facet of the methodology (Hildebrand et al. 2003). It does require more expertise than the other aspects and takes a bit more time, but is easily accomplished during the time the sub teams are working with the farmers. It also requires a laptop computer loaded with Excel with backup batteries in case the farmers do not have electricity. It has been successfully and productively used in many development situations. See for example: Cabrera et al. 2005; Kaya et al. 2000; Litow et al. 2001; Mudhara et al. 2003; Mudhara and Hildebrand 2004; Thangata et al. 2007a; Thangata et al. 2007b, and Gill 2010.

Adaptability analysis

Most often, on-farm trials are designed by researchers with several treatments and three or four replications on each farm and require more land than most small farmers are willing to utilize for such an experiment. Further, they are more complicated than farmers should be expected to manage. Utilizing the on-farm trial design discussed above, a very efficient means of analyzing the combined results from those conducted on several farms is Adaptability Analysis (Hildebrand and Russell 1986), formerly called Modified Stability Analysis (Hildebrand 1984). With this in mind, the simpler trials should be conducted over a wide range of environments.

Second year and beyond

Most of the above activities can be completed during the first year a team is in the field. The Index of Acceptability obviously awaits farmers' decisions the year following the first year's farmer-managed trials. The Ethnographic Linear Program model can be refined as well in the second year. But starting the second year in the field, the team will have a reliable basis upon which to make recommendations to improve the livelihood system of the farmers in their area—whether for immediate extension efforts, new farmer-managed trials, or for other technologies that may be better suited to their farmers than those tested the first year based on best bet estimates. In addition, recommendations can be made for new infrastructure including markets or credit, or policies such as price supports that would benefit the diverse households in their livelihood system.

ON THE NON-NEUTRALITY OF SCALE OF AGRICULTURAL RESEARCH

In this section it is argued that the majority of the research or plans conceived as scale neutral by the researchers and planners is, in fact, not scale neutral and is strongly biased toward large-scale, commercial agriculture and against small, limited-resource family farms.[4] This is true in the United States but even truer in developing countries. Three reasons are primarily responsible for this bias. These reasons are not recognized by most agricultural researchers and planners and have not entered into the evaluation criteria regarding scale effect of their research and plans. These reasons, all interrelated, are:

1. *The quality of resources* is frequently lower on small farms than on large farms. This has the effect of *shifting a small farm production function downward* in comparison with large farms so that response from a technology on a small farm is often less than on a large farm. This means that the use of a given technology will produce less on most small farms than on large, commercial farms.
2. Limited quantities of resources, fixed in a higher proportion result in a *concave opportunities curve* for the low-volume farm resulting in a reduction in income when enterprises are combined. Yet many small farmers are forced to diversify for subsistence or because they have little confidence in support from normal or planned market infrastructure or policies.
3. Forced farm enterprise diversification and/or off-farm work reduce the quantity if not the quality of *management in each enterprise* on the family farm. This influences the time required to *learn to use a new technology*, making learning more expensive. Low volume output prevents spreading the higher learning costs (loss of income or product from not achieving anticipated results) over a sufficient number of units to make complex learning situations feasible for the small farm. This also influences the capability to reap the benefits from many policies and some infrastructure.

The combined effect of these three factors is to make it infeasible for the low-volume farm to adopt more complex technology or respond to changes in policy or infrastructure. The need under the conditions of low volume is for technology that is simple, as opposed to complex, and uses mostly resources already on the farm, as opposed to purchased inputs. This is not the kind of agricultural technology being produced by most research establishments in developing countries.

Resource and input quality

Not universally, but frequently enough to make it a general rule, small farmers operate with inputs and resources of inferior quality compared to large or commercial farmers. It is common to see small farms pushed off onto steep or rocky hillsides with obviously poorer soils. Animals, if they exist at all, are weaker or smaller and do a less effective job in soil preparation and

[4] This section is taken heavily from Hildebrand 1986.

cultivation. Purchased inputs are more apt to have been poorly stored or otherwise arrive at the farm late or with inferior quality. These and other reasons account for a lower quality input base on a small farm. Combining these inputs with a new technology leads to lower responses than those achieved on farms with a higher quality resource base and reduces potential for adoption. *It is not the size of the field* in which an improved seed is planted that is important. It is the quality of the soil, the amount of moisture, the presence or absence of pest and disease control, and the losses between maturity and harvest, when combined with the improved seed or other introduced technology that influence response. Technical innovations that appear promising with high quality resources are much less so with a poor resource base (Fattori et al., 1990).

Fixed resources

Undoubtedly the least considered effect of producing on a farm with a high proportion of fixed inputs or resources is the influence of those fixed resources on responses to introduced technology, policy or infrastructure. The effect of the resources fixed for the farm but variable between enterprises is usually ignored. Rather, it is assumed implicitly by researchers and planners that the amount of fixed factors in *each* of the production activities on the farm is adequate. This implies that sufficient fixed factors exist for each of the two or more enterprises. This clearly is not the case with a limited-resource farm.

Consider a limited resource farm with four units of labor available on the farm during a particularly critical period such as at planting and choosing between two activities. If all four units of labor are used on one of the activities then a favorable response could be expected. However, if both activities are required to provide for the household livelihood, then fewer than four units of labor can be used in each of the two, resulting in less favorable responses of the introduced technology. This effect exacerbates even more the consequences of forced diversification for subsistence.

Cost of learning

Farmers have to learn to use a new technology. Depending on the nature of the technology, it may take several attempts before its anticipated potential can be reached. The responses achieved at each different attempt form what can be called a learning curve (Wake et al., 1988). It can take several attempts for a farmer to learn to use the new technology sufficiently well that it achieves its potential. A person who has less time to devote to the learning process cannot achieve the potential from the new technology as rapidly as a person who has more time available for learning. Hence, for a manager of a small-scale family farm who has many enterprises to manage, more attempts will be required before potential is achieved. On the other hand, the simpler the technology, the more rapid will be the learning.

Conclusions

One conclusion is that simple rather than complex technology is more appropriate for the small-scale family farmer with little time available for learning how to use the new technology for each individual enterprise. However, simpler technology usually is associated with a lower potential benefit. This leads to a rejection of the simpler technology by scientists when evaluating alternative technologies in favor of more complex technologies with higher yield potential. For a scientist who assumes instantaneous learning, this is a logical decision. But for the small, diversified farmer who does not learn instantaneously, the simpler technology may be more acceptable and more adoptable than a higher-payoff technology that takes several attempts to learn and may therefore be rejected.

Low quality resources on small farms compared with large farms shift downward the response associated with a technological change making the potential for adoption less than for a large farm. Any of a number of the characteristics of small farms reduces the acceptability of a high-cost or complex technology to the small farmer. And if small farmers are unable to adopt new research results (technology), or benefit from new policies or infrastructure because of these straightforward economic reasons, *it is not correct to argue that most of our attempts at agricultural development have been or are scale neutral*.

For these reasons, technology, policies and infrastructure oriented for small farmers should be evaluated and tested under the resource conditions found on the farms of the clientele for whom they are designed to *reduce inflated estimates of potential response*. Agricultural researchers and planners need to *understand* the economics of small farms if they intend to produce technology, policy or infrastructure for them. Otherwise, attempts at agricultural development will continue almost inevitably with a bias, albeit unintentional, toward large commercial farms and worldwide efforts to aid small family farmers will continue to have only limited effects.

SONDEOS

Following Easterly's (2006) suggestions on being a "searcher," the way to begin to learn about diverse, limited-resource, small-scale family farmers is to go where they live and work and have conversations with them. The word 'conversations' is used here because the Sondeo methodology is not a survey in the common sense with a preconceived questionnaire to which the 'respondents' are expected to answer. Rather, a multidisciplinary team comprised of people who will be working in an assigned area go to listen and converse with the farmers and their families about things that interest the team and the farmers. Of course, how they farm, who does what and when, what they have to work with, and their household goals will be discussed but only if the farmer and his family are interested. If a particular farmer or his or her family is not interested, then the team moves on to another farm to converse with them. The term 'Sondeo' meaning "sounding out" was developed in Guatemala over about four years of working with the Guatemalan agricultural research organization (the Instituto de Ciencia y Tecnología Agrícolas, ICTA) in response to budget restrictions, time requirements and the other methodology utilized to augment information in a region where agricultural technology generation and promotion[5] were being initiated. It is summarized in Hildebrand 1979b. Much of what follows was taken from Hildebrand 1981.

The purpose of a Sondeo is to provide the information required to orient the work of the technology generating, testing and promotion team, all of whom should participate in the Sondeo. Once a region is selected, the livelihood system or systems should be broadly described by a pre-sondeo and one should be chosen for concentration. For example, in eastern Guatemala, the livelihood system of small-scale farmers who were struggling to earn their living on rocky hillsides where even animal traction was not available was chosen as the target to work with, Figure 1.[6] Prior to the time these farmers were selected, all technology generated and tested was done for and on farms either in the level valleys or on the scarce hillsides that were relatively level and had few rocks to impede the animals and their equipment, Figure 2.

The premise on which the selection of a single livelihood system is based is that all the farmers who are in it have made similar adjustments to a set of restrictions which they all face, and since they made the same adjustments, they must all be facing the same set of agrosocioeconomic conditions. For example, those on the rocky hillsides in Guatemala did not have the option of using animal traction so all work was done by hand. This must be recognized by the technology generating team so that unrealistic technology requiring animal traction is not proposed for on-farm trials. Those farmers who are able to use animal traction and have much better soil to work with are in a different livelihood system. Much, if not most technology cannot be expected to work in both nor should it be expected that technology appropriate for those on level land can "trickle down" to those on the rocks.

[5] Promotion is used rather than extension because another organization in Guatemala was charged with extension.
[6] Also used to help designate this livelihood system was an air photo reconnaissance project that helped "discover" that nearly two thirds of the cultivated area was in *ladera*, the steep, mostly rocky hillsides (ICTA 1976).

The optimum number of persons for a Sondeo is about 12, but it can be done with fewer if necessary. Breuer (2000) even conducted a successful Sondeo by himself, though this is not recommended. It is critical that team members come from both agricultural and socio-economic sciences and if possible have both men and women so that conversations can be digested from multiple perspectives. Team members, however, should not feel the need to defend themselves and their fields from intrusion by others on the team. The final product will be a joint effort in which all have participated and for which all are equally responsible. Each member should be satisfied with the final product (a report) and both willing and able to defend it.


Figure 1. Conversing with a farmer planting on a rocky hillside.


Figure 2. A farmer on a level, more fertile field in the same area.

After looking over the region such as eastern Guatemala as a full team, and deciding on a particular livelihood system with which to work, 4 sub teams of 3 persons (the optimum) or as many as 6 sub teams of 2 persons depending on the situation, then begin having conversations with members of farm households in the chosen livelihood system. The teams disperse in the mornings, have conversations without taking notes nor recording the sessions, but after each session with one or more members of a household the sub team members find a comfortable location out of sight and make their individual notes. In the evenings each day the full team meets to compare findings and begins to outline a report of the livelihood system. The sub teams are then mixed to prevent one person dominating the conversations with farmers and the daily process is repeated about two days more. On the evening of the third day, sections of the report are assigned to each of the individuals participating in the Sondeo. The purpose of assigning sections that late is so the individuals do not know ahead of time what they will be responsible to write up. This helps them *concentrate on the big picture* and not just one part. These sections are written on the fifth day, working with others as necessary to fill in information or uncertainties. When that task is completed, the individual reports are combined into a full report that is read to all participants who then discuss sections, suggest modifications, or dispute a finding to then be agreed upon by the group. Conclusions are drawn from each section. With the availability of laptop computers, this is a fairly easy procedure.[7] Recommendations are then formulated and these form suggestions to be incorporated in the work of the team during the year. Figure 3 shows a team in the state of Acre in Brazil creating a schematic model (McDowell and Hildebrand, 1980) of the livelihood system in their Sondeo.

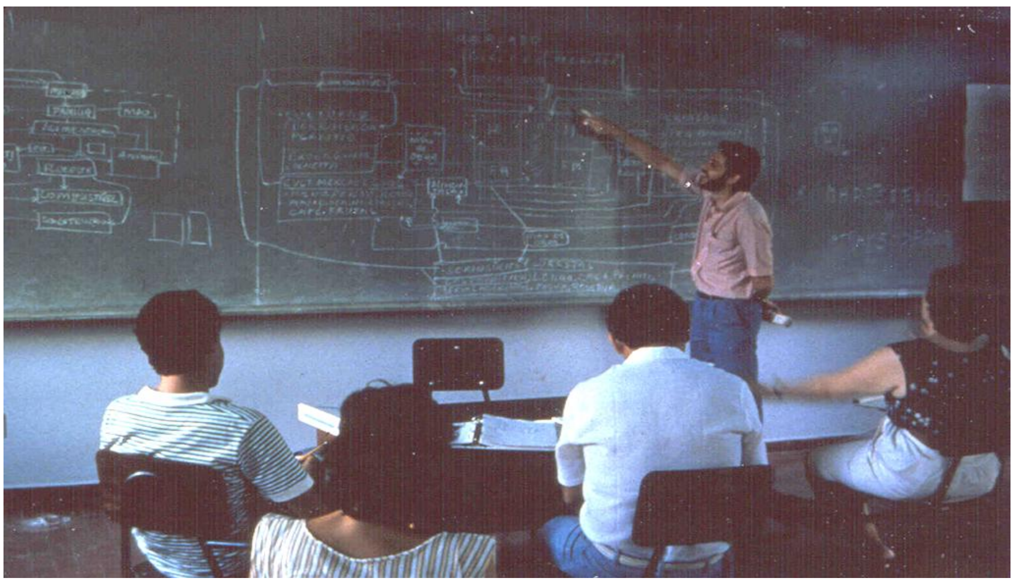


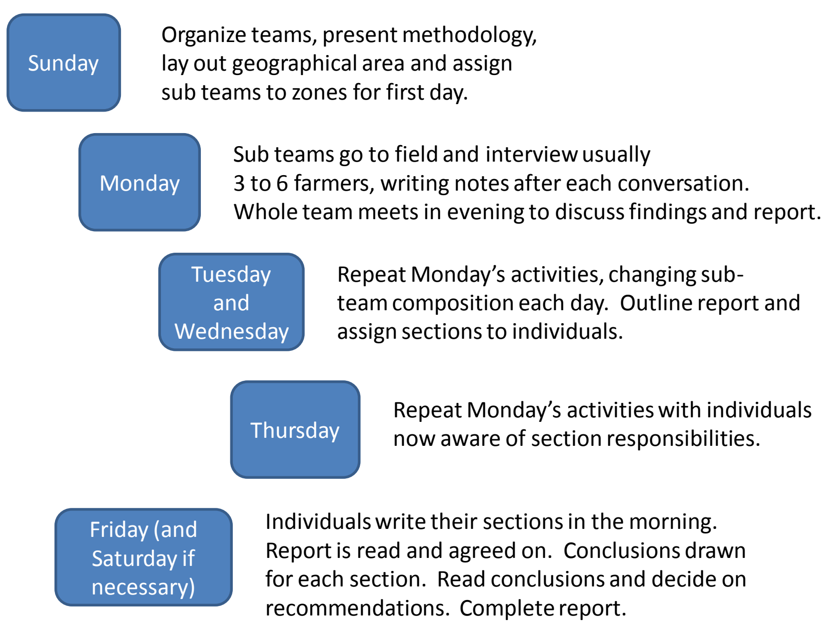
Figure 3. Creating a schematic model of one livelihood system in Acre, Brazil.

[7] In one farming systems training program in the state of Acre in western Brazil prior to the time laptop computers, or even computers were widely available, two Sondeos were conducted in the second week of the three-week course. The hand written reports were delivered to secretaries who typed and compiled them. The final reports, one with colonists and one with rubber tappers, were printed and available at the end of the three-week short course.

The Sondeo also has value in beginning to construct the ELP (see a following section). Even without going into the quantitative values (input/output coefficients), the team will find out what crops and livestock are common, which are primarily for home consumption and which primarily for sale. Also they should find out which crops are sole cropped and which are combined in intercropping. All of this information becomes activities in the ELP. It is easy to find out roughly how much of each of the crops and animals used for consumption is normally retained in the household. This information becomes some of the constraints in the ELP.

To a certain extent, the Sondeo report, itself, is of secondary value because the same team that will be working in the area has written it. Most of its value lies just in the fact that they wrote the report. By being in a situation where many different points of view had to be taken into consideration and coalesced, the horizons of all will have been greatly amplified. However, the report can serve as orientation for non-participants when discussing the merits of various courses of action regarding potential technology, policies or infrastructure to introduce. It is also obvious that the report will appear to be one written by several different persons in a hurry, which is exactly what it is! It is not a benchmark study with quantifiable data that can be used in the future for project evaluation; rather it is a working document to orient the program and serves that function in just being written. On the other hand, a Sondeo report can be incorporated with additional information and be published such as in the case of Cabrera et al. 2006.

Outline of Sondeo Methodology



ON-FARM, FARMER-MANAGED TRIALS

During the first year, utilizing previous research or "best guesses" based on information from a Sondeo, the best bet alternatives are placed in farmers' hands for their evaluation and to start the process of working with farmers and understanding their livelihood systems, goals and constraints (Hildebrand and Poey, 1985). This section covers only the trials that are in the hands of the farmers *for their evaluation* and from which they are expected to draw conclusions—farmer managed trials[8]. Keeping in mind that farmers themselves make the final decisions concerning adoption or rejection of a technology, farmer-managed trials (FMTs) need to be designed to provide the opportunity for farmers to become the primary evaluators of new technology. For farmers to have the opportunity to make sound decisions, the trials should possess three critical characteristics:

1) the technology, itself, must be simple enough for the farmers to *comprehend* and *manage* it;
2) the farmers *must use their own resources* so they can understand all the implications of the alternative or alternatives being tested; and
3) design of the trial has to be simple enough that farmers can *observe differences* in treatments and/or measure them, with their own means of measurement.

An example of a very simple FMT might be the testing of a new cultivar under the farmers' normal planting and cultivating procedures. The farmers contribute all their usual resources and/or costs plus the cost of the seed if the variety is new. Design of the trial would be simple: farmers plant one plot with the new variety and a similar check plot with their usual variety. Both plots would be managed by the farmers *just like they do their entire field*.

Because there is a relatively large number of farmers involved in FMTs and because the trials are not managed by the team members, there is a limit to the number of measurements the team members personally will be able to make during the trials. The most important, and usually the only one, will be yield. Other information will be available from the farm enterprise records maintained in collaboration with the farmers.

Check Plots. On each farm there must be a means for comparing the new technology or technologies with that of the farmer. This may come from a check plot or from sampling the farmer's field. Each of these methods has advantages and disadvantages. One of the main advantages of the check plot is that it is identified ahead of time on a representative part of the farm and it can be harvested at the same time as the treatment plot or plots. When a sampling procedure is used, it may delay the farmer's harvest because sample sites must be harvested prior to the regular harvest of the farmer. If delays are encountered, the farmer may harvest the whole field before data are collected. An advantage of the sampling procedure is that the farmer has no means of previously identifying the check area so it cannot be treated differently from the rest of the field.

[8] Much of this chapter comes from Hildebrand and Poey, Chapter VII.

Farmers may treat identified check plots differently from their own fields for a couple of reasons.

1. The usually *know how* to produce more than they do normally and want to prove this to the team members with whom they are working. The reason(s) they do not produce more on their own fields should be investigated. *Results will usually reflect constraints that are imposed on a whole farm but that can be relaxed on a single small plot.* The tendency to prove something to the team members is reduced as confidence builds between them and the farmers.
2. Because check plots are part of the "trial," farmers may wait until researchers tell them something like weeding needs to be done before doing it and not do it at the same time they do their own fields. Good (and frequent) communication between team members and farmers reduces this problem.

Number of Sites. The number of sites in FMTs depends on several factors, including:

1. The nature of the alternative to be tested,
2. The budget available to the team,
3. Other demands on the team members' time, and
4. The number of farmers involved in the FMTs.

Usually the fourth factor is not limiting. The first factor is important because a more complex technology or alternative requires more learning time from each farmer and team members will have to visit each farm more often for supervision. Team members require transportation to move among widely dispersed trial sites. A minimum number of farmers is 12, but up to 20 or more should also be considered. However, these should be *distributed in a wide range of environments* to improve the adaptability analysis (see a following section).

FARM ENTERPRISE RECORDS

The ICTA farm record project with small farmers in Guatemala (Hildebrand 1979a) began in 1975 as an additional means for obtaining agro-socioeconomic information in areas where the ICTA "technology testing teams" were working. The project began modestly and grew into a national project with records on many crops and cropping systems. From the beginning, it was conceived as a *crop* record project and was not intended as a whole-farm record program. No attempt was made to take full farm inventories or impute depreciation costs of equipment to each crop. This characteristic had three important advantages. One was that it held to a minimum the amount of time and bother the farmer had to put into the data gathering process. Second, training of personnel was simplified, and third, the analyses were simplified. This was the main reason the project had the success it enjoyed.

During the first year, and working in an agrarian reform parcelization area, the farmers were given simple tables on which they were to record their activities each day for the crop on which they were keeping records. These "Daily Work Sheets" were kept as simple as possible and included only the information that could not be obtained on periodic visits by team members (Hildebrand 1982). Those details were left for another sheet that the team members filled out when they visited the farmers. Following each cycle of work (land preparation, planting, weeding, etc.) the technicians collected the daily work sheet after verifying facts with the farmer. Following the end of the harvest and final collection of information the data were analyzed and a report prepared for ICTA and for each of the farmers who had participated in the project. In this first year, 20 farmers kept 40 records on maize, rice and sesame. From this modest beginning, the project grew in four years to include 34 different crops or crop systems in 11 areas where ICTA worked and included 593 separate records. It was obviously important information for the institute and not a burdensome task for the team members.

There has always been some doubt about the precision of yield measurements given by farmers. There are several reasons why the yields may be erroneous. First, the farmers do not measure their production with scales or by volume. In the case of corn in some areas of Guatemala the ears are gathered in large nets each of which, when shelled, produces "100 pounds" (Figure 4). This weight varies by variety, level of humidity of the grain, and by the size of the net that is made by hand and subject to error. Hence, there is no comparison between the farmers' method of measurement and that of the technicians. However, to be able to compare on-farm, farmer-managed trial data with data from farm records, the records that are kept on the trials must coincide with those kept by the farmers, and they must represent the same conditions. Also the yield figures must be compatible.

Figure 4. Sacks of ear corn supposed to produce 100 pounds of shelled corn and an ICTA team member checking with a farmer.

ETHNOGRAPHIC LINEAR PROGRAMMING

The most common criterion used by agronomic researchers is yield per unit of land area, commonly kg/ha. Choosing this criterion to the exclusion of criteria important to the diverse farmers in the livelihood system and their families most frequently results in the rejection by the farmers of the technology selected by researchers. *Understanding* farmers' criteria is critical when choosing a new technology, policy or infrastructure to be introduced to those in the livelihood system. But the criteria will also vary among households with different compositions. For those households with several small children who are too young to work in the fields with their parents, labor during critical periods such as planting may be the most limiting resource for that household. Thus, *kg/day of labor in that period* will be more meaningful than kg/ha. If a farm household has some adolescents to help in the field then this may not be so important (Figure 5).

(a) (b)

Figure 5. A man planting with his three adolescent sons (a) and a man with only small children (b). They probably have different criteria to judge a technology.

Seasonal cash availability and needs may dictate a relevant criterion. If cash is required at a particular time, say for controlling pests, when cash is not readily available, and any surplus products may already have been sold, then *kg/$ spent on that item* may be the relevant criterion. If a new technology may increase risk associated, for instance with drought, then the minimum acceptable risk (percent of time the yield may fall below an acceptable level) may be most important. In addition, other household activities may well compete for resources needed for the technology being tested and this will create other criteria. Ethnographic linear programming (ELP) can account for most of these criteria in a well-designed model.

Much of the data for an ELP will have come from working closely with the farmers in the Sondeo, their farmer-managed trials and their enterprise records. The person or persons in charge of the ELP should be constructing a matrix including columns of all the activities available to the farmers in the livelihood system (Figure 6). Rows for land, labor and cash resources (constraints) are included as are rows for consumption of farm-produced items. In the simplified example in Figure 6, labor and cash are entered on a semester basis, usually too broad. The input/output coefficients in the body of the matrix are data from the on-farm trials, the farm records and from discussions with the farmers. Consumption requirements must come from discussions with the farm families, most often the women.

	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
2				SELL	TR		TR M $	TR M $	TR F $	TR F $		SELL	SELL					
3	VARIABLES >>		MAIZE	MAIZE	MAIZE	HAY	BI-BII	BII-EYR	BI-BII	BII-EYR	GOATS	GOAT I	GOAT II					
4	AMOUNT >>		**1.58**	**12.50**	**35.00**	**0.30**	**28.33**	**98.33**	**10.00**	**172.00**	**2.00**	**1.00**	**1.00**		RESOURCE			
5	RES/CONST		ha	cwt	cwt	ha	$	$	$	$	head	head	head		RHS	USE	RES/CONST	
6	LAND	ha	1			1					0.1			<=	3	**2.08**	LAND	
7	M LABOR I	days	30			5					0.5			<=	50	**50.00**	M LABOR I	
8	M LABOR II	days				20					0.5			<=	20	**7.00**	M LABOR II	
9	F LABOR I	days	10								3			<=	25	**21.83**	F LABOR I	
10	F LABOR II	days				5					3			<=	20	**7.50**	F LABOR II	
11	HAY ACCTG	tons				-4					0.6			<=		**0.00**	HAY ACCTG	
12	MZE ACCTG	cwt	-30	1	1									<=		**0.00**	MZE ACCTG	
13	MZE CONS'N	cwt			-1									<=	-35	**-35.00**	MZE CONS'N	
14	GOAT ACCTG	head									-1	1	1	<=		**0.00**	GOAT ACCTG	
15	M CSH BEG I	$	200			150	1				5			=	400	**400.00**	M CSH BEG I	
16	F CSH BEG I	$							1		20			=	50	**50.00**	F CSH BEG I	
17	M CSH BEG II	$					-1	1			5	-80		=		**0.00**	M CSH BEG II	
18	F CSH BEG II	$							-1	1	19	-200		=		**0.00**	F CSH BEG II	
19	M CSH END YR	$		60				1					130	>=	500	**978.33**	M CSH END YR	
20	F CSH END YR	$								1			200	>=	200	**372.00**	F CSH END YR	
21	TOT CSH END YR	$		60				1		1			330	>=		**1350.33**	TOT CSH END YR	
22																		
23															T LABOR	**86.33**		
24															CSH/LAB	**15.64**		

Figure 6. Example of an ELP matrix. This *simplified* livelihood system includes the production of maize for consumption and sale, the production of goats, and the production of hay for the goats—the livelihood activities available to the household. The matrix is constructed in an Excel® worksheet.

The most efficient means of constructing the ELP model after the basic matrix (input/output coefficients) has been established and some of the data have been collected by the above procedures, is to select a willing household in the livelihood system with which the team is working and whose farming practices reflect those in the basic matrix and model their resources and constraints.[9] The process is to obtain information from the household members, individually and as a group, on all the relevant activities and constraints. The complete descriptive model of a specific household can be constructed and modified as these discussions are going on. Inconsistencies can be spotted when the model is infeasible or the solution is inconsistent with what is known or described.

On- and off-farm production activities.

Crop and livestock production, fishing, fiber, and forestry activities conducted on the farm or vicinity are included in this category as are activities off the farm such as hiring out labor, working for another entity, production of remittances, etc.

*Common reproductio**n** activities.*

Reproduction activities (cooking, laundry, care of children, fetching water, etc.) are those that contribute to the maintenance of the household and its members. These are mostly, but not exclusively performed by the women in the household. Women may also perform other duties, Figure 7, as well as farm themselves whether in male or female-headed households. (See the cover photo of a woman farmer in the highlands of Guatemala in her on-farm, farmer-managed trial talking with one of the ICTA technicians.)

[9] Much of the following comes from Hildebrand et al. 2003.

(a) (b)

Figure 7. Some women's activities. Cooking meals (reproduction) in eastern Guatemala (a) and weaving (production) in the Guatemalan highlands (b).

Available resources and constraints to be met (food, cash, other household goals.)
Most limited resource farm households face similar kinds of constraints (land area, household labor availability, hired labor availability, consumption requirements, seasonal cash needs, markets, water availability), but the degree that these constraints are binding on household options varies with the specific circumstances of each household. Some (markets, hired labor, and sometimes land and water) are exogenous to the household and fixed in quantity, quality and/or capacity. Others are endogenous to the household (household labor, consumption requirements, cash needs, and sometimes land and water) and vary over time with household composition.

The primary goal of most limited resource farm households is to meet minimum household consumption requirements (including food, clothing and shelter) in an endeavor to reproduce the family unit. Beyond the basic necessities, decision makers may wish to maximize discretionary cash for items that might be desirable, in this day and age perhaps a cell phone, but not for necessary expenditures such as children's education (usually considered a constraint to be met, if possible). Other household goals could include minimizing labor according to gender, season or age, maximizing the production of a particular crop, or maximizing availability of discretionary cash during a specific season, etc. These goals can be included in the model as fixed minimum or maximum constraints or for comparison can be incorporated—one at a time—in the objective function to be minimized or maximized while holding the others at specified levels.

Seasonality.
Seasonality or periodicity is important in small farm livelihood systems (White, Labarta, and Leguía 2005). Intra-annual fluctuation in resources, requirements, activities and goals are frequently buried in traditional economic analyses, yet emerge as drivers of limited resource

systems when disaggregated. Depending upon overall research objectives, labor and cash resources should be considered at least by semester. Shorter periods such as months or even weeks may be necessary and more useful in some cases. In ELP, expenses are usually incurred (show up) at the beginning of the respective period, and income is generated at the end of the period.

Common input-output coefficients.

Information is needed on type and quantity of system inputs and outputs, including when, where, how much, and time of acquisition. Input coefficients for each of the production and reproduction activities generally will be quite similar within a given livelihood system and can be obtained using a combination of focus groups, in-depth interviews, and observations of farmers. In ELP it works best to use coefficients consistently reported by farmers because the quantity of inputs, length of time required per task per unit of land area, and the gender and age of the person responsible tend to be similar within a livelihood system. The same can be said of time and other resources required for reproduction activities such as food preparation, washing clothes, tending children, etc. However, ELP is flexible enough to account for variation in individual farmer conditions or practices by incorporating them as separate activities in the model. For example, if different kinds of soil are managed differently and produce different yields, each should be a separate activity. Also, coefficients for reproduction activities can vary with different household composition and must therefore be modified for each household.

Data are also needed for each perennial crop or crop association the household pursues, on a per unit of land basis or per plant basis, if appropriate (for instance, in the case of some trees). Numbers needed are the same as for annual crops, with the addition of number of years before the crop produces.

The same data needed for annual crops are required for each kind of livestock activity the household pursues and on a per animal (or herd, flock, etc.) basis. Additionally, data for death loss, birth rate, weaning rate, etc., must be obtained.

All data elicited for other activities (annual and perennial crops, livestock) should also be gathered with regard to forest, bush or body of water. These might include extraction of firewood, medicinal plants, or food stuffs in time of shortage, etc. Ownership (community, *ejido*, tribe, other) should be explored, as well as traditional or locally accepted standards for use of these resources.

As previously mentioned, particular attention must be paid to seasonality of strategies within each livelihood system. Fluctuation of everything from consumption to labor availability throughout the year can be expected. In addition to understanding what fluctuates, the temporal dimension of these changes must be recognized; for example a hungry season, months when school is in session, time when men migrate to find work, etc. This seasonality needs to be incorporated into to the model to ensure adequate simulation. Essentially all aspects of the model are subject to seasonal fluctuation. Recognizing and accommodating this in the model is crucial to ensuring adequate simulation of livelihood systems.

It is necessary to elicit and include in the model the amount produced of each usable product, when it is available, how it is used, and who has access to and control of it to determine 'whose' account receives benefits. These types of data are often difficult to ascertain, yet are crucial for accurately simulating livelihood system.

Dependable yield.

Although it is conventional to use "usual" or "average" yields when modeling livelihood systems, it is not the measure of productivity that will accurately describe these systems, nor the one used by farmers. We suggest that as a risk aversion strategy, farmers make their cropping decisions based upon a 'dependable' yield, or yield that they 'count on' for their basic food crops. Farmers cannot depend on "average" yields; they know that their yields will often be below "average." Therefore, *for staple consumption crops they calculate area to be planted based on a yield level they know from experience will occur with greater frequency*. They may plant a large enough area so they can feed the household 80 or 90% of the time, or eight or nine years out of ten. The yield level that meets this criterion will be much lower than average yields widely accepted in economic analyses. This dependable lower yield level is what farmers can "*count on*" most of the time (Figure 8). Because this is the yield level farmers use when planning how many resources (land, labor or other inputs) to invest in their basic food crops, this is the level that should be used in the ELP model in order to accurately simulate the household's livelihood strategies. Allan (1965) recognized this situation in what he termed the production of a 'normal surplus' of food in the average year.

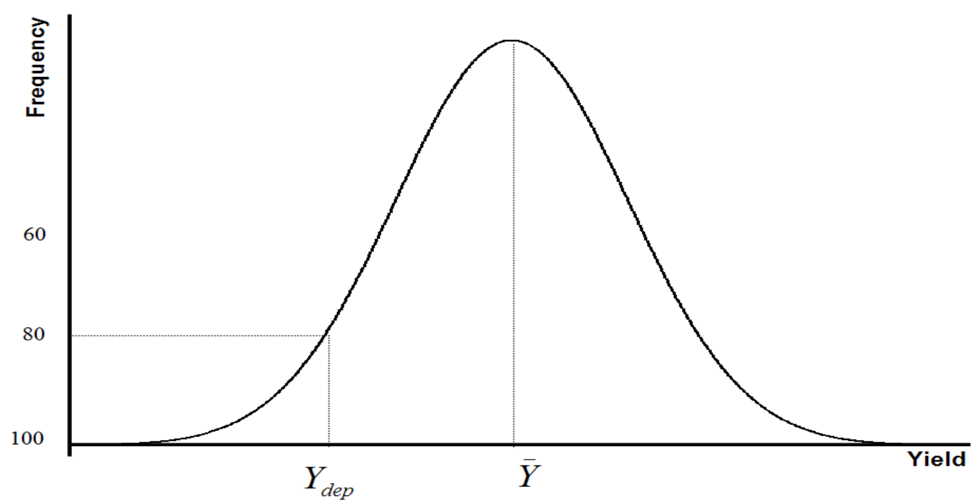


Figure 8. Y_{dep} represents a dependable yield that is exceeded at least 80% of the time.

It is more difficult to obtain an estimate of dependable yield than of average yield. One way found to be useful is first to find out how much of a basic food crop the household needs for a year's supply (for an annual crop) and then ask about how much land is usually planted to this crop. Another would be to ask about how much land is planted to the crop and then ask about how much product they get from this land most of the time.

Prices.

Prices of products sold are often taken from local markets, or worse, national data. For farm products sold at the farm gate, the price paid to the farmers at that point (if a common selling activity for farmers in the livelihood system) should be used. If farmers take the products to a road or waterway where buses, trucks or boats pass by then the price paid the farmers at that point, or the charge for taking the farmer and his/her produce to a market must be taken into account. The time required for marketing farm produce must also be considered. This is not charged as a cash cost but rather as time used (labor) by the relevant person or persons in the selling activity. Sometimes farmers are not paid at the time of transaction, but must wait days or weeks to be paid. This affects seasonality of cash flow so must be taken into consideration in the model. The additional labor for returning to the source of the cash should also be considered. Local market prices of items purchased by farmers are probably relevant, but cost of getting some of these items to the farm must also be considered.

Credit.

Costs of credit are complex. Limited resource farmers often pay very high interest for credit supplied by local money lenders simply because of convenience or lack of other real alternatives. Transaction costs for formal credit often include the labor costs of multiple visits to the lending agency, first for purposes of formalizing the loan application, and second, to return for the money if the application is approved. If a formal credit scheme is to be considered, these costs must be taken into account as they can require cash (for bus fare, for example) as well as lost time away from the farm. And this may be during periods when the labor is critical at home.

Units.

In talking with limited resource farmers, care must be taken to assure that all units are completely understood. Local usage of weights (quintal, kg., lb., headload, ton) or volume (bushel, fanega, almudes, latas) must be conversed with the farmers in their own language. Conversions can later be made (or not) to scientific units to be acceptable to professional journals.

Labor requirements.

It is crucial to understand labor required during each period, for each activity, and disaggregated by gender and age. It is important to obtain data that reflect each step (land preparation, seeding, weeding, harvest, etc.) in each activity and who (men, women, children) is responsible for them. These data must account for alternative types of households, such as female-headed or multi-generational, as well as any activities undertaken by hired or exchange labor.

Length of a working day.

The concept of the eight-hour working day is uniquely Western and Northern. Local peoples have different ways of describing and understanding the length of a working day. It may vary depending on effort (toil) expended, length of walk to reach working place, opportunities for gathering fruits, vegetables, firewood or water on the way home, etc. A day in the field could be 4 to 10 hours long. This must be taken into account. A day's work may vary depending on whether a person is working his or her own land rather than as a laborer for another farmer. Food may or may not be included when wages are collected or paid. Boys and girls begin working in the fields or with livestock at different ages in different cultures. Time spent on farm tasks usually varies when school is in session and when not (seasonality). Likewise, children help with household chores. The age at which this begins, as well as time spent daily is important to know. Observations, focus groups, informal interviews, and participatory tools including mapping and ranking, are useful for obtaining as well as understanding these data.

Land.

The amount of land a farmer has access to and control of as well as how much he or she farms is important to know. Land in use (for crops, livestock, fallow, etc.) may vary from one season or one year to another It is also quite common for farmers to rent fields in or out, and this is relatively easy to incorporate into models. Local rates, as well as if payment will be made in cash or kind should be known. Time required to travel to distant fields must also be accounted for.

Some examples of the use of ELP.

One of the first linear programs (preceding the term ELP, but related) was the MS thesis of Zimet, (reported in Zimet et al.1976) done in El Salvador as part of the team effort of the University of Florida assigned to assist the national agricultural research and extension program (CENTA). It looked at the potential for increasing vegetable production in a newly formed agrarian reform area that had irrigation. He found that vegetable production was limited by insufficient labor during the critical months when sugar cane, coffee and cotton harvests were underway unless vegetable production technology was improved.

In its developing stages ELP has been used for a number of other applications by researchers in the fields of rural development and natural resource management. Of particular note are the following. Peralta incorporated household composition and changes over a 40 year family life cycle in the Amazon area of Peru. When aggregated, Cabrera et al.'s 2005 individual simulations of 60 small farm households indicated that only 40% of the small farmers in the Cañete community in Peru would have sufficient resources to take advantage of the newly introduced and highly recommended asparagus crop enterprise. Litow's ELP (Litow et al. 2001) showed that *milpa* (a mix of maize, usually beans, and other crops) is a key element of household livelihood strategies in Uaxactún in the Maya Biosphere Reserve in Guatemala. Its importance relative to other livelihood activities changes over time as households respond to variation in their bio-physical and socio-economic environments. The ELP also showed that *milpa* is always raised if adequate household labor is available. Household size and composition largely determine *milpa* size, and households utilize *milpa* to reduce their food expenses and achieve a more assured level of food security. Bellow's ELP modeling of households in two communities in Guatemala based on differences in family composition, extent of agricultural land-holdings, off-farm labor opportunities, and differences in field crop yield potential indicated that food security was a limiting factor in the adoption of fruit-tree based agroforestry (Bellow, 2004). Factors that enhanced food security tended to promote adoption. He concluded that fruit-tree based agroforestry technology was not scale neutral and would be preferentially adopted by families with greater security and economic resources. The most disadvantaged families in each community were predicted to be low adopters in the absence of additional interventions that would have the effect of increasing their food security during the juvenile (pre-production) phase of tree establishment.

ELP and the efficient methodology for designing policy and infrastructure. Ethnographic linear programming, which combines methods from anthropology and economics, is a useful tool for researchers and technology developers, policy makers, and managers of infrastructure and natural resources. It can help them understand the varied responses of diverse households to past or potential modifications. The methodology is a working tool applicable before and during project implementation, rather than a purely analytical tool for obtaining static results after the fact.

One of the most important influences on the livelihood system Pluke (2004) was studying in Puerto Rico was the government incentives program, which actually had the negative effect of stifling diversity while striving to ensure stability and security. In his analysis he looked at the effect of partially removing and then completely removing the incentives and found that this increased the diversity of crops grown. This reflects another important aspect of the ELP and this methodology: its use in designing policy and infrastructure. If a policy or infrastructure is proposed and an ELP has been developed for a livelihood system, it can then be used to predict the potential impact of alternative policies or infrastructure on different kinds of households in the livelihood system.

ADAPTABILITY ANALYSIS

One research tool widely used by plant breeders for many years to evaluate genetic material and new lines, varieties and hybrids is called "stability analysis" (Hildebrand and Russell, 1996).[10] This procedure provided a means to assess the response of new materials to different environments and the interaction of different materials to environmental changes. Because these materials were initially and extensively tested on experiment stations, yield levels generally reflected highly productive environments. The highest-yielding materials under these conditions often exhibited large linear coefficients (>1) when regressed on an index of the environmental quality of the plots, indicating that they tended to be very fragile and break down in poor conditions. Materials that were more robust and held up in poor conditions tended to yield relatively poorly in the experiment station conditions, resulting in small linear regression coefficients (<1). The higher-yielding materials with linear regression coefficients approaching one were considered to be the "best," "most stable" or "most broadly adaptable".

It has been argued (Hildebrand, 1984) that rejecting materials that excelled in the best environments but collapsed in poorer environments (Technology A, Figure 10) and those that excelled in poor environments but did not respond to good environments (Technology B) was a negative interpretation of the results of stability analysis. In essence, it was a compromise stemming from the assumption that one "best" variety had to be selected based on the belief that environments could not be stratified adequately to allow for specific recommendations or could be so modified by use of inputs that "poor environments" would be due only to unpredictable characteristics such as rainfall and pest incidence. This compromise resulted in the rejection of many materials that otherwise might have been well adapted to the poor environments inhabited by most of the world's small-scale farmers (Figure 9).

(a) (b) (c)

Figure 9. Tobacco on a north Florida experiment station in1982 (a), large tobacco farm in same area, earlier in same year (b) and small tobacco farm in same area, same year (c). Obviously the small farmer will not achieve the same results with technology as the large farmer who may come close to results on the experiment station.

The modifications to traditional stability analysis that resulted in Modified Stability Analysis (Hildebrand, 1984), or MSA, included a rethinking of this negative interpretation. To generate materials or other technologies for specific environmental situations, those that do well in "good" environments are accepted *for those "good" environments* even if they do not do well in

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[10] Much of this section comes from Hildebrand and Russell, 1996.

"poor" environments. Conversely, those that do well in "poor" environments, even if they do not respond to "good" environments are accepted *for those "poor" environments* (see Ceccarelli, 1994). This *positive* interpretation of environmental interaction (Figure 10) provides the opportunity to identify not only genetic materials that excel in different and wide- ranging conditions, but also any other kind of technology being evaluated as potentially useful.

The incorporation of the evaluation of other kinds of technology (fertilizers, rotations, intercropping systems, livestock practices, etc.) by means of MSA was another modification of stability analysis. Thus, MSA could serve as a comprehensive method for the design, analysis and interpretation of on-farm research data for *specific adaptability*. It can be useful in the developing countries, where tremendous environmental variability exists, and in industrialized countries where concerns with a more sustainable agriculture require more location-specific technologies than have been the norm over the past half century. Since the method in fact aims at specific adaptability and not broad adaptability, i.e., not stability across diverse environments, we proposed the name ***Adaptability Analysis (AA),*** rather than Modified Stability Analysis (MSA), as a more accurate description of the method.

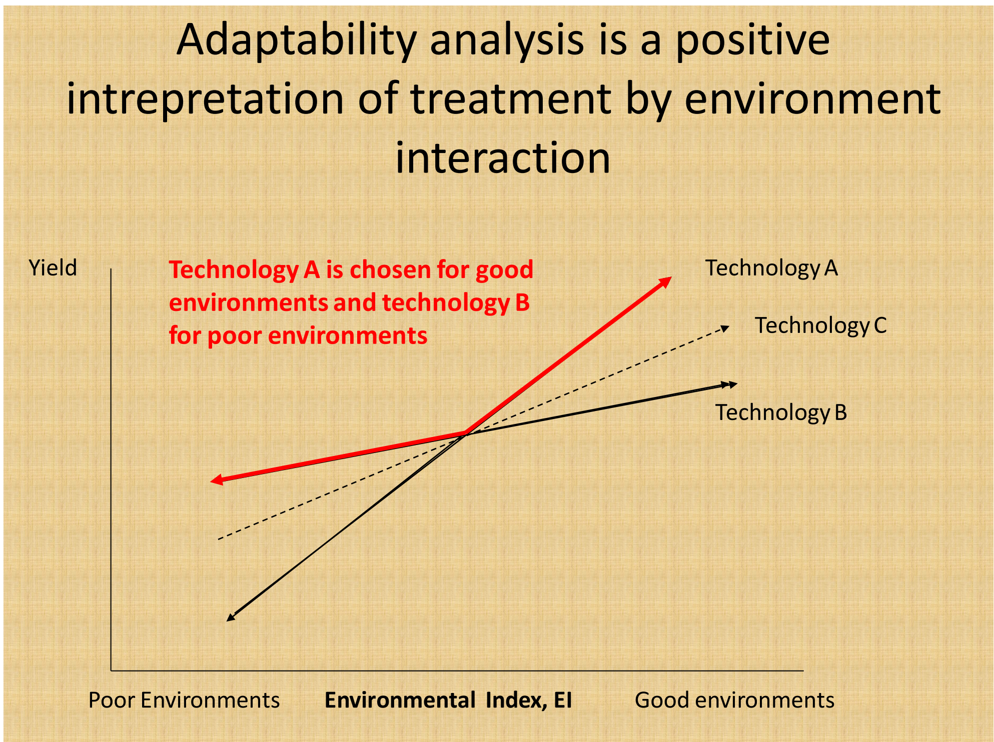

Figure 10. Positive interpretation of environmental interaction.

On-farm trials, particularly single-replicate, farmer-managed on-farm trials are the usual source of biological and socioeconomic data susceptible to full exploitation by Adaptability Analysis. For the most efficient use of trial data, it is imperative that sufficient characterization, both biophysical and socioeconomic, of each on-farm trial environment be done. Deciding just how much and what kinds of data need to be collected is often not immediately evident; making these decisions is itself an iterative process. Over time, and through trial and error, team members should establish a *minimum data set* for on-farm trials in their research domains.

Quality of data. Data from the on-farm trials do not require more than one replication per environment to be amenable to Adaptability Analysis. However, there are some characteristics of the data that improve its quality and reliability (Stroup *et al*., 1993). To allow for adequate verification of treatment performance within two or three potential recommendation domains, a minimum of 15 to 20 environments should be aimed for. Experience in analyzing numerous data sets has indicated that if three conditions are met *in a single year's trial*, the estimates of environment- by-treatment response will be consistent across years. These conditions (adapted from Stroup *et al*., 1993, p. 172) are:

1. The range of the environmental index (EI)[11] should be at least as great as the mean of the index values, i.e., the ratio of the EI range to mean should be at least one.
2. The distribution of environments (EIs) should be reasonably uniform from best to worst.
3. The range and distribution of the yields of farmers' current practices should approximate those normally expected over a period of years. That is, it was not an exceptionally good or poor year. The distribution of environments is more important than number as long as some minimum number (again, around 15 to 20) is achieved.

A cowpea trial in Brazil (Singh 1990) can demonstrate how use of AA can quickly and accurately produce technology recommendations for a variety of recommendation domains in a way that traditional methods alone cannot. It does this chiefly through recognizing that the farming systems research-extension concept of *recommendation domain* is a function of the farmers' specific socioeconomic circumstances that determine what farmers want from new technologies and the specific biophysical circumstances of their farm environments, which determine how new technologies perform. With just a few simple analytical tools requiring only limited statistical expertise or computing facilities, AA allows team members to completely exploit adaptive research done under farmers' conditions. When these conditions are characterized by a full range of *environmental characteristics* (usually biophysical) and interpreted in light of farmers' *multiple evaluation criteria* (usually socioeconomic), Adaptability Analysis can result in *multiple extension recommendations* appropriate for specific groups of farmers and specific groups of farm environments (Singh, 1990; Stroup *et al*., 1993).

In the case of Singh's research (Figure 11), the government of Brazil was supporting colonization in the area and was concerned about the loss of rain forest. The problem this research addressed was the rapid loss of fertility, particularly phosphorus, in forest land cleared for cropping. The research domain chosen was a colonization area along the Rio Preto da Eva, some two hours by boat upstream from the market town of Rio Preto da Eva, which was on a paved road connecting to Manaus.

Primary information was collected by means of a Sondeo involving B.K. Singh, persons from the Brazilian research and extension agencies and a local organization. Farmers' knowledge of indigenous technology, agronomic practices, and land types being used were recorded. An extensive soil sampling program was carried out to understand soil physical and chemical characteristics and relate them to farmers' rationale for assigning a particular cropping pattern to a given land type. Classified by land use type, some were from primary forest farmed for one year (PF1), others from primary forest farmed for two or for three years (PF2 or PF3), and still others

[11] The EI at each location (or replication, if used) is the mean yield of the treatments at that location. Higher average yields correspond to better environments and lower average yields to poorer environments.

from secondary forest farmed for one, two or three years (SF1, etc.); one field, cleared by bulldozer, was even classified as wasteland. Constraints to maintaining fertility included distance to market and the availability of cash for purchasing and transporting inputs. Thirteen on-farm trial sites were selected in the research domain and four fertilization treatments were applied in a randomized complete block design with only a single replicate of the treatments in each environment. The four treatments, based on previous on-station research were selected:

1. The farmers' local practices *(FP)*, which had essentially no or very low levels of fertilization, i.e., 0-4 kg/ha P;
2. A "full dose" of triple superphosphate *(TSP)* plus potassium containing roughly 0-18-60 kg/ha N-P-K;
3. Chicken manure *(CM)* plus a "half dose" of triple superphosphate, equivalent to the same total amounts of P and K as the TSP treatment, but with half the P coming from chicken manure;
4. Processed city waste *(PCW)* plus a half dose of triple superphosphate, again with the same levels of P and K, but with half the P coming from the city waste.

For cowpeas in the Manaus trial, the higher-yielding (t/ha) environments (those with EI > 1.3) corresponded to fields taken from primary forest and in first or second year of use (PF1 and PF2), or from secondary forest and in first year of use (SF1). For these situations, *if t/ha is the relevant criterion*, the recommendation would be to use TSP, the highest-yielding treatment for these environments. For all other fields, if cowpea is to be grown and t/ha is the relevant criterion, chicken manure (CM) would be the amendment recommended. However, *if kg/$ cash cost is the relevant criterion*, then the farmers' practice would be recommended on PF1, PF2 and SF1. On all other soil types CM would be recommended if the farmers needed to plant cowpea in those conditions.

(a) (b) (c)

Figure 11. B.K. Singh's research location. (a) going upstream from Rio Preta da Eva, (b) arriving at the community where he did his research, and (c) in the field with some collaborators and farmers.

SECOND YEAR AND BEYOND

During the first year in the field, the technology tested in the on-farm trials would be the best bet based on a very early assessment of the farmers, their environments and the resources and objectives they worked with. By necessity, to be available prior to the planting season, it had to be mostly top down and designed more by "planners" than by the "searchers" out in the field. However, because of the continued contact of the "searcher" sub teams in their respective livelihood systems, after the first year there is now excellent information to help design and test the technology, infrastructure or policy that will affect even the poorest in the region.

Adaptability analysis from the on-farm trials and summaries of the enterprise records, along with the information from continuous conversations with the farmers provide the basis for a new view on the kind of technology that would be acceptable to the poor and diverse farmers with whom the sub teams are working. This can be tested in the second year in the on-farm trials.

After planting season in the second year, an index of acceptability can be calculated for the technology tested in the first year. An evaluation can be made to suggest anything with an index of 25 (providing that at least 50% of the farmers were trying it) for broader diffusion. The Index of Acceptability is calculated from the following formula:

$I_a = (C \times A) / 100$

Where: I_a = the Index of Acceptability

C = the percentage of the farmers who used the practice on at least part of the crop the year following the farmer-managed trial in which they participated

A = from among those farmers who used the practice the next year, the *percentage of the area* they have planted to that crop on which they are using the new practice.

As an example, say 60 farmers collaborated in the farmer-managed trial the year before, and 40 were interviewed for purposes of calculating the Index of Acceptability. Of the 40, there were 20 (C = 50) who used the alternative on 70% of their crop (A = 70). Thus, I_a equals 35 or (50 x 70) / 100). This technology has an excellent chance of wide adoption.

A second use of the survey for the Index of Acceptability is to ascertain *why* farmers accepted or rejected the alternative or alternatives. This information can be used to help guide the development of other alternatives and usually provides additional insight into problems and concerns of target farmers. In the case of a rejected alternative that shows great potential to increase the productivity of a particular crop, a further analysis of why it is not acceptable will guide the team in how to improve it to meet the farmers' demands. In Guatemala, a maize variety that promised high yields did not have complete cover of the ear by the husk. For the breeders this was not a problem because they protected the crop with insecticides and hired boys to chase the birds. But for the farmers it was not acceptable. Also this kind of information will help in further calibrating the ELP.

The Ethnographic Linear Program, with improved coefficients calibrated and validated during the first year provides information on technology acceptable to farmers with different kinds of household composition and resources. It can be used prior to the second year to help decide on what kind of technology should be tested with which kinds of farmers. This allows the base of farmers collaborating in on-farm trials to expand in the second year. Further, the ELP can help the team in making suggestions for infrastructure and policies that could be useful to different kinds of households by testing these prior to deciding upon which to propose.

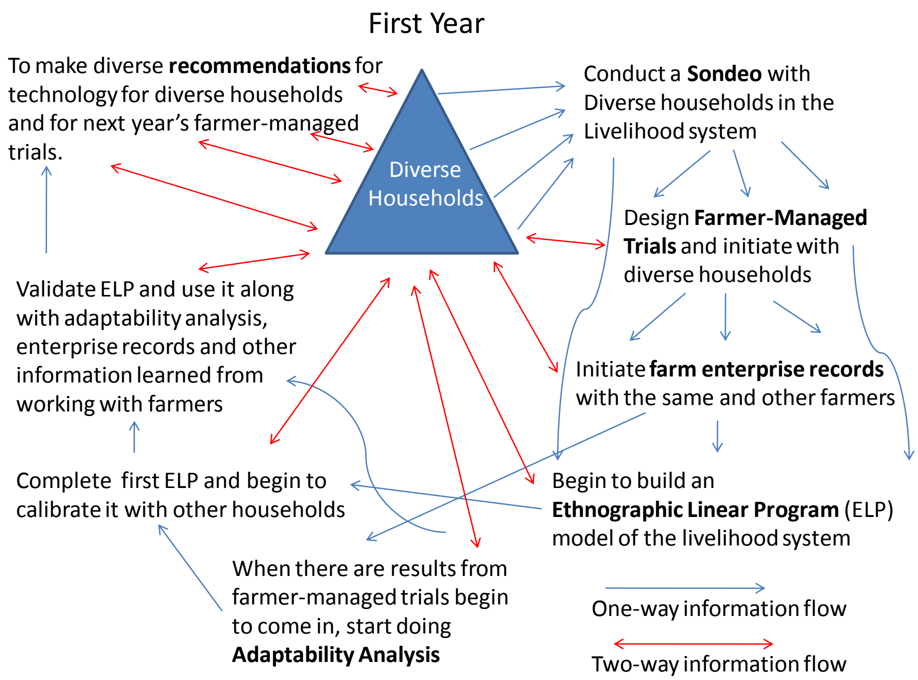

Figure 12. The interactive methodology can be done the first year. The Index of Acceptability is done as soon as farmers begin planting in the second year.

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BIOGRAPHICAL SKETCH

Peter Hildebrand got his early farming experience with horses, and later tractors, in eastern Colorado. After obtaining a BS degree in Animal Science and an MS in Agricultural Economics at Colorado A & M College, later Colorado State University, he earned his PhD degree in Agricultural Economics at Michigan State University in 1959. Following two years as an assistant professor at Texas A & M University and three at Colorado State, he spent two years working on irrigation projects in the Punjab of Pakistan. He then spent one year with USAID in Bogotá, Colombia and four plus years with the University of Nebraska mission working with the Colombian agricultural research and extension institute (ICA). He spent two plus years in a University of Florida project creating an agricultural economics department for the agricultural research and extension institute, CENTA, in El Salvador. The next five plus years he was a field staff member of The Rockefeller Foundation, assigned to ICTA, the agricultural research and promotion organization in Guatemala. ICTA had specific focus on small and medium sized farms and much of what became known as farming systems research-extension, FSRE, methodology was developed there. After leaving Guatemala and spending several months on a Rockefeller Foundation study leave at the University of Florida, he decided to stay at the university and was one of the principal participants in the USAID-funded Farming Systems Support Project with global training and outreach responsibilities for farming systems research and extension methodologies. He was the founding president of the international Association for Farming Systems Research-Extension, now the International Farming Systems Association. In his career, he has worked professionally in some 35 countries in Europe, Asia, Africa, the U.S. and most of Latin America and the Caribbean, mostly with organizations focused on developing agriculture for small, limited resource family farmers. Although he is officially retired from the University of Florida, he continues an active program of working with and teaching graduate students in methods of working with limited resource farmers.