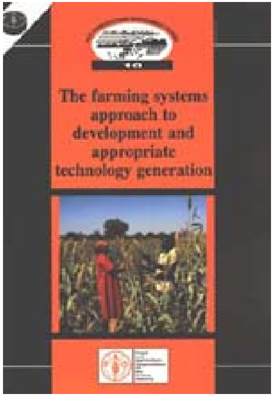

The farming systems approach to development and appropriate technology generation

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Preface

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This manual on the farming systems approach to technology development is based on the experiences of the authors over the last two decades. Much of the documentation of these experiences has occurred over the last five years with the production of three sets of documents on the methodology for undertaking the farming systems research approach. These were a!; follows:

- The production of a farming systems research manual for Botswana [Worman, Norman et al, 19901 which was first published under the auspices of the Department of Agricultural Research in the Ministry of Agriculture in Botswana. A slightly revised edition was later printed in 1992 by courtesy of the Food and Agricultural Organisation/Swedish International Development Agency (FAO/SIDA) sponsored Farming

Systems Programme headquartered in Gaborone. Botswana.

- A series of lectures given at Mahalapye Rural Training Centre, Botswana, in May 1992 at a Fanning Systems Research In-Service Training Course for Research and Extension Staff in the Ministry of Agriculture
- A series of lectures given as part of a Sustainable Farming Systems Course at the Swedish University of Agricultural Sciences (SUAS). Uppsala, Sweden in November 1992, which resulted in a publication [Norman et al, 19941 produced by the FAO/SIDA project with its headquarters in Gaborone, Botswana.

Therefore, although the authors have been responsible for developing the current manual it is important to acknowledge the contributions made by many others in producing materials for the original handbook [Worman, Norman et al, 1990] including S. Bock, A. Caplan, G. Heinrich, C. Koketso, E. Makhwaje, S. Masikara, and N. Persaud. These materials have been used extensively in the current primer. Also, D. Baker deserves credit for quite a few of the ideas developed in the manual.

The authors also wish to express appreciation to the following:

- Dr. Lucas Gakale, Director of Agricultural Research, Ministry of Agriculture, Botswana for supporting the development of the original handbook.
- Mr. Gustav Boklin, SUAS, who coordinated the course in Uppsala and who encouraged the publication of a slightly modified version of the lecture notes, and Dr. Bo Gohl and the Steering Committee of the FAO/SIDA Farming Systems Programme who were

responsible for the FAO/SIDA publication.
- Dr. Peter Hildebrand and Dr. John Russell, who kindly made available material from a book they are currently preparing on modified stability (i.e., adaptability) analysis.
- Mr. Lex Roeleveld and colleagues in the Lake Zone FSD team in Tanzania, who specially prepared one of the case studies in the manual relating to their experiences with farmer groups.

The intended audience for the material presented in this document is for those who wish to understand, and harness the power of, the principles of the FSD in the quest for developing relevant improved technologies for farmers, particularly those who have very limited resources,

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Begin

1. Introduction

The farming systems approach to development (FSD) has two inter-related thrusts. One is to develop an understanding of the farm-household, the environment in which it operates, and the constraints it faces, together with identifying and testing potential solutions to those constraints, The second thrust involves the dissemination of the most promising solutions to other farmhouseholds facing similar problems. This manual primarily concentrates on procedures useful to FSD personnel in addressing the first of these thrusts, particularly with respect to designing and developing relevant improved technologies.

The material presented in this manual primarily stems from work undertaken in Botswana and other countries, mainly in Africa. However, the authors have also benefited greatly from the experiences of individuals in other parts of the world and have illustrated these guidelines with examples from the work of others. The manual is divided into four major parts and a number of chapters within those parts. Briefly, these can be summarised as follows:

- Part I concentrates on the conceptual framework underlying the FSD approach. Major sections are devoted to the rationale and philosophy of the approach (Chapter 2), a description of the general approaches used in implementing FSD (Chapter 3) and a discussion of some of the key concepts underlying the approach (Chapter 4).
- Part II discusses the implementation of the FSD approach, with one major section devoted to the steps involved in its implementation (Chapter 5) and the other to some of the important operational issues that are involved in its implementation (Chapter 6).

- Part III, the biggest part, deals with methodological issues. It consists of four major sections relating to an overview of the data collection methods used in implementing the FSD approach (Chapter 7), followed by a more detailed discussion on survey (Chapter 8) and trial (Chapter 9) techniques. In Part III, most of the emphasis is placed on data collection rather than analysis and evaluation, for which many references are available, particularly concerning the technical areas. However, the last major section (Chapter 10) does deal with certain aspects of analysis and evaluation that are less familiar to those on FSD teams who come from a technical science background.
- Part IV, which consists of the appendices, has three components. Appendix A I provides a list of references relating to the methodology and implementation of the FSD approach. This list is divided into two parts, The first part consists of those cited in the text, However, because this is not an exhaustive list of papers on FSD. the second part consists of other useful references, not cited in the text, to provide a foundation on which the reader can build a more in-depth knowledge, Appendix A2 defines the acronyms used in the guidelines. Appendix A3 deals with the measurement of plant stands and yields, two of the most critical agronomic variables that FSD activities usually have to address when directed to identification of relevant improved technologies,

To illustrate some of the major points in the manual ample use is made of examples of FSD activities throughout the world. These are usually presented in boxes in the text. However, because of their size, three case studies, one from Tanzania and two from Botswana, are presented in specific sections.

Part I - Conceptualising the farming systems development approach

The material in Part I is designed to provide background information that will be useful in placing the more technical discussion in Parts II and III on the implementation of the FSD approach in context.

Part I consists of three major chapters, dealing with:

- The rationale and philosophy underlying the FSD approach (Chapter 2).
- The general approaches used in the application of FSD (Chapter 3).
- Some key concepts involved in the application of FSD (Chapter 4).

2. Rationale and philosophy of the farming systems development approach

2.1 Objectives of the chapter

The objectives of this chapter are to:

- Describe briefly the reasons why the FSD approach evolved.
- Look at the differences between station-based research and farm-based FSD.
- Describe briefly the process and interactive nature of agricultural development.

FSD grew out of, and is closely related to, the farming systems research (FSR) methodology. In order to fully understand FSD with respect to technology generation, it is useful to examine the development of FSR.

2.2 Evolution of the FSD approach

In the mid-1960's, there was little interaction between technical scientists (who were mostly on experiment stations) and social scientists (who tended to be concentrated in planning units). The Green Revolution was beginning to have a great deal of success in Asia and Latin America, being based on good climate (i.e., plenty of water) and soils; very homogeneous and favourable production environments; and the adoption of Improved varieties of wheat, maize, and rice that were very responsive to fertilizer. Improved inputs also were readily available and there was an accessible market for the products. However, in most of Sub-Saharan Africa, and certain parts of Latin America and Asia, there has been no Green Revolution. This is because climatic conditions are often not as favourable (i.e., too much or too little rainfall and limited amounts of irrigation), soils are generally poor, production environments are very heterogeneous and poor, and the input and output markets are poorly developed. Not surprisingly, there has been great difficulty in developing improved technologies that are attractive to farmers in such areas.

In Green Revolution areas, farmers were able to benefit from the improved technologies even if they did not do things quite right and the inputs they used were very divisible (e.g., they could use a little or a lot of improved fertilizer or seed). However, in areas with less hospitable environments (e.g., low rainfall areas that are found in many countries in Africa and Latin America), farmers have to do things exactly right if they are to benefit (e.g., planting on good soil moisture) and also they need lumpy inputs (e.g., control over traction). In addition, yield increases are not so good -- they tend to involve incremental rather than major (i.e. revolutionary) changes in yields.

Thus, in the Green Revolution areas, because of the spectacular nature of the technology, experiment-station based technical scientists were very successful in their work. However, the lack of success in using a similar approach in poorer agricultural areas (i.e., with resource poor farmers), led to the evolution of the FSR approach, in which there is close cooperation between technical and social scientists. Work done with farmers in various countries in the 1960's and early 1970's revealed that these limited-resource farmers [Norman, 1993]:

- Are rational (i.e., sensible) in the methods they use. For example, in Africa, there was little support for station-based research on mixed cropping until the early 1970's. although earlier farm-based research had revealed the rationality of the practice

[Norman, 1974].

- Are natural experimenters [Biggs and Clay 1981]. Obviously, the methods farmers naturally use will be those that appeal to them and are informal in nature [Lightfoot, Bottrall et al, 1991] in the sense that they are not usually amenable to formal statistical analysis.
- Understand the environment in which they operate rather complex farming systems, consisting of crops, livestock, and off-farm enterprises [Norman et al, 1981]. In fact, it could be asserted that such systems are often more complex than the specialized farming systems found in many high income countries. Unlike the case with limited resource farmers in low income countries, many of the constraints in specialized agriculture in high income countries can be broken or avoided through seeking advice and taking advantage of and receiving external help [Norman and Collinson, 1986].

Consequently, considerable respect developed for limited-resource farmers. The FSR approach evolved because of an increased awareness on the part of researchers that such farmers:

- Had a right to be involved in the technology development process, because they stood to gain or lose most from adoption of the technology.
- Could productively contribute to the development of appropriate improved technologies.

Therefore, the fundamental principle of FSR was that farmers could help in identifying the appropriate path to agricultural development. It is now recognized that limited resource farmers can be involved productively in all stages of the FSR approach. Farmers' participation at all stages relates in one way or the other to the selection, design, testing, and adoption of appropriate technologies.

FSR rapidly became popular and was strongly supported by many donor agencies. By the mid 1980s, about 250 medium- and long-term projects worldwide were carrying out FSD type work. As one of the major donors, USAID between 1978 and 1988 had funded 76 bilateral, regional, and centrally funded projects containing either a farming systems orientation or clearly focusing on farming systems type work. Forty-five of these were in Africa [Brown et al, 1988]. Now, many of those projects are being institutionalized within national programmes with considerable domestic financing.

Thus, the FSR approach evolved primarily as a result of a lack of success in developing relevant Improved technologies. The strong technical focus that characterised the evolution still persists to this day, although increasingly many, including FSD practitioners, are advocating that the approach can be used constructively in addressing not only technological solutions but also those relating to policy/support systems, a topic that will be considered further later in the manual (Sections 3.6 and 6.3.3).

In the mid-1980s, the Farm Management and Production Economics Service of FAO became actively involved in the farming systems movement and developed the FSD approach. FSD is based on the farm-household focus of FSR and emphasizes the central role the farmer plays in farming systems development. In addition, this approach incorporates an increased emphasis on the dissemination of improved farming systems based, in the process, on active involvement of those responsible for the policy/support systems. In the rest of the manual the term FSD will be used instead of FSR in order to avoid any possible confusion.

2.3 Comparing station-based research and FSD

The literature frequently compares and contrasts station-based research and FSD. The tone in such comparisons often implies that they are substitutes for each other. However, both station based research and farm-level FSD are needed. This is because they focus on different things that are complementary to each other.

A major difference between them is the following:

- On the experiment station, ***applied*** research is usually undertaken, in which new technologies are created.
- FSD, on the other hand, concentrates mainly on ***adaptive*** research, which involves helping to adjust technologies to specific environmental conditions. FSD also helps feed back information about future priorities for applied research to experiment stations.

Table 2.1 illustrates some of the major differences between station-based research and FSD and helps indicate why both are necessary, particularly in areas where the Green Revolution has not occurred. In such areas, greater attention will need to be paid to adaptive research, if relevant improved technologies are to be developed and adopted by farmers.

Figure 2.1: Process of agricultural development

Obviously, strong linkages between these various contributors are of crucial importance. The FSD approach, involving working directly with the farmers, is a more 'bottom-up' or 'micro to macro, orientation, compared with the more 'topdown, or 'macro to micro' orientation of research work or planning exercises that start at the experiment station or the upper levels of planning ministries. Part 'B' in Figure 2.1 indicates that FSD can help in strengthening 'bottom up' linkages amongst the various groups. In doing so, it helps in the process of improving productivity but does not result in a product by itself. (i.e., facilitates a process rather than producing a product).

As mentioned above, relevant improved practices/technologies and policy/support systems are needed to bring about increased agricultural productivity. Decisions on which strategy is to be emphasized to increase agricultural productivity will depend on circumstances. For example, if no technology is available to ensure an economic return to fertilizer, there will be little value in concentrating on developing an input distribution system that makes fertilizer available to farmers. Therefore' the complementary nature of the relationship between developing and disseminating relevant improved technologies and policy/support systems needs to be constantly borne in mind, if the agricultural development process is to proceed efficiently.

In the above discussion, it is apparent that the FSD approach has a broader focus than simply addressing technological issues -- the primary focus of early FSR activities. The FSD approach, can help also in facilitating linkages not only between farmers and station-based researchers but also with other 'actors,, including those responsible for designing and implementing the policy/support system. In fact, most work in the farming systems arena to date has concentrated on the technology thrust or farming systems activities relating to FSD. This manual concentrates most attention on the research or technology thrust of FSD although linkages with other 'actors' besides farmers and station-based researchers are discussed to some extent.

3. General approaches to the farming systems approach to development

3.1 Objectives of the chapter

The objectives of this chapter are as follows:

- Indicate the objective of FSD.
- Briefly describe the different stages of FSD.
- Briefly discuss evolutionary stages of FSR, here termed FSD.

- Outline some of the major characteristics of FSD, especially as it relates to technology development.
- Compare the system and reductionist approaches.
- Emphasise the broad applicability of the FSD approach,
- Indicate some of the challenges facing FSD.

3.2 Introduction to FSD

Details concerning the characteristics and methodology of the FSD approach, as developed by the Farm Management and Production Economics Service of FAO, are available elsewhere [FAO, 1989, 1990; Friedrich et al, 1994]. Thus, the following discussion represents only a brief summary.

The primary objective of FSD is to improve the well-being of individual farming families by increasing the overall productivity of the farming system in the context of both the private and societal goals, given the constraints and potentials imposed by the factors that determine the existing farming system. It is based on the development principles of improving productivity, increasing profitability, ensuring sustainability, and guaranteeing an equitable distribution of the results of production,

The farm household is the principal system and focus of FSD and consists of three basic subsystems, which are closely interlinked and interactive: the household, the farm, and off-farm activities. The two major categories of activities or thrusts of FSD, both of which involve intensive interaction with farmers? are:

- ***Farming Systems Analysis***. This involves studying, together with the farmers the natural (i.e., technical) and socio-economic (i.e., human) environments in which farm households operate. The aim is to identify the constraints limiting farm productivity and production and hindering improvement in the welfare of the farm households themselves. Potential solutions to these problems are identified, and the results of this analysis, formulated as suggestions for further action then are passed on to the relevant 'actors'. These could include researchers, extension and support service staff, and/or policy makers.
- ***Farming Systems Planning, Monitoring, and Evaluation***. These involve testing, monitoring, and evaluating improvements on-farm, with the direct involvement of farmers. Examples of such activities include those regarding proposed technological improvements, proposed revisions in farm plans, and improvements in support services and farm-level impact of proposed policy changes. Those improvements thought to be potentially useful then are disseminated to other farmers via the extension service. Prior to this stage, it may be necessary to negotiate adjustments in the policy/support services that will facilitate the dissemination and adoption of the improvement. After dissemination, it is of primary importance to monitor and evaluate the adoption rate of the proposed improvements by the farming community. This provides an indication of the actual value of the improvement being disseminated.

Many individuals in the last 15 to 20 years have written extensively to clarity the concepts of the farming systems, particularly with respect to the development of relevant improved technologies. There are many ways of presenting a diagram involving the application of farming systems methodology to research (i.e., technology development). One such way of emphasizing the technical research aspects of FSD is in Figure 3.1 There are four fundamental stages in the FSD approach.

- ***The Descriptive or Diagnostic Stage***, in which the actual farming system is examined in the context of the 'total, environment (see Section 4.2) -- to identify constraints farmers face and to determine the potential flexibility in the farming system in terms of timing, unused resources, etc. An effort also is made to understand the goals and motivation of farmers that may affect their efforts to improve the farming system,

Figure 3.1: Farming systems development

The following sequence of activities is usually undertaken:

  - After deciding on the location of the work, start-up activities include reviewing secondary sources of information, making the necessary contacts, assembling the professional team, and making logistical arrangements,
  - Farming families are classified tentatively into homogeneous groups. The farming families within each group or domain usually practice the same farming system(s), face the same constraints, and have the same potential

solution(s) to their problems. This tentative classification can be modified as additional information becomes available.

- An informal exploratory diagnosis or survey is undertaken to obtain a qualitative understanding of the determinants of the existing farming systems (i.e., both biophysical and socioeconomic). At the same time, efforts are made with farmers to ascertain the constraints, flexibility, and potential opportunities in the farming systems they are using currently.
- Sometimes a verification survey involving a structured formal survey, suitable for statistical analysis, is undertaken to quantitatively confirm insights obtained in the exploratory diagnosis. It also can be used to provide a database for farm and development planning, policy analysis, monitoring, and evaluation.

- ***The Design Stage***, in which a range of strategies is identified that are thought to be relevant in dealing with the constraints determined in the descriptive or diagnostic stage.

  The usual sequence of activities involves the following:

  - Together with the farmers, the constraints are ranked according to their severity, and potential solutions are identified after determining what flexibility exists in the farming systems currently practiced. Information for designing such strategies (i.e., particularly relating to technological issues) comes from experiment station work, researcher managed and researcher implemented (RMRI) type work on farmers' fields, and from other farmers.

- An evaluation is made of the proposed solutions before putting them into practice. These solutions can be technological or institutional in nature. A number of analytical techniques can be used to evaluate the potential technical feasibility? economic viability, social acceptability, and ecological sustainability of the proposed solutions before they are put into practice. One or more of the proposed solutions are selected for actual evaluation on-farm.

- ***The Testing and Implementation Stage***, in which one or more promising strategies, arising from the design stage, are examined and evaluated under term conditions to determine their suitability for producing desirable and acceptable changes in the existing farming system.

  Activities at this stage involve the following:

  - On-farm testing or evaluation with farmers determining how well the potential improvements fit into the system, whether or not they are acceptable to farming households, and what modification may be needed to make them acceptable. In terms of technological issues, this stage conventionally has consisted of two steps:

    -- Researcher managed but farmer implemented (RMFI) tests to

establish whether previously determined technical relationships are altered by farmers' management of non-treatment variables.
-- Farmer managed and implemented (FMFI) tests, when the team is confident that technical relationships will hold but needs to evaluate the proposed technologies under local socio-economic circumstances. In addition to the on-farm evaluation of the proposed technologies, evaluations also can be made of the proposed farm plans and of proposed changes in support systems and/or policies.

  - Positive results of such evaluations provide justification for the FSD team to advocate further action. The tested technologies can be disseminated through the extension service to other similar farming households, The same applies to the farm plans that have been tested successfully. Favourable test results for proposed changes in support services and/or policies provide valuable farm-level information on necessary programme or policy adjustments (e.g., in extension, marketing inputs and products, pricing policy, credit, etc).

- ***The Dissemination and Impact Evaluation Stage***, in which the strategies that were identified and screened during the design and testing stages are extended to farmers. In terms of activities at this stage, impact/adoption studies can be very important. These potentially can be very useful, not only in giving some idea of the impact of, for example, agricultural research, but also in giving some idea of future priorities for agricultural researchers and indicating what adjustments are required in the policy/support systems to ensure better rates of adoption. Thus, through monitoring and evaluating the impact and rate of adoption of the changes that have been implemented and proposed/tested earlier, it is potentially possible to provide some indication of further desirable activities by both researchers and planners.

There are often no clear boundaries between the various stages, Design activity, for example, may begin before the descriptive and diagnostic stages and may continue into the testing stage, as promising alternatives emerge from RMFI trials. Similarly, testing by farmers may mark the beginning of dissemination activities.

Also, going through all stages may not always be necessary. FSD team confidence in transferability during design/planning activities can sometimes mean going straight to FMFI work or even to recommendation/dissemination activities. Thus, the process of FSD is recognized as being dynamic and iterative, with linkages in both directions between farmers, researchers, extension staff and policy/support service staff, The iterative characteristic can improve the efficiency of the development process by providing a means of identifying and fine tuning improved technologies for a specific location -that is, climatic situation, soil type, and/or farmer resource base.

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3.3 Approaches within farming systems research

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Because FSD has its roots in farming systems research, the following comments on approaches within FSR are applicable to the technology research activities of FSD.

The term FSD often is used loosely. An activity is considered to be a legitimate part of the technology research function of FSD if the following situations hold:

- The whole farm is viewed as a system.
- Research is conducted with a recognition and emphasis on the choice of priorities that reflect the whole farm.
- Research on a farm sub-system is legitimate FSD, provided the connections with other sub-systems are recognized and taken into account.
- Evaluation of research results explicitly takes into account linkages between sub-systems.
- As long as the concept of the whole farm and its environment is preserved, not all the factors determining the farming system need to be considered as variables -- some may

be treated as parameters or constants.

A distinctive feature of FSR, or rather FSD, is that a systems perspective is constantly borne in mind. Within this framework, one can look at either a small or a large number of variables in the system. In general, because of the complexities of simultaneously handling a large number of variables, most FSR programmes have tended to limit the number of variables they study and to regard the other factors that influence the farming system as parameters or constants.

Figure 3 2: Progression in farming systems thinking

Three general approaches to FSR or FSD with a technology generation focus, have been defined relating to the number of variables being investigated. These approaches can be described as FSD '***with a pre-determined focus***', '***in the small***', and '***in the large***' [Norman and Collinson, 1986], In a sense [Norman and Lightfoot, 1992], these types represent an evolution in FSD as techniques have been developed to handle progressively more complex situations -- defined as involving a higher ratio of variables to parameters, The progression, which is illustrated in Figure 3.2, where it has been expanded to four phases, can be articulated as follows:

- In its early days, FSR (i.e., FSD) type activities concentrated on how farm yields of particular crops could be raised. This form of on-farm research stood in sharp contrast to earlier multi-locational on-farm trials, in which only the effects of the physical (i.e., natural or technical) environment were tested, Even though this FSD approach did involve the inclusion of socio-economic elements and, hence, had a farming systems perspective, it was done with a 'predetermined focus' on the productivity of a particular commodity. Thus, this approach involves looking at one facet of an enterprise (Box 3.1) or one specific enterprise (Box 3.2) and identifying improvements within that focus that are compatible with the whole farming system. With the creation of distinct FSD teams -- in contrast to an on-farm testing component located within each station based commodity team -- FSD activities generally have evolved beyond this level. However, it is important to recognise that this type of activity still is a legitimate part of any FSD in the sense that it can provide a very useful input into the activities of commodity research teams.

- In the pursuit of greater farmer participation, research shifted to addressing farmers' articulated problems directly. Still, farmers' problems were very much con fined to crop production, although links with other components of the whole farm system were studied. An alternative name for this 'farming systems in the small' focus could be '***farming systems with a whole farm problem focus***' (Box 3,3), Many FSD efforts currently tend to be at this point, However, currently, on-farm research projects that seek to improve whole farm performance through manipulation of the linkages between all enterprises are few,
- Looking further ahead and to enable addressing issues of sustainable agriculture effectively, concerns for maximizing the economic and biological performance of enterprises will be modified by concerns relating to ensuring sustainability, including the

rehabilitation and regeneration of natural resource systems. This natural resource system dimension to sustainable agriculture can be thought of as a type of 'farming systems in the large, or '***farming systems with a natural resource systems focus***' (Box 3.4),

- Similarly, attention to ecological sustainability will need expanding to include the many off-farm and non-farm activities that make up sustainable livelihoods. This also can be thought of as a type of 'farming systems in the large, or '***farming systems with a livelihood systems focus***' (Box 3,5).

These notions, particularly the last two, have been largely unexplored until recently, when techniques have evolved to handle complex situations in which the ratio of variables to parameters is high. Formal modelling techniques by themselves generally have limited value in addressing such situations because of the complexity of the relationships and the degree of understanding that is required initially to develop a realistic model. However, the major breakthrough that has occurred is the ability to pursue a less formal or more informal modelling approach through application of farmer participatory type techniques that, in essence, involve using farmers' minds as computers!

BOX 3.1: FSD WITH A 'PRE-DETERMINED FOCUS' ON SPECIFIC TECHNOLOGY

Researchers in station-based programmes often want FSD workers to evaluate specific technologies they have developed to see how they fit in with constraints of the farming system currently used by farmers. This type of work is referred to as FSD with a 'pre-determined focus' or 'predetermined technology focus,' In Botswana, FSD teams and participating farmers have assisted station programmes in testing cowpea varieties, evaluating the desirability of hilling groundnuts, ascertaining whether the Dutch hoe can help with the weeding operation, and so forth.

This type of testing in FSD is not analogous to typical technical transfer. Rather than testing fully finished products, FSD assists technology generating programmes, usually based on research stations. Often, the types of technology tested in this manner have not been identified as having high leverage power in the system (see Section 6.4.1). Leverage power refers to the ability of a technology change to have a major impact on the performance of the farming system. However, these technologies do fit possible needs and asking farmers to participate in their development is worthwhile, It is desirable to test technologies as early as possible in their development, This is to facilitate making modifications and to minimize waste of research resources. It also may accelerate the dissemination of suitable technology, Such technology, even if not fully appropriate, may sometimes stimulate thinking among farmers if they are not accustomed to these types of interventions. Feedback in these instances can contribute to new innovations in technology generation.

BOX 3.2: FSD WITH A 'PRE-DETERMINED FOCUS' ON A SUBJECT

A great deal of FSD work, particularly in its earlier years, was not focused on testing specific technology as much as a pre-determined focus on a subject matter area. FSD within the CGIAR institutions such as IRRI, CIMMYT, and ICRISAT have focused on issues related to production of their respective commodity crops. ILCA focused on issues in livestock production, ICRAF in agroforestry' etc. Some FSD teams within the national agricultural research systems (NARS) also worked under limited mandates to deal with particular enterprises; commodities; or other subject areas (e.g., soil water management). The judgements of farmers, the end-users of products developed by these organizations, were foremost in these FSD activities. However, the parent institution with its technologygeneration activities would be a primary client in these instances.

BOX 3.3: FSD WITH A 'WHOLE-FARM PROBLEM PERSPECTIVE, OR 'FSD IN THE SMALL'

An FSD interdisciplinary team conducted a diagnostic survey (see Section 8.4.3) and determined that labour for satisfactory weed control in field crops is a major constraint to farm production and farm family well-being. The survey also showed that due to population pressures, farmers were no longer able to shift field sites as in the past and that deteriorating soil fertility also was becoming a major issue. However, during the course of farmers participating in testing possible solutions to these problems, discussions between the FSD team and farmers identified the potential for intensified poultry production as an additional means of improving farm income. This resulted, in addition, in collaborative testing in the area of intensive poultry production and, as a result, exemplifies FSD with a 'whole-farm problem perspective.'

The major breakthrough that has occurred is through supplementing the rapid rural appraisal (RRA) techniques, which have been available for some time. with the participatory rural appraisal (PRA) techniques (i.e., see Chapter X), which have developed rapidly in recent years.

To date, the first two approaches listed above have been used. Although FSD 'in the small' arrives at a focus within the system in the course of diagnosis, FSD 'with . pre determined focus' moves into the system to research an enterprise or one facet of an enterprise looking for improvements within that focus that are compatible with the whole farming system.

BOX 3.4: FSD WITH A 'NATURAL-RESOURCE MANAGEMENT FOCUS.

A non-governmental organization (NGO) has adopted, as one of its aims, the conservation of the natural resource base within areas of agricultural production. This NGO sponsors FSD activities in a village in which participating farmers look at current and prospective problems in natural resource conservation and management. They evaluate potential solutions to these problems at the same time issues in agricultural production and family income are considered.

The FSD team from the NGO and farmer participants discovered a number of incongruencies between issues of conservation and present day agricultural production. They included the following:

- Natural-resource conservation analyses focus on the landscape (e.g., possibly a watershed), which in some instances does not even correspond to a village or to any other political entity. On the other hand, agricultural production analyses tend to focus on individual farms, units within farms, or smaller interacting networks of farms.

- Conservation invariably takes a long-term perspective of problems and solutions, whereas production analyses consider short-term returns and immediate survival issues.
- Natural resource conservation often involves community or ultra-community efforts and goals, which might conflict in terms of labour or other requirements, with individual farm production activities.

Integrating these apparently opposing sets of objectives for natural resource conservation and production poses a major challenge for FSD. Participating farmers recognize many of the conservation issues and trends and some express concern for the future. In some cases, traditional techniques for conservation such as gully amelioration have been identified and are being promoted, but other issues remain unresolved. Some of the constraints encountered today or anticipated in the future were unknown to farmers in the past. Solutions therefore, are not known, and innovative and problem-solving thinking is required. However, given farmers' intimate knowledge of their current and past production environment, their input in designing appropriate strategies for the future based on an analysis of what has happened in the past is indispensable. This is clearly a fertile area for active collaboration between on-farm and on-station work: a give and take between farmers, scientists, and policy makers.

3.4 Some characteristics of FSD

Some of the major characteristics of FSD are as follows:

- ***Farmer Centre Stage***. The farmer, as the consumer of the improved technologies, is in the centre of the stage. This provides an opportunity for researchers to learn from the farmer, enables him or her to have an input into the research process, and ensures that criteria relevant to him or her are used in evaluating proposed technologies. For the farming family, evaluation criteria (i.e., for the adoption of the improved technologies) can be divided into the following groups:

    - Necessary conditions determine whether the farming family would be able to adopt the improved practices. Such conditions include technical feasibility, social acceptability, and compatibility with external institutions -- that is, support systems.
    - Sufficient conditions determine whether the farmer would be willing to adopt the improved practices. Obviously, the necessary conditions will be influential in determining this willingness. Sufficient conditions include the compatibility of the improved practices with the goal(s) (e.g., food self-sufficiency, profit maximization, risk minimization, etc.) of the farming family; the resources they have access to; and the farming system they now practice.

- ***Work with Representative Farmers***. Although the input of farmers is critically important in FSD it is impossible for FSD teams to work with all farmers. Therefore, a few are selected that are thought to be representative of all farmers. Because there are many types of farmers -- with differences in the products they produce, the resources they possess, and the problems they face -- it is necessary to put farmers with similar characteristics in the same group (i.e., stratum or recommendation domain) (see Section 4.5). A small sample of farmers in each of these groups then is selected to work with the FSD team. If the grouping and selection of farmers are carried out correctly, then the results obtained by these representative farmers should be achievable by other farmers with similar characteristics, when the technologies are extended to other farmers by extension staff.

- ***Involves an Interdisciplinary Approach***. As indicated earlier (Section 2.2), farmers have complex farming systems. As a result, changes in one part of the farming system may have a good or bad impact on another part of the farming system. For example, in some areas, it is not realistic, or indeed desirable, to try and increase crop productivity without considering livestock at all,' Also, attaining a successful solution to a technical problem that has been identified will depend on whether the farming family has the labour and money to adopt (i.e., an economic issue) and any sociological reasons preventing them from adopting. Therefore, to address the wide range of farming systems' issues, FSD teams generally consist of representatives of a number of disciplines -- usually agronomists, animal scientists, and agricultural economists and sometimes sociologists. As a result, an interdisciplinary approach, that is a number of disciplines working together on the same problem, has to be used to solve the problems of farmers (see Section 6.2).
- ***Dynamic and Iterative Approach***. Because of the dynamic nature of agriculture, research

is a never-ending process. Farmers always face problems to varying degrees in their farming operation, and many of these problems can be solved through research. Sometimes the solutions suggested as a result of research don't work and need to be modified. This is implied in Figure 3.1, where the dotted lines indicate that such failures require moving back to an earlier stage in the FSD process and repeating one or more of the steps in the process. This makes FSD an iterative as well as a dynamic approach.

- ***Complementary to Station-based Research***. In the context of technology choice and development, the role of FSD (i.e., utilising a systems approach) is seen to be complementary to technical component research (i.e., which primarily employs a reductionist approach), most of which is undertaken on experiment stations and is usually commodity-based, With respect to such research, FSD has three roles:

    - To look at recognized farming systems and the stock of materials and techniques accumulated from station-based research, so as to be able to choose technical solutions to problems that have been identified, On-farm experimentation then adapts chosen solutions to the local situation. This is a mobilizing and adaptive role, shaping the product for an identified market.
    - To pass back unsolved technical problems, important to the system, to the appropriate commodity research team on the experiment station, This role is one of identifying and helping to prioritize the agenda for technical research.
    - To link with farmer clients and extension staff in local farm situations, drawing both farmers and extension workers and other relevant 'actors' into the

technology-generation process.

Two examples indicating the perils of not exploiting the complementarily between onfarm and station-based research are given in Boxes 3.6 and 3,7. Similar linkages could be established with planning and development agencies concerning proposed policy/support programme changes. Unfortunately, these are not yet strongly developed in most countries.

BOX 3.5: FSD WITH A 'LIVELIHOOD-SYSTEMS FOCUS'

There are, to date, relatively few good examples of applying FSD with a 'livelihood systems focus.' One organization that in recent years has expended considerable effort in integrating 'off farm' with 'on-farm' activities in a sustainable manner has been ICLARM which has concentrated on integrating aquaculture with crops and livestock [Lightfoot and Noble, 1992].

Certainly integration of 'on-farm' and 'non-farm' activities deserve much greater emphasis than it has to date, especially as increasing pressures develop on the natural resource base. 'Non-farm' activities car provide an outlet for surplus labour and contribute to the attainment of sustainable livelihoods. In many areas (e.g., semi-arid parts of West Africa), particularly where agricultural activities are seasonal in nature, farmers have always recognized the complementarily between farm and non-farm activities, through emphasizing the latter particularly during slack periods in the agricultural cycle [Norman et al, 1981], Many of these jobs are in the non-formal sector and involve micro-enterprises [Liedholm and Chuta, 1976; Liedholm and Mead, 1993], also an area that needs much greater emphasis than it has to date.

BOX 3.6: TECHNOLOGY THAT WORKS UNDER EXPERIMENTAL CONDITIONS WILL NOT ALWAYS BE RELEVANT ON-FARM

In Botswana, precipitation is low and variable, creating erratic conditions for crop production. Under these conditions, farmers minimize risk by adopting an extensive low-input cropping system that is moderately productive under favourable conditions but minimizes losses when rainfall fails. Under research-station management, an intensive system for maize increased average yields and dramatically improved yield stability. The intensive system consisted of controlled pathways for planting with minimal tillage of the soil and water concentration onto the plant zone. It is the water concentration that stabilizes maize yields. Weed control was as used needed but weed pressures were minimal when crops were established early.

This technology failed when it was tested under farmer management. It failed because critical resources are not available on the farm at the right time to meet the schedule requirements of the new technology. The intensive system requires that soil preparation be finished before the rainy season begins and that planting be carried out on the first rain(s) of the year. Meanwhile, draught animals to do this work are kept near watering points at distant cattle posts until rains have filled shallow wells and ponds near the herds. Farmers and their draught animals cannot plant early in the season, and when they do not, weed growth overruns the controlled pathways. The Ministry of Agriculture made a fitting decision to conduct farmer-managed tests before recommending this system to farmers based on station results alone.

3.5 A systems or reductionist approach?

Is this the only choice? It might be popular to think in terms of the one or the other; systems, approaches or reductionism, each with its characteristics and methodology. Should one 'divide and conquer' or accept that 'the whole is greater than the sum of its parts"? A distinction is made between science and art but also it is reflected in divergent schools of thinking within some disciplines. However, in FSD, this rigid dichotomy of perspective is neither necessary or feasible.

FSD recognizes that farming systems are highly complex and not fully reducible. They are too complex for human intuition to deal with all the factors involved but, at the same time, consist of such a fuzzy web of interactions that currently available analytical tools are not powerful enough to describe them.

Over the years, science in agriculture has attempted to model the factors and relationships within a farm operating in an agro-ecological situation. The purpose of this modelling invariably has been to engineer optimal solutions or strategies. An important limitation to this approach is that optimization has been for the research model and not for the farm and the farming family itself. A larger purposeful framework comprising a farm value system and related decision making patterns cannot be incorporated so readily into this research model.

FSD seeks to ***synthesize*** human intuition and judgement with analytical science. To accomplish this, FSD uses farmer perspectives on issues, problems, etc. Even when these are not completely exact, they help create holistic or logical frameworks within which technical alternatives can be screened or engineered. FSD also seeks to render the holistic framework as explicit as possible. Farmers and FSD staff seek to differentiate uncertainty in the system that is due to randomness (i.e., rainfall probabilities) from that due to lack of experience (i.e., ignorance about new technology) from that due to vagueness (i.e., typically, decision making patterns). By integrating relevant scientific information, hands-on experiences, and intuitive managerial skills, FSD can be effective in evaluating scenarios, even those involving future changes in the farming environment.

Within this framework, numerous scientific information needs will be recognized. Within this framework, the need is to obtain rather unequivocal answers to the specific and well defined questions. Reductionist's techniques are better suited for this purpose, especially if the question pertains to objects in the system rather than human behaviour, which involves human intuition skills. The key to successfully designing this type of focused research is the incorporation of different perspectives through interdisciplinary teamwork and participation of farmer managers.

Thus, 'rigour versus relevancy' need not be a dilemma in FSD, On the contrary, rigour and relevancy are both possible and essential, if solutions are to be found in time for the many pressing problems that confront farming systems in a rapidly changing world.

The systems analysis employed in FSD should do the following:

- Pay particular attention to formulating problems within the holistic framework.
- Review each result within the general systems framework and never exclude an alternative without having done this. Sometimes, the best alternative in a systems framework is tar from optimal when evaluated separately.
- Set forth hypotheses early, so that all 'actors' with their perspectives can participate in reformulating these questions. After all, it is these questions more than 'responses, that set systems approaches apart.
- Avoid overemphasizing mathematical representation at the earliest stages.
- Treat even uncertainty as explicitly as possible.
- Sub-optimize with care. With reference to this, see the second point in this list.

Thus, there is a complementarity between the reductionist and systems approaches. This is why it was argued earlier that the FSD approach is complementary to station-based research, which usually employs a reductionist approach. The holistic approach in FSD is needed to ensure that experiment stations develop relevant technologies and needs to exploit the power of the reductionist approach, which can be a very efficient way of developing new technologies, once the priorities have been ascertained correctly. The results of this potentially relevant technological work can then be given to the FSD team for on-farm evaluation.

BOX 3.7:'APPROPRIATE TECHNOLOGY' WILL NOT ALWAYS BE RELEVANT ON-FARM

Appropriate technology is characterized as low cost, technologically simple, labour intensive, making use of local materials and existing methods of production, and responding to identified constraints in the farming system. FSD generally seeks technologically appropriate solutions to problems but these should not be promoted automatically without on-farm assessments.

The Bolivian altiplano is a hostile environment for agricultural production. The zone is dry and cold with nightly frosts occurring at any time of year. In earlier periods, farmers of this area traded products of their system for various food products of the lowlands. In recent times, their access to other markets has partially been broken off. Land degradation and pressures on use of the land have further reduced the ability of farmers to maintain their traditional crop and livestock production strategies.

Protected horticultural systems were identified by several NGOs as appropriate ways to solve problems in this system [Kohl, 1991]. For the most part, these systems were promoted directly without an objective assessment including testing under farmers' conditions. Initial glasshouses were soon found to have difficulties with high insolation costs and were replaced by adobe structures covered with plastic. But many other problems were not addressed or proved unsolvable: guaranteed water supplies, local and distant markets for excess production, nutritional benefits of products, and so forth.

An important finding of a study of this large and costly effort is that promoters of development have not taken experimentation seriously enough. The value of farmer and expert involvement in design, testing, and dissemination is that irrelevant or incorrect designs and management systems can be screened out or corrected.

3.6 FSD in the context of other agricultural institutions

Work relating to FSD might be incorporated as a working tool for several different types of institutions. These could include such diverse institutions as agricultural research, extension, community development (particularly in regards to NGOs), or even ministerial or national units interested in policy design and assessment.

FSD thus can he used to focus on family income. technology design, dissemination, and adoption: or designing solutions to the problems associated with a deteriorating natural resource base in agricultural areas. At another level of viewing the institutional setting of FSD, it is apparent that not only some disciplines but also various technical and sociological approaches and methods, are evolving to better deal with systems analysis. Take, for examples, the use of Geographic Information Systems (GIS) as a tool integrating large amounts of data into a single framework useful for technical as well as sociological and economic analyses. On the other hand, community development and policy reform programmes use increasingly sophisticated techniques (i.e., tools or methods) that contribute to decentralized planning, grass-roots participation, and empowerment in assessing problems and designing solutions.

The emphasis in many areas is on developing integrated approaches and system type analytical methods. With the possibility of increasing convergence occurring in some of the methods and, in some cases, objectives, the unique contributions by FSD will be brought into question by some. And, in fact, the institutional role or mandate of FSD will vary. FSD in one setting may focus largely on trials and farmer testing of new technology. In another setting, a greater emphasis may be placed on surveys, sociological or information related to the financial picture of the whole farm, and so forth, In the larger picture, none of this matters too much. But it should be remembered that FSD does have certain fundamental characteristics (See Sections 3.2 and 3,4). These include:

- Iteration, such that no single proposal should be considered definitive.
- Integration, usually involving multiple disciplines and explicit building on managerial perspectives and managerial values.
- A consistent orientation towards problem solving and an attitude that no perspective on this problem should be discounted.

FSD also must focus on appropriate linkages with other development support programs and institutions (for example, see Section 2.4). In this regard, FSD emphasizes a strongly integrative and integrating philosophy, not just for disciplinary and farming perspectives within FSD itself; hut integrating strengths of personnel, resources, information, and location of the FSD programme with other research and development programmes working in the same area or domain. A critical element of this inter-institutional integration is a logical division of labour for the problem-solving task, This invariably will encourage collaboration in the development of work plans both for short-term as well as medium- and long-term objectives.

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3.7 Challenges facing FSD

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A number of challenges face FSD if it is to continue playing a significant role in facilitating the process of agricultural development. Some of these are:

- ***Better Incorporation of Farmers***, Incorporating farmers into the research process was one of the most important principles underlying the evolution of the farming systems approach. The basic justification for this was that farmers could improve the efficiency of the research process. At a minimum, it was argued they could prevent the use of research resources on types of technologies that they would be unlikely to adopt, while even more Importantly, it was anticipated they could, in their own right, contribute positively to the research process. Unfortunately, farming systems workers often have not sufficiently recognized this positive and interactive contribution of farmers. Consequently, this spawned the farmer participatory research (FPR) movement [Farrington and Martin, 1988]. The problem of not utilizing the farmer sufficiently in FSD activities is not due to inherent deficiencies in FSD itself but rather with the way in which it has been applied, Techniques of FPR or PRA need to be incorporated into FSD, a subject which will be discussed later (see Section 8.4).

- ***Continued Evolution of FSD***. FSD is relatively new. Therefore, the methodology is still evolving and, as a result, universally accepted 'standard texts' on the 'nuts and bolts, of how to do it are still to emerge. Related to the methodology issue is that time and cost-efficient (i.e., money and people) methods for undertaking FSD still need further development. This is important because of the limited resources available for undertaking research, both on-station and on-farm. In this manual an effort has been made to address this issue in a number of places -- particularly in Chapters 7 and 8.
- ***Greater Incorporation of the Policy/Support System Perspective***. As has been stressed already' the farming systems approaches implemented to date have focused mainly on the technology dimension (i.e., FSR). However, a basic principle of the FSD approach is that the farming systems perspective is critically important in formulating and adapting policy/support systems in ways that will facilitate and accelerate the agricultural development process, Once again, discussions relating to the policy/support system are scattered throughout the manual, and it is highlighted as an essential component of FSD in Figure 3.1. Failure to incorporate this dimension in FSD activities is likely to have an

impact analogous to playing soccer on one leg, Nevertheless, because of the lack of much proven experience and documented material on the farming system perspective with respect to the policy/support system, this manual does not deal with this dimension to the extent that would be desirable. Hopefully, this lack of experience will be rectified in the fairly near future. An example of the potential value of using a policy/support perspective in FSD is given in Box 3.8.

- ***Incorporating Equity Issues -- Intra and lnter-Generational***. FSD tries to help the farmer with the problems he or she has identified. Of course, the reason for this is the necessity to introduce an intervention in which they are interested, It its likely that these 'felt, problems of farmers are likely to have a short-run focus (i.e., particularly when the farmer is operating very close to the survival level). Also, it is possible that helping to solve the individual farmers' problems creates others for the society as a whole. Although the example given in Box 3.9 pertains to inter-household relationships, equity considerations within a particular generation also apply to what is happening within farming families. As will be discussed later (see Section 4.4), it is wrong to assume that all farming households or families operate in such a way that distribution of effort and benefits is equitable. For a positive example of the benefits of understanding intra household relationships, see Box 3.1(). When designing a technology to help farmers increase their productivity, consideration must be given to the possible long-term effects (e.g., decreasing the amount of productive land available) of that intervention. Therefore, if farming system (FS) workers are not careful, their work can result in creating two types of inequalities, that is, helping some farming households -- or even certain individuals within those households -- at the expense of others and/or reducing the quantity and quality of land that can be productively farmed by future generations. Avoiding the development of such inequities constitutes a major challenge to FSD teams who need techniques to be able to screen out proposed technologies and policy/support systems that would encourage or exacerbate such trends. Once again, issues relating to equity matters, although generally recognized as important, still need attention in farming systems type activities. This will require continued evolution of FSD towards the FS 'in the large' approach mentioned earlier (Section 3.3).

- ***Assessing Agricultural Research Impact***. Related to the research resource issue is the importance of devoting some effort to assessing the impact of the research process - something that often has been done inadequately. More attention needs to be paid to adoption/diffusion studies. Such studies, of course, are the best measure of the impact of the agricultural development process, Therefore, the credit for favourable results from such studies cannot be allocated to FSD activities alone. However, FSD teams, because of their on-farm location and pivotal linkages with other actors, are often in the best position to take a leadership role in their execution. Also, as suggested earlier (Section 3.2), such studies can and should be used for other purposes, such as feeding back priorities for further research and providing evidence for adjustments in the policy/support system to encourage greater adoption,
- ***Improving Credibility of FSD***. Establishing credibility for FSD-related activities is a major challenge and is necessary to ensure that some of the limited research resources always will be allocated to them, As argued earlier (Section 2.4), FSD staff constitute only one

set of the 'actors' in the agricultural development process. Additionally, FSD helps facilitate a process and does not result in a product by itself. Thus, FSD cannot claim sole credit for any technologies developed for, or adopted by, farmers. However, it achieves credibility through its linkages and cooperative efforts with other 'actors' in the agricultural development process. These 'intermediate products' need to be documented and publicized to a greater extent than often has been the case.

BOX 3.8: FSD CAN HELP IDENTIFY APPROPRIATE DEVELOPMENT STRATEGIES

On-farm systems studies were carried out in village areas south of Bangalore, India [Rushton, 1994] to determine the appropriateness of the current livestock policy.

Farmers without irrigated crop land are the poorest in this area and at greatest risk from the effects of climatic and biological variations. These farmers depend on small livestock herds for cash income and on subsistence cropping for home consumption. When their small-scale livestock production fails, farmers are forced to seek outside employment for cash, and thus cropping activities suffer.

This farming system study identified two improvements that would contribute to better livestock productivity: control of epizootics and a 'preventative veterinary medicine service' focused on improved fertility management among small herd-owners. Previously, veterinary service policy had been to target larger herds where the immediate payoff had appeared to be much greater.

Such a livestock policy change should lead to greater stability in the production of animal products for local markets; less reliance on seasonal employment and, therefore, greater stability of the household labour force; and more stable subsistence cropping activities.

BOX 3.9: INTER-HOUSEHOLD RELATIONS AND TRADE-OFFS: AN INTRAGENERATIONAL ISSUE

In Botswana, farmers have a tradition of sharing draught power, In this semi-arid environment, field operations such as ploughing and row planting depend on access to draught in a timely fashion (i.e., days on which there is adequate soil moisture for ploughing/planting).

If a technology system is introduced that requires more draught, rather than less, it may mean that the household controlling the draught may not be able to routinely allow other households to also use their animals under a sharing arrangement. Thus, helping one household may harm other households in the community.

BOX 3.10: INTRA-HOUSEHOLD DECISION MAKING AND TRADE-OFFS: ANOTHER INTRA-GENERATIONAL ISSUE

An FSD programme in Amphoe Pharao, Thailand [Shinawatra et al, 1992] discovered a positive and unexpected benefit from interaction at the intra-household level. The introduction of improved and more commercially oriented poultry operations was targeted towards women members of households, because they traditionally manage and derive income from poultry. However, improved technological interventions not only required new inputs by men but were discovered to provide profitable use of under-employed male labour in many households.

This example demonstrates decision making with interactions between members of the household that are desirable for all: a win-win situation. Often, however, decisions for change favour one segment of the household, while adversely impacting on another.

4. Some key concepts important in the farming systems approach to development

4.1 Objectives of the chapter

The objectives of this chapter are to:

- Briefly define a farming system.
- Describe the status, goals, and appropriate technology for limited-resource households.
- Briefly discuss issues relating to equitability,
- Describe the recommendation domain concept.

- Briefly describe the significance of a participatory approach to FSD.

4.2 Definition of a farming system

To design appropriate or relevant ways of helping farmers, it is essential to understand the conditions under which farmers are operating. They have in fact, very complicated farming systems. Figure 4.1 shows some of the factors that have an influence on what the farming system will be. The operator of the farming system is the farmer or the farming family. To farmers, the way in which they earn their living and the economic, social, and cultural well-being of their households are linked closely and cannot be separated.

The members of the farming household have three basic types of inputs: land, labour, and capital. Management involves allocating these to three different activities or processes, that is, crops, livestock, and off-farm enterprises. In making decisions on how to allocate their inputs in producing one or more products, farmers have to make some difficult decisions. These decisions will involve using their knowledge to come as close as possible to fulfilling the goal(s) for which they are striving. These goal(s) may vary from farmer to farmer (e.g., maximizing their income, producing enough food to feed the family, etc.). Many farmers are likely to want to maximize their incomes, once they have made sure they are producing enough food to feed their family and have met other societal obligations. The resulting combination of products (i.e., crops, livestock, and off-farm enterprises) they are producing with their inputs results from the farming system they have adopted. Nevertheless, the extent to which the farming system fulfils the goal(s) they have chosen will depend on the managerial skills of the farming family and its ability to make good decisions in the allocation of inputs in a very uncertain production environment.

Figure 4.1: Schematic representation of some farming system determinants

However, some parts of the environment that influence what the farming system will be are outside the control of the individual farming family thus causing uncertainty as far as the farmer is concerned. The ***'total' environment*** in which farming households operate consists of two parts: the technical (i.e., natural or physical) element and the human element [Nonnan et al, 1982].

- The ***technical element*** determines the types of, and physical potential of; livestock and crop enterprises. For example, in some areas, the low level of rainfall allows sorghum, but not maize, to be grown on rainfed land. The technical element includes physical and biological factors. These often are modified to some extent through technology developments -- for example, increasing water availability through irrigation Improving soil quality by adding fertilizer, breeding for yield stability during drought, etc.
- The farming system that actually evolves, however, is only part of what is potentially possible. The ***human element*** is important in determining what the actual farming system will be. The human element consist of two types of factors: exogenous and endogenous.

Exogenous factors (i.e., the social environment) are largely out of the control of the individual farming family. These factors will influence what the farming family can do and can be divided into three broad groups:

- Community structures, norms, and beliefs.
- External institutions, which include extension, credit, and input distribution systems on the input side and markets on the output side.
- Other influences, such as population density, location, and infrastructure.

Endogenous factors, on the other hand, are those the individual farming household controls to some degree. These include the types of inputs mentioned earlier, that is, land, Iabour, and capita]. It is important to recognize that these resources and managerial ability vary among households and regions. The resources vary on the basis of quantity and quality, both of which influence the performance and the potential of the system. In addition, these inputs or resources may or may not be owned by the household. Access to one or more of these resources may be on another basis of use (e.g., borrowing draught animals), which may limit or restrict the ease or intensity of use and thus, in turn, affect the goals and performance of the farm family.

Nevertheless, it is the fanning family that decides on the farming system that will emerge. However, this system will be influenced and sometimes constrained by the technical element and exogenous factors.

The farming system is obviously complex, and the results can vary greatly because of differences in the 'total, environment. These facts help explain why some technology thought to be relevant often has not been adopted, or when it has, why the degree of adoption has varied widely. Not considering the human element in agricultural research has contributed to many socalled 'improved' technologies being irrelevant.

4.3 The limited-resource household: status, goals, and appropriate technology

Typical limited resource farm households in low income countries generally are characterized as follows [Ellis, 1988: p. 12]:

> "Farm households, with access to their means of livelihood in land, utilizing mainly labour in farm production, always located in a larger economic system, but fundamentally characterized by partial engagement in markets which tend to function with a high degree of imperfection."

Important points to note about this definition are that:

- Such households often are subordinate to some other external forces. That is, they do not have complete control over their own destiny and are in a process of transition. This is because of not being integrated fully in the market economy.
- They have access to land to pursue their livelihood. They cultivate the land largely with

family labour, in conjunction with only small amounts of capital.

- The input or factor markets (i.e., land, labour, and capital) work poorly. Concerning land, non-market rights of access or non-price forms of tenure are more likely to operate than a freehold market. The capital markets usually are developed poorly and variable production inputs are often not available. As a result [Ellis, 1988: p. 12]:

  "Credit and interest rates may be tied to other factor prices like land and labour within a dependent economic relationship. Thus factor markets may be locked together contractually rather than being independent."

  Also, market information may be highly imperfect (i.e., not available or readily accessible). Thus, it is not surprising that sharing and reciprocity often exist between households. In these non-market transactions, exchange of unlike goods and services take place, which are not valued by market prices. Sometimes, such relationships exist between households that are related to each other.

- Another reason why such households are integrated only partially into the market economy is because they consume a proportion of the product they produce. This enables them to have some ability to survive independently of the larger system, which may be important in explaining their economic behaviour.

A number of microeconomic theories have been developed in an effort to explain the economic behaviour of farm households. These are based on various assumptions about household goals and the characteristics of the markets within which households make their decisions. Ellis [1988] notes that these theories are not mutually exclusive, sharing as they do certain key assumptions such as:

- The household is a single decision-making unit for economic analysis purposes. As a result, it maximizes a single utility (satisfaction) function that represents the joint welfare of its members.
- Profit maximization and utility maximization coincide where income is the only variable in the utility function. Profit maximization is always one of the components of utility maximization" when all the input and output markets are fully formed and competitive.

Ellis [1988] suggests that the theories predict different results because of different assumptions about the working of the factor and product markets, rather than because of differences in assumptions about household goal(s). In fact, an important characteristic distinguishing many of the theories results from different assumptions about labour markets and the allocation of household labour time, In support of these assertions, Ellis [1988] then discusses a number of these theories of economic behaviour. He calls these profit maximization, risk aversion, drudgery aversion, farm household theories, and share tenancy. In doing so, he recognizes the impossibility of separating short-run household decisions from the wider social relations of production.

Consequently, there is likely to be a certain universality in the aspirations of limited-resource farming households. The most important elements are income, effort avoidance, and risk avoidance. In economic terms, this means such households try to increase their utility or satisfaction, which increases with income but decreases with greater effort or higher levels of risk. This can be restated as maximizing income for any given level of effort or risk. Alternatively, it can mean reducing risk, or effort, for a given level of income [Norman, 1982].

Attempts to maximize utility or satisfaction take place within a set of constraints. As implied above, differences in the constraints, rather than the aspirations, lead to the most important differences in farming systems. As discussed earlier (Section 4.2), Figure 4,1 indicates some of the determinants of the farming system. It is easy to visualize constraints relating to the technical element causing differences in the type and productivity of farming systems, However, also important in the differentiation process are the factors relating to the human element. The quantity, quality, and ratios (i.e., particularly between land and labour) of the endogenous factors (i.e., factors of production -- land, labour, and capital) play an important role in further differentiating farming systems. The extent to which they can be modified will depend on the degree of integration into the factor markets (i.e.? input markets). Also the products resulting will be influenced to some extent by community norms and beliefs and the degree of integration into the product market.

The above discussion has important implications for what is appropriate technological change. For example, limited resource households often are likely to be very little above survival level and, hence, will place a very high premium on improved stability of production. The levels, qualities, and relative proportions of the factors of production are important in indicating the most appropriate route for improving the productivity and profit of the farming system -- which is maximizing the return to the most limiting factor. For example, in areas of high land/labour ratios (i.e., low population densities), labour saving (e.g., mechanical, extensive livestock production) types of technology/systems are likely to be most appropriate. In contrast, in areas of low land/resident ratios (i.e., high population density) land saving technologies/systems (e.g., biological and some chemical, intensive livestock production) will likely be more appropriate. However, as Table 4.1 shows, increasing the return to the most limiting factor can have an indirect positive or negative impact on the use and productivity of other inputs. Thus, in view of the imperfect operation of the factor markets, care has to be taken in evaluating what would be the most relevant technologies.

For example, in a semi-arid area, initial superficial examination may indicate that because of the high population densities, strategies designed to increase the productivity of land would be most important. However, given the seasonal nature of agriculture in semi-arid areas, there will be periods of intense labour activity during the year. These will create labour bottleneck periods, followed by periods of underemployment. Thus, land-augmenting strategies using labour at critical labour bottleneck periods -- when the opportunity cost of labour is high (i.e., there are good alternative uses for labour that can yield an equally high return) -- could be unattractive to the household (see Box 4.1). This is likely if adoption of such strategies involves the use of more labour at such labour bottleneck periods. It will also be likely if the productivity per unit of labour applied at that time is higher in alternative uses.

TABLE 4.1: RELATIONSHIP BETWEEN TYPES OF REQUIRED TECHNOLOGY AND LAND/LABOUR RATIOS

LAND/LABOUR RATIO	TECHNOLOGY REQUIRED	PRODUCTIVITY OF[a] LAND	LABOUR
High	Labour saving	I+ or I-	D+
Low	Yield increasing	D+	I+ or I-

a.

D = Direct impact
+ = Positive impact
I = Indirect impact
- = Negative impact

BOX 4.1: TECHNOLOGIES ARE RARELY SUPERIOR IN TERMS OF RETURN PER UNIT AREA AND LABOUR

In the early 1970's, three technological packages were tested with farmers in Northern Nigeria [Norman et al, 1982]. Farmers involved in testing them used animal traction and, operating in a semi-arid production environment, were faced with a major weeding

bottleneck in June-July. The three technological packages were compared with each other and, in the case of sorghum and cotton, with indigenous practices, Summarized results were as follows:

Variable	**Sorghum**		**Cotton**		**Maize[a]**
Technology	Indigenous	Improved	Indigenous	Improved	Improved
Yield (kg/ha)b	641	1330	409	718	2897
Percent covering costs	86	100	94	90	100
Net return (N/ha)	45.02	81.62	19.68	40.73	190.36
Net return (N/man-hour):					
June/July	0.93	0.74	0.31	0.31	1.68
Excluding harvesting	0.43	0.52	0.11	0.16	1.29
Total	0.21	0.22	0.06	0.08	0.51

a. Indigenous practice , for maize could not be compared because maize was rarely grown in that area at that time.
b. Average of the results in 1973 and 1974 seasons.

The results indicated the superiority of the improved maize technology over both improved or indigenous practices for sorghum and cotton in terms of both return per unit of land and labour. Note that for both the sorghum and cotton improved technologies, the return per unit area was higher than that from employing indigenous practices; but that the return per unit of labour used during the June/July period was the same or lower. Unlike the sorghum and cotton improved technologies, the improved maize technology was, from a profit viewpoint, suitable for farmers whether they were faced with a labour or land limitation.

Not surprisingly, since the 1970s, improved maize technologies have been adopted widely in Northern Nigeria, in a mini-Green Revolution [Smith et al, 1994]. Although, initially the prime motivation for growing maize was as a cash crop, it eventually became a more important dietary item as farming households made trade-off decisions between growing the high yielding maize rather than the low yielding sorghum.

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4.4 Equitability considerations - intra- and inter- generational

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4.4.1 Intra-Household or Gender Issues

Many development projects have assumed that the male head-of-household provides the majority of agricultural labour and is the sole decision maker concerning agricultural activities. This approach fails to recognize the important contribution to women and children to agricultural production in many parts of the world. Although data are very unreliable, the indications are that female family labour ranges from 2 to over 50 percent of farm labour [Boserup, 1970]. Women's participation in production agriculture may range from zero in some Moslem countries to the situation in Africa south of the Sahara, which is a region of 'female farming systems' where women may manage and work more than one-third of the farms. Despite the great contribution made by women, development projects have been slow to recognize this contribution. As Jacobson [1993: pp. 61-62] points out:

> **"The reason is brutally simple: women perform the lion's share of work in subsistence economies, toiling longer hours and contributing more to family income than men do. Yet in a world where economic value is computed in monetary terms alone, women's work is not counted as economically productive when no money changes hands."**

She goes on to suggest that this gender bias is compounded in many societies by discrimination based on class, cast, or race.

This situation can lead to complications because of differentiation in the types of labour available from household sources, Microeconomic theories that make simplistic assumptions about farming households add to the problem, For example, they assume a single decision-making unit and a single utility function representing the joint welfare of family members. However, increasingly this has been recognized as a problem, because intra-household relationships can have a major impact on economic behaviour, Some important points to note about intrahousehold relationships are as follows [Ellis, 1988; Feldstein et al, 1988]:

- **Such relationships are of particular importance in situations where there is a high degree of congruence between the production and consumption units. They are also important where there is some imperfection in terms of integration with the factor and product markets.**
- **The economic situation of individuals within households is influenced by the social norms or behaviour of the society within which they reside, Therefore, specific economic roles are socially assigned to men, women, and children, Also, division of property, labour and income within households is socially, and not biologically, determined. As a result, males and females within households sometimes may have different income streams, with different sources and different destinations.**
- **Thus, it is wrong to assume that male and female labour can substitute for each other across the range of household activities. As a result, rigidities in time allocation may reduce the ability of households to respond to market signals. Therefore? such division of labour can impose constraints on seasonal labour inputs and ability to respond to**

price changes. As a result, it can have a major impact on the composition and level of farm output.

- **Because of the above, increases in household income are unlikely to benefit all members equally. This often is exacerbated by the social subordination of women in many societies. As pointed out above, agricultural policies and projects often have ignored the role of women in agricultural production -- not only as operators but also as decision makers. As a result, it is not surprising that technological innovations have tended to disadvantage women relative to men.**

Therefore, an understanding of operational constraints facing limited resource households, and the relationships that exist between members of the households and between households is critically important in determining what are likely to be appropriate criteria for evaluating potential technologies. In connection with this, it is also important to understand the farming household members' goals and incentives, farming and non-farming activities, and resources available.

4.4.2 Inter-Generational or Sustainability Issues

As was pointed out previously (Section 3,7), incorporating equity issues relating to the intergenerational impact of development is one of the challenges facing FSD. There is a great deal of concern about the impact of an ever increasing world population on the world's natural resources. This concern was evident at the Earth Summit held in June 1993 in Rio de Janeiro. Part of this concern was related to the loss of nearly 500 billion tons of topsoil

through erosion in the 20 years between the previous meeting in Stockholm and the Rio de Janeiro meeting. According to Brown [1993], this and other environmental factors have contributed to a decrease in the rate with which food output is growing -- an alarming situation given the increasing population to be fed.

Most farmers, and hence development programs, are concerned with local short-run production problems rather than the broad picture presented at the Earth Summit. This its logical, given the farmer's need to survive at the present, but it does not excuse the FSD team from considering the long-term, intergenerational and sustainability, impacts of their programmes, Although not the only factor to consider in the inter-generational and sustainability area, a major concern is soil conservation,'' Norman and Douglas [1994] identify a number of concerns when addressing soil conservation issues.

- **Good land husbandry requires a mix of improved farming practices integrated with farm policies and programmes. Thus, it is essential to understand the current farming system in order to design effective conservation measures. This implies that a systems perspective be used.**
- **The goal should be to prevent rather than cure soil erosion. This means that the causes of soil erosion must be understood and treated, rather than concentrating on treating the symptoms.**
- **To be most effective, conservation programs should be planned with the full knowledge and participation of the farmers. FSD team members must be able to communicate**

effectively with farmers to identify their ideas, perceptions, and priorities, so these can be taken into account in developing strategies for improvement.

- **If farmers are going to implement changes, they must be convinced that they can obtain short-term benefits from change (i.e., have an incentive to alter present practices). Thus, it is important to try and identify strategies that will have short-term benefits as well as provide long-run conservation improvements. When dual-purpose strategies cannot be designed, the long-term conservation activities should be linked with measures that provide short-term production/welfare benefits.**
- **For any conservation activities that require community action (e.g., soil conservation on a watershed), it is important that the communities have responsibility and control and also reap the benefits of such action, in an equitable manner.**
- **Long term programmes are more effective than short-term programmes. Thus, it follows that the change will take place over a long period, necessitating adjustments and iterations in programmes.**

BOX 4.2: BALANCING INDIVIDUAL FARM AND COMMUNITY OBJECTIVES

Rapid changes are occurring in cropping system recommendations and practices in the Andes of Bolivia [Genin et al, 19941. Some of these changes are in conflict with objectives and beliefs held by the community.

Individual villagers in this region occupy field sites for two or three years within communal lands and then shift to new sites. Individuals make their own decisions about cropping

practices, and the community collectively decides when shifts are in order. The fallow period typically lasts from 3-15 years and provides communal grazing, rejuvenates soil fertility, aids with pest control in crop production, and provides fuel for the household. Furthermore, the long-term fallow system, aynuga, contributes symbolically to the well-being of the community and its sense of stewardship.

Adoption of 'improved, cropping practices by individual farmers on their fields could change the way in which they wish to occupy space in the long-term fallow system. Solutions to this restraint will require balancing objectives of individual farmers and community.

These considerations are in addition to technical considerations in soil conservation and imply that the FSD team must possess skills other than just technical skills. This is implied in the example given in Box 4.2.

Although this discussion has centred on soil conservation, the approach and factors to consider can he applied equally well to other programme areas where there are inter-generational or sustainability considerations -which will include most programme areas.

4.5 Recommendation domains

A recommendation is information that farmers can use to improve the productivity of their resources (i.e., farming system) [CIMMYT, 1988A]. A good or successful recommendation,

therefore, would consist of the practices that farmers would follow, given their current resources. if they had all the information actually available to the researchers. Obviously, the development of recommendations for farmers should be as efficient as possible. Because it is impossible to make a separate recommendation for each farmer practical compromises have to be made. As indicated earlier (Section 3.4), this is done by stratifying the farmers into groups as homogeneous as possible. Farmers in these groups should have similar circumstances. resources, problems, and solutions to those problems. In this situation, therefore, it is usually assumed that the same recommendation will be suitable for all the farmers in the group. Such a group of farmers is a particular recommendation domain [Byerlee et al, 1980]. Recommendation domains may be defined by agro-ecological (technical) and/or by socio-economic (human) circumstances (Box 4.3). The definition of the recommendation domain depends on the particular recommendation [CIMMYT, 1988A] (see Box 4.4).

Therefore, by dividing farmers into homogeneous groups or recommendation domains, one is recognizing:

- **The heterogeneity that exists in the farming population.**
- **The likelihood that farmers, within a group, will have similar problems.**
- **The increased probability that farmers within a group, will be interested in the same potential solution to the identified problem(s).**

Thus, the purpose of the groups is to highlight similarities within the recommendation

domains and the differences between and among the recommendation domains. Similarities and differences are important only with respect to the objectives: increasing agricultural productivity by establishing experiments and generating recommendations. Because farm families differ from one another, it is important to distinguish the characteristics on which they vary, how those variables relate to the problems they have, and the usefulness of solutions to resolving those problems.

In the descriptive/diagnostic exercise, as will be seen later (see Section 5.7), one of the purposes is to tentatively define the potential recommendation domains, although these may need to be adjusted in the light of later experience. An interesting short-cut that does not require a very precise definition of recommendation domains is the use of research-oriented farmer groups. These are discussed in a later section (see Section 9,8,6), Briefly, this involves offering to the farmers a number of technologies, from which they select those they are interested in testing. The characterization of the group selecting the option provides a quick indication of the possible recommendation domain for the proposed technology and reduces the chance of possible errors in the definition of the recommendation domains.

BOX 4.3: SOLUTIONS MAY DIFFER FOR FARMS WITH THE SAME PHYSICAL AND BIOLOGICAI. PROBLEM

An underlying problem for all farmers in arid and semi-arid zones is the limited availability of water for plant growth. Consequently, a key management factor is their ability to perform timely operations in order to make water available for germination and plant growth and to

improve the efficiency of water use.

The ability to pursue 'timeliness,, however, is not a function of management alone but also of resources available to farmers. For example, in Southern Africa it is much easier for a farmer owning a tractor to carry out timely operations than for a farmer hiring donkeys. Although the problem for both farmers is the same, the potential solutions for helping them will be different. Therefore, in much of the FSD work, such farmers have been allocated to different recommendation domains.

Some FSD workers have found, on the other hand, that recommendation domains in their farming systems tend to conform to geographic differences (e.g., soil type, climate, and so forth) and less to resource differences between farmers. This was the case for dryland farming systems in India [Walker and Ryan, 1990].

BOX 4.4: EXAMPLE OF A GENERALIZED RECOMMENDATION DOMAIN

Over the years, one FSD team in Botswana did a great deal of crop variety testing for stationbased researchers, One example is the cowpea variety ER-7, which has now been released officially, In the case of this variety, there was no need to differentiate the farmers according to different socio-economic groups. Rather, the appropriate recommendation domain appears to be all farmers in a particular geographic area (i.e., eastern half of Botswana which has the best rainfall).

4.6 Participatory research

During recent years, the farming systems approach has shifted dramatically from an emphasis on farmer based but researcher managed studies towards methods that stress farmer participation, or say, in the research process. The question asked is 'who is best positioned to lead an inquiry into a farming system'?'. Farmer-based, researcher-managed studies are necessary when [Shaner et al, 1982: p. 19]:

> **"Farmers may not have adequate technical explanations of their problems nor know the range of opportunities for improving their conditions, but [that] learning more about farmers helps the researchers produce better technologies and extension workers promote FSR results more effectively."**

However, participatory techniques have proven very useful in allowing farmers to express themselves on a wide range of issues. In the extreme, the purposes of a participatory orientation could be simply to organize a voice for farmer concerns and to impact on political decisions. Another focused objective might be to establish nearly autonomous farmer groups that can be self-motivated and self-directed in problem-solving investigations, But, in practice, most participatory activities involve some balance, or a partnership, between researcher management and farmer say in the research dialogue,

The justification for shifting towards participatory techniques lies in the need to give farmers

or groups of farmers the freedom to conceptualize and express an accurate model of how their farming system works, Participants can synthesize and exploit a comprehensive farm model in terms of systems structures, processes, and farm objectives certainly more efficiently, and often more effectively, than can FSD teams who study the system from the outside,

When embarking on greater farmer participation, FSD can choose to invite farmers to manage or comanage all or only some stages of the research effort, These stages might include: descriptions of the system, diagnoses of constraints, designs of new options, pre-screening or other assessments of options, selections of options for actual testing, reporting assessments of options to FSD, and even taking charge of disseminating useful information to other farmers.

The role of FSD team members in participatory research usually is not reduced. In tact, it may require a greater awareness of issues (i.e., farmers sensitivities, social customs, and technical understanding) than in more researcher managed work. In participatory research, FSD members should search out ways to:

- **Facilitate the articulation of the participants' positions -- often consensus of a group.**
- **Present hypotheses for discussion or testing.**
- **Link discussions with information from secondary sources that is not being taken into consideration by the participants.**
- **Communicate findings to outside agents.**

- **Link findings to the larger agricultural research and development context.**
- **Bring outside decision makers (e.g., research, extension, development, and planning agencies) directly into the participatory process.**

The correct balance between participatory methods and farmer-based, researcher-managed methods must be determined by the FSD team based on what is appropriate for each activity. The choice should be for the method or combination of methods that will give the greatest problem-solving efficiency. The choices, especially when a large degree of uncertainty exists about the issues and about the types of responses that can be anticipated, might be arrived at through an iterative process in which FSD teams routinely re-evaluate the techniques in their work plan.

Farmer participation is discussed or implicit under a number of the specific methodology sections of this manual. Obviously, a strong participatory role occurs in informal survey work (Chapter 8) and more particularly for PRA in Section 8.4. A range of participation in trial management is discussed with emphasis on how this participation corresponds to the objectives of the trial (Sections 9.2 and 9.3). A participatory mode is greatest in FMFI trials (Section 9.8.5). Farmer groups (Section 9.8.6), listed under trial management methodology, are actually useful participatory forums to address essentially all stages of the research effort. Participatory evaluation objectives are discussed under Section 1().3.

Part II - Implementation of the farming systems development approach

This part furnishes a broad but systematic view on how to successfully set an FSD programme in place. The two chapters in this part deal with the following:

- **The steps involved in implementing FSD (Chapter 5).**
- **Operational issues involved in implementing FSD (Chapter 6).**

5. Operational steps

5.1 Objectives of the chapter

The objectives of this chapter are to:

- **Provide an outline of steps needed in FSD, This information will provide ideas on types of implementation methods, data, and analyses required,**
- **Evaluate the linkages between various steps.**

- **Describe the desired links between FSD team members and other 'actors' at different steps in the FSD process.**
- **Describe criteria that permit decisions on when a step can begin.**

5.2 Step involved in FSD

Although earlier FSD was conceptually broken down into stages (in Section 3,2), it is important to recognize that, in implementation, the boundaries between the stages can become quite blurred, especially because the FSD team may be working at different points on the continuum for different technologies. For example, the FSD team may still be in the design stage for a technology to address a particular problem but in the final level of testing with respect to a second technology, while continuing routine diagnostic work,

Before FSD can actually begin, sites for conducting research must be selected. Then the list of the steps involved in FSD should include:

- **Selection of target areas and sub-areas.**
- **Selection of research areas.**
- **Selection of villages.**
- **Selection of cooperators.**
- **Description and diagnostic-stage activities.**
- **Design-stage activities.**
- **Testing-stage activities.**

- **Dissemination-stage activities.**

Aspects relating to each of these steps are discussed in greater detail in the following sections. Some of the material on the steps builds on Zandstra [1985: pp. 168-172].

5.3 Selection of target areas

5.3.1 Scheduling of Tasks and Key Actors

The selection of target areas usually is completed before FSD team members have been assembled to begin organizing FSD work. Because FSD output should feed into long-term planning and development, it is best if a framework for planning national development is defined before the selection of target areas for FSD is made.

Generally, the selection of a target area for a FSD programme is made by national decision makers, usually in Ministries of Agriculture or their equivalent,

5.3.2 Details on the Selection of Target Areas

Two reasons often used for selecting specific target areas are:

- **To meet the needs of the people living there and/or**

- **To take advantage of the agricultural potential of the area.**

If conditions within the target area vary substantially, it can be subdivided on the basis of similar physical, biological, socio-economic, and farming systems characteristics.

Criteria considered in the selection depend on the purpose of establishing the FSD programme. This purpose may be to deal with a specific part of the country or specific agricultural problem, such as low productivity in rainfed agriculture, or to be an on-going segment of the national research organization, dedicated to on-farm research. Whatever the purpose of the farming systems effort, the criteria considered may include compatibility with national policy and priorities and/or may be based on physical limitations or problems, such as poor water availability and distribution, erodible slopes, flooding, or animal disease.

Answers to the following types of questions can help assist decision makers in selecting target areas:

- **Is the target area large and relatively similar in those environmental characteristics that have the most bearing on potential research results? If so, the FSD team can apply the research results broadly and meaningfully within the target area.**
- **Is the target area similar to other areas? If so, some of the technologies developed in the target area can be used in other areas.**
- **Does the area have the potential for rapid pay-off from FSD? Factors that often determine the potential are:**

- Physical and biological conditions,
- Markets and infrastructure,
- Available technology, and
- Farmers' willingness to accept innovation,

- Do the area's environmental conditions facilitate application of technologies developed elsewhere? If so, the time period for reaping returns from the FSD process could be shortened greatly,
- What are some of the cost factors? For example, is the target area now served by existing governmental programmes or private institutions? If so, cooperation with such programmes or institutions could enable the FSD team to accomplish more, reduce costs, and/or save time.

5.4 Selection of research areas

5.4.1 Scheduling of Tasks and Key Actors

After the target area has been chosen, a research area or areas within the target area will be identified. This selection is usually made by members of the FSD team as one of their first activities in the field, The selection process, however, will usually be improved through close consultation with government and non-government agents involved in agricultural development in the research area,

5.4.2 Details on Selecting Research Areas

The following factors can be important considerations in defining a research area(s):

- ***Representativeness of the Research Area*. This is usually the most important criterion for selection of a research area, It must be representative of the target area or sub-areas with respect to environmental conditions -- that is, physical, biological, and socio economic -- and the farming systems practiced,**
- ***Accessibility*. The ability to travel easily to all parts of the research area generally will enhance cooperation between the research team and farmers, allow for easy distribution of inputs and access to markets, and reduce the team's operating costs. However, with respect to this, it is important to take into account the types of issues raised in Section 5 .5 ,2,**
- ***Existence of a Nearby Agricultural Research Station*. Research areas located close to research stations generally have more cooperation between on-station and off-station researchers and can provide a more integrated approach to the overall research programme (i.e., enable the synergism between the reductionist and systems approach to be fully exploited -- see Section 3.5).**
- ***Cooperation of Farmer Contact Agencies and Leader Support*. Good working relationships with agencies operating directly with farmers, such as extension and development agencies, can increase the effectiveness of the FSD team. This is particularly important when such agencies must be relied upon to provide information,**

inputs, credit, etc. Help and support from formal and informal leaders at the national and local levels, can be critical to the success of the FSD programme,

In order to make an informed selection of a research area within a target area, a good deal of information must be available to the decision makers, Table 5,1 identifies many of the data categories necessary for research area selection. Many of these data can be collected by the FSD team from secondary sources, such as existing reports, aerial photographs, etc. Additional information can be obtained by spot visits in the proposed research areas and/or reconnaissance type surveys (see Section 8,4), The final decision about the research area often involves input from national, regional, district and local level government officials, as well as from the FSD team, Research area selection may take as little as two weeks when relevant data are readily available, or it may take six weeks or longer when several areas are being considered, secondary data are scarce, or there are other problems. I

TABLE 5.1: DATA CATEGORIES FOR RESEARCH AREA SELECTION

PHYSICAL ENVIRONMENT	
Climate	Rainfall, temperature, wind, sunny days
Soil	Physical, chemical, hydrological conditions
Topography	Slope, flood plain
Irrigation	Water source and quality, means and

	frequency of delivery, on-farm practices
BIOLOGICAL ENVIRONMENT	Weeds, insects, diseases, birds, rodents, crop yields
SOCIO-ECONOMIC ENVIRONMENT	
Resource availability	Land, labour, cash, type, and source of traction
Infrastructure	Supply of farm inputs, markets for farm outputs, transportation, governmental policy/support system
Market data	
Socio-cultural characteristics	Prices of farm inputs and commodities, traders
	Land tenure and inheritance systems, sexual division of labour in agriculture, religious beliefs concerning agriculture, openness to change
Political and economic structure	
	National regulations, community groups, patron client relationships, cooperatives
PRODUCTION SYSTEMS/LAND USE	Major crops and livestock, cropping patterns, livestock characteristics, management practices

5.5 Selection of villages

5.5.1 Scheduling of Tasks and Key Actors

As is the case for selection of the research area, village selection usually is made by the FSD team as part of beginning FSD work, Close consultation with, and advice from, senior agricultural officials in the region and other informed regional, district, and local officials in making this selection is preferable and even necessary, if information for making these selections are to be complete and verified during early periods of FSD work in an area. Decisions after the beginning phase of FSD to abandon work or initiate activities in new villages also should be made by the FSD team in consultation with appropriate advisors outside the team -- see discussion under Section 5.4.

5.5.2 Details on the Selection of Villages

An important point in selecting villages in which to concentrate FSD activities is to improve the efficiency of research resource use. This 'clustering' of research activities in a limited number of villages has become important as research resources have become more limiting, because it can often substantially reduce recurrent expenditure.

BOX 5.1: BIASES IN VILLAGE SELECTION

Obviously, it is important to be sensible and practical when selecting villages in which to concentrate efforts. However, Chambers [1986] in a challenging, but valid, critique concerning biases that impede outsiders' contact with rural poverty, notes that one of the six he discusses relates to the use of vehicles. This bias, which he calls spatial bias, involves the tendency for rural development practitioners to concentrate activities near urban areas, near tarmac, and close to roads. Obviously, such a strategy in village selection, if carried to the extreme, would seriously reduce the ability of outsiders to develop strategies appropriate to the whole rural population.

FSD teams generally will use several criteria in selecting villages within the research area. These may include factors considered in choosing the research area (Section 5.4). Some of the more important considerations are:

- ***Representativeness*. This is of primary importance because, if the villages selected for research are not representative of the target and research areas, technologies developed to be applicable to these villages may not be transferable to the larger research and target areas.**
- ***Logistical Considerations*. These considerations are particularly important. The number of villages to be selected for research activities may well be limited by the number of field staff who will be available to the farming systems team, the ease of access to the chosen villages, their proximity to one another, etc. Trade-offs may be necessary between the desirability of selecting certain villages for representativeness or other**

factors and the need to limit village numbers or locations because of resource constraints faced by the FSD team (see Box 5.1).

- *Characteristics of the Village*. In addition to being representative in physical, biological, and socio-economic senses, some other characteristics may be important, such as availability of markets, the presence of an extension agent, etc.
- *Other Factors*. Other factors may be considered in a particular village selection. For example, if several villages are to be selected, it may be desirable to select a 'traditional' village, a 'progressive, village, and a village that is in 'transition' because of its location on a main roadway (see Box 5.2), The team's assessment of local support, both by local officials and by farmers, also may be important.

BOX 5.2: POPULATION- AND MARKET-DRIVEN AREAS

The International Institute of Tropical Agriculture (IITA) in Nigeria recently commenced work in two benchmark study areas in the northern part of Nigeria. Three villages have been selected in each benchmark study area differing in certain characteristics such as accessibility. The benchmark study areas also were selected on the basis of significantly different criteria, one being deemed primarily as market driven and the other being characterized as being primarily population driven. Obviously, strategies for improving the productivity and sustainability of agriculture in the two areas are likely to differ because of differences in the exogenous factors (see Section 4.2), which influence the way in which the resources, such as land and labour, are used.

The selection of villages is based on much of the same data used to identify the research area (Table 5.1). This information is collected from secondary sources, from discussions with extension and other government officials, and by direct observation. Background information must be relatively recent to be of most value. information from extension personnel who have worked in the area for five or more years and from leaders (i.e., formal or informal) who have lived in the village for 1() years or more is usually most valuable, Team members should do at least a 'windscreen' survey of potential villages. More satisfactory results may be obtained from interviews with key community members and officials and possibly from a more formalized rapid reconnaissance survey. The assessment of local support can take place during these visits.

When the information is collected, the team is in a position to make a decision, If numerous villages are being considered, a matrix of each village's characteristics, according to key factors, can be constructed. For example, what is the average land holding in the village? This then can be ranked in relation to the mean for the target area. After all factors are ranked for each village, the rankings can be totalled and, based on the factors considered, the village with the lowest total is the most representative of the target area, This type of assessment of quantitative factors may be of assistance to the farming systems team in making village selection but must be modified in light of qualitative information available to them, The existence of already defined recommendation domains (see Sections 4.5 and 5.7,2) can greatly reduce the amount of effort necessary and implies that there is a good deal of existing (ex ante) knowledge of the area.

Once research village(s) have been selected, FSD activities obviously will tend to be concentrated in them, This is particularly true if the field staff are permanently stationed in the village, because housing, etc., may have been provided by the project, However, reasons sometimes arise for changing villages, These might include:

- **The discovery that the village is not representative, at least in certain key characteristics,**
- **Evidence that past research activities have changed the character of the farmers and the village, so the present research activities are not taking place in a 'typical, environment.**
- **A change in the mandate of the FSD team.**
- **A change in the resources available to the FSD team, requiring a corresponding change in team activities.**
- **Philosophical reasons such as the desire to provide exposure of the FSD to a larger number of farmers.**

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5.6 Selection of cooperators

5.6.1 Scheduling of Tasks and Key Actors

The final step in identifying individuals to be interviewed or individual fields for experimental purposes is the selection of participating farmers. This selection is made by FSD team members but often may be improved by consulting with local authorities, agents, etc. The importance of a team approach to this selection (i.e., interdisciplinary selection process) cannot be overemphasized.

Participating farmers need to be selected at the beginning of every season or at the start of any new research initiative. Whether these participating farmers or cooperators are part of a repeat core of collaborators in the village or are new selections is a question that each FSD team must resolve based on the needs of the research programme.

5.6.2 Details in the Selection of Cooperators

The cooperating unit may be a dwelling unit, a farming household, or specific members within a household. A representative farmer is one member of a group of farmers within a recommendation domain, having similar circumstances for which one can make more or less the same recommendations (see Section 4.5).

In selecting farmers to participate in formal interviews or in hosting trials, the FSD team may

use several criteria. As with the selection of research areas and research villages, the most important criterion for choosing farmers is their representativeness. The farmers selected must be as representative of the area's average farmer as possible, to allow for extensive use of the results. However, they also may be chosen to be representative of farmers in a particular recommendation domain or target group. In the latter situation, farmers with certain characteristics are preferred. These characteristics may be: the gender of the head of the household, a wealth factor (e.g., number of cattle owned), the type of draught used and whether the draught is owned, specific characteristics of the type of land farmed or animals owned, etc. These factors can be used to stratify a sample to ensure representation by both male and female heads of households, by wealthy and poor farmers, etc.

For certain types of work, problems can arise from using a farm household (i.e., a group of people eating from one pot (see Section 4.3) consisting of a unit composed of multiple dwelling units, with their own lands, and linked by extended family and/or other ties) as the research unit. The choice of an appropriate research unit may be an important consideration in selecting cooperating farmers. The dwelling unit may be more appropriate than an entire family compound, if members of the dwelling unit operate somewhat independently in their agricultural activities. This question is related closely to the one of intra-household division of labour and decision making (see Section 4,4.1), For some studies, the head of the household may not be the most appropriate cooperator, particularly if some other family member has responsibility for, and decision making power over, the particular activities of interest (Box 5.3).

BOX 5.3: THE APPROPRIATE COOPERATOR MAY NOT ALWAYS BE JUST THE HOUSEHOLD HEAD

Households may contain independent decision makers, thus complicating the issue as to whom attention should be focussed on with respect to different technologies, For example, in Senegal, fields under the control of households have traditionally been divided into common and individual fields. The common fields controlled by the household head provided food for all members of the family. Increasingly, because of stresses and strains in complex household units (i.e., traditionally composed of more than one nuclear unit -- husband, spouses and other dependents), an increasing proportion of fields is controlled by individuals, However, because of poorer access to labour and improved inputs -- which are usually channeled through the household head -- yields of crops are often lower on such fields than on the fields under the control of the household head, For example, with respect to groundnuts, Venema [1978] found that yields were lower on fields controlled by individuals (i.e. particularly when they were women) than on those controlled by the household head). He attributed this partly to lower labour inputs and poorer timeliness with respect to field operations (i.e., particularly dates of planting and first weeding),

Consequently, in such a situation, strategies for improving the productivity of groundnuts perhaps would need to be differentiated according to who controls the field, thus influencing the choice as to who is the most appropriate cooperator. Obviously' however, in the process of such selection, it is important to have the explicit support of the household head, if the

main cooperator becomes someone other than the household head himself/herself.

The interest, willingness, and ability of farmers to cooperate are also important selection criteria. Farmers may be interested and willing to cooperate, but they may not have the resources to participate, or they may face conflicts in the use of resources if they do participate. Also, the head of household may be willing to participate, but not some other members of the family who will face an adverse situation if the family participates in the FSD effort. Thus, FSD teams selecting farmer participants must make sure that all members of the household, who may be affected by the household's participation, are willing to cooperate.

Logistical considerations are also important in selecting trial or interview participants. To facilitate visiting participants, particularly at their fields, the FSD team may choose to select farmers from one or two geographical groupings of fields or select participants to reflect groupings or communities within the village. Farmers belong to communities within villages that are linked by family, social, and/or economic ties. Participants in such communities are often located in the same general geographic area within the village, and selecting several community members not only will reduce logistical problems, but can provide additional information on linkages between households for shared resources, work, consumption, etc.

Once the FSD team decides on the criteria for farmer selection that are most appropriate for their situation, they must contact the potential cooperators and make their choice of cooperators. Most farmers will be somewhat suspicious of, and curious about, researchers entering their village. Because of the complicated social structure of most small villages, it is

often important to identify village leaders and seek their support or approval. Village leaders who may provide necessary or helpful support include traditional leaders, such as the village headman, and community leaders (e.g., an influential school teacher). Gaining the support of such community leaders will often:

- **Reassure the farmers of the team's intentions, thereby reducing their suspicions and encouraging them to cooperate with the team.**
- **Help elicit meaningful answers from survey participants.**
- **Allow the team to check the accuracy of the interview data with the leaders.**

Suggestions of ways researchers can gain local leadership support include:

- **Explaining the project.**
- **Emphasizing that farmers, answers to surveys will be kept confidential.**
- **Stressing that no names or specific individual information will be given to other government agencies.**
- **Explaining how farmers will be selected.**
- **Keeping the leaders informed on the project's progress.**

Although it is important to obtain the support of the village leadership, it is also important that the FSD team itself has a high degree of autonomy to avoid such leadership having undue influence on the types and levels of activities undertaken, the farmers involved, etc.

Farmers to be surveyed or to host trials usually are selected from some kind of a list of farmers in the village. Devising such a list is often a challenge (see Sections 8.4.4 and 8.5.3).

Once an FSD team has selected a group of farmers to participate in a survey or to participate in an on-farm trials programme, there is a tendency to work with the same group over a period of years. This has both positive and negative effects. Working with the same farmers provides information over time, which is useful in identifying changes in the system. On the other hand, the farmers may become atypical of the average farmer in the area because of their contact with the FSD team. Thus, it may be important to change the group of cooperating farmers for some surveys (e.g., particularly single purpose surveys) and for some trial work. Whether a change in cooperators is necessary depends on the objectives of the trial or survey and numerous other factors, such as whether the farmers are still representative. It is also important to consider updating the list of farmers from which cooperators are chosen, either randomly or purposively, on a regular basis. This is particularly relevant it. the list is several years old and if substantial in- or out-migration has occurred in the village.

Finally, in selecting farmers for on-farm trials, it is important to match farmers with trials that suit their farming system in terms of resources, preferences, and management abilities. How well a farmer will carry through on a trial may depend on perceived benefits associated with the trial. Thus, the more appropriate the trial is to the farmer's circumstances, the better are the chances that it will be completed,

5.7 Descriptive/diagnostic

The objectives of the descriptive and diagnostic activities are to:

- **Develop a basic understanding of how the farming system is operating within the research area.**
- **Use this information to identify problem areas or areas of under-utilized potential that could benefit from change. These may differ for different farmers, therefore, requiring preliminary identification of recommendation domains.**

To put it more simply, in order to introduce change, it is first necessary to understand what farmers are doing, and why they are doing it in a particular way. Then, in the diagnostic activity this information can be used to identify areas within the farming system where improvements can be made.

5.7.1 Scheduling of Tasks and Key Actors

Descriptive and diagnostic research begins even during the study conducted to evaluate and select sites for research. FSD team members also will want to exploit all pertinent information already collected at the time FSD work is initiated. However, many formal descriptive and diagnostic studies will begin after research sites have been identified fully.

Descriptive and diagnostic research is never completed fully (Box 5.4). However, because FSD

work must proceed to subsequent stages of research (i.e., design and testing of technology) as rapidly as possible, formal descriptive and diagnostic research is likely to peak in the earliest phase of FSD work in an area, At a minimum, however, informal descriptive and diagnostic research continues to re-evaluate the hypotheses formulated before technologies are designed, Descriptive and diagnostic research also can be on-going for special subject areas even years after work was started.

In the classic model, FSD team members generally have written up descriptions and diagnosed priority constraints. Station-based or other visiting scientists have assisted with diagnostic activity in selected subject areas. Far too often, descriptive and diagnostic research has ended with narrow disciplinary oriented perspectives of constraints (Box 5,5). It is imperative that all disciplines, including farmers, collaborate to provide an integrated analysis at this stage (see Section 10,2). Increasingly, FSD teams are asking farmers to take a more proactive role in identifying constraints (e.g., see matrix scoring and ranking in Section 8,4.4) and potential solutions (see Section 5,8).

BOX 5.4: CONTINUOUS DESCRIPTIVE/DIAGNOSTIC WORK IS NECESSARY WHEN RAPID CHANGE IS OCCURRING

The first diagnostic-stage analyses of the Adaptive Research Planning Team in Western Province' Zambia (ARPT-WP) tended to be formal and deal with the local fanning system as though it were static and as though problems identified today would remain as such into the future [Kalonge and Lof, 1994]. This diagnostic approach failed to account for significant

evolutionary changes occurring in the economic, social, and political environment of the country and in the adaptive responses within farming to these changes

Zambia is implementing a structural adjustment policy to deal with its economic problems. One response of farmers to these changes is to diversify their mix of enterprises and move away from an emphasis on previously subsidized cash crops. Several specific changes are noted or predicted maize farmers face a sharp increase in fertilizer prices; rice growers face declining profit possibilities because of high transportation costs; and new opportunities are emerging for cassava production.

To address research needs in this changing environment, the ARPT-WP is developing an approach with emphasis on informal and or-going diagnostic procedures Explicit assessments using participatory rural appraisal (PRA) methods are incorporated into the routine activities of farm research groups (see Section 9 8 6) The purposes of this diagnosis are to monitor changes in the environmental circumstances of farmers and in household adaptations to these changes and to evaluate or forecast the impact of technological interventions in these changed circumstances. The aim is to be able to address issues for both the near and long term

5.7.2 Procedures for the Descriptive and Diagnostic Stage

These consist of the following:

- ***Analysis of the Research Area and Farming Systems*. Once the research area has been selected, the design methodology begins with an analysis of historic events, migration flows, customs of ethnic groups, population growth rates, and development trends that are necessary to arrive at an understanding of the factors that might stimulate or impede activities rerquired for the improvement of the production systems**
- ***Definition of Development Objectives in the Research Area*. One basic consideration is to determine how important the production system under study is within the area (e.g., how important is a sorghum-millet-cowpea food crop system with animal traction in the region?). Secondly, it is important to consider the reasons behind the particular form of the existing production system. Too often, the diagnostic phase provides information on the systems, form, without an understanding of why farmers do or do not utilize par ticular technologies, for example, why don't farmers use row planting, or produce fodder crops when these practices have been promoted extensively'? If one does not properly understand the current situation, solutions that are developed to help farmers overcome their problems/constraints are unlikely to be attractive/relevant to them.**
- ***Analysis of the Production System or Sub-System to be Modified*. This step generally includes three levels of analysis:**
    - **The first is to consider outside or exogenous factors that have an impact on the system. These often explain certain characteristics in the system, such as disease occurrence? genetic potential of livestock, etc.**
    - **The second is structural and refers to an inventory of land use, structures, and**

equipment.

- **The third focuses on the way the system functions and, thus, addresses the management of the production system and the interaction of the production system under consideration with other systems on- and off-farm, It is at this point that constraints to production and flexibility in the farming system are determined. Critically important in this exercise is obtaining the opinions of farmers themselves as to their problems (Box 5.5), In tact, farmers are often able to pinpoint problems that would take researchers a long time to discover. Simple qualitative modelling of the system also can be a potentially useful approach to help structure understanding of researchers at this point.**

Just to identify the problems or areas of potential improvement is not sufficient (Box 5.6). To help farmers solve a problem, a researcher would need to have a clear understanding of the source of the problem.

The information sought during the diagnostic activity usually involves collecting more details on specific questions that come out of the descriptive activity. These details most commonly need to be collected in the field. While examining problem areas in detail in the field, researchers also should try to assess how widespread and severe particular problems are among the target group. Questions like: how often the problem occurs over years, how many farmers it affects. does it have a severe impact on

production and incomes etc., need to be answered. This type of information is necessary for deciding what problems or opportunities are most important and for setting the priorities of the research programme. The issue of setting research priorities is discussed in more detail later (see Section 6.5.2).

- ***Preliminary Definition of Recommendation Domains*. At this stage, the team is interested in identifying a maximum percentage of the potential target population in a minimum number of stratifications, The stratification of domains usually starts with factors relating to the technical element such as climate and soil, but also includes factors relating to the socio-economic element such as farm size, family labour supply, distance to markets, control of traction, etc.**

BOX 5.5: DIAGNOSING AND RANKING OF PROBLEMS CAN BE BIASED

Busch et al [1983] in a survey of 1,400 American agricultural scientists discovered that the major determinant of why they concentrated on specific research projects was that they enjoyed doing them and that demands raised by clients ranked 13th!

Even if researchers do want to respond to clients' needs, the approach is often wrong, Box [1989: p. 61] reports a revealing incident as follows:

> **"When we had just met, Virgillo stood up and said: 'Lucas, I understand you want**

to know. You are a scientist and you want to know, But there is only one way to know what I know about cassava. Speak with me; don't speak to me like others did. Ask me about my life and I will tell you about cassava.' "

This lack of truly interactive communication combined with a degree of arrogance, often results in researchers diagnosing and ranking problems differently from farmers, and from each other when more than one discipline is represented, This is well illustrated by Hawkins [1994] based on work in China, Ghana, and Tanzania, Also, of course, women often are likely to rank problems differently from men, Inappropriate problem diagnosis and ranking are obviously undesirable, because the chances of 'irrelevant' research resulting are high.

BOX 5.6: DIAGNOSING THE PROBLEM IS NOT SUFFICIENT

Farmers in Southern Africa often do not plant in a timely manner, even though planting opportunities are scarce. It is not enough just to go to the farmers and tell them to plant in a more timely manner. It is first necessary to understand *why* they are not doing so. It may be because most of the farmers are sharing draught power, so that they work first on one field, then on the next. Or it may be that farmers do not have enough labour to look after the cattle and kraal them every night, so they let them wander in the bush. Consequently, when it rains, the farmers have to go and look for the cattle. So, to help farmers solve the problem of delayed planting, a researcher would need to have a clear understanding of the source of the problem.

5.8 Design

The design work involves proposing new technologies to address constraints or opportunities identified in the description and diagnostic work. Usually, the process involves the development of ideas and little field work.

5.8.1 Scheduling of Tasks and Key Actors

The design of new technology or interventions follows the identification of constraints and the prioritization of these constraints. An unfortunate and tar too frequent situation occurs when design focuses on ideas that interest particular researchers but are not justified based on identified constraints.

Because there is no simple formula for generating new technological solutions, creative input must be brought to bear in whatever manner possible. In FSD work to date? visiting scientists and cooperating colleagues from other agencies often have contributed ideas to FSD stall.. In many cases, in fact, it is beneficial to have subject matter experts who can best know what is on the shelf in order to make first-round suggestions to FSD team members.

Sometimes off-the-shelf proposals are not appropriate, given farmer circumstances and FSD researchers need to look elsewhere for creative input. Increasingly, forums are being developed within FSD work in which farmers can discuss options and suggest new ideas that

could be tested (e.g., see discussion on farmer group methodology under Section 9.8.6).

Experiences indicate that design should be done carefully but should not result in long delays in the FSD process. In most cases, many unknowns about new technological options can be determined in an appropriate manner during testing followed by an iterative test-redesign-test process in which the options are fine-tuned.

5.8.2 Procedures for the Design Stage

The steps involved at this stage are:

- ***Identification of Technical Interventions*. The research team should now be able to identify a number of practices or technologies that have the potential to increase productivity, through breaking the constraint itself or avoiding it through exploiting flexibility in the farming system. The solutions identified should be related closely to the production constraints previously identified and to specific recommendation domains. Those solutions are derived mainly from three sources (see Figure 3.1): farmers; experiment station research; and, only when necessary, RMRI trials on farmers' fields. In general, no actual field research is undertaken during the design stage. However, some field activity is required in that farmers, other researchers, and extension personnel need to be consulted for ideas on improved systems and equipment. The more ideas (i.e., potential solutions) that can be collected, the better.**

After gathering ideas on the priority topics, researchers and farmers need to work together to select the most promising ones for testing (Box 5.7). Researchers can use their scientific knowledge to select the theoretically best options and use the descriptive data to gauge which options are most likely to fit farmers' resources within the target areas. However, the farmers' judgement also will be Important in determining which systems are most practical and socially acceptable within the target area. Thus, the design activity should include farmers, input and interaction among scientists of different disciplines. Generally, this activity is quite informal among scientists, and informal discussion sessions with groups of farmers are good approaches for obtaining farmer input. Gathering a broad range of ideas during the design activities will increase the interest of all parties involved in the testing and will lead to a higher success rate among the technologies that are tested eventually.

Occasionally, it may be necessary to undertake a more formalized trial/survey activity before technologies can be designed for testing. However, these take time and should be undertaken only when absolutely necessary, because they delay implementation of the testing stage. The two types of more formalized activities that can arise are as follows:

- **Trials, usually done in an RMRI format, to determine cause-effect relationships about which there is some uncertainty. In this case, researchers need to improve their understanding, before they can suggest strategies for farmers to** test, which will overcome the constraints that have been identified or take advantage of the opportunities that exist through exploiting flexibility in the farming system.

- Surveys to quantify farmers' attitudes or preferences are needed to help in prioritizing what should be tested. This type of survey usually is needed to identify points to include, for example, in designing equipment to be developed in prototype form for testing.

- *Ex Ante Analysis of Potential Alternatives*. The design alternatives can be specified as a set of proposed changes in the existing production system. The ex ante (i.e., before the event) analysis seeks to evaluate the expected biological, economic, and social impacts of making these changes. The difficulty and risk associated with crop and livestock systems make this step of predicting the outcome of a change particularly important in order to reduce the chance of adverse effects on the farmers. The analysis will require information on resources and their costs. A partial budget (i.e., looking at the changes in costs and returns compared with the current situation -- see Section 10.5.2) can be constructed for each alternative to predict its economic viability. In addition, the impact of the proposed changes on the whole farm, particularly in terms of changes in farm labour demand, cash inputs, or specialized equipment, must be evaluated. The outcomes of the ex ante analysis can be compared with similar types of information about the existing system and with other potential production systems to determine the acceptable range of production outcomes and to see if the proposed changes are

feasible. In addition, changes in the levels of inputs and management components need to be evaluated.

- ***Listing of Assumptions and Requirements for the Potential Alternatives*. Once an alternative has been selected provisionally for field evaluation, it must be described in detail' specifying inputs required and assumptions concerning levels of management? institutional support, etc.**
- ***Identification of Applied Research Needs*. Information gaps that have been encountered in the design process. such as unspecified biological relationships, prediction of the performance of alternative management practices, or questions of farmer attitudes, should be listed. These then become the bases for a set of research priorities -- often undertaken in applied research -- and trials can be designed on-station and, if necessary. on-farm to provide the needed information.**

BOX 5.7: FARMER INVOLVEMENT FACILITATES RAPID UNDERSTANDING AND SOLUTION IDENTIFICATION

McCorkle [1986; 1989], amongst others, has been involved in a number of empirical studies that highlight, in the interest of efficiency, the need to:

- **Solicit local knowledge in obtaining a rapid understanding of the local production environment.**
- **Tap that knowledge in the process of identifying potential solutions to the problems that have been identified.**

She has also emphasized another advantage of using such knowledge which is that it is not only technical in nature but also is sociological. Knowledge of the latter can be particularly important in deriving locally relevant solutions.

In one paper, McCorkle [1989] gives two examples from her own experience (i.e., *striga* from Niger, and salty soils in Tunisia) where researchers could have saved a great deal of time and resources through consulting farmers at the appropriate time. In the same paper, with an example from Bolivia, she illustrates the need to complement farmers' knowledge with that of researchers. The Bolivian example involves livestock diseases. An earlier paper [McCorkle, 1986] developed the case for ethnoveterinary research and its potential value to livestock scientists.

5.9 Testing/implementation

Once the best ideas have been selected, they will need to be tested. The ultimate objective of FSD is to produce new technology options that will be used by farmers to increase their productivity and incomes. It is very important that researchers keep this objective in mind during the testing activities, because it determines the type of testing that is carried out.

5.9.1 Scheduling of Tasks and Key Actors

When moving from design to testing, care must be taken not to overextend the testing

programme. It is very easy to design more solutions than can be tested in a satisfactory manner.

FSD team members need to be certain that the experimental interventions can be implemented in a manner that will not cause undue risk to environment, farm operation, or community well being. Otherwise, there is usually little reason for delays at the design stage (see Section 5.8). Nonetheless, a firm basis is needed for interventions selected. In the case of divisible inputs (i.e., chemical fertilizers), the appropriate level(s) to test may be in doubt. Where 'best bet' information can be obtained from station-based research or other secondary information, this might be used and testing could begin, Otherwise, technical and economic trials, which are part of the design stage, may be required before proceeding to farmer testing.

Proceeding to farmer testing should be an interdisciplinary team decision. In farmer-implemented trials, particularly within a farmer group format, the decision to accept a new option for testing is really that of the farmers. This acceptance or rejection is part of the testing process.

Evaluation of test results is primarily the responsibility of the FSD interdisciplinary team and the collaborating farmers. The integrated analysis of these results needs to include an assessment of technical feasibility, economic viability, social acceptability, and above all a farmer view point.

The role of station-based researchers and other resource individuals from outside of FSD is often critical in order to complete these evaluations when FSD staff or the farmers lack a particular expertise ,

Evaluation of test results is followed by a decision on further on-farm research or complementary station research and perhaps proposals on necessary adjustment of the policy/support system, which collectively will hopefully eventually culminate in the release and dissemination of new technology recommendations.

BOX 5.8: TECHNOLOGIES MUST BE APPROPRIATE TO THE RESOURCES AND PRODUCTION ENVIRONMENT OF FARMERS

In the semi-arid areas of Southern Africa, it is well known that winter ploughing will help to increase crop grain yields. But farmers who use animal traction do not apply the system, because the soil is too hard for their animals to plough during winter, For them, the option is not practical.

Most farmers know that applying phosphate fertilizer will increase their crop yields. When fertilizer is given to them free, they are very happy to apply it, However, when they have to purchase it, they know that unless the rainfall is very good, the increase in grain yield will not be enough to pay for the fertilizer. So they do not buy it. In some years, it is not profitable.

5.9.2 Procedures for the Testing Stage

Steps involved at this stage include:

- ***Testing the Technologies*. New production systems must be examined from a number of different perspectives. First of all, the new options must be examined to see if they do, in fact, as a result of addressing the identified problem(s), increase farm production, make farm production more reliable and/or improve the output per unit of the most limiting input (i.e., profit ability). Additionally, because of the differences between research stations and farms, the new options must be shown to be effective under actual farmers, conditions, as well as on the research station. In fact, this is one of the reasons for on-farm testing -- of which there are a number of types involving different levels of farmer participation. But for farmers to use them, new options also must be practical, that is, technically feasible, profitable, and socially acceptable and must fit within the resources that farmers have available (see Box 5.8).**

  To try and ensure acceptability, representative farmers must be included not only in the initial design but also in testing activities. Farmer groups -- both research- and extension-oriented -- can be used to implement testing of technologies by farmers on their own (see Section 9.8.6). The opinions of these farmers need to be carefully considered, and, if necessary, the technology should be modified before it goes to the dissemination phase.

- ***Improving the Applicability and Acceptability of the Technology*. The first important point to make with reference to this topic is to emphasize that the results from the**

evaluation procedure determine whether a recommendation is made for extending the technology through the extension service. It is now accepted generally that both technical and formal socio-economic evaluation are important, although FSD workers increasingly advocate paying more attention to farmer assessment.

However in drawing up recommendations, it is important to bear in mind that there is a great deal of variation in the natural (i.e.' technical) environment that farmers face and in the socio-economic characteristics or resources they possess. In spite of this variation, standardized technological packages often are recommended. It is not altogether surprising that, where technological packages have been disseminated, many farmers have adopted components rather than the complete package. In such cases, often little advice is available on what farmers should do. For example, should they use top dressing of fertilizer when they don't weed? The return from the limited research resources can be improved by:

- **Incorporating *conditional clauses*, which state what to do under circumstances different from those originally envisioned in the recommendation. These deviations could be attributable to the farmer, weather conditions lack of availability of some of the technological components, etc. Included in the conditional clauses are possible variations, such as recommending a step-wise approach to the adoption of the different components of the package (i.e., a type of *technology ladder*) and suggesting a number of options for the farmer**

to pursue.

- ◦ **Including *targeting information* showing under what technical and socio-economic conditions the technology being recommended would be most applicable. For example, a particular technology may be most suitable for one soil type or for farmers with a specific resource base. For instance, as will be seen later (Section 10.8), in Botswna, double ploughing is most appropriate on soils that are reasonably deep and have a fairly high clay fraction, whereas the rotary injection planter is most suitable for farmers who do not have good control over draught power.**

Thus, in recognizing the diversity of farmers, FSD can help in developing targeted and conditional clauses for proposed improved technologies. In a sense, these guidelines indicate how greater numbers of farmers can more closely approach the optimal situation.

- ***Try to Ensure the Appropriate Policy/Support System is in Place*. Too often, technologies are not adopted because the policy/support system required is not in place or it is operating ineffectively. Many FSD workers used to believe that a 'submissive' approach should be taken with respect to policy/support system parameters, and that no effort should be made to influence their change. Obviously, this places major constraints on the types of relevant technologies that could be developed. Now fortunately, FSD workers increasingly believe that a more 'interventionist? approach should be taken**

with respect to the policy/support system. Technical and socio-economic information relating to trial results under farmer conditions can, and should be, used in influencing changes being made to the policy/support system to ensure that technologies have a better chance of being adopted. If this is the intention, then the sooner the potential support of those responsible for designing and implementing the policy/support system is obtained, the higher will be the chances of success. This potential support is obtained best at the design stage, whereas at the testing or, at the latest, the dissemination stage, the objective is simply to ensure that the appropriate policy/support system is put in place (see Box 5.9).

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5.10 Dissemination and impact

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Involvement by FSR (i.e., technology oriented) teams in the dissemination process traditionally has been very limited. This is because extension/development agency staff

obviously play the major role in such activities, The FSD approach, on the other hand, emphasises that the FSD team should play certain specialized roles to improve both the efficiency of the research process and the rate of return from the limited research resources,

The FSD team can support dissemination activities by monitoring rates of adoption and the impact of changes resulting from dissemination activities, which can help not only to justify future funding for agricultural development activities but also to provide ideas on future research priorities and, if necessary, indications on adjustments in the policy/support system that to facilitate greater adoption and/or more favourable impact,

5.10. 1 Scheduling Tasks and Key Actors for Dissemination Activities

Within FSD research areas, there may not be a decision to release a particular technology. However, farmers who have been exposed to the idea through trials work, farmer groups, or field days may choose to try to adopt on their own.

To move past the research area into the larger target area, usually the following two decisions are required:

- **The FSD team must have determined that using the technology provides a significant benefit in the recommendation domain indicated.**
- **A national or regional ministerial or equivalent level body usually would review test data and officially release the recommendation (see Section 10,7).**

Dissemination at this point usually involves a different set of actors with FSD playing more of a supportive role, Typically, the extension service takes the lead, with government agricultural policy makers playing a lesser or greater part in the effort, However, other government and nongovernment agencies and, not least of all, farmers from

BOX 5.9: POLICY/SUPPORT SYSTEMS SHOULD BE TREATED AS VARIABLES, NOT PARAMETERS

Upton and Dixon 11994] stress the importance of FSD in policy and programme analysis and the critical complementarily between development and dissemination of appropriate technologies and policy/support systems. They cite an FSD exercise in a maize-based system in Haiti [Martinez et al, 1991], in which significantly different responses to nitrogen were found from different types of fertilizer. Consequently, because of these findings, plus a number of demonstrations, it was possible to bring about a change in fertilizer marketing policy as a result of presenting the findings to the appropriate authorities. The state-sponsored agricultural input organization made the more effective type of fertilizer available to farmers. the research area can be involved in this process.

BOX 5.10: KEY TO INTERACTIVE LINKAGES IS COLLABORATIVE ACTIVITIES

In Botswana, for example, FSD teams have helped in training courses for extension/development agency staff and have helped extension/development agency staff train farmers in row planting via courses and competitions at agricultural shows, Row planting has been recommended officially for many years. These types of collaboration are

arranged easily when Regional Coordinating Committees are functioning (see Table 6.2).

5.10.2 Details on the Process of Dissemination

Steps involved at this stage include:

- ***Supporting the Dissemination Process*. Once technology options are released for dissemination, it is up to the farmers themselves to decide whether or not to adopt them. Extension/development agency staff have the major responsibility for informing and helping them in this process, If FSD teams are involved at all in the dissemination process, it should be purely in a supportive role, Some effort in this activity often can be justified in the interests of establishing good interactive linkages with extension/development agencies (see Box 5,10),**
- ***Assessing Impact and Adoption*. A distinction can be made between adoption studies per se and research impact-assessment studies that have enjoyed increased popularity as of late. The latter are cost/benefit studies that measure the internal rate of return to money invested in research efforts compared with the benefits of that research (i.e., both the level of adoption and benefits to producers who adopt).**

  With reference to adoption studies, the increasing need for FSD teams to incorporate a monitoring/feedback activity has been mentioned earlier (see Section

3.7) and an introductory discussion on the methodology for adoption studies is presented later {see Section 10.9). Points to note with reference to adoption studies are:

- **Adoption studies, which are still relatively uncommon, have another important unexploited dimension. Assessment of reasons for non-adoption and/or adoption in unanticipated ways provides a potentially fertile area for feeding back relevant research priorities to researchers and information to help those responsible for the policy/support systems. With reference to the latter, such information can involve marketing (i.e., both inputs and output), credit, and extension data, which can indicate how to modify policy/support systems in a way that will improve farmer adoption.**
- **FSD is often in an ideal position to assess impact of research efforts generally. Because of the sunk costs already incurred in developing and disseminating specific technologies, implementing adoption studies (i.e., preferably with the support or active collaboration of extension/development staff) can yield substantial returns with relatively little additional investment, thereby improving the impact of on-farm research.**

With reference to the internal rate of return to research, specific points to note include:

- **The issue of the cost effectiveness of research is an important concern of many**

decision makers. Related to this is an increasing need for accountability in the use of the limited resources available for agricultural research, This alone provides sufficient justification for the implementation of technology adoption studies.

- **However, in this type of impact-assessment study, several factors (i.e., research and non-research) need to be considered, including all research inputs used in developing the technology including both station-based and on-farm components, policy issues that may pose a constraint on adoption and yet affect the impact of research assessment, and the effectiveness of the information delivery system (i.e., extension programme).**
- **In this type of assessment, FSD is likely to be only a collaborator along with station-based researchers, possibly extension staff, and agricultural policy makers.**

6. Operational issues

6.1 Objectives of the chapter

The objectives of this chapter are to look at some general issues in Implementing FSD. These

include:

- **Interdisciplinary cooperation.**
- **Establishing FSD linkages with other 'actors, in the agricultural development process.**
- **Issues relating to leverage and handling constraints.**
- **Issues relating to limited research resources, including assessing the level of understanding required and setting priorities.**

6.2 Interdisciplinary cooperation

What factors are important in creating conditions that will encourage an interdisciplinary approach'? Obviously, an important necessary, but not a sufficient, condition is the presence of representatives on the FSD team of more than one discipline -- preferably both technical and social. Although the choice of disciplines represented on FSD teams should be influenced by factors such as the major enterprises in the farming system and the major problems/constraints that are to be addressed (i.e., sometimes related to the mandate of the institution in which the team is located), in fact, more practical constraints such as research resource limitation or staff availability are often the major determinants. Most FSD teams consist of crop-oriented scientists (i.e., particularly agronomists) and agricultural economists. Disciplines sometimes, but not always represented, are animal science and sociology. Representation from other disciplines is often obtained on a part-time basis, as and when

required, from thematic researchers.

Multidisciplinary teams obviously enable a multidisciplinary approach (i.e., individuals of different disciplines working independently on the same or different research topics) to be used but they do not, without further action, ensure that an interdisciplinary approach (i.e., individuals of different discipline working together on the same research topic) is adopted. The preconditions for an interdisciplinary approach to work rely heavily on personal characteristics of the team members. The team members must have compatible personalities, have confidence in using the analytical tools of their own disciplines together with a healthy respect for the role of other disciplines, and be willing and able to be team players. Above all, they need to be able to listen, understand, and accept other viewpoints and be prepared, when appropriate, to modify their own views. Finally, whoever the team leader is, it is important that he/she tries to exploit the strong aspects of the team members' personalities and minimize the negative impact of the weak aspects that everyone possesses. On balance, competence and personality rather than a specific discipline? are more important in the selection of a suitable team leader.

It is important to emphasize at this point that, unless these personal characteristics are present, interdisciplinary cooperation will not be possible. The following organizational and activity considerations simply help to create a more formalized structure that will nurture and support interdisciplinary work.

The keys to operating effectively in an interdisciplinary mode are:

- **Ensuring good communication between the team members.**
- **Assuming joint responsibility in planning, implementation, analysis, writing, and disseminating the results of the research programme.**
- **Making sure that recognition for work done is distributed equitably,**

With reference to the second point, this does not mean that everyone should contribute equally in all individual activities, but rather, in terms of the overall effort, everyone should play his or her part, Obviously, the roles and skills of specific disciplines and individuals should be taken into account in the apportioning process, For example, the agronomist is likely to take major responsibility for RMRI work, whereas the agricultural economist plays a much more visible role in FMFI type work. Also, one team member may have special administrative or analytical talents that can be exploited constructively for the benefit of the team as a whole.

Strategies that have been found to be important in team building and encouraging interdisciplinary cooperation include the following:

- **Holding regular team meetings, both formal and informal, to discuss both administrative and professional matters. Outside representation is sometimes useful in helping the team think through issues, in providing specific expertise, and in encouraging the development of linkages.**
- **Equitable sharing of administrative responsibilities. This is particularly relevant in cases where teams are very small and having a specific team leader may be of little advantage.**

- **Careful coordination of the planning, implementation and evaluation of the various items in the work programme. Because most items in the work programme are likely to involve more than one discipline, attention to the following points can be very important:**

    - **The work plan that is developed should result not only from discussions between the team members but from interaction with the extension- and development-oriented personnel in the region, station-based researchers, and, of course, farmers.**
    - **Well before the agricultural cycle starts, the following should be written down and agreed to: the objectives; a justification for doing the work: and the approach to be used for each proposed trial, survey, or study, in the work programme. The justification might include a description of how this activity fits into the stages of development of the technology.**
    - **At this stage, someone should be designated to take primary responsibility for the trial, survey, or study.**
    - **Additionally at this time, any special materials for the proposed trial, survey, or study should be obtained; any necessary support from farmers should be enlisted; and agreement should be reached on the data collection procedure and forms that are to be used and on the possible analytical framework for evaluating the results.**
    - **Finally, at this stage, responsibilities for different activities with reference to**

the specific trial, survey, or study should be apportioned. Some of these activities or responsibilities will be done jointly. A protocol for the list of activities, the name of the person responsible for supervising them, and the expected dates of completion should be drawn up for each trial, survey, or study in the work programme. Such a list is desirable to facilitate communication and to help ensure successful implementation of the work programme. This can be supplemented during the implementation stage by a checklist indicating, by farmer for each trial, the dates on which the various activities were undertaken.

- Analysis and writing up should be done in a timely manner and joint authorship of papers encouraged,
- After approval by the relevant authorities, the results of the work should be distributed in a timely manner to interested institutions and individuals.

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6.3 Linkages

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Obviously, as already emphasized, FSD teams themselves do not have all the expertise necessary to undertake FSD work. Thus, FSD is very dependent upon contributions by people outside the teams. At least three groups of people have important roles to play in helping to plan, implement, evaluate, and use the results of FSD work. As mentioned earlier (see Section 2.4), in addition to the obvious ones, farmers, these are station-based researchers, extension/development staff, and planners.

Although these linkages are important, the relative contribution that each linkage will make depends on the stage in the FSD process. In Figure 6.1, the relative contributions at each research stage are indicated schematically. However, it should be borne in mind that a number of research activities generally are occurring at the same time, some of which are likely to be at different stages in the research process. Therefore, linkages are likely to be Important all the time.

Figure 6.1: Contributions of various "actors" at different stages in the FSD process

A key principle behind any linkage activity is to be sure at the outset that all parties:

- **See the benefits of specific activities.**
- **Benefit from, and receive credit from such activities,**
- **Make some commitment in terms of approval, effort, and/or resources to ensure that**

they take place.

With reference to the last point, commitment or cooperation can be thought of at three levels, namely.

- The minimal degree of cooperation required would be consultation and 'approval, of activities that may be of interest to, or have an impact on, other 'actors, before their implementation.
- The next level would be to get the other interested parties to provide resources to help defray expenses of activities that have linkage connotations.
- Obviously, the most desirable commitment would be for direct collaboration for staff on both sides of a linkage each to devote staff time to common activities.

Therefore, in nurturing linkages, it is important to observe the above points, Even the first one is better than nothing. Obtaining, the blessing of other potentially interested parties before undertaking activities has proven to be far superior in terms of winning acceptance of the results rather than discussing them only after their completion, The latter approach often results in a 'them versus us' stance, which does not engender an attitude of mutual help, cooperation, and collaboration. Thus, the above principles are important in ensuring the development of mutually beneficial interactive linkages -- the focus of the next three sections.

6.3.1 Links to On-Station Research

Earlier discussion indicated the complementarily between FSD and station-based research (Section 2.3). Mention also was made that collaboration between the two groups was likely to result in two approaches to FSD, that is FSD 'with a pre-determined focus' and FSD 'in the small, (Section 3.3). Obviously, collaborative activities represent the most intensive form of interaction. This is the most desirable form, because it eliminates the division between the two groups, thereby minimizing the probability of miscommunication and improving the chances that the results will be accepted by all concerned (see Box 6.1). However, as can be seen in Table 6.1, there are various degrees of collaboration. Also, there is some potential overlap between the various activities. For example, participation in the research programme team meetings can result in visits by station-based research scientists to the field to see plots, address farmer groups about specific technologies, and cooperate in joint trials.

6.3.2 Extension/Development Linkages

The value of the interaction between FSD workers and extension/development staff can be summarized as follows:

- **Extension/development staff possess substantial knowledge about the area where they are posted and know many of the farmers personally, This local knowledge is invaluable to FSD teams in their diagnostic, design, and testing work.**
- **FSD workers interact with small numbers of farmers -- hopefully representative of a much larger number of farmers -- whereas extension staff have a mandate to work with all farmers. In a sense, the extension service provides a conduit for FSD teams to reach**

farmers as a whole. Therefore, interaction between FSD teams and extension/development staff can help provide a multiplier effect for FSD work, can assist in providing extension/development staff with relevant messages to disseminate, and can help extension staff in developing appropriate methods and systems for disseminating technologies to farmers.

TABLE 6.1: POSSIBLE TYPES OF COOPERATION BETWEEN EXPERIMENT STATION-BASED RESEARCH TEAMS AND FSD WORKERS

NATURE OF COOPERATION	**DEGREE OF COMMITMENT**	
	STATION	**FSD**
A. Mainly Communication:		
Circulating papers on work programme and results to interested parties	Low	Low
Research programme team meetings	Some	Some
B. Visits:		
By station-based researchers to farmers' fields, to farmer groups, to give advice in identifying and solving problems, etc. -- usually at the invitation of FSD workers	Some	Low

By FSD workers to station-based researchers	Low	Some
C. Collaborative work:		
Surveys undertaken by FSD researchers to address specific issues raised by station-based researchers -- sometimes latter help in design, implementation, etc.	Some	Much
Farmers evaluation of technologies station-based researchers are interested in (e.g., crop varieties, implements, etc.)	Some	Much
RMRI trials undertaken on experiment station to address issues raised by farmers, FSD workers and extension staff	Much	Low
Joint responsibility for designing, implementing and evaluating on farm trials by FSD and station-based researchers	Much	Much

BOX 6.1: COLLABORATIVE ACTIVITIES BETWEEN STATION-BASED AND FSD RESEARCHERS ARE PREFERABLE

A technological package for cotton was tested in Northern Nigeria and proved to be unsuitable, because it involved substantial labour inputs at a time of the year when farmers wished to concentrate on their food crops, However' there was immediate acceptance of this

preference by the station based cotton researchers, who collaborated with FSD staff in testing the cotton package with the farmers. As a result, attention focussed on developing a cotton technology package that fitted in better with the farmer priorities (i.e., could involve planting later to avoid the labour bottleneck for food crops) and eliminating the need of large amounts of water for spraying with the help of ultra low-volume sprayers [Beeden et al, 1976; Norman et al, 1974 and 19751.

Thus, extension staff can make constructive contributions at all stages of the FSD process, although, as indicated in Figure 6. 1, the relative level of contribution will vary.

FSD teams usually are located in research institutions that are separated from institutions responsible for extension/development. In spite of control being exerted 'vertically' in most institutions, some 'horizontal' linkages usually can be developed, as indicated in Table 6.2. The activities involved once again imply various levels of commitment and can result in promoting further collaborative efforts. Once again, there is considerable potential for the overlapping of activities. For example, consultation activities may lead to collaborative activities, whereas FSD participation on a supportive basis in dissemination-type activities may lead to new items for the research agenda.

6.3.3 Support Systems and Policy Linkages

As indicated earlier (Section 2.4), important factors influencing whether the productivity and the welfare of farmers will improve are the policies that shape the economic environment in

which they operate. Many policies influence production decisions by farmers. The influence of these may be direct or indirect. For example:

- **A policy decision to distribute sorghum seed but not cowpea or groundnut seed through the government distribution system directly influences farmer decisions.**
- **Most policies indirectly influence farmer behaviour through their effects on input prices (e.g., through subsidies) or product prices (e.g., through marketing boards).**

Obviously, such policies not only influence the farmers, but can also have an impact on what constitutes relevant agricultural research. FSD programmes can provide information to the policy makers that may be used to create new policies to enable farmers to adopt relevant improved technologies (see Box 5.9).

TABLE 6.2: POSSIBLE TYPES OF COOPERATION BETWEEN EXTENSION STAFF AND FSD TEAMS[a]

	COMMITMENT LEVEL	
NATURE OF COOPERATION	**EXTENSION**	**FSD STAFF**
A. Consultation:		
Regional Coordination Committees involving discussion of work programme -- proposals and results -- with regional extension staff and other interested parties in	Low	Some

the region (e.g., development agency staff, NGOs etc.)		
Attendance, when desirable, by FSD staff at regional extension meetings and district monthly management meetings	Much	Low
B. Visits:		
Local extension staff help in organizing village meetings to present proposals and results of FSD work programmes	Some	Some
By senior extension staff to trials undertaken by FSD teams	Low	Some
Attendance by extension staff at farmer field days - sometimes help in organization	Low	Some
C. Work Programme Collaboration:		
Assignment of locally stationed extension staff to the PSI) teams to help in implementing all the activities of the FSD teams	Much	Some
Joint planning, implementation, and evaluation of trials (e.g., national tillage trials)	Much	Much
D. Dissemination		
Participation by FSD staff in in-service training courses	Much	Some

forextension staff		
Supportive role by FSD staff in organizing competitions at agricultural shows to encourage adoption of improved technologies	Much	Some
Supportive role by FSD staff in extension-oriented farmer groups	Much	Some
Supportive role by FSD staff in helping extension staff in 'hands-on' training of farmers to adopt improved technologies	Much	Some

a Non-Government Organizations (e.g., development trusts cooperatives. etc.).

For example:

- **On-farm trials may demonstrate the potential pay-off to a particular input that is not currently available. This information can be fed to the policy makers to convince them to make that input available.**
- **Information obtained from on-farm work with farmers can identify possible discrepancies between stated policy goals and policy implementation -- thereby alerting the policy makers to the changes that are required.**

In general, however, linkages of FS teams with those responsible for both developing and

implementing policy/support systems still remain poorly developed (Box 6.2). Both linkages deserve and need greater emphasis at two levels: regional and central (see Section 3.6).

6.3.4 A Case Study: Institutionalization of FSD Activities in Botswana

The FS approach has become institutionalized within the NARS in many countries throughout the world. Although FS activities have had a long history in Botswana, institutionalization has occurred fairly recently (i.e., late 1980's). For illustrative purposes, the institutional set-up in Botswana is described, where it is still called FSR. However, to be consistent with the terminology in the rest of the manual the term FSD is used in the following discussion.

For many years in Botswana, FSD activities were donor financed and largely donor controlled. With institutionalization of the FSD approach, three significant changes took place:

- **All the FSD teams were placed under the Department for Agricultural Research.?**
- **Greater domestic responsibility for funding FSD activities made control by the Director of Agricultural Research easier to exert.**
- **FSD-related activities developed much closer relationships with the other 'actors in the agricultural development process, especially with the station-based researchers.**

BOX 6.2: INCREASING REALIZATION OF VALUE Of LINKAGES BETWEEN RESEARCHERS AND PLANNERS

Although very rarely formalized, linkages between FSD researchers and planners appear to be evolving. For example, in Tanzania, meetings between planners and FSD economists have been organized; in Botswana, FSD teams have been asked by planners to help in evaluating development programmes; and in Bangladesh and Kenya, recommendations have been made in development projects for linkages to be strengthened between researchers and those involved in input distribution and product marketing.

With reference to the last point, the current administrative arrangements are as follows:

- **The top level administration in the department consists of the Director of Agricultural Research, Chief Arable Research Officer (CARO), and the Chief Animal Production Research Officer (CAPRO). The office of the director provides direct scientific and administrative leadership to the overall research programme and helps in defining its objectives. Thus, the office is also responsible and accountable for decisions relating to overall strategy, research policy, and resource allocation with respect to research.**
- **The second level of the administrative structure occurs at the programme level, At the national level, there are a number of Programme Committees that are headed by Programme Leaders. Such Programme Committees exist under the offices of both the CAPRO and the CARO. For example, the CARD's office includes six programmes, namely:**
    - **Cereals Crop Improvement Programme.**
    - **Oil Seed and Small Grain Improvement Programme.**
    - **Soil/Water Management and Agricultural Engineering Programme.**

- **Horticulture Crop Improvement Programme.**
- **Grain Legume Crop Improvement Programme.**
- **Production Systems Programme.**

The programme activities are directed by Programme Committees, to which the Programme Leaders are accountable, The functions of these Programme Committees are to:

- **Evaluate research proposals in terms of their potential practicability and relevance in addressing a specific need and compatibility with the overall research programme.**
- **Monitor and evaluate on-going projects and make decisions relating to priorities, continuation, and/or phasing out.**

- **In the Botswana context, the Production Systems Programme (PSP) constitutes the FSD thrust. Currently, four regional teams with Regional FSD Team Leaders are in place and are located in different agro-ecological zones. The Programme Committee for the PSP is composed of the National Programme Leader, who is the chairman, and the Regional FSD Team Leaders together with other senior scientists within the PSP.**

  Although the regional FSD type teams operate somewhat independently of each other, all have functions in common, namely:

- **On-farm testing with farmers of new technologies developed by other programmes or from on-farm research activities,**
- **Feeding back information from on-farm testing, farmer opinions and needs, and possible research priorities to station-based researchers in other programmes.**

- **In addition to developing interactive linkages with on-station researchers, being responsible for developing interactive linkages with development-oriented staff and agencies operating in their own region (e.g., extension, NGO's, cooperatives, etc.).**

The National Programme Leader of the PSP provides a vital interactive linkage between the Regional FSD teams and the station-based programmes. In support of this, the National Programme Leader of the PSP and the Programme Committee of the PSP play critical roles in terms of disseminating information, helping decide on the appropriate research priorities and methodologies, and apportioning the research resources available to the PSP.

Given the special requirements of FSD type work and the fact that staff relating to activities under the PSP are geographically very widely dispersed, the National Programme Leader of the PSP has two other major responsibilities, namely:

- **Ensuring that staff at both the junior and senior level are trained adequately.**

Field assistants usually are trained in situ at in-service training courses, whereas appropriate short and long term training opportunities are sought for technical staff [Modiakgotla et al, 1991].

- Ensuring that staff have adequate access to scientific information. Libraries are usually not available in areas where the regional teams operate. Thus, the National Programme Leader maintains a list on all the literature available and circulates this list to all staff members who select material they want. Selected material then is photocopied and sent to them.

The Regional FSD Team Leaders, as indicated above, are responsible not only for the on-farm research programme in their areas but also for liaison with development-related activities in their areas. There are two formalized mechanisms for facilitating this.

- Regional Coordination Committees (RCCs) (Table 6.2) have been established, chaired by the Regional Agricultural Officer (i.e., the most senior extension staff in the region), to provide a formalized means for efficient interaction not only between research and extension but also with marketing board personnel, NGO's and Cooperatives operating in the area. Because all agricultural research and development-oriented staff interact with farmers, there is considerable merit, whenever possible, for coordinating activities. This helps in ensuring that there is consistency in the information provided to farmers and avoiding duplication of effort. The composition of the committee is determined by the agencies that prevail within each region and are interested in agricultural development. At these meetings, the Regional FSD Team Leader presents the results from the last year and provides a workplan for the next year, for comment and discussion. These meetings also provide a forum for discussing regional agricultural development problems and for seeking practical solutions. In conclusion, the RCCs provide a useful conduit in ensuring a coordinated approach for implementing government initiatives at the regional level.

- The District Development Committee (DDC), chaired by the District Officer, is not confined to agricultural matters but is concerned with all developmental issues in the area. Consequently, in addition to members from Agriculture, there are representatives from Water Affairs, Health, Labour Affairs, Community Development, etc.

Finally, the Regional FSD Team Leader also is invested with a high degree of accountability for research resource allocation and utilization, He or she is also accountable for obtaining results for the region and for effective monitoring and feedback,

Although the above administrative setup does have considerable merit and operates reasonably well, there are also obvious problems. These basically stem from the appropriate

split between coordination and control from the centre or from the periphery. Three problems that are by no means unique to Botswana are as follows:

- **Programme Leaders do not have complete control over their own budgets.**
- **Programme Leaders do not have total control over staff in their programmes, because staff members within programmes can be transferred unilaterally between programmes.**
- **Because the contact person on FSD issues is the Director of Agricultural Research, all incoming requests still need to go through him, thus often delaying action.**

In spite of some problems relating to the current administrative setup, which are inevitable in any NARS, it is a significant improvement over the situation in the late 1980's in terms of accountability and constructive interaction.

6.4 Leverage and handling constraints

The two approaches of FSD mentioned earlier (i.e., FSD with a 'pre-determined focus' or FSD 'in the small' in Section 3,3) have different implications for the degree of leverage obtained in the system and for the problem of breaking constraints versus exploiting flexibility in the system, This section briefly examines these topics.

6.4.1 Leverage

FSD workers obviously are interested in maximizing improvements in the productivity of the farming systems being implemented by farmers, which hopefully will lead to improvements in their welfare. To accomplish this, it is important to identify the parts of the farming system where adoption of a change can have the greatest positive impact on productivity. In such a situation, potential leverage on the farming system is maximized.

***High leverage interventions* involve introducing changes in an operation or enterprise in a part of a farming system that is a major absorber of farm resources and/or where the timing of those resources is restricted. All other things being equal, the adoption of technologies that improve the productivity of such resources is likely to maximize improvement in the productivity of the farming system as a whole. *Low leverage interventions*, on the other hand, may not have a major impact on the productivity of the farming system as a whole, but may help in improving the productivity of a particular enterprise, Such interventions involve less change and are sometimes likely to be more acceptable to farmers (Box 6.3).**

One issue relating to this is whether to focus research on a pre-determined commodity (i.e., FSD 'with a predetermined focus,) rather than on the whole farming system or on the crop subsystem (i.e., FSD 'in the small') (see Section 3.3).

When research is undertaken in which the pre-determined enterprise in question is a major absorber of farm resources, then that enterprise usually will offer the best leverage on such system-problems as deficient income, excessive risk, and seasonal variability in the use of farmer owned resources. In fact, this approach with a small ratio of variables to parameters

is methodologically much easier to undertake than one in which the ratio of variables to parameters is much larger. Geographically based FSD teams have the responsibility for looking at all crop and livestock enterprises in the system. Usually, the most leverage can be obtained with the major crop or livestock enterprises. However, this still is a complex situation when viewing the relationships between the various enterprises. Certainly, focusing on the broader farming system is advisable when there appears to be little scope for improvement by focusing solely on the farmer's major enterprise .

BOX 6.3: LOW-LEVERAGE INTERVENTIONS CAN HELP ADDRESS INTRAHOUSEHOLD INEQUITIES

Women are often responsible in many African countries for minor crops (i.e., often for home consumption purposes) and own small amounts of livestock (i.e., particularly chicken, goats and sheep). Helping women to improve the productivity of these socalled 'minor enterprises' can help improve their well-being and their position in the household, although the impact on the household as a whole may be limited.

6.4.2 Breaking Constraints or Exploiting Flexibility

There are two possible ways of dealing with an identified constraint: break the constraint or avoid the constraint by exploiting the flexibility in the farming system. For example, in a situation where sorghum is affected by a particular disease, numerous strategies could be applied to deal with the problem. The constraint may perhaps be broken by applying a seed dressing (i.e., requiring an input distribution system); breeding a disease-resistant sorghum

(i.e., a long-term strategy requiring an input distribution system); or exploiting the flexibility in the farming system by planting the sorghum at a sub-optimal time, in terms of yield potential, to reduce or eliminate the disease attack. The decision on which approach to use in dealing with the constraint will depend on its severity, the flexibility of the existing farming system, and the availability of potential Improved strategies that break the constraints or exploit the flexibility. Breaking a constraint is a much more difficult problem, for both researchers and farmers, than the strategy of exploiting flexibility. However, major long-term increases in productivity have to come through breaking constraints. This must be a step-by-step approach moving away from the present system towards a new one -- each step being one that is acceptable and absorbable by farmers.

In fact, if one looks at the success of FSD to date, it generally has been most successful in more equable climates than exist in Botswana -- which is given as an example in Box 6.4. Examining the relative success of FSD in equable environments shows that much of it can be attributed to exploitation of flexibility in the farming system -- often requiring only minor changes on the part of the farmer -- rather than breaking constraints, Technologies involving exploiting flexibility in the farming system thus are more likely to be adopted spontaneously and are less likely to require strong policy/support systems and rigorous farmer training programmes to encourage their adoption (Table 6.3). Thus, effective interactive linkages between research and those responsible for designing and implementing policy/support systems are critically important in creating conditions conducive to agricultural development, particularly in harsh climatic areas,

TABLE 6.3: HYPOTHESIZED SIGNIFICANCE OF POLICY/SUPPORT SYSTEMS

CLIMATE	ROUTE TO IMPROVEMENT	NATURE OF NECESSARY CHANGE	SIGNIFICANCE OF SUPPORT SYSTEM	POTENTIAL TYPE OF ADOPTION
Drier	Mainly break constraints	Lumpy inputs/major changes	Very critical	More induced
Wetter	Break constraints or exploit flexibilitya	Divisible inputs/can be minor changes	Important but less critical	More spontaneons

a. Most success in FSD to date has been achieved in wetter areas through exploiting flexibility in the farming system.

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6.5 Research resource considerations

Maximizing the return from the limited resources available for research must always be a major consideration. Two areas that are important in ensuring that research resources are allocated in an optimal manner are considering very careful the level of understanding that is required -greater accuracy often requires more research resources - and ensuring that the research priorities selected are the correct ones. These two topics are considered in a little more detail in the following sections.

6.5.1 Degree of Understanding Required

At first glance? it seems that going through all the steps described above could take a great deal of time. This is likely to be the case, if an effort is made to collect at first hand large amounts of accurate quantitative-type data. However, this is not always necessary and, therefore, is not desirable. After all, collecting descriptive information is not an end in itself but is used to provide an input into designing and testing work,

BOX 6.4: BOTH HIGH AND LOW LEVERAGE ACTIVITIES CAN BE USEFUL

In Botswana, FSD teams have worked with both high- and low-leverage interventions. For example, a good deal of the work done in collaboration with the commodity researchers on the experiment station has a low leverage characteristic -- particularly in the case of an enterprise that is not a major component in the farming system. However, adoption of the

proposed changes can help improve the productivity of that enterprise, in particular, and possibly have some impact on the farming system as a whole. This occurs if the enterprise concerned uses a significant proportion of the resources involved in implementing the farming system as a whole.

FSD teams in Botswana have been willing to support work with low-leverage characteristics because of the difficulty, in this harsh climatic environment, of developing interventions with a high leverage characteristic that will be adopted readily by farmers. The difficult environmental conditions provide little flexibility in the farming system, because a key management factor is the ability of farmers to plough and plant when they are likely to optimize the use of water available for plant growth and maximize efficiency of water use. Therefore, researchers are faced with the challenge of trying to develop relevant technologies to break a major constraint, rather than having the easier task of developing technologies that will avoid the constraint by exploiting the flexibility that exists within the farming system.

Under the harsh climatic conditions of Botswana, major emphasis has had to be on developing technologies that break constraints. Adoption of such technologies by farmers involves major changes in their farming systems. For example, much of the FSD work has concentrated on changing the ploughing-planting operation to improve water availability. However, strategies to improve water availability to the plant at planting time require more draught than the traditional strategy of broadcasting the seed and ploughing it in.

Therefore, in summary, a good deal of the FSD work done in Botswana 'with a pre-determined focus, tends to have a low-leverage characteristic, whereas FSD work 'in the small' tends to have a high leverage characteristic. Unfortunately, it involves interventions that have to break the major constraint of limited water availability, rather than being able to exploit the little flexibility that generally exists in Botswana farming systems.

In deciding what quantitative-type data to collect, guidelines such as the following can be used:

- **As much use as possible has been made of existing secondary information.**
- **Very careful consideration is given to just how accurate descriptive information needs to be in order to provide an adequate guide or input into the designing and testing stages of FSD. Emphasis is placed on collecting the required information in the cheapest possible way, with a method that allows attainment of the degree of accuracy that is required. Examples of cheap methods are those that emphasize qualitative rather than quantitative type of data and relative ranking of data rather than actual accurate measurement (i.e., ordinal rather than cardinal). Also, greater interaction with, and participation by, the farmer at all stages of the FSD process can provide many short-cuts in the research process,**
- **Informal interdisciplinary surveys are used whenever possible to collect information required to fulfil the point above that cannot be obtained from secondary sources, The major respondents for this information are the farmers themselves, If necessary, these**

findings are supplemented or confirmed with a formal one-time survey that can be analyzed quickly (see Section 7,2).

- Bearing in mind the three preceding points, the amount of time taken in doing the initial descriptive/diagnostic work is minimized so that design and testing activities are started at the earliest possible opportunity.
- Descriptive/diagnostic activities to verify the initial quick descriptive/diagnostic work, if necessary, are undertaken at the same time as the initial testing stage, These descriptive/diagnostic activities can be in the form of more formal surveys and studies such as monitoring fields, etc. In fact, results arising out of design and testing activities can help in refining future descriptive/diagnostic activities. This is an example of the iterative nature of FSD work,

6.5.2 Setting Priorities

During the descriptive and diagnostic work, it is likely that farmers will articulate, and researchers will observe, more problems in the farming system than can possibly be addressed, Researchers' time and resources often are limited, so they must consider carefully how much work can be done and restrict the number of activities undertaken, Setting research priorities is a complex process and will be influenced somewhat by information and analysis arising out of the steps that were outlined in Sections 5,7 and 5,8, Four general factors that are important in influencing the setting of the research priorities are as follows:

- Farmers' objectives have a direct effect on the types of technology that they will adopt.

If researchers and farmers have different objectives, a good deal of research work may end up being wasted. Therefore, it is very important, to try and find solutions to the problems farmers feel are most important. They are likely to result in technologies that have high-leverage characteristics,

- **Other clients for FSD teams are station-based researchers who play a major role in providing a 'bank' of potentially useful technologies that can be considered in the design stage and used in the testing stage. Although the farmer remains the major client for FSD work, FSD teams can help in developing a more useful 'bank' of technologies by responding to on-station researcher requests to test specific potential technologies on farmers' fields. Some of these are likely to have low-leverage characteristics.**
- **To benefit from the interdisciplinary nature of FSD, research priorities must be set by the whole team, and not just by discipline (see earlier discussion in Section 5.7,1). For example, if descriptive and diagnostic activities indicate that labour is the most limiting factor in the system, then the agronomist should give priority to this and work with the economist to develop labour-saving technologies or increase the return per unit of labour used during the labour-constrained periods, rather than addressing some other topic that may be only an agronomic issue, such as rice variety yield trials. Any rice varieties selected for testing should be based on the preferences of the farming households and take into account the resources (e.g., money, labour) that farmers have at their disposal.**
- **The mandate and the location of the research will have an influence on setting research priorities. For example, a team may be responsible for increasing crop production among**

limited-resource farmers working in a particular area. Thus, the team usually starts out with some target areas and specified objectives.

Other important issues to consider when setting priorities for research include the following:

- How common is the problem within the research area, and how many families does it affect? Higher priority should be given to problems that affect most families.
- How severe is the problem and how much does it affect the productivity of the system? For example, head smut in sorghum may occur in all fields throughout a region, but the actual reduction in grain yield may be very small. Higher priority should be given to problems that have the most severe effects on farm production.
- If there is major concern about addressing intra-household relationships via the technological route, considerations mentioned under the two previous points may need to be modified. For example, helping improve the position of women within the household may involve low-leverage types of interventions that will not necessarily greatly improve the welfare of households as a whole.
- What is the potential for solving the problem? It may not be appropriate for an FSD team to tackle a problem like bird control, even though all parties recognize it as a problem. FSD teams generally should give priority to problems they feel they have some chance of solving and try to feed back problems they can't solve to other groups that have a better chance of identifying a solution (e.g., station-based researchers).
- If solutions to problems are likely to result in technologies that require new, or changes

in existing, policy/support systems, then it is important to ascertain the potential attitude and responsiveness from those responsible for developing/implementing such systems. There is little object in undertaking such research if there is no hope of any changes. An analogous idea applies to research that is likely to have a long gestation period (e.g., much livestock research). It would be important' for example, in pert-urban dairy research to know the priorities of government in supporting such systems both now and in the future.

- **Are there areas of opportunity for increasing farm production that are being under utilized at present? For example, could certain types of fruit trees planted around the home compound provide useful income? Not all improvements come from solving problems. Some may come from starting new and profitable activities.**

Part III - Methodology for the farming systems development approach

Descriptions and 'how to' guides for a number of data collection and analytical methods are presented in this part. The four chapters in this part, which contain information for both technical and socio-economic scientists, are devoted to:

- **An overview of the data collection methods used in FSD (Chapter 7).**

- **A discussion of survey methods and their implementation in FSD (Chapter 8).**
- **A review of trial methods and their implementation in FSD (Chapter 9).**
- **An introduction to analytical and evaluation techniques used in FSD (Chapter 10).**

7. Data collection methods

7.1 Objectives of chapter

The objectives of this chapter are to:

- **Briefly outline and evaluate the different methods of data collection.**
- **Indicate the major methods of data collection desirable at each stage of the FSD process.**

7.2 Common data collection methods

Obviously, both technical and socio-economic data are needed in the development of relevant improved technologies for farmers. For example, the time spent on ploughing a field is dependent on the type of draught used and the number of hours per day that it is used. However, ploughing time also is determined by a number of technical factors, such as

moisture in the soil and the soil type. Unfortunately, data collected and analysis undertaken often reflect only socio-economic or technical data. Looking at only one aspect does not represent the whole picture. Collecting both types of data is not always possible, but the limitations of collecting only one type should be recognized.

The most common methods of collecting data in FSD work are the following:

- **Surveys (interviews and questionnaires).**
- **Observation.**
- **Direct measurement.**

Surveys, which involve interviewing, include many different types. One possible schematic breakdown, although not perfect in that it would probably not be universally accepted, is given in Figure 7.1. It is important to note that usually, in formal (i.e., structured) surveys, only one respondent is interviewed at a time, whereas in informal (i.e., unstructured) surveys, respondents may be interviewed individually' or quite often, as a group. Direct observation, because of its expense, has tended to be used sparingly in FSD work and, when utilized, has tended to be undertaken in conjunction with other methods. Direct measurement activities often are associated with monitoring and trial activities (see Section 8.6).

Figure 7.1: Types of surveys (interviews)

A number of factors influence what method or methods of data collection are used. Some of these are:

- **The discipline of the researcher(s) and the objective of the specific research. For example, historically in FSD-type work, social scientists have tended to concentrate on surveys, economists have relied more heavily of formal surveys, and sociologist/anthropologists have emphasized more informal surveying and direct observation methods. In contrast, the major thrust of technical scientists has been, and continues to be, direct measurement. Attitudinal information is collected, for example, by informal survey methods, whereas technical information concerning performance of technologies requires the implementation of trials.**
- ***Quality and quantity of research resources available*.Limited financial resources obviously limit the use of direct measurement and formal surveys involving multiple visits. At the same time, the skills involved in undertaking informal surveys may inhibit their widespread use.**
- ***Time available to undertake the study*. Surveys, particularly informal, are clearly less time-intensive than activities involving direct measurement,**
- ***Whether the type of farming system on which the study is to be undertaken is complex or simple* (e.g., year-round versus seasonal farming, mixtures versus sole stands of crops, etc.). It is difficult to make categorical statements on the relative ranking of the data collection methods, although assuming all other things to be equal, direct measurement and observation are likely to yield the most accurate results in more complex systems.**

- ***How important it is to reduce sampling error*. Basically this means that a sample chosen from a population does not perfectly represent the population. For a number of reasons, sampling error tends to be a problem in much FSD work (e.g., because of imperfect sampling frames, use of small samples, etc). Unfortunately, the likelihood exists in FSD that sampling error, which generally means larger samples, increases the possibility of larger measurement errors.**
- ***How important it is to reduce measurement error*. This relates to mistakes in the enumeration and analysis of data. The type of data being collected determines whether a high or low potential exists for measurement errors. This is illustrated in Figure 7.2. There are two continua:**

    - **The '*single point*' to '*continuous*' continuum (i.e., relating to an event or activity that occurs over a brief time span, as against one that has much longer duration).**
    - **'*Registered*' to '*non-registered*' continuum (i.e., relating to an event whose occurrence and dimensions leave a written record or distinct and vivid recollection as against one less likely to be recorded or remembered).**

    Usually, measurement errors are lower with single-point registered data (i.e., when memory recall would be good) and higher with continuous non-registered data (i.e., when memory recall would be bad).

It is possible to subjectively evaluate the methods of data collection in terms of the above

factors. In Table 7.1 the significance of each factor or operational constraint with respect to each method is given a ranking of I to 6, with '1' indicating a very favourable ranking and '6' indicating a very unfavourable ranking.

TABLE 7.1: EVALUATION OF DATA COLLECTION METHODS IN TERMS OF OPERATIONAL CONSTRAINTS[a]

	STRATEGIES				
CONSTRAINTS	INFORMAL SURVEY	FORMAL SURVEY		OBSERVATION	DIRECT MEASURE-MENT
		ONE/FEW VISITS	MANY VISITS		
Finances	1	2	3	6	6
Staff skills	6	3	3	6	5
Time required	1	1	5	6	6
Type of system:					
Simple	1	2	1	1	1
Complex	5	5	2	1	1

Errors:					
Sampling	6c	1b	3b	5c	5c
Measurement:					
SPRDd	3	3	1	1	3
CNRDe	6	6	2	1	1

Source: Modified from Kearl [1976].

a. Evaluation of data collection strategies in terms of cost per unit with respect to various operations (1=lowest cost per unit, 6 = highest).
b. Evaluated in terms of ability to reduce sampling error.
c. Evaluated in terms of ability to specify sampling error.
d. Single-point registered data.
e. Continuous non-registered data

Because of different disciplinary needs, as well as needs to mesh together the use of limited research resources, a strategy consisting of a combination of methods normally is used. The results in Table 7.1 show that no one method of data collection is basically superior in minimizing operational constraints.

As indicated earlier, careful thinking is required about how accurately the data must be collected (Section 6.5.1). Keep in mind that the costs (e.g., financial and time) associated with a data collection method should be comparable to the type of information sought. For example, multiple-visit surveys for quantifying actual seasonal labour flows are expensive and require a good deal of time. A rough estimate based on a much cheaper and quicker, oneshot survey, in fact, may be sufficient for the purpose required. It is important to consider whether a more accurate measurement would improve the understanding enough to justify giving up other opportunities, such as working with more farming families, As indicated earlier, depending on the type of data being collected, measurement errors are reduced with more frequent interviewing techniques, whereas sampling errors are reduced by involving larger numbers of farmers. Because, in FSD work, research resources are invariably limited, a trade-off between these two errors is necessary.

Related to the above, and to efficiency, is the idea that cheaper, qualitative type data sometimes may provide sufficient understanding rather than expensive, quantitative type data. Qualitative information can include not only attitudinal information, but information on the relative labour requirements of different operations, etc. Limiting quantification to key characteristics reduces the cost involved in collecting data,

Surveys involving interviews are used a great deal in FSD, Figure 7.1 illustrates the different types. The most suitable type of interview will depend on circumstances. In general greater emphasis now is being placed on informal surveys to get the necessary information in a quick

and efficient manner. All surveys, no matter how they are undertaken, need to be designed to facilitate quick processing so as to simplify the transfer of data to computerbased systems.

Structured interviews, using schedules with pre-coded, closed-ended questions (see Section 8.5), are potentially more efficient in this regard and should be used whenever possible, especially il.:

- **The researchers themselves are not conducting the interviews.**
- **The enumerators are not particularly well-qualified.**
- **Comparative analysis, such as cross tabulation, etc., is to be undertaken.**
- **Statistical analysis is required.**

7.3 Major data collection methods by FSD stage

Table 7.2 is an attempt to indicate the major data collection methods now considered by most FSD practitioners to be best at each FSD stage. Once again, there is a degree of personal subjectivity about the degree of importance attached to each method in each stage of FSD. Indeed, some of the weighting reflects what is considered to be desirable rather than what is currently done. As examples, multiple-visit formal surveys used to be very important in the descriptive/diagnostic stage, and a one-visit formal survey still is considered to be important by some practitioners in the same stage. Also impact/adoption studies still are not undertaken in the dissemination stage to the extent that would be desirable. Therefore, it is

important to note that changes have occurred in priorities given to different methods over the years. Reasons for this relate to evolution in methodology and increasing concern with maximizing the return from limited research resources. Related to the latter have been three considerations, namely:

- **Not aiming for near perfect understanding and great accuracy but doing enough to get the job done. Attainment of such goals would involve considerable expense.**
- **Moving through the different stages of FSD as quickly and efficiently as possible. Obviously, this helps in improving the return from limited research resources.**
- **Development of better technologies but not necessarily the perfect solutions to problems. All farmers are different in some respect, and the perfect solution, or near perfect solution, is an impossible goal idealistically and practically in terms of the limited resources available for research.**

TABLE 7.2: CURRENTLY USED DATA COLLECTION METHODS BY FSD STAGE[a]

APPROACH	DESCRIPTIVE/ DIAGNOSTIC	DESIGN	TESTING	DISSEMINATION
Secondary information	1	1		2
Talk with knowledgeable people	1	1	2	2

Data collection method:				
Informal surveys	1	3	2	2
Formal surveys:				
One/few visits	2		3	1
Multiple visits	5		5	
Observation	3			3
Direct measurement	5	4	1	4

a. Those efforts not involving primary data collection are separated out in the table. Also within each stage, a subjective evaluation is given of the importance of each method with 1 indicating most important. A value of 5 indicates that it is generally undesirable and should be undertaken only in extreme situations. Values between 1 and 5 reflect the gradient between important/desirable and unimportant/undesirable. Cells with no entry reflect little or no reliance on that method/approach.

8. Survey methods (indirect measurements)

8.1 Objectives

The major form of data collection through indirect measurement is via surveys. Therefore, this chapter concentrates on surveys, The objectives of the chapter are to:

- **Provide guidelines on eliciting the cooperation of the respondent,**
- **Describe different types of informal and formal surveys.**
- **Discuss some of the issues relevant to the implementation of informal and formal surveys.**

8.2 Obtaining farmer cooperation

Without doubt, in order to benefit from any type of collaboration with farmers, it is important to develop a good relationship with them, The initial approach to the farmer and the relationship that develops over time, are critical elements in creating an environment conducive to collaboration, Two points are important in developing a good relationship:

- **When working in the village for the first time, the objectives of the survey, work programme, and the proposed approach should be explained to, and approval for undertaking the survey should be obtained from, the village leadership. If desired by the leadership, a presentation can be made at a village meeting. Such meetings provide an opportunity to obtain general information about the village, institutions, etc.**
- **It is important to respect the customs of the village. Related to the issue of respect is the need for a collegiate or partnership type of relationship to develop between the FSD**

workers and farmers. So often, because of differences in educational levels, a paternalistic or master/servant type of relationship develops.

There are a number of tips on executing interviews in a way that will maximize the interaction between the farmers and team members and the value of information that is obtained. Four stages in the interviewing process are [Rhoades, 1982]:

- ***Approach*. Keep a low profile; interview when it is convenient for the farming family; whenever possible, conduct the interview at the farm,**
- ***Warm-Up*. Use a polite form of address; if necessary, make appointments to discuss the survey; take time to approach the survey topics (i.e., be prepared to talk on other topics of interest to the farmer); if desirable, indicate you are there to learn and he/she is the expert,**
- ***Dialogue*. Be natural and relaxed; let the discussion flow and be flexible with the ordering of the questions; use plain understandable language and terms farmers can relate to; make sure the questions take into account the cultural setting, avoid sensitive questions at first, and, if possible, obtain such information through indirect questioning; if the farmer can't answer a question, try rephrasing it; don't ask questions that are too abstract; observe the farmer's reactions to questions, because these may reveal a great deal about his/her concerns or reservations; remember that what people say and do may be different; record the information in writing during the interview only if the farmer does not appear to be inhibited or suspicious; don't let the interview last more**

than 30 to 45 minutes unless the farmer is talkative, etc.

- *Departure*. Bring the conversation to an end when the topics have been discussed or the farmer can spare no more time, thank the farmer for his/her time, and depart respectfully.

8.3 Formal (structured) and informal (unstructured) surveys compared

Surveys are obviously very useful and efficient means of collecting data. Table 8.1 presents, in general terms, some of the distinguishing characteristics of the two major types of surveys, namely informal (unstructured) surveys and formal (structured) surveys. These characteristics highlight the different uses and means of implementing them.

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8.4 Informal surveys: features, types and uses

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8.4.1 Common Features

All informal surveys have five important features or distinguishing characteristics, which are illustrated in Table 8.1 :

- **There is direct FSD worker-farmer interaction because the interviews are conducted by the FSD workers themselves, with FSD workers learning directly from farmers. Existing information and direct observation are also important sources of information in an informal survey. Special efforts are made to meet those (e.g., women, poorer people' more isolated people, etc.) who otherwise tend to be missed.**
- **Interviews basically are unstructured and semi-directed. As a result, learning is rapid and progressive with a flexible use of methods to explore relevant issues as they arise with Improvisation, iteration, and probing. Questionnaires are not used, although FSD workers often use topic guidelines to make sure all relevant topics, on a given subject, are covered. Written notes sometimes are taken during the interviews, but the emphasis is on dialogue and questioning to obtain information.**
- **The data collection process is dynamic and iterative, because FSD workers evaluate the data collected and reformulate data needs on a regular basis (i.e., often daily). More than one method or source of information often is used to cross check and confirm data and to improve approximations. Also, efforts are made not to find out more than is required and not to make, because of expense, inappropriately precise measurements.**
- **The interviews often are conducted by an interdisciplinary team with each discipline**

contributing to the identification of problems and identifying and evaluating potential and actual solutions. These take into account factors influencing both the technical and human environment within which farmers operate (see Section 4.2).

- **Informal surveys don't permit statistical analysis, because they are undertaken without a formal sampling procedure, do not involve obtaining responses to a standard set of. questions, etc.**

TABLE 8.1 : COMPARING GENERAL CHARACTERISTICS OF FORMAL AND INFORMAL SURVEYS

CHARACTERISTIC	INFORMAL	FORMAL
Background information required	Minimal	Substantial
Time allocation by researchers:		
Preparation	Less	More
Implementation	More	Less
Analysis/writing	Less	More
Total time	Less	More
Hypotheses: Required beforehand	Not essential	Essential
Created during	Yes	No
Likely discipline interaction	More likely	Less likely

Implementation:		
Questionnaire used?	No	Yes
Interviewers	FSD worker(s)	Mainly enumerators
Potential for creativity/literation	Maximum	Minimal
Potential for learning/verification	Mainly learning	Mainly verification
Potential for representative sample	Le likely	More likely
Potential quality of information:		
Attitudinal	Better	Poorer
Qualitative	Better	Poorer
Quantitative	Poorer	Better
Probability of high: Sampling errors	Higher	Lower
Measurement errors	No difference	No difference
Value of statistical techniques in analysis	Little	Great

In FSD, informal surveys have developed as a result of:

- **Increasing realization by scientists that a relationship with the farmer based on treating her/him as a person with whom one could interact constructively was much more fruitful than one based on treating her/him as a object from whom one collected data to be analyzed independently.**
- **The increasing need by scientists to become acquainted with, and learn from, farmers.**
- **The need to find a method for rapidly obtaining technical and socio-economic information to help researchers in developing relevant improved technologies,**
- **The need to identify a cost-effective survey procedure.**

There is no question that the popularity and use of informal surveys will continue to grow in the future. However, at least four critical factors will be important in determining whether this approach will be successful or not.

- ***Human Resources*. Informal surveys will give reliable findings only if the interdisciplinary team of researchers/FSD workers is familiar with the techniques; possess interviewing, observational, and analytical skills; and can work well together in the field.**
- ***Flexibility in Decision Making*. Informal surveys can provide timely information for improved understanding throughout the research process. However, benefits from these inputs will be achieved only if the FSD programme can be structured in a flexible enough manner to permit, and react to, the input of new information as specific FSD activities proceed. FSD certainly should be able to respond in this manner, but on station research is likely to be less flexible,**

- ***Intended Use of Information*. Informal surveys are particularly appropriate whenever open-ended learning is needed or desired, but will not be appropriate when data are required over a long period of time or when more precise and statistically reliable data are needed from a large number of units. However, informal surveys can be used to better design and complement/supplement other data collection methods.**
- ***Intended Audience*. The results of informal surveys, because of their lack of statistical validity and heavy reliance on attitudinal/qualitative information, are inherently unlikely to hold much appeal to those used to relying on, and working with, quantitative data and statistical techniques (e.g., station-based scientists, planners, etc.). However, one way of often reducing such scepticism is to elicit the support of such individuals before undertaking such surveys and, if possible, persuade them to participate directly in their implementation as one of the interdisciplinary team members, Under such circumstances, they not only have an opportunity to make a contribution in theta. own right but also have a vested interest in the results, which, consequently, are likely to be more acceptable.**

8.4.2 Types: General

In recent years, there has been an methodological explosion in terms of how to undertake informal surveys. Very simplistically, these new survey methods can be classified into two mayor groups:

- ***Rapid Rural Appraisal (RRA) Surveys*, which sometimes are called a variety of other** names including sondeos, rapid reconnaissance surveys, and/or exploratory surveys. These often are undertaken with individual respondents, although a number of respondents occasionally might be interviewed at the same time.

- *Participatory Rural Appraisal (PRA) Techniques*. such as mapping, seasonal diagramming, matrix ranking and scoring, etc. These usually are done with groups of respondents.

In considering the two types of informal surveys, a number of points can be made' for example:

- The philosophy, approaches, and methods of RRA began to develop into a coherent and identifiable form in the late 1970's, whereas most of the PRA techniques developed later.
- RRA often is considered extractive in the sense that outside professionals go to rural areas, obtain information, and then take it away to process and analyze. PRA, on the other hand, is participatory in the sense that its role is more to facilitate the collection, presentation, and analysis by the farmers themselves.
- RRA and PRA have a number of features in common such as those indicated above (see Section 8,4.1). However PRA has a number of features that have not been prominent in RRA including:
    - Getting the farmers themselves to do the investigation, analysis, and presentation, with the outsiders simply playing a facilitating role.

- **Outsiders emphasizing self-critical awareness (i.e., examining their behaviour) so that they play a truly facilitative rather than interventionist role, including that of relaxing and not rushing the farmers.**
- **Outsiders using their own best judgement at all times rather than relying on a manual or a rigid set of rules, and learning to welcome any errors as an opportunity to do better.**
- **Greater sharing of information among farmers and between farmers and outsiders,**

- **Although RRA and PRA differ in approach, the distinction is becoming increasingly blurred, because much of the methodology is shared. However, in this manual, RRA is distinguished from PRA in the sense that they are considered as semi- structured interviews. This often has been viewed as the 'basic foundation, of good RRA. It means having a mental or written checklist but is open-ended in approach, allowing following up on unanticipated issues and/or responses.**

8.4.3 RRA: Uses and Implementation

Over the years, properly executed RRA surveys have proved to be low-cost ways of obtaining information and opinions from farmers; of tapping the indigenous knowledge and wisdom that exists on agricultural matters; and of developing a rapid understanding of farmers' circumstances, practices and problems,

A large body of literature is becoming available on the techniques of RRA. A particularly useful overview is given in Khon Kaen L 1987]. Three organizations that regularly produce information and results from the application of RRA are the International Institute for Environment and Development (IIED) in the UK; the Forest, Trees and People (FTP) Network organized jointly by the Community Forestry Unit in FAO and the International Development Research Centre (lDRC), SUAS in Sweden; and the Information Centre for Low External Input Agriculture (ILEIA) in the Netherlands. CIMMYT was one of the earliest CGIAR institutions responsible for demonstrating the value of informal or RRA surveys in FSD activities, while the Institute of Development Studies (IDS) at the University of Sussex, UK, also played an important role in advocating RRA during the early days..

BOX 8.1: RRA IS USEFUL IN SELECTING REPRESENTATIVE RESEARCH AREAS

In Botswana, such surveys were extremely useful in initiating activities of two of the FSD teams. There was concern about the potentially high logistical costs of interviewing farmers spread over large areas. Therefore, RRA-type surveys were undertaken in the two areas to ascertain whether the needs of different types of farmers in each area could be captured by confining the bulk of the teams' activities to working with a cross-section of farmers in three villages in each region. It was concluded that the variation in the farming systems within the selected villages -- which had different characteristics, such as size, settlement patterns, accessibility to the urban area, etc. -was as great as the variation throughout the region as a whole. Thus, research efforts could be concentrated geographically.

RRA-type surveys can serve five main functions in FSD-type work:

- ***The Feasibility Survey*. RRA surveys can be useful in planning a project in a region, particularly in cases where relatively little is known such as obtaining an understanding of the target area and in selecting the research area (see Sections 5.3 and 5.4) (Box 8.1).**
- ***Reconnaissance Surveys to Prepare Formal Surveys*. The objective of these surveys is to quickly obtain basic information for designing and executing formal surveys or more in-depth investigations that may lead to on-farm experimentation. Such surveys help in developing an understanding of the area and can help ensure that the formal questionnaire is designed in a manner understandable (e.g., in terms, standards of measurement used, etc.) and relevant to farmers' circumstances and sensitive to local issues, etc. Such formal surveys, as follow ups to informal surveys, are firmly entrenched in the methodologies of some institutions. See, for example the so-called formal verification surveys advocated by CIMMYT [Byerlee et al, 1980]. However, questions are now being asked whether in an era of increasingly limited research resources, this is really necessary, because it often simply verifies what is already known .**
- ***Informal Surveys for the Direct Planning of On-Farm Trials*. The formal survey stage is skipped and on-farm experiments are undertaken on the basis of an informal survey, which identifies problems that need to be addressed. For example, FSD work in the ploughing/planting area may evolve out of the informal surveys supplemented later with data derived from studies and formal surveys.**
- ***Informal Group Interviews on Selecting, Monitoring, and Evaluating On-Farm Trials*.**

Conventionally, much of the literature emphasizes the use of RRA techniques in the planning stages of FSD work. However, such techniques also have been used in the monitoring and evaluation of on-farm trials, particularly those at the FMFl level. Research-oriented farmer groups provide a particularly good forum for such interaction (see Section 9.8.6).

- ***Assessing Impact and Adoption*. The recent increased emphasis on looking at the impact of research resources in terms of success and problems of adoption provides another potential role for RRA type surveys. As yet, this has been done rarely, but it could provide a quick and cost efficient way of feeding back issues to station-based researchers and to planners. Such surveys also could provide valuable insights in the design of more formal surveys addressing adoption.**

A number of decisions and actions must be undertaken in implementing RRA type surveys. Important points to consider are:

- **The major objectives of the survey need to be determined. These should be finalized after taking into account the needs and inputs of the relevant authorities and interested parties (e.g., FSD, extension/development and station-based personnel).**
- **The size and composition of the survey team needs to be decided. Usually, the size of the team should be determined by the objectives or focus of the survey. The more complex the objectives and the more complex the technical and human environment (see Section 4.2), the more desirable a larger team would be. In general, both technical**

and social scientists and, whenever possible, both men and women, should be included in teams. It is also desirable to include women on the teams to ensure that gender issues are taken into account. Also in some societies, it may be imperative to have women on the team to interview women in the survey area, Inclusion of extension/development and station-based personnel sometimes can be useful both in terms of the potential contribution they can make and the professional benefits they can receive as a result of interaction between disciplines and with farmers,

- **Background information relating to the objectives and area to be surveyed need to be assembled and digested, Such information can be obtained from: reviewing secondary data -- both published and unpublished -- acquiring maps, and interviewing key informants, These are knowledgeable personnel such as local government officials, leaders, extension, and development staff who have good background information relating to the objectives and the area to be studied, The amount of time required for obtaining and digesting background information will be minimal, if the FSD team is already working in the area,**
- **If it is the team's first time to work in the area, then approval to undertake the survey must be obtained from the appropriate authorities, This often means obtaining the support of regional and district agricultural officials and leaders in the villages.**
- **It is desirable to produce interviewing guidelines, These can be divided into two groups: content and process.**

    - ***Content*. These are topical lists to help interviewers address topics and aspects**

of a topic that they might otherwise omit, The list should arise out of a consensus among team members and should consider the objectives, background information, and prior knowledge of the area, Making the list provides an ideal opportunity for promoting team building, because it allows each team member to contribute to the list, emphasizing topics relevant to his/her own interests/discipline, As a result, survey priorities are established before going to the field, and the team begins to operate as a single unit. If possible, the topical outline should be tested prior to going to the field. However, this list should not be considered binding. Sometimes, team members may not want to pursue all the topics on the list in order to obtain more detailed information on a particular aspect.

- ***Process*. In addition to deciding on the topics to be addressed in the survey, it is also important to agree on the appropriate interviewing procedures before starting the survey. Topics that might be useful to agree on before going to the field include: how to approach the farmer in terms of introduction; interaction, encouraging single or group interviews, length of interview, etc.; how to handle translation and sensitive topics; and how to avoid asking biased questions.**

- **Interviewing procedures, of course, will be somewhat location-specific. Some points that are important to take into account, in addition to those mentioned earlier (see Section 8.2) include:**

- **If the team is large, it is a good idea to break it up into groups of two - consisting ideally of a technical and social scientist -- to conduct interviews with a range of farmers, These farmers usually are selected in an informal manner; for example, every fifth farmer who is met or a certain number of farmers who have particular characteristics, such as being female and head of a household or who hire draught animals,**
- **Rotating team members on a daily basis gives each person a chance to work with and learn from other team members, thereby facilitating the exchange of ideas and helping to establish better communication among team members. It is also a good idea for the team to get together as a whole, on a frequent basis (e.g., daily), to review tentative hypotheses and compare and discuss observations and conclusions that have arisen. Also, at this point, some notes should be made, if not done earlier, to avoid points being forgotten at a later date. Such discussions can help stimulate team members' thinking and result in a modification of the topical outline for further interviews.**
- **At the end of the survey, which usually will not last more than a week, a written report should be prepared by team members reflecting a consensus on the hypotheses, findings -- which usually will include information on farmers' attitudes, constraints, and indigenous knowledge -- and recommendations for future action.**

A great deal of FSD work has involved using informal survey methods (e.g., see Box 8.2),

which include one or more of the elements discussed above. Obviously, once familiarity with the area and individual farmers has been established, many short cuts can be made in the implementation procedure, although it is always important to bear in mind some basic principles (e.g., use terms farmers can relate to, develop a collegiate or partnership type relationship with farmers, etc.). RRA type survey techniques have been used in many situations, for example:

- **Consultations with individual farmers on their farms concerning the practices they are using, the trials in which they are participating, etc.**
- **Farmer field days in which farmers played prominent roles.**
- **Farmer groups (i.e., both research- and extension-oriented) where farmers out-number the outsiders (i.e., researchers and extension staff), and, as a result, often express their views quite vigorously.**

These forums provide important opportunities for learning from the farmer in order to help in planning, implementing, monitoring, and evaluating formal surveys, studies, and trials. Because a good deal of this information is not documented formally, the significance of this informal interaction in shaping thoughts and actions tends to be forgotten. indeed, it is probably true to say that many strategies developed in on-farm trials over the years have been stimulated in such discussions (see Box 8.3).

BOX 8.2: UNDERSTANDING THE ROLE AND LIMITATIONS OF RRA SURVEYS

RRA surveys, in many different versions, have been used in FSD as quick and cost-effective means of obtaining a broad overview of technical and human constraints and potentials within a farming system, McCracken and Conway [1988] list five features of all good RRA surveys: iterative (i.e. between disciplinary perspectives); innovative (i.e., fit the situation); informal; interactive; and involving appropriate members of the target community.

In the medium altitude zone of Kirinyaga District of Kenya, an exploratory RRA survey was carried out with the primary extension agents of the areas in which an FSD team was doing research [Franzel, 1992]. The purpose was to use these agents as informants to obtain a comprehensive picture of the situation even more rapidly than could be done by interacting with farming members of the community. This RRA survey did provide the comprehensive information and was rated quite cost-effective. However, the FSD team members recognized that the chance that bias (i.e., perspectives different from those of farmers) would exist among agents and go unnoticed, and that the false results might be worse than no survey information at all.

A team working in Marit village of Plateau State, Nigeria, compared findings obtained through RRA surveys and those obtained through an Intensive Residential Study (IRS) [Merit Team, 19931. Most of the key issues discovered during the IRS were confirmed by the RRA: problems with soil fertility, water quality, income potential for the young in agriculture, rural electricity, marauding livestock, and others. Priorities for the elaboration of projects in the community -- these priorities naturally would correspond to the problem areas -- also were

well identified by the RRA survey. At a general level, RRA proved effective at identifying issues. However, the Marit Team found that RRA could not be relied on to reach the same level of understanding as IRS for more subtle relationships and values, For example, the RRA identified problems that informants thought could be corrected by outside inputs (e.g., fertilizer, seeds, etc.) but not those problems that surfaced over time in IRS that would require 'inside, solutions (e.g., mismanagement of funds). In terms of values, the RRA survey results reflected more 'promodernization, thinking, whereas the IRS revealed certain traditional values that the RRA did not. These included such value issues as matrimonial happiness, respect, etc.

The RRA survey is an important tool in FSD work. It provides the broad perspectives necessary to correctly orient FSD activities. However, RRA surveys should not always substitute for further in-depth appraisal.

8.4.4 PRA: Types and Uses

As indicated earlier (see Section 8.4.2), PRA techniques are evolving rapidly. As a result, it is impossible to provide an exhaustive description of the different methods, because it would become dated very quickly. A large number of papers are being published currently on new techniques and refinements to existing methods and should be consulted by those interested. Particularly useful sources of information are the same ones cited for RRA earlier (Section 8.4.3), namely IIED, FTP Network, IDS, and ILEIA. In addition, Clark University in the USA has produced a number of informative publications in this area, while a number of

CGIAR institutions have done some innovative work using PRA techniques. Those with particularly noteworthy work in this area include ICLARM, ICRAF, and CIMMYT.

BOX 8.3: FARMER-INITIATED STRATEGIES CAN IMPROVE THE PRODUCTIVITY OF RESEARCH

- **In one part of Southern Africa, it was observed that many farmers recognized high potential sites on their fields where soils were deeper, had a relatively high clay fraction, and tended to be at the bottom of slopes. These characteristics create conditions conducive to high water retention, important in that drought-prone environment, Consequently, some farmers used strategies to take advantage of these high potential sites. As a result, FSD researchers also accepted the potential payoff from targeting strategies towards these high potential sites by implementing trials on manure and phosphate application.**
- **A couple of FSD teams did a lot of trial work on double ploughing to increase infiltration of water in the soil profile thereby improving the length of time planting can be done under optimal soil moisture conditions (see Section 10.8). Because, at times, the traditional ploughing/planting system can be effective if soil moisture conditions are satisfactory, farmers in one village indicated that they could reduce the cost of the first ploughing in a double ploughing system by doing it when the soil moisture conditions were not suitable for planting, therefore, not sacrificing potential production. This observation encouraged the FSD team to rethink ideas on the double ploughing strategy as a substitute for the traditional system. It is now viewed as an option that farmers can**

pursue for increasing the potential number of days in which planting can be done on subsequent rains.

The objective here is to give, by way of illustration, summaries of four techniques that appear to have particular potential in FSD type activities.

Before doing so, four important points to note about the use of PRA techniques are as follows:

- **All involve having a group of respondents who together, after discussion, come to a consensus on the subject being considered. Thus, care must be taken that the respondents selected for the exercise are knowledgeable about the subject being discussed, and where results are likely to differ by recommendation domain, gender, etc., that those in a specific group are of the same 'type' or 'class'.**
- **They can be used effectively where the level of literacy is low. Lack of reliance on the written word appears to positively influence memory or visual retention. Such information can be transmitted effectively to others in pictorial form through drawing outlines on the ground supplemented with different objects or symbols reflecting different things/events/orders of magnitude, etc.**
- **Because the respondents are the major 'actors' in the activity and primarily interact amongst themselves, they can become very enthusiastic in, and derive considerable enjoyment and satisfaction from, undertaking the exercise.**
- **For those who doubt the results of a particular exercise, it can be repeated with**

another. group of respondents who have similar attributes, and the results compared.

Four examples of PRA techniques and their potential uses, are as follows:

- ***Mapping*. Examples are of farms, residences, and/or points of major interest (e.g., wells, cooperative, etc.) in a village, Names of individuals farming each plot of land can be identified, and characteristics of households living in each residence (e.g., gender of household head, size of household, type of traction used, whether traction is owned or borrowed, etc.) can be obtained, The potential value of such an exercise is obvious in providing a low-cost and quick way of assembling a sampling frame from which stratified random samples can be selected for formal surveys (see Section 8,5.3).**
- ***Trend Analysis*. This involves use of a historical perspective and provides a way of relating changes (e.g., crops and their varieties, customs, land use and practices, ecological, etc.) and their causes to specific major events, which, in turn, can be related to specific years. Such trends, together with information relating to their causes, can obviously be useful inputs into addressing ecological sustainability issues, designing solutions that will overcome undesirable trends, providing some idea on how desirable trends can be encouraged, etc.**
- ***Seasonal Diagramming*. Examples are many and can include: amount and distribution of rainfall; specific operations by crop: level and distribution of labour (e.g., overall, by gender, etc.) by crop and livestock enterprise, total agriculture, off-farm, domestic household related; level and composition of food consumption through the year; level**

and composition of animal fodder through the year, etc. In these examples, levels are expressed in relative terms through comparing one part of the year with another (e.g., the longer the vertical line in relation to another, the greater is the level or amount compared with the other). When households are very close to the survival level, the they are likely to be more vulnerable to seasonal fluctuations, such as in food supplies, and less likely to be able to supplement their labour supplies at times of peak labour demand. Therefore, seasonal diagramming potentially can be very important in highlighting problems that need to be addressed by FSD teams and in helping to evaluate the value or relevance of potential solutions.

- ***Matrix Scoring and Ranking*. Once again, there are many examples where this method can be applied. Possibilities are farmer assessment of: different varieties of crops, livestock, fodder crops, trees; treatments in an RM-RI trial; types of soil; methods of soil and water conservation, etc. The idea is to encourage and enable farmers to debate, decide, and weight the characteristics of the different alternatives and perhaps also indicate what they ideally would like to have. The weighting is constrained? forcing them to make judgements and trade-off decisions. The procedure is as follows [Chambers, 1992A]:**

    - **Decide what you want ranked or scored (e.g., varieties of sorghum, different treatments in a tillage trial, etc.).**
    - **Find one or more (preferably more than one) informants who are knowledgeable and willing to discuss -- preferably from the same**

recommendation domain.

- **Decide with them which items (i.e., under the first point above) to rank or score -- for example, if they know nothing about a particular variety, it should not be included.**
- **For each in turn, ask them what is good about it, what is bad about it, what else (i.e., any other point that is relevant in ranking/scoring) -- their ideas, not yours!**
- **List the criteria and make negative ones positive, For example, 'attracts pests' becomes 'does not attract pests'.**
- **Ask informants to rank or score each one (i.e., 1 = best, 2 = second best, etc. or score each out of 10, 5 or 3). This could be done visually with a matrix drawn on the ground and asking farmers to select their preferences, for example, by distributing I () identical objects (e.g.? bean seeds) between the various choices.**
- **At the end, ask the informants to rank them according to their preference if they could have only one. At that time they are aggregating the different criteria according to some weighting system. In fact it might also be useful to ask them to rank the importance of the different criteria. This could be done in a way Chambers calls a 'wish list, by distributing the objects according to the relative importance of the different criteria. This could provide very useful information for researchers, especially if the criteria are in potential conflict with each other.**

An illustration of one such test of the approach used in India is given in Box 8.4.

Additional points that Chambers emphasizes are:

- **Don't use your criteria. If you do so, clearly separate them from theirs.**
- **Don't lecture -- listen and learn!**
- **Probe for farmer criteria.**
- **Follow up on points of interest.**
- **Try different sorts of people -- who often are in different recommendation domains.**
- **Experience has indicated ranking is all right up to about seven items, whereas scoring is all right for any number of evaluation criteria.**

BOX 8.4: MATRIX SCORING CAN BE VERY USEFUL IN RANKING EXERCISES

The following example of four women in India ranking the characteristics of different trees was provided by Chambers [1992A].

CRITERION	**NEEM**	**PEEPUL**	**GUAYA**	**JAMUN**	**BER**	**JUHUL**
Shade	1	3=	3=	2	6	5
Medicinal	1	-	-	-	-	-
Fodder	1	-	2	-	3	4

Durable	1	5	4	3	2	6
Furniture	1	6	5	2	3	4
Building	1	4=	4=	2	3	4=
Fruit	4	5=	2	1	3	5=
Fuel	1	2=	2=	2=	2=	2=
Safe to climb	-	-	-	6	5	-
Income	2	6	3	1	4	5
Agricultural tools	2	-	-	-	1	-
Not thorny	2=	2=	2=	1	5	6
Charcoal	-	-	-	-	-	1
Choice if could have only one	2	5	4	1	3	6

a. In the table, the '=' means the different tree , were ram ted equally in terms of the specific criterion.

This is one of the most exciting of the PRA techniques in the sense that it has tremendous potential for obtaining farmer assessment during design and testing activities (Box 8.5) and

possibly even relating to adoption in the dissemination stage. However, as implied above, this has? not been exploited to date. Also the techniques

PRA techniques are facilitating the move to practical implementation of FSD with a 'natural resource systems focus' (see Section 3.3). Staff at ICLARM have played a leadership role in applying PRA techniques to addressing such sustainability-related issues (e.g., see Lightfoot, Bottrall et al [1991] and Lightfoot, Noble et al [1991]).

In a sense, these PRA methods provide a way of quantifying qualitative type data and, therefore, potentially could be more appealing to technical scientists not associated with FSD teams, This is particularly likely to be the case once they have observed these methods in operation. These methods as well as adding an extra dimension to RRA-type surveys during descriptive/diagnostic work (e.g., see Box 8.6), could, as mentioned above, be important during the other stages of

FSD work in evaluating technologies. For example, a possible application of the matrix scoring and ranking method would be in farmer assessment of technologies tested in farmer groups. This could take the place of an end-of-season formal survey (see Section 9.8.6).

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8.5 Formal surveys: value, design, and implementation

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8.5.1 Efficient Use of Formal Surveys

Informal surveys can make an important contribution to the design of the more expensive, time consuming, formal surveys. However, these formal surveys are still cheaper and less time consuming than direct measurement. Formal surveys involving the use of questionnaires provide a systematic, ordered way of obtaining information from respondents and enable precise and statistically analyzable data to be obtained. Earlier (see Figure 7.1), it was indicated that formal surveys can be divided into single (i.e., one-shot) or few- and multiple- (i.e., frequent) visit surveys. The two major issues concerning the use of formal surveys are to ensure that:

- The benefits from such surveys justify the costs involved.
- Turnaround is reasonably quick in teens of incurring the costs and reaping the benefits.

Multiple-visit surveys with multiple objectives can yield useful information, but the research resources required -in terms of level and time -and the slow turnaround time in terms of the results not being available until much later' means that they have limited value in feeding, in a timely manner, into new research initiatives.

Therefore, the above issues have been addressed increasingly, in the following ways:

- Emphasizing special subject surveys with limited objectives rather than more general multi-purpose surveys.
- Implementing single-visit rather than multiple-visit surveys.
- Carefully considering how accurately individual variables need to be estimated in order to answer the objectives of the survey. Relative rankings may be sufficient, or if accurate measurements are required, a direct measurement rather than using a survey format may be more appropriate. Yet another alternative may be to use 'standard coefficients, obtained from other work for variables that are not critically important or are fairly predictable.
- Making sure the links between data collection and checking, followed by microcomputer data entry, processing, analysis, and writing are made as efficient as possible,

BOX 8.5: TAKE CARE WHO PROVIDES EVALUATION CRITERIA IN MATRIX SCORING

In assessing different varieties of sorghum in Southern Africa, the respondents indicated that, apart from palatability, the criteria farmers used to evaluate sorghum varieties related to yield stability. Yet sorghum breeders place a great deal of emphasis on yield level plus some degree of yield stability. When gender issues were introduced? females evaluated each of the criteria the group had selected as equally important, but the males evaluated palatability as

most important and the need to do bird scaring (i.e., an activity done by women and children) as least important! There are obvious implications of using this method in helping breeders evaluate what criteria might be important to farmers in assessing varieties. The method also could be used in getting farmers to evaluate the criteria already in use in breeding programmes.

BOX 8.6: PRA TECHNIQUES CAN FACILITATE RECOMMENDATION DOMAIN IDENTIFICATION

A farm typology that is relevant to the key issues at hand is necessary to develop recommendation domains (Section 4.5) that are appropriate, PRA techniques, sometimes in combination with other methods. have been used to identify local people's own criteria for such important issues as wealth or poverty and their perceptions on how to measure differences between households within the community,

Informants were selected by an FSD team from among farmers of Kiponzelo and Kihanga farming communities in Tanzania to help with determining relevant criteria for measuring wealth as it relates to agriculture [Ravnborg, 1992], In consultation with village members, it was decided that the household would be the relevant unit of analysis for this determination.

Informants were asked first to map agro-ecological zones in the study areas, Next, names of households were written on pieces of paper, Each informant independently segregated names into different piles, If especially large piles appeared, the informant was asked to try

and make divisions within just that pile. At each turn, the informant was asked to characterize the households of a pile: how they are similar among themselves and different from those of other piles. This exercise generated a set of qualitative criteria that might be used to distinguish households.

The FSD team then developed a questionnaire survey that addressed quantitative measures of the qualitative descriptive criteria that had been identified, Cluster analysis was applied to data from this questionnaire, and four categories of households were identified and characterized, Agriculturally wealthy households used improved seeds, applied chemical fertilizers, were middle aged, had large household labour pools, and consumed as well as sold relatively large quantities of maize and beans. These criteria were more important than the agro-ecological zone where the farms were located, The poorest households used fewer recommended inputs, tended to be younger or older, or were headed by single individuals. Two intermediate farm types also were characterized.

With a well organized system, it is possible to design, implement, process, analyze, and write up the results of a reasonably long, single-visit, special-subject survey of 100 households in a period of three months, half of which could be devoted to the design and implementation stages.

However, key pre-conditions for making this possible are the design of an efficient questionnaire and the ease with which a sample can be selected. Designing questionnaires, generating the sample frames, determining the required sample sizes, and selecting samples

are all important ingredients in determining the value of formal surveys. These are discussed in the following sections,

8.5.2 Designing Formal Surveys

There is a logical sequence to producing a good questionnaire. The process of designing good questionnaires can be divided into six steps as follows:

- ***Determining Data Needs*. It is first important to determine why the survey is required (i.e., justification) and, therefore, the objectives of the survey, Good definition of these then will help guide what topics need to be covered and, therefore, what the data needs are. Where information on both the technical and human environment are to be collected, determination of the data required and the design of the questionnaire itself should be a collaborative effort of technical and social scientists. Data needs should be viewed not only in terms of variables on which information is required but also in terms of the degree of precision with which they need to be measured. Making a decision at this planning stage on the type of analysis proposed can help in determining the answer to this and the cost of collecting the data.**
- ***Determining Question Content*. Three important issues to address with respect to question content are:**

    - **Appropriate identification information and variables should be placed at the beginning of the questionnaire.**

- **Variables need to be included that enable the sample to be classified or stratified appropriately. Inclusion of possible classification variables in the questionnaire is important for meaningful comparative analysis to be carried out later.**
- **Obviously, questions must be developed for each of the variables in the hypotheses, and a determination must be made of the farmers, ability and likelihood of answering the questions, For example: questions must use terms and units of measure (e.g., for weight, area, distance, etc.) with which the farmers in the area are familiar; questions should not be used that require calculations (e.g., average bags of sorghum per hectare) by the farmers; and special care should be taken over questions that are sensitive.**

- ***Determining Question Format*. Four categories or classes of questions generally are used:**

  - **Open-ended questions where the interviewer writes down the response in full.**
  - **Close-ended (i.e., multiple choice) questions where the enumerator checks the appropriate response category.**
  - **Dichotomous questions where only two responses are allowed (e.g., yes/no, sell/consume, etc.).**
  - **Tabular questions where a question is asked after which rows and columns in a table are completed.**

All have a role to play (e.g., dichotomous questions as a lead into close-ended questions, open-ended questions when it is difficult to develop a list of categories before the survey, tabular questions when there is a lot of comparable quantitative data, etc.).

- ***Determining the Wording of Questions*. Good wording is critically important to avoid biased or inadequate responses to questions. Some examples are:**
    - **Every question should focus on one point and have only one answer.**
    - **Questions should be specific and not contain vague words such as many, often, and frequently.**
    - **Every question should use terms the farmers commonly use rather than technical terms of the FSD workers.**
    - **Every question should be phrased neutrally to avoid biasing the response.**
    - **Questions should be phrased so that the respondent cannot determine which answer is preferred.**
    - **Questions should specify the relevant time period for consideration.**
    - **Some questions (e.g., on management practices) often can be clarified by increasing the similarity in the way a number of related questions are asked.**
    - **Frequently, a pre-qualifying question may be necessary to verify that the question of interest applies to the respondent,**
    - **Questions on management practices should be asked with respect to**

individual plots. A tabular question often works well in such cases.

- **Questions that require accurate answers for aggregate values will be more reliable, if the amounts are first collected on an individual basis (e.g., weekly, monthly, or per parcel basis) and then summed by the FSD workers during the analytical stage,**
- **Each question should be numbered to aid in the processing of data. With respect to facilitating the collection-entry-analysis linkage, it is important to try to enter the data into the microcomputer straight from the survey form. This cuts down the possibility of errors in the collection-entry stage. To facilitate entry, it is good to record the name of the variable -- as it appears on the microcomputer -- on the survey form itself during the design stage and to provide a space for entering the figure that will appear in the computer (Box 8.7).**

- ***Deciding on Question Sequence*. Questions should be presented in a way that is logical from the farmer's standpoint, starting with the simple, more general questions and proceeding to the more specific, difficult, and sensitive areas, For some data, it may be advisable to check the validity of the farmers' responses by asking the question in more than one way.**
- ***Physical Layout and Length*. The beginning of the survey form, in addition to including identification and classification type information and data, also should have, where desirable, information that the interviewer can give the farmer on the purpose of the**

survey, who is being interviewed, etc. Any instructions on completing and coding the form for entry into the micro computer also should be given at the beginning of the survey form or at relevant points on later pages. Sufficient space for recording responses and any remarks should he provided on the survey form itself. In general, the length of interview should not exceed one hour. If it takes longer, the questionnaire should be divided and administered on separate days.

- ***Pretesting and Revision*. After the initial design of the survey, it is worthwhile to ask interested and knowledgeable individuals for comments and suggestions for improvements. After making any changes that appear desirable, it is a good idea to pretest it with a limited number of farmers, after which changes can be made prior to its reproduction and implementation. These types of checks can help in:**

    - **Determining whether questions are properly worded, understandable, sensitive, irrelevant, etc.**
    - **Checking questions for adequacy of format and sequencing, adequacy of categories in close-ended questions, etc.**
    - **Identifying missing information, estimating time requirements for the interview. testing the training and understanding of interviewers, etc.**

BOX 8.7: IMPROVING THE EFFICIENCY AND ACCURACY OF DATA COLLECTION AND TRANSFER

Formal surveys often are implemented by relatively inexperienced enumerators, whereas transfer of the data to microcomputer databases commonly is done by fairly unskilled clerical

staff. Close-ended questions can help to reduce ambiguity data collection, whereas mistakes in transferring data to the microcomputer can be reduced by having the acronym under which the variable appears in the database, entered on the data collection form itself. An example is as follows:

(6). What type of row planter do you own'?

1. Sebele Row Planter

2. Sebele Plough Planter TYRP[a]________
3. Safim Row Planter
4. Other (Specify)____________

a. This is the acronym for the type of row planter that appears in the database.

8.5.3 Sampling for Formal Surveys

There would be no need to worry about a sampling procedure, if the characteristics of all members of a population were exactly the same. It would be necessary only to select one individual to identify the population characteristics. However, because of diversity in the technical and human environment, it is necessary to sample several members of the population before any conclusions can be drawn. Therefore, the purpose of sampling is to

select a subset

BOX 8.8: WATCH FOR BIASES IN SAMPLING FRAMES

The problem with many sampling frames is that they usually are drawn up for particular purposes and thus may be biased, especially if they don't represent the whole population, It is important to be aware of the possible biases when sampling frames are used. Sutherland [1988], based on extensive experience in Zambia, has identified four common types of biases, These are as follows:

- ***Middleman bias*. When an extension agent or local leader provides a list or recommends a group of farmers, there is often a bias in favour of more progressive farmers, male-headed households, and friends or family of the middleman.**
- ***FSD team characteristics*, FSD teams may have internal biases resulting in a gender bias (i.e., favouring either male or female participants), a language bias, or an innovator bias, Also, there may be a bias because teams have a preconception, inappropriate definition, or a lack of under standing about what constitutes a farmer and/or a household,**
- ***Logistical factors*. These may be the most difficult biases to avoid and involve a bias towards farms with cropped areas near roads and a bias towards working with progressive farmers in order to show results.**
- ***Local circumstances*. Other biases can arise from local circumstances depending on the ecology, geography, and social structure of the village. There may be a bias for 'home-centred farmers', when farming is a seasonal activity, and away from farmers who leave**

the area for certain periods of the year in order to find of the population that has the same characteristics as the whole group or is representative of the population. The term population refers to all of the elements -- such as farms, households, etc. -- from which the sample actually is selected, whereas a sample is a representative portion of the population under study.

The objective of sampling is to undertake statistical tests and, as a result, be able to say (i.e., predict) that the results of working with all the farms/households in the population would give the same results. The sampling process requires five activities:

- ***Specification of the Sampling Unit*. Examples would be farming households, fields of a specific type, etc.).**
- ***Preparation of an Adequate Sample Frame*. This constitutes a list of the units from which to select the sample (e.g., lists of farmers kept by extension staff; a list of people receiving food at schools/ clinics during a drought relief programme, lists of farmers participating in government production campaigns, a list of households associated with a community development project, list derived from sources outside the village, for example, a census listing, etc. (Box 8.8). Preparation of sampling frames can be very demanding (i.e., in terms of time and money). An approach that has great promise and is relatively cheap is to use PRA techniques (see Section 8.4.4), particularly mapping, in which villagers themselves can give relevant information concerning the families whose dwelling units are given on the map they have drawn.**

- ***Selection of the Sampling Method*. These consist of two major types, namely probability (i.e., random) and non-probability (i.e., non-random). Probability sampling methods consist of simple random sampling, stratified random sampling, systematic sampling, cluster sampling, etc. When sampling frames are not available, then non-probability sampling methods have to be used such as purposive sampling and quota sampling. Probability sampling is preferable because statistical testing is then more valid. It is desirable in sampling that strata correspond to the tentative recommendation domains (see Section 4.5). Many references are available on sampling methods, and, consequently, there is no need to discuss them in detail in this manual (see, for example, Worman et al 1 1992: pp. 137-14()1 and Dillon and Hardaker [1993: pp. 47-501).**
- ***Determination of the Sample Size*. This is a complicated process and often requires the help of a statistician. A number of factors influence the sample sizes used in FSD. These include: variability of local farm conditions, degree of precision required, available time and research resources, type of data handling facility, details and complexity of the questionnaire, etc. It is important to understand that the appropriate sample size depends on the variability in the population and not on the size of the population. Therefore, the percentage of farming families that must be included may vary substantially between recommendation domains. It has been found that 3() to 5() farmers for each recommendation domain usually will reflect reasonably well the circumstances of farmers in that recommendation domain [Byerlee et al, 1980]. Others have suggested a minimum sample size of 20 from each sampling category [Yang, 1965:**

p. 9: Shaner et al, 1982: p. 471

- ***Selection of the Sample*. Once the preceding considerations have been taken into account and related activities accomplished, the selection of the sample can proceed. As discussed earlier (see Section 5.6.2), to ensure the cooperation of the leadership, their involvement in the actual selection process may be desirable,**

In conclusion, it is important to remember the following points when making decisions about sampling:

- **Be practical.**
- **Sample design and logistics of field work are often complementary.**
- **Statistical desirability and practical feasibility often conflict.**
- **Knowledge of the area and the subjective judgement of FSD workers is crucial in selecting villages and samples.**
- **Use the simplest procedure -- in terms of costs and resources -- that will permit the achievement of the FSD goal.**
- **Remember, biased selection of farmers will give rise to biased answers and conclusions.**
- **Both FSD workers and extension staff can be guilty of selection biases.**
- **Use probability sampling whenever possible, but in any case, always be aware of the limitations of the method that is used.**

8.6 Direct physical survey measurements

Discussion in this chapter has focused on surveys involving interaction with people, However, surveys do not necessarily have to involve people, For example, FSD teams often employ direct physical survey measurements to obtain baseline and progress information that contribute to other aspects of FSD work, Basically, such physical types of surveys fall under the 'direct measurement' -- and perhaps the 'observation' -- category indicated in Tables 7,1. and 7.2, because they usually require direct measurement techniques. Consequently perhaps, physical surveys should not be considered in this chapter, which concentrates on indirect measurements that usually are associated with surveys. However, because they do constitute a special type of survey, they are dealt with briefly at this point of the chapter.

- **FSD tasks that often benefit from these physical types of measurements are:**
- **Making comparisons with scientific data from outside the FSD target area,**
- **Developing sample-frames for locating trials or other studies,**
- **Formulating the range and the severity of problems in the descriptive and diagnostic stage of FSD.**
- **Forecasting impacts that interventions might have.**
- **Contributing to the interpretation of subjective data obtained through farmer surveys and often providing a groundwork for dialogue with participating farmers,**

Direct physical survey measurements can provide more precise quantitative information about certain aspects of the farming system that arise from indirect farmer surveys, However, this level of precision is not always necessary, and for each activity, the FSD team must

determine the level of precision required, In general, direct measurements are most useful for describing objects and events of the farming systems' natural resource base: weather events, soil conditions, biological cover, and so forth. In addition, direct measurements often will be made for inputs and outputs when describing cropping and livestock management.

Many physical measurements are fixed to land and calendar coordinates and, thus, can be used to help define space-time frameworks for FSD analyses, Because of problems in managing large data sets, these types of frameworks have been under-utilized in FSD.

Techniques used in these measurements are frequently the same standards used by scientists in ecological and production research. Following are several suggestions for applying direct physical survey measurements in FSD:

- **The FSD team, often in consultation with experts and with participating farmers, must determine which measurements are relevant and cost effective to the analyses planned. In making this decision, consideration should be given to both short-term and long-term planning of FSD work.**
- **The FSD team must be assured that staff members have the skills for making these measurements in a manner consistent with established standards. The FSD team must also ensure a consistency in the way any single measurement is made across project activities, Achieving this consistency may require training for staff in the procedures used (e.g., rating weed levels, determining soil texture by 'feel' method, etc.).**
- **Even with training, bias can occur in the way measurements are scheduled, and this will**

distort the objectivity of direct measurements. Remember, essentially all objective measurement techniques depend on some amount of human judgement. It would be inappropriate, for example, for one staff member to rate weed cover -- which can be somewhat subjective -- in one village area, and another staff member to make this rating in a second, and then plan to do statistical analyses comparing these village areas.

- **FSD teams will find that many standard direct measurements are too time consuming and costly to be carried on the scale necessary for project work. FSD teams should constantly be seeking proxy variables that represent the variable(s) at issue but can be measured more quickly and at less cost. Proxy variables are only as good as their relationship with the variables that are important. For example, in some environments, earthworm counts have been found to be good indicators of soil health variables such as soil porosity, aggregation, and organic matter content. Developing or validating appropriate proxy variables is an excellent subject area for collaboration between FSD and scientists based on experiment stations. Another benefit in identifying good proxy variables, is that these sometimes serve later, as well, by helping farmers and dissemination agents monitor the impact changes are having on farms.**
- **The use of direct physical survey measurements should not be allowed to compete with indirect farmer surveys. FSD teams may find advantages in asking participants to help assess the need for various measurements. Results should be reported back to FSD participants. Exchanging notes in this way between what farmers observe and believe with relevant scientific measurements -- from both surveys and trials -- will bolster the opportunity for identifying problems and solutions.**

- **Even with this potential synergism, FSD teams can readily over-extend physical measurement work. Teams might experience some difficulties in completing data collection, but a more common problem is the management of data and integration of its analysis into the broader FSD picture. Developments in data management technology will help ease some of these problems in the future. Very powerful relational database management (RDBM) programmes are becoming increasingly available that combine analysis and graphics to present results in meaningful ways.**
- **Geographic Information Systems (GIS) technology, a further extension of RDBM, is also emerging as a tool with potential applications in FSD. GIS programmes and projects exist in many countries and zones where FSD teams operate. However' because work on developing initial layers of information for GIS is demanding and time consuming it probably should not be part of the work load of an FSD team. GIS programmes that are already developed and include relevant information for the target area on soils, weather, vegetation, demographic, etc., could be used and added to by FSD.**

9. Trial methods (direct measurements)

9.1 Objectives

The objectives of this section are to discuss:

- **The main types of trials used in FSD, the purposes of each, and some of the issues related to their design and planning,**
- **Some of the issues related to trials designed to address crops and livestock.**
- **Some of the issues involved in trial implementation, including selection and involvement of farmers and the specific use of farmer groups.**

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9.2 Types of trials

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Once research priorities have been identified within the research programme and suitable hypotheses have been developed for testing, trials work can begin, The first requirement is for researchers -- and participating farmers, if appropriate -- to define the trial objectives as specifically as possible. This then will influence the type of trial that is most suitable for fulfilling the objectives. However, as indicated earlier (Section 2.4), FSD teams have multiple

clients namely, farmers, station-based researchers, extension and development agency staff, and sometimes planners. Similar types of trials do not have equal appeal to all the clients.

One somewhat simplistic way of classifying trials undertaken on farms is differentiating them on the basis of who manages and who implements them (i.e., researcher (technician) or farmer (Table 9.1)). Thus, three major types of trials are possible:

- **Researcher managed and researcher implemented (RMRI).**
- **Researcher managed and farmer implemented (RMFI).**
- **Farmer managed and farmer implemented (FMFI).**

TABLE 9.1: EXPECTATIONS OF DIFFERENT TYPES OF TRIALS[a]

ITEM	RESEARCHER MANAGED AND RESEARCHER IMPLEMENTED (RMRI)	RESEARCHER MANAGED AND FARMER IMPLEMENTED (RMFI)	FARMER MANAGED IMPLEMENTED (FMFI)
Experimental:			
Stage:	Designb	1st stage testing	2nd stage testingc
Design:			

Complexity	Most	Less	Least
Type	Standard	Simple standard	With and without
Replication	Within and between sites	Usually only between sites but can also be within	Between sites only
Levels of treatment	Most	Less	Least
Standardized level of			
non-experimental			
variables?	Most	Less	Least
Plot size	Smallest	Larger	Usually largest
Who selects technology?	Researcher	Researcher/farmer	Farmer
Who shoulders risk?	Mainly researcher	Researcher/farmer	Mainly farmer
Main discipline of researcher	Mainly technical	Technical/social	Mainly social
Participation by:			
Farmer	Least	More	Most
Researcher:	Most	Less	Least

Number of farmers	None	Some	Most
Farmer groups	Least	More	Most
Potential:			
'Yield'	Most	Less	Least
Measurement errors	Least	More	Most
Degree of precision	Highest	Less	Least
Data:			
'Hard, (objective)	Most	Less	Least
'Soft, (subjective)	Least	More	Most
Determination of cause/			
effect relationships	Easiest	Less easy	Least likely
Incorporation into farming			
system	Least	More	Most
Evaluation:			
Who by?	Mainly researcher	Researcher/farmer	Mainly farmer

Nature of test	Assesses technical feasibility	Technical feasibility plus economic evaluation	Validity for farmers - practicality, acceptability
Appeal to:			
Researchers	Most	Less	Least
Extension Staff	Usually least	More	Most
Farmers	Least	More	Most
Ease of acceptance of results of trial	Researcher	Researcher/farmer /extension	Farmer

a. There is a degree of subjectivity m some of the entries in the table, but they generally reflect what is the case. In a sense, these expectations also reflect the reasons why the different types of trials are undertaken. In the literature, RMRI trials sometimes are called exploratory trials, whereas RMFI trials sometimes are termed refinement trials.
b. Standard multilocational trials are also RMFI. Multilocational trials are differentiated from trials undertaken in a farming systems context in that they are not designed, implemented, or evaluated with a farming systems perspective in mind.
c. In a sense, there are two types of FMFI trials, those done through research- oriented farmer groups

A careful study of Table 9.1 indicates that the three trial types can be differentiated in terms of research objectives, methods, experimental design, types of data collected, methods of analysis, evaluation criteria, and likely appeal to the different 'actors' in the agricultural development (equivalent to validation trials in the literature) and the more widespread testing done through extension-oriented farmer groups (equivalent to verification trials in the literature). process. Generally in FSD, technology design work begins at the RMRI level; then when a technology is thought to be appropriate, it is passed on for testing by the farmer, first at the RMFI level, and then at the FMFI level, Obviously the farmer becomes progressively more involved as one moves from experimentation at the RMRI to the FMFI level. Farmer groups - which will be discussed later (see Section 9.8.6) -- are particularly useful for implementing trials at the FMFI level and to some extent at the RMFI level. In RMRI type trials, undertaken on-farm, the researcher input is much greater. RMRI trials on farmers, fields are most similar to those conducted on the experiment stations. Therefore, the level of testing achieved meets the standards demanded by station-based researchers. However, FMFI trials are the most satisfactory for the farmer and provide the most practical test of the technology. Because of management and resource constraints, yields or returns will diminish from the RMRI to the FMFI level. The information in Table 9.1 notes the major differences between RMRI work -mainly the preserve of experiment station researchers -- and RMFI and FMFI trials that emphasize on-farm work. One such difference, for example, is the tact that cause-effect relationships and 'hard' (quantitative) objective-type data are obtained more easily from RMRI work, whereas farmer attitudes and inputs into the research process are obtained more readily from RMFI and FMFI work undertaken on farmers' fields, However,

data collected under such formats, particularly at the FMFI level, are likely to be 'softer' (more qualitative) and more subjective in nature. Once one understands the purposes of the different types of trials, it is easier to recognize the complementarities that exist between them and? therefore, easier to adopt appropriate criteria in evaluating their worth.

All three types of trials are vitally important in contributing to a well rounded FSD programme. Yet surprisingly, a survey of 41 FSD projects undertaken a few years ago indicated that only 32% undertook all three types of trials, 12% percent undertook only RMRI trials, and only 46% undertook any FMFI trials [Barker and Lightfoot, 1986].

There is also another type of trial, called superimposed, which has considerable potential that often is not exploited fully. Superimposed trials include elements of management by both farmers and researchers, with implementation primarily the responsibility of farmers. These trials tend to be single-factor experiments such as looking at the response of fertilizer superimposed directly on a farmer's own plot where he/she is providing both labour and management. Although, not strictly correct, these can be considered a type of FMFI trial.

Mainstream FSD, in spite of the iterative principle that underlies it, often has been implemented in somewhat of a linear mode. For example, often technology design work begins at the RMRI level; then when a technology is thought to be appropriate, it is passed on for testing with the farmer, first at the RMFI level and then at the FMFI level. Obviously the farmer becomes progressively more involved, on a daily basis, as one moves from experimentation at the RMRI to the FMFI level.

It is legitimate to be somewhat uneasy about this linear connotation. Because of this and other considerations, such as the research capacity of farmers, the comparative advantage of FSD, and the need to improve the efficiency of the technology development process combined with recent methodological advances, there are strong arguments for moving in the following direction with respect to on-farm trials:

- **Farmers should be involved much earlier in the research process than often has been the case to date, Good examples of where this has been done involve farmer assessment of varieties on experiment stations and farmer input into designing and evaluating treatments (Boxes 9,1 and 9,2).**
- **Minimal emphasis should be placed by FSD teams on RMRI type trials, FSD teams have a comparative ad vantage in trials that maximize farmer participation and assessment (i.e., trials at the RMFI and FMFI levels).**
- **Methods that have developed in recent years should be introduced that will enable the needs of more than one client (i.e., researchers and farmers) to be better satisfied in FMFI type trials. Farmers' needs are more likely to be satisfied as a result of their being involved as much as possible in such trials, At the same time, researchers' needs can now be better met through:**

    - **Using methods that can express farmers' assessment in a more quantitative manner -- which will more likely appeal to technically oriented scientists (e.g., using PRA techniques (see Section 8,4.4)).**

- **Making greater use of alternative statistical techniques such as regression analysis including modified stability analysis (see Section 10,4,3) [Hildebrand, 1984; Stroup et al, 1991],**

Thus increasingly, the objective of ensuring farmer precision in assessing whether the technology fits his/her needs does not have to be accomplished at the expense of 'statistical' precision.

- **Research resource efficient methods should be utilized in implementing on-farm trials, Clustering work (see Section 5,5) and using farmer groups (see Section 9.8,6), especially in FMFI trials, are good examples of such approaches. Also relating to maximizing the return from limited research resources, the trials should be sufficiently documented (e.g., contain site descripters) and potentially relevant to large numbers of farmers (i.e., the recommendation domain should be extensive).**

BOX 9.1: INTEGRATE FARMER EXPERTS INTO ONSTATION RESEARCH

In Rwanda, Sperling [1991], Sperling and Ntabomvura [1994], and Sperling and Berkowitz [1994], have demonstrated that local commodity experts (i.e., farmers) can be brought usefully onto the experiment station to participate in the early screening of experimental bean varieties, Station based researchers learn farmer and user criteria, whereas farmers make selections for on-farm experiments. Thus, women farmers and research station scientists have collaborated in evaluating the new bean lines, Such collaboration recognizes

farmers' knowledge of soils, seasons, arid planting practices. After four years of testing, farmers' and breeders' selections have been evaluated in terms of farmer acceptance and diffusion. The implication is clear: involve farmers as early as possible in the research process!

Use of superimposed trials should be encouraged not only because they provide a flexible approach in responding to unexpected experimental opportunities or issues, but also because the non-experimental variables reflect farmers' actual situation.

BOX 9.2: USE LOCAL KNOWLEDGE IN DESIGNING TRIALS

Local knowledge about soils, paddy types, and fertilizer resources available to farmers helped in the design of on-farm trials for the Hibunawan barrio on the west coast of Leyte, Philippines [Perrot Matre and Weaver, 19921. Results from these trials led to the design of technology in the form of strategies that are more appropriate for farmers than current recommendations.

From their experiences, farmers thought that rice response was most related to the soil and paddy types and to the timing of application, especially with respect to the type of fertilizer used. None of the Hibunawan farmers applied a pre-harrowing basal application, as was done on research stations, because of the high risk of crop failure that can not be discerned at that early period in the season. Farmers also observed several rice variety and fertilizer application interactions that would be important. Their foremost concern was on how to

make the most effective use of set amounts of fertilizer available to them.

Farmers and FSD workers were able to design trials that incorporated these specific questions, including trial sites, as part of the experimental design. From these trials, participants hoped to complement and adjust the farmer's own rules-of-thumb to engineer helpful fertilizer recommendations.

9.3 Functions of different trial types

In designing all trials the objectives should be specified clearly, which, in turn, will help indicate the most appropriate trial type. In order to make this determination, it is important to understand the functions of the different types of trials. These are as follows:

- ***RMRI Trials*. This format is used most commonly in FSD during the design stage, when the objective is to determine whether a new technology will function, in a technical and biological sense, in the physical environment of a farmer's farm. Because all of the work. at least with reference to the treatment variables, is handled by researchers, the trial design can be as large and complex as is needed to answer all the relevant questions. Generally, formal, replicated designs are used in these trials. Such trials, which are designed to answer cause-effect relationships, should be carried out on experiment stations whenever possible. The reasons for this include: lower implementation costs (e.g., in terms of logistics or time) and potentially better control (e.g., in terms of easier**

supervision or easier maintenance of ceteris paribus conditions). However, there are occasions when conducting such trials on farmers' fields is highly desirable and sometimes even essential. Such situations arise if the special environmental situation of the experiment station does not seem to provide a realistic environment for testing a technology (Box 9.3).

When RMRI trials are undertaken on-farm, it is desirable to have station based researchers play a major role in implementing them on behalf of? or in collaboration with, FSD team staff.

- ***RMFI Trials*. The primary purposes of RMFI trials are to determine whether farmers can implement a particular technology using their own resources and to determine how much benefit the technology provides when this occurs, The benefit may be measured in many ways, including grain yield, net profits, cash returns to farmers' labour, net production per unit of ploughing time, etc. The participation by the farmer is essential in order to get a realistic picture of whether farmers will be able to implement the technology with the resources they possess, to develop a realistic economic picture, and to obtain initial farmer assessment of the technology,**

  At the RMFI level, researcher management still is required, because researchers need to collect basic data on what happens when farmers implement a new technology and on the performance of the technology, or technologies, versus the farmers' own production system. Accurate descriptions of technology performance

and accurate estimates of values required for partial budget analysis (see Section 10.5.2) both require well designed and properly implemented trials and a good deal of fairly detailed data collection -- both technical and socio-economic in nature.

The involvement of the farmer has a major impact on the design of RMFI trials. It is necessary to keep in mind that the farmer is not a paid or unpaid labourer. Rather, the farmer is an independent person who is trying to run a business (i.e., the farm). Hence, the researcher should not take any more of the farmer's time than is absolutely necessary. For this reason, a good rule of thumb might be that trials should not require more than a single day for planting. If the farmer is using draught animals for ploughing, this will limit the size of the trial. The trial design should be simple enough that the farmer will understand clearly what the treatments are and how they need to be implemented.

- ***FMFI Trials*. The primary purposes of FMFI trials are to determine how a technology will perform under farmer management and to gather extensive farmer assessments of the technology, so that it can be modified, if necessary, before it goes into the dissemination stage. Farmer assessments generally are collected through discussions (i.e., informal surveys) and through one-shot, formal, structured surveys. The more farmer opinions collected in this activity, the better, One good way to handle these types of trials is through the use of farmer groups (see Section 9,8.6). Because these trials are both farmer-managed and -implemented, they need to be extremely simple in design so that**

they can be implemented without any guidance from researchers.

BOX 9.3: RMRI TRIALS CONCENTRATING PRIMARILY ON TECHNICAL OBJECTIVES SOMETIMES NEED TO BE ON FARMERS' FIELDS

Much work relating to weeds needs to be implemented on farmers, fields. This is because the weed complex is likely to be very different from that found on experiment stations. Examples of such work are as follows:

- **Field tests were conducted on-farm in Illinois, USA, to evaluate herbicide control of bigroot morningglory (BM) [Horak and Wax, 1992], BM is a weedy perennial vine with a deep taproot and occurs in corn and soybeans, particularly on sandy bottomland. Populations of this weed occur in patches on infested fields though these fields can be scattered widely. Such patches are identified readily by farmers but are not represented adequately on research stations in the area.**
- **Field tests to evaluate genetic resistance to herbicide effects among populations of Palmer amaranth (PA) were conducted at numerous on-farm locations in South Carolina, USA [Gossett et al, 1992], These tests were on natural populations at their original locations, because researchers were fearful that harvesting and importing seeds to research stations might spread the genetic resistance to other populations of PA in the area.**
- **Leafy spurge (LS) is a serious economic problem on rangeland of the northern plains of the USA [Lym and Carlson, 1994]. Research has focused on use of biological control**

agents because of the long-term resurgence of this weed following treatment with herbicides. Technology development work in North Dakota, USA, was carried out on farm range sites. This work lead to a strategy of combining leafy spurge gall midge, a biological control insect that is most effective at LS control in wooded areas, with herbicide treatments to knock back LS populations in open areas of the range. The midge was able to exert biological control in open areas once the LS populations were reduced by the herbicide.

- **Another weed technology is being designed through on-farm research. Common crupina (CC), a fall germinating, annual range weed, was first recorded in the northwestern USA in 1969 [Zamora et al, 1989; Zamora and Thill, 1989]. Its distribution is still limited, and a plan is being designed to eradicate this weed before it becomes a major economic threat. Seedling emergence and seed bank longevity were monitored in farm range areas during a four- year period to understand the biological characteristics of CC necessary to plan its eradication. Farmers on whose land CC is growing are participating in assessing human health risks and potential environmental disruptions from the eradication treatments before the plan is implemented.**

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