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PLANNING AN ADAPTIVE PRODUCTION RESEARCH PROGRAM
FOR SMALL FARMERS: A CASE STUDY OF FARMING
SYSTEMS RESEARCH IN KIRINYAGA DISTRICT, KENYA

presented by

Steven Charles Franzel

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PLANNING AN ADAPTIVE PRODUCTION RESEARCH PROGRAM FOR SMALL FARMERS: A CASE STUDY OF FARMING SYSTEMS RESEARCH IN KIRINYAGA DISTRICT, KENYA

By

Steven Charles Franzel

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ABSTRACT

PLANNING AN ADAPTIVE PRODUCTION RESEARCH PROGRAM FOR SMALL FARMERS: A CASE STUDY OF FARMING SYSTEMS RESEARCH IN KIRINYAGA DISTRICT, KENYA

By

Steven Charles Franzel

This thesis uses the farming systems research (FSR) methods of the International Maize and Wheat and Improvement Center (CIMMYT) to plan an experimental program for farmers in Middle Kirinyaga, Kenya, and to address several methodological issues concerning FSR. The approach includes three stages: (1) interviews with extension agents to identify recommendation domains (RD's), i.e., fairly homogenous groups of farmers; (2) an informal survey in which researchers interview farmers; and (3) a formal sample survey. An agronomist collaborated with the author in mounting the research.

The two RD's identified in Middle Kirinyaga were high income farmers and low income farmers. Farmers' circumstances are described and "leverage points" are identified, which represent opportunities for increasing productivity in ways acceptable to and feasible for farmers. An experimental program is presented; the two most important research priorities are:

1. Improving soil fertility and structure through on-farm experiments to test the effectiveness of readily available coffee husks as manure.

2. Reducing the draught power bottleneck by selecting bean cultivars with superior ability to withstand dry planting, treating seeds against ant damage, and deeper planting.

Two methodological issues are addressed. The first is how to obtain normative and prescriptive information, i.e., information on

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farmers' values and decisions. Two techniques, repertory grid (RG) and hierarchical decision tree models (HDM), are incorporated into the informal and formal surveys and are evaluated. The techniques were found useful for assembling data concerning preferences and decisions in a systematic fashion and for assisting the researcher to develop an understanding of farmer decision-making.

The second methodological issue concerns the quality of data at different stages of the investigation. First, data from the RD-identification exercise are evaluated in comparison to those of the formal survey. The exercise is found to be reasonably effective for tentatively classifying farmers into RD's.

Next, the utility of the formal survey is evaluated by comparing its results with those of the informal survey. The formal survey contributed relatively little to the understanding of farmers' practices and constraints or to the experimental program developed in the informal survey. These findings support the hypothesis that the informal survey can be an effective and sufficient method for planning experimental programs for farmers.

ACKNOWLEDGEMENTS

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in this research project. I am also grateful for the cooperation and assistance of a number of institutions: Scientific Research Division (SRD) of the Ministry of Agriculture of Kenya, the Kenya Agricultural Research Institute, and the District Agricultural and District Administrative Offices of Kirinyaga. I also thank Mr. Njogu Njeru, formerly Senior Maize Research Officer, SRD, who collaborated with me in mounting the informal survey and drawing up the experimental program. Appreciation also goes to my research assistant, Mr. Simon Muthangia, my four enumerators, and to the sub-chiefs and extension agents of Middle Kirinyaga, whose cooperation was invaluable. Others who provided useful assistance include Mr. Fred Chege, Dr. H. A. van Rheenan, Ms. Juliet Gathee, and Dr. Christina Gladwin.

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CHAPTER 1

BACKGROUND AND OBJECTIVES

This study has two types of objectives: methodological and problem-solving. The methodological objectives concern the use of three techniques, the CIMMYT diagnostic survey, repertory grid, and hierarchial decision-tree modeling, for analyzing a farm system. The problem-solving objective involves using farming systems research (FSR) methods to plan an adaptive production research program for small farmers. In the first section of this chapter, we present the background to the methodological objectives, highlighting the emergence of FSR as a technique for planning farmer technologies. A statement of the methodological objective follows. Next, background to the problem-solving objective, planning an adaptive production research program in Middle Kirinyaga, Kenya, is presented. Finally, the specific problem-solving objectives are stated.

1.1. Background to the Methodological Objectives

Rural development planners in the Third World are becoming increasingly aware that information about small farmers is crucial for planning rural development programs. The widespread failure of large scale, capital intensive agricultural projects and the increasing concern for a more egalitarian distribution of benefits have led to increasing emphasis on small farmer oriented programs (Lele, 1975). The development and exte

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and extension of new technologies for small farmers is often seen as an important and effective measure for enhancing rural welfare.

Nonetheless, there is a growing perception among policymakers and research administrators that national agricultural research institutions are not contributing as well as they could be to the development and diffusion of new technologies for small farmers. Often there is a wide gap between what researchers recommend and what farmers practice. When planners seek to impose on the farmer new production systems and packages which have proven to be effective on research stations, the result is failure. The usual scapegoats for these failures are: the farmers themselves, who are alleged to be lazy or irrational; the extension service, which is blamed for not transmitting the research station's message to the farmers; the delivery system, which fails to deliver inputs to farmers when required; or policy distortions, which make unprofitable the use of purchased inputs and the cultivation of crops for the market.

However, many studies point to another cause of low adoption rates--station recommendations which are irrelevant to the farm family's priorities, resource constraints, and physical, cultural, and economic environment (Winkelmann, 1977). In many countries, extension recommendations are developed by researchers on experiment stations whose work is aimed at maximizing yields per unit of land area. This yield-oriented approach often brings forth recommendations which are irrelevant to farmer circumstances, for two main reasons. First, the recommendations are developed under physical conditions different than those of the farmers, since they are generally formulated based on the results of experiments mounted on research station plots. These plots are usually plowed by tractors, kept weed-free, sprayed, and fertilized so as tc

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so as to ensure a significant response from the experimental variable. Hence, (1) responses to experimental variables are generally much higher than could be expected on farmers' fields and (2) it is unlikely that the actual response functions would have the same shape as the experimental ones.

Second, researchers' criteria for evaluating new technologies are much different than those of farmers (Collinson, 1980). As long as inputs have costs, it is never in the best interests of farmers to adopt those levels of inputs which maximize yields. Many researchers recognize this fact and use the point of maximum profit for making their recommendations. Unfortunately, the problem of what is best for farmers to adopt is much more complicated than this; farmers seek to maximize utility as well as profit. Thus, economic optimality for a given farming situation depends on the objectives, resources, and priorities of the farmers concerned. Farm management studies in Africa have shown that small farmers operate their farms so as to (1) provide a reliable supply of food for their families, and (2) provide cash for what they regard as essential purchases (Eicher and Baker, 1982). They take into account both natural (temperature, rainfall, soils, etc.) and socioeconomic circumstances (prices, riskiness, sociol acceptability, etc.) in deciding what enterprises and management practices to adopt. Farmers operate a system made up of many enterprises, and are often forced to diverge from the ideal management of one enterprise in order to devote resources to another enterprise, in the interests of overall system performance.

Farming systems research offers an alternative approach in adaptive research to the conventional yield-oriented perspective, common among physical and biological scientists. FSR begins with the farmer's own situati

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situation, rather than a pre-defined package of high yielding technologies. FSR researchers purport to be holistic, that is, they view the whole farm as a system of interdependent components and focus on how these components interact in their physical, biological and socio-economic setting (Shaner, Philipp and Schmehl, 1982). The approach is most effective if it is multi-disciplinary; hence, FSR is generally mounted by teams of scientists from both the agricultural and social sciences.[1]

In FSR, insights into how current practices fit into the farm system are used as a basis for proposing improvements. Researchers focus on identifying and overcoming critical constraints which the farm family faces so that they can better meet their priorities (Norman, 1976). The immediate goal is to offer a few technological improvements which are compatible with the farm household's activities and circumstances, not to replace the current farm system with a radically different one. Emphasis is given to identifying and developing new technologies which (1) have potential for increasing productivity and, hence, enhancing the farm family's ability to meet its own objectives, (2) will be acceptable to farmers and feasible for them to adopt, and (3) will promote developments which are consistent with national policy objectives. Generally, FSR also includes the mounting of experiments on farmers'

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[1]It is incorrect to consider FSR as a completely new approch with no antecedents. Johnson (1981) and Ramaratnam (1981) discuss the forerunners of FSR in farm management and farm home development programs in the United States in post-World War II years. In fact, some of these programs were considerably more holistic than is FSR, as currently practiced. For example, the Kentucky Farm and Home Development Program gave considerable attention to institutional and human change, the production of household goods and services, and firm/household interrelationships. These topics are frequently neglected in most current FSR. A review of previous holistic approaches to farm research and extension would therefore be valuable for current FSR practitioners.

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fields, in conjunction with on-station research. In on-farm experiments, the farmer and extension staff join the researcher in managing the experiments and evaluating the results.

In summary, FSR is an important tool for agricultural research institutions to use for increasing the effectiveness of their programs.[1] FSR is important both for identifying the broad, long-term research priorities of disciplinary and commodity programs as well as for planning and executing adaptive research to formulate recommendations for farmers.

Farming systems research programs are being undertaken by a variety of institutions throughout the world. Guatemala (Gostyla and Whyte, 1980), Honduras (Whyte, 1981) and Zambia (Collinson, 1982) are among several national programs utilizing the FSR approach. Moreover, many international agricultural research centers and bilateral donors are mounting FSR programs and promoting the use of FSR by national agricultural research institutions.

The International Maize and Wheat Improvement Centre (CIMMYT) has been active in developing FSR concepts and procedures for planning technologies for farmers.[2] CIMMYT promotes "on-farm research" with a farming systems perspective (OFR-FSP) which aims to generate higher-productivity technology for specific groups of farmers, especially in the short term. The program uses on-farm research methods, such as

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[1]Researchers in marketing management would view FSR as an example of the application of "the marketing concept" to a non-profit organization. The marketing concept states that the function of an organization is to match the production and services it offers to the needs and wants of the target consumers it serves (Kotler, 1980).

[2]CIMMYT's procedures receive special emphasis in this thesis since CIMMYT procedures were used in carrying out the research.

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farm surveys and on-farm experiments, and is conceptually based on a farming systems perspective (Byerlee, Harrington, and Winkelmann, 1982).[1] Figure 1.1 presents CIMMYT's view of an integrated research program and the role of on-farm research in the program. The on-farm research team plans new technologies, mounts experiments on farmers' fields, formulates recommendations, assesses farmers' experiences with the recommendations and promotes improved technologies through demonstrations. Moreover, the on-farm research team identifies problems for station researchers and policy-making bodies to address.

The planning stage, in which researchers obtain information for planning experiments to test new technologies, is the stage addressed by the research reported in this thesis. FSR practitioners tend to agree that the overall objective of FSR is to develop an understanding of the farm system in order to plan improvements in the system. However, there is much disagreement concerning methods of data collection and analysis, and the use of the results for planning experiments. CIMMYT economists have developed FSR methods and procedures which differ considerably from those used in farm management research carried out in most Third World countries (Byerlee, Collinson, et al., 1980). The approach, called the CIMMYT Diagnostic Survey in this thesis, includes the following steps:

1. Identification of recommendation domains (RD's) or farmer target groups. An RD is a group of farmers with a similar

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[1]The authors claim that a new acronym is required because of the increasing amount of confusion over the use of the term FSR. FSR is a very general term, they argue, and FSR programs have objectives, ranging from solving a specific problem to increasing the body of knowledge. They define OFR/FSP as a subset of FSR which emphasizes on-farm research methods to generate technology to increase productivity for a specified farmer group. In this study FSR and OFR/FSP will be used interchangeably to refer to the subset of FSR described above.


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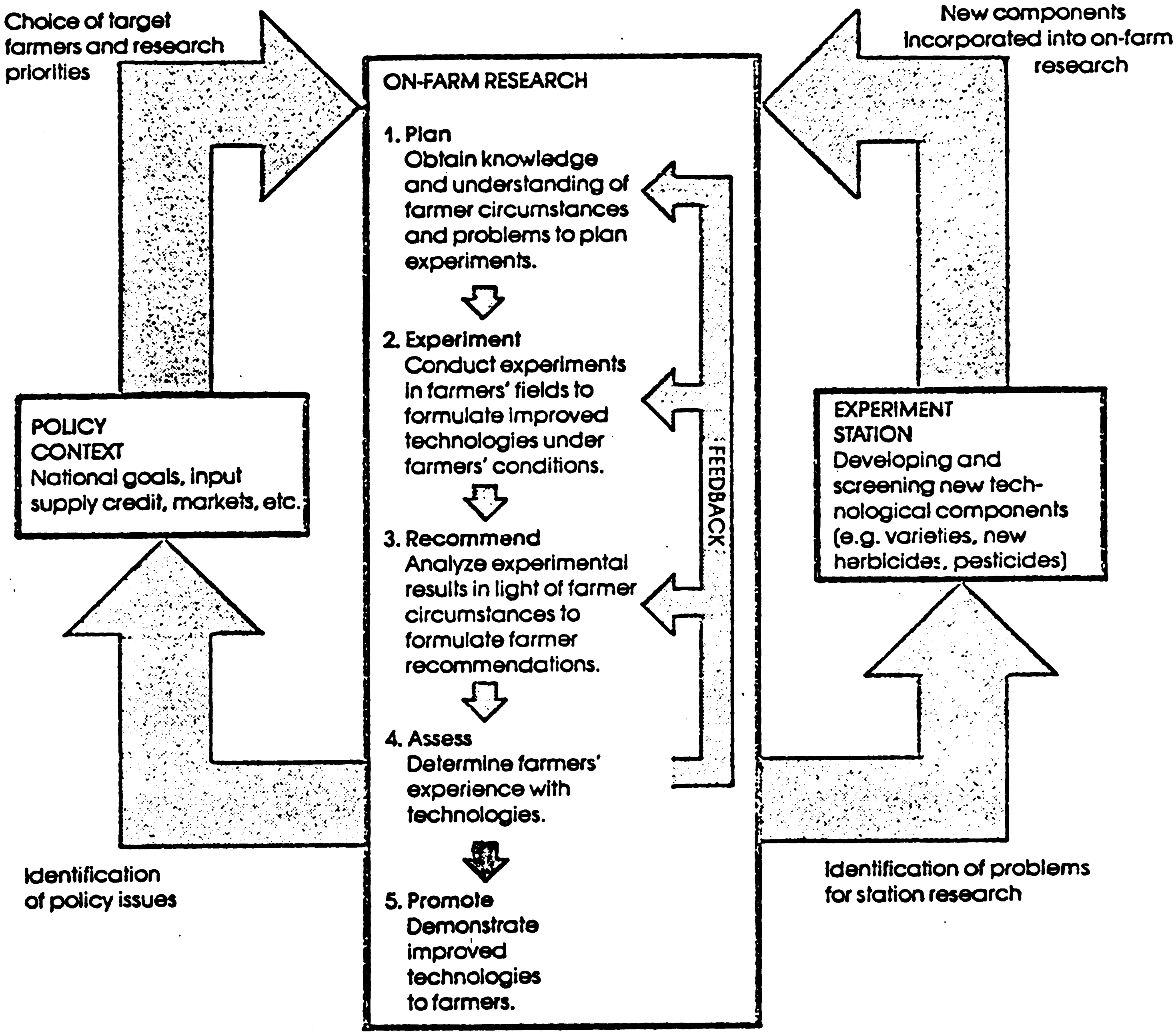
Figure 1.1 Overview of an Integrated Research Program



Source: International Maize and Wheat Improvement Center, Economics Staff, 1981.

farming system; that is, farmers in the group operate their farms in a similar manner under fairly homogenous eco-climatic and socioeconomic conditions. Thus, they have similar problems and similar development opportunities and it is likely that a given recommendation will be more or less applicable to all farmers in the RD. An exercise to identify RD's in a given area is useful for establishing the numbers and main characteristics of the different farmer groups. Policy makers can then decide which groups merit the attention of the research services.

2. Informal Survey. In an informal survey, a multi-disciplinary team of researchers using detailed but essentially unstructured guidelines holds informal interviews with farmers. The objectives are to develop an understanding of the farming systems, identify priority research topics, pre-screen possible new technologies for their introduction into the system, and plan the formal survey which follows.

3. Formal Survey. In a formal survey, a questionnaire is administered by enumerators to a random sample of farmers to verify the findings obtained in the informal survey and to measure important parameters in the system. Generally, the information is collected in a single visit to each sample farm.

4. Planning on-farm experiments. The purpose of the survey work is to plan on-farm experiments for farmers in the RD.

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Experiments are mounted under farmers' conditions and farmers participate in the planning, monitoring and evaluation of the results.

The CIMMYT Diagnostic Survey differs from most other FSR procedures[1] in five principal ways. First, objectives are focused on field experimentation. The purpose is to provide production researchers with information to help them plan technologies which will be acceptable to farmers and feasible for them to adopt in their existing environment. Thus, many institutional and policy variables are treated as fixed in the short run.

Second, the primary data collection instrument in the CIMMYT approach is the informal survey whereas the formal survey is the principal instrument in most other approaches.

Third, the CIMMYT approach gives more weight than many other FSR approaches to the collection of normative and prescriptive data,[2] such as data on farmers' attitudes, opinions, and reasons for employing particular practices. Less emphasis, relative to other FSR approaches, is placed on collecting quantitative, non-normative data such as levels of inputs and outputs.

Fourth, the CIMMYT approach does not use quantitative methods to model the farm system. Rather, an informal technique based on

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[1] Other FSR approaches include those of American universities administering FSR projects in Africa, e.g., Michigan State University in Senegal, Purdue in Upper Volta; Winrock Foundation in Kenya; West African Rice Development Association; and the International Center for Research in the Semi-Arid Tropics.

[2] Normative information is information about the goodness or badness of a condition, situation or thing. Prescriptive information concerns the rightness or wrongness of goals or acts and are always based on both normative and non-normative (or positive) information (Johnson and Zerby, 1973).

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developing an understanding of the farmer's perspective[1] through intensive interviewing and observations provides the "model" which is used to analyze the farm system and test the impact of proposed changes.

The fifth distinguishing feature of the CIMMYT procedures is that turnaround time is more rapid than in most other FSR approaches. A "complete" inventory of resources and input and output flows, based on data collection of one year or more, is not regarded as essential for planning experimentation for farmers. Rather, the CIMMYT procedures are sequential--at each stage the understanding attained is used to guide and focus data collection during the subsequent stage. Turnaround time ranges from three to six months, measured from the time researchers enter an area to the time detailed experimental plans are formulated and a survey report is issued.

CIMMYT's approach to FSR is considerably less holistic than certain other FSR and farm management approaches, because of several practical considerations. First, CIMMYT's mandate is limited to maize and wheat; thus, proposed improvements in CIMMYT surveys are generally limited to these two crops and related operations. Second, CIMMYT seeks to work through national agricultural research organizations; therefore, they require an approach which is flexible enough to accommodate the manpower and financial constraints which these organizations face. Unfortunately, these constraints often limit the holistic nature of the diagnostic survey, as when multi-disciplinary teams are reduced to only two or three members. Third, the approach generally avoids proposing changes in government policy, e.g., credit, land tenure, prices. There are two

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[1]Of course, several members of the household may be involved in making decisions on the farm. Thus, it is often incorrect to refer to the farmer in the singular, or as "he".

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reasons for this: (1) agricultural researchers generally have little influence over such policies and (2) most governments are more interested in obtaining assistance to promote the development of agricultural technologies than assistance to promote changes in their agricultural policies.

The procedures developed by the CIMMYT Economics Program are by no means a rigid recipe for mounting FSR. For example, the preface to the CIMMYT manual, "Planning Technologies Appropriate to Farmers: Methodologies and Procedures", states that CIMMYT's approach "has evolved from our experiences with farmers and researchers in many countries. We fully expect that these guidelines will be improved through the experiences of other researchers" (Byerlee, Collinson, et al., 1980).

1.2. Statement of the Methodological Objectives

The primary methodological objective of this study is to use and evaluate two methods, repertory grids and hierarchical decision-tree models, as supplements to the CIMMYT diagnostic survey for collecting and analyzing normative and prescriptive information about farmer decisions. The field of agricultural economics in general, and farm management in particular, has relatively little experience in collecing non-monetary normative and prescriptive data, compared to other disciplines in the social sciences. Collinson (1981a) argues that the CIMMYT informal survey is "almost an anthropological approach to understanding the farming system", referring to the need for examining farmers' values and for probing into the complex reasons underlying farmer practices. One possible area of improvement in the CIMMYT approach is the incorporation of tools from other disciplines for more systematic collection and ana

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and analysis of normative and prescriptive information. Repertory grid, first used by clinical psychologists, is a method for (1) eliciting from respondents the criteria they use in differentiating among items, e.g., alternative technologies, and (2) recording respondents' evaluations of how each item performs on each criterion. Hierarchical decision-tree models, used primarily by anthropologists, depict the decision process people use when considering alternative actions. Thus the two approaches assist the researcher in understanding the preferences and reasoning underlying the decisions farmers make.

Two secondary methodological objectives concern the quality of information gathered at different stages of the diagnostic survey sequence.[1] First, we test the effectiveness of the exercise for identifying recommendation domains. This exercise has two purposes: (1) to delimit RD's and (2) to provide some preliminary data on RD's in the study area. The method, a single-page questionnaire administered to local leaders, is admittedly open to a broad range of error. Collinson (1982) states that "it is important to emphasize that these [the RD's specified by the exercise] are preliminary groupings. As the diagnostic sequence is implemented within these identified target groups, the characteristics of each domain will be more fully understood." If the errors are significant, the exercise can be wasteful and misleading. This thesis will evaluate the quality of the information obtained in the exercise by comparing the information with that of the formal survey.

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[1] This is an important issue because national research institutions seek to lower the cost of diagnostic studies in terms of cash, time, and use of scarce skilled manpower. Evaluating the quality of data at different stages of the investigation and the impact of the differences on an experimental program can guide us in assessing the importance of each stage.

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Possible biases leading to incorrect information at the preliminary stage will therefore be identified and ex-ante corrective measures will be proposed.

Second, we evaluate the utility of the formal survey, by comparing its results with the informal survey results. As stated above, the primary purpose of the formal survey is to verify the findings of the informal survey. However, the formal survey is too expensive and time-consuming an exercise if it serves only to confirm informal survey findings. This thesis will examine the changes in the understanding of the farm systems and in experimental content which occur as a result of mounting the formal survey. We will then conclude whether a formal survey was indeed necessary and identify characteristics of a farm system which make the formal survey more or less necessary under differing circumstances.

1.3. Background to the Problem-Solving Objectives

Kenya's agricultural research system is relatively strong, compared to most African countries. In 1978, there were 255 Kenyan staff above the B.S. level and 96 expatriates on research stations throughout the country (Jamieson, 1979).

Since independence, there has been a shift of resources from cash crops to food crops, and from high potential areas to marginal areas, reflecting the government's efforts to change certain policies inherited from the colonial era. The research system has made some significant achievements in developing technologies for small farmers, most notably concerning pyrethrum and maize development (Heyer and Waweru, 1976).

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However, non-adoption and partial adoption of recommended technologies in Kenya is widespread and has been well-documented (Kariungi, 1977; Gerhart, 1975). The 1979-83 five-year development plan notes the lack of new technologies available for immediate adoption and the irrelevance of many research packages. The plan calls for reorienting research and extension towards alleviating production constraints in smallholder farming systems (Government of Kenya, 1979a).

With these policy objectives in mind, the Committee on Maize and Pasture Research of the Ministry of Agriculture recognized the potential usefulness of the farming systems approach and recommended that:

> KARI/SRD [Kenya Agricultural Research Institute/ Scientific Research Division] should lay more emphasis on problem identification of the zonal and farm level through diagnostic studies which take account of the physical environment and social and cultural attributes of the target population (Government of Kenya, 1980).

1.4. Statement of the Problem-Solving Objectives

This thesis holds that FSR is a more effective and efficient approach for developing small-farmer technologies than is the conventional yield-oriented approach. The general problem-solving objective of this thesis is to plan an adaptive production research program for farmers in Middle Kirinyaga. More specifically, the problem-solving objectives are to:

1. Describe farming systems in the study area.
2. Identify priority research areas for planning technologies appropriate for farmers. These are points of the system where changes can increase productivity and where such changes can be readily acceptable and feasible for farmers.

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3. Examine selected farmer decisions related to the priority research topics. These decisions are selected because an understanding of the issues involved will assist researchers in proposing new technologies and formulating recommendations for farmers.
4. Plan an adaptive production research program to develop technologies for farmers in the study area. Recommendations will also be made for planning technical research on research stations and for mounting extension programs in the area.

As stated above, this thesis addresses only one stage in the technology development process, the planning stage. Therefore, the thesis does not purport to solve any farmer problems, per se. Rather, our problem-solving objective is to help researchers solve their problem of planning biological and physical research to aid Middle Kirinyaga farmers. The researchers' problem is seen as one of making experimentation more effective in developing technologies for small farmers.

1.5. Overview of the Thesis

Chapter 1 presents the objectives of the thesis--both methodological and problem-solving--and the background to these objectives. Chapter 2 discusses the research design of this thesis. The chapter begins with a discussion of the objectives and attributes of the planning stage of FSR, highlighting the importance of understanding farmer decisions for planning new technologies. Theoretical contributions from managerial decision theory are presented which provide a framework for explori

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exploring farmer decisions. Some practical considerations in selecting an approach and methods are also examined. Next, approaches to understanding farmer decision-making are reviewed and their relevance to meeting the objectives of the planning stage of FSR are assessed. Finally the approach and specific methods used in this thesis are presented and discussed.

Chapter 3 presents the procedures for collecting data in this thesis. First the selection of Middle Kirinyaga as the study area and the delineation of recommendation domains in and around the study area are discussed. Next sampling methods, fieldwork procedures, and specific problems in mounting the informal survey and the formal survey are presented.

The survey results, a description of farming systems in Middle Kirinyaga, are presented in Chapters 4 and 5. In Chapter 4, natural and socio-economic features are described and farmer objectives and sources of income are examined. This is followed by discussion of the management of the farm system, resource use, and system constraints. In Chapter 5, we analyze selected farmer practices, focusing on the area's two principal crops, maize and beans. The chapter highlights strategies farmers use for meeting their objectives in the circumstances they face.

Chapter 6, which addresses the problem-solving objective of this thesis, presents an adaptive production research program appropriate for Middle Kirinyaga farmers. Criteria for selecting research priorities are discussed in the light of farmer practices, the context in which experiments will be mounted. Detailed discussions of two priority research areas and three areas of lesser priority are discussed for maize

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maize and beans. Comments are also offered on other crops. This section also presents some problem areas for the extension service to address in Middle Kirinyaga.

Chapter 7 addresses the methodological objectives of this thesis. Two methods from outside the field of Agricultural Economics--hierarchical decision modeling and repertory grid from Psychology--are evaluated as supplements to the CIMMYT diagnostic survey approach. This chapter also examines how the quality of data changes as one proceeds through the stages of the diagnostic survey sequence. The chapter includes proposals on the use of hierarchial decision-making and repertory grid in the CIMMYT approach, survey methods for identifying recommendation domains,and the use of the formal survey for verifying the results of the informal survey.

Chapter 8 summarizes the principal findings of the thesis. Suggestions for further research are also presented.

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CHAPTER 2

RESEARCH DESIGN

This chapter presents the approach taken and the methods used in this thesis for planning an adaptive production research program for small farmers. First, the objectives and main attributes of the planning stage of FSR are presented. Next, we discuss the analytical approach used to diagnose farmer problems, highlighting the importance of understanding farmer management strategies and decisions. The theoretical contributions of managerial decision theory for understanding farmer decision-making are examined; these serve as a conceptual framework for empirical studies examining farmer decisions. Also, some practical considerations in selecting an approach and methods are outlined, based on principles of the economics of information.

The methods selected for planning an adaptive agricultural research program are presented in the last section of this chapter. Three approaches to understanding farmer decision-making are reviewed. The cognitive, anthropological approach is identified as best suited to the objectives of this study. Specific methods include the CIMMYT diagnostic survey for obtaining an overall understanding of the farming system and repertory grid and hierarchial decision-tree modeling for examining selected farmer decisions in greater depth. In this last section, we also highlight the principal methodological issues to be addressed in this thesis.

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2.1. The Planning Stage of FSR

As stated in the previous chapter, the objectives of the planning stage of an integrated on-farm research program with a farming systems perspective are to develop an understanding of the farming system and to use that understanding to plan improvements appropriate for farmers. Understanding how the farming system functions--what farmers do and why--serves as a basis for identifying problems of farmers and evaluating the potential success of possible solutions.

There is a broad consensus among FSR practitioners on the attributes of FSR and in particular, the characteristics of the planning stage. While many of these attributes may also be found in other research programs, their combination distinguishes FSR from other approaches. These attributes, summarized below, are discussed in the principal works on FSR: Technical Advisory Committee, 1978; Norman, 1980; Gilbert, Norman and Winch, 1981; and Shaner, Philipp and Schmehl, 1982.

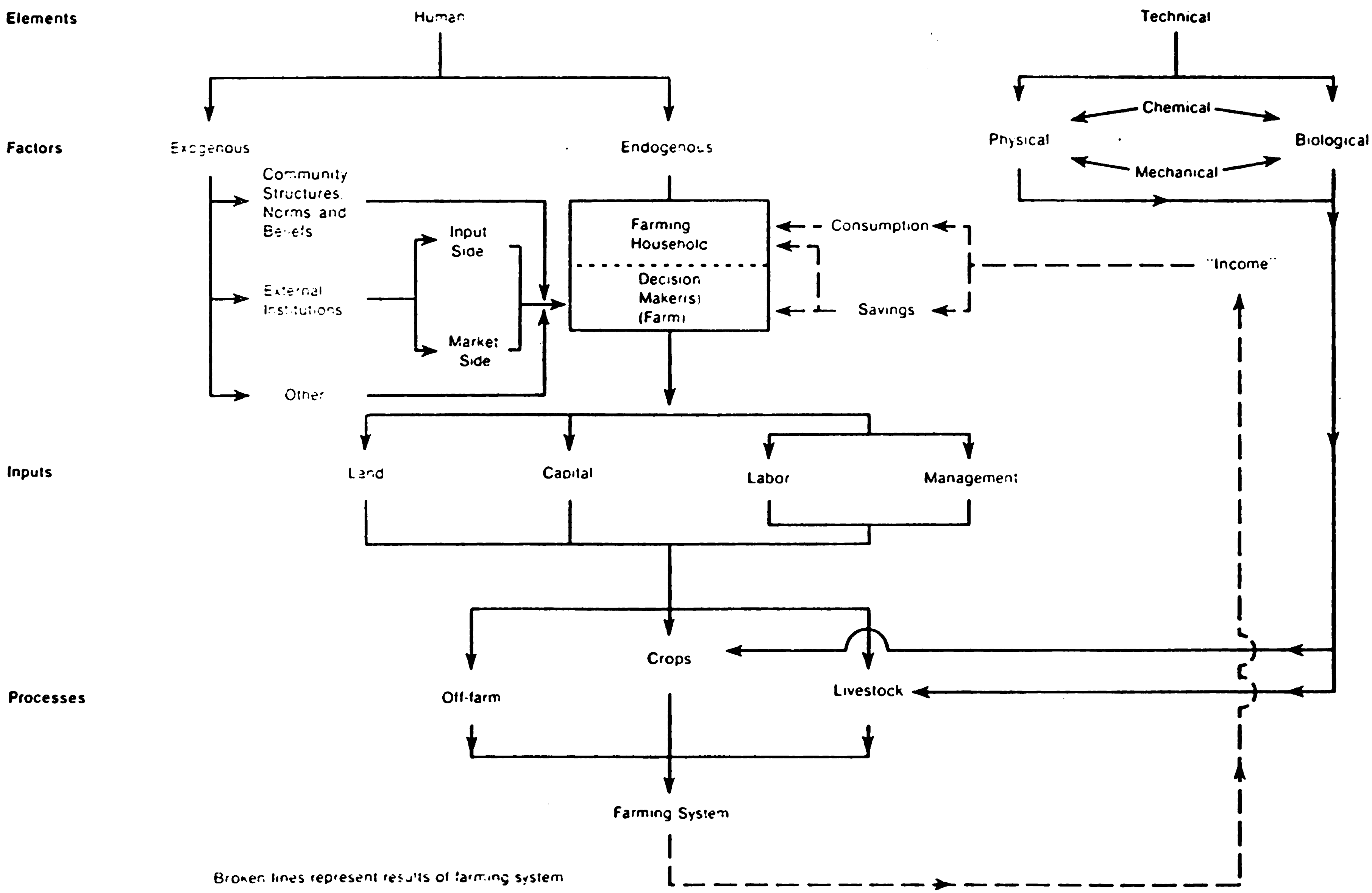
1. Farmer-Based. One of the principal functions of FSR is to strengthen the links between farmers and researchers. A presumption of the FSR approach is that it is difficult to introduce improvements to a system which is not well understood. Therefore, as a basis for developing new technologies, it is necessary to develop an understanding of the farmer's aspirations, environment, resources, constraints, and practices.

2. Holistic. Farming systems researchers begin by considering the farm family's activities--including crop, livestock, household, and off-farm processes--as a whole and analyzing the various elements which influence the farming system. Figure 2.1 presents a schematic representation of some possible determinants of a farming system. The figure

Elements

Figure 2.1 Schematic Representation of Some Determinants of the Farming System

Figure 2.1 Schematic Representation of Some Determinants of the Farming System



Source: Gilbert, Norman and Winch, 1981

highlights the importance of the human element, including both exogenous factors such as community structures, and endogenous factors such as the farming household's decisions. Moreover, the figure depicts the household as both a production and a consumption unit with interactions between the two.

Researchers use a holistic approach to focus on system interactions--the impact that particular elements of a system have on each other. For example, maize stover may be an important input into livestock production, and farmer practices concerning maize production may be influenced by the objective to produce stover as well as grain for human consumption. Another important type of system interaction is the production compromise; farmers are often prevented from managing a particular enterprise in what would be an ideal manner for it alone because they wish to allocate scarce resources over a wide range of enterprises or activities.

In actual practice, many FSR programs are not very holistic due to practical considerations. For example, in countries where skilled researchers are scarce, FSR teams may include only two persons. The team is likely to neglect many factors outside of its expertise which influence the farming system.

In using a holistic approach, FSR practitioners consider a fairly substantial array of possible improvements for any given group of farmers. This does not imply that all parameters are variables, or that all variables require the same degree of attention. Rather, it is likely that FSR researchers will quickly focus on particular commodities or operations because making improvements in that area will benefit the farmer. However, they must consider explicitly how the facet under study relates to other system components.

Many FSR programs fail to consider a broad range of improvements for the same reasons they lack holism. For example, a shortage of skilled manpower and the compartmentalization of research departments often limit the scope of improvements considered in FSR programs. Moreover, some claim that it is more efficient to limit FSR's focus in the short run to production improvements; policy, institutional and off-farm improvements may be incorporated into the approach at a later date when FSR has gained more experience and credibility.

3. Multi-disciplinary and Inter-disciplinary. Because of its holistic approach, FSR is multi-disciplinary. Specialists provide expertise from their respective disciplines on: (1) how the farm system functions, (2) what its key problems are, and (3) how to solve them. Most FSR researchers highlight the interaction between technical scientists and social scientists as critical to success. The technical scientist examines the biological and physical environment and evaluates farmer management of an enterprise in light of what ideal management should be. The social scientist examines the socio-economic environment, endogenous factors, and system interactions to explain why the farmer makes the decisions he does. Working together on a commonly defined research agenda, they prescreen possible solutions to farmer problems which will raise productivity and be both feasible and acceptable to the farmer. Thus, FSR requires "a multi-disciplinary team working in an inter-disciplinary manner", that is, specialists from several different disciplines working together using mutually understandable language to solve a particular problem (Gilbert, Norman and Winch, 1980).

4. Farmer-group Specific. Because of prohibitive costs, it is impossible to plan research for individual farmers in developing countries. Planning research for large regions, or even nationwide, is also impractical since such research glosses over important variations between and within areas. Farmers with similar farming systems have similar problems and opportunities; thus they require a common experimental program and set of recommendations. Therefore, a preliminary step in an FSR program should be to identify fairly homogenous farmer groups, or recommendation domains (RD's). The criterion for including farmers in a single group is whether a single set of recommendations would be generally appropriate for all members of the group. Farmer-group specificity should not be confused with area-specificity; it is farmers and not fields which make decisions on technologies. Thus, farmers of different RD's may be interspersed in a given area.

5. Flexible in Accommodating Technical and Non-Technical Improvements. FSR has been applied almost exclusively for identifying improved techniques in crop production. However, the approach can and is being used to identify other kinds of improvements--in infrastructure, policy, land tenure, etc.--needed for rural development.

6. Consistent with Societal Objectives. FSR is used to enhance the welfare of farmers within the guidelines of national policies and the long-term interests of society. On occasion, short-run measures to enhance farmer welfare may conflict with these policies and interests.

For example, hillside farmers may be guided by profit considerations to plant annual cash crops, causing severe soil erosion, at a time when national policy is seeking to minimize soil erosion. Because farming system researchers draw upon the objectives and considerations of both farmers and policy makers, they are able to identify solutions which will serve the interests of both groups. For example, in the above case, FSR researchers may seek to introduce relay and mixed cropping patterns which are profitable to farmers and conserve the nation's soil resources as well.

2.2. Analytical Approach

In the planning stage of FSR, researchers examine how the farmer allocates his scarce resources of land, labor and capital among competing enterprises to best meet his objectives. Key farmer problems are identified and technological alternatives are proposed. The following analytical approach was used in this thesis to develop an understanding of the farming system and to identify system improvements. The steps overlap significantly and are not necessarily undertaken in sequence.

1. Describe the Farmer's Environment and Environmental Constraints. An understanding of the environment and how it shapes the farmer's activities is essential for understanding the system and evaluating the appropriateness of proposed improvements. The aspects of the farmer's environment are: natural (e.g., rainfall, soils, topography), institutional (e.g., transportation, government programs), and social (e.g., ethnic group, societal values, family structure). In most cases, FSR does not seek changes in the environment but rather changes which the farmer can make given his environment.

2. Examine Farmer Objectives and Priorities. Collinson (1981) lists the objectives of small farmers as:

(a) meeting the social and cultural obligations of the community;

(b) providing a stable, reliable supply of food for the family;

(c) providing cash for basic needs;

(d) providing extra cash.

An understanding of the farmer's objectives and the relative weighting of each objective is required so that researchers can propose improvements which help him meet his objectives or, at least, are not inconsistent with them.

Specifically, researchers must assess farmer preferences concerning aspects of production and consumption alternatives (e.g., risk-yield tradeoffs, differing maturity length of varieties, storage decisions, and tradeoffs between farm investment and consumption). Researchers obtain information about farmers' preferences through interviews and inferences concerning enterprises farmers pursue, the choice of period to perform operations in enterprises, and when and how products from the enterprise are used.

3. Evaluate Resource Use and Constraints. The farmer has limited amounts of land, labor and capital resources at his disposal; how he allocates and uses them are key elements to understanding how the system functions. Comparing resource use to resource availability helps the researcher identify farmers' resource constraints and priorities. The researchers understand how a single enterprise should ideally be managed in order to maximize returns to that enterprise. They then examine how enterprises and consumption opportunities compete for resources in order to explain the compromises made by farmers combining enterprises.

4. Examine Farmer Management Strategies. The analysis of farmer management strategies pulls together the information thus far collected--how farmers seek to allocate their resources to best achieve their

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objectives given the environmental constraints they face. Collinson (1981b) states that farmer management strategies are

> . . . devices for reconciling the satisfaction of a variety of priorities with resource limitations and uncertain production circumstances. Identifying farmers' management strategies, understanding how they satisfy farmers' priorities and how they compromise production methods is a prerequisite for evaluating new techniques proposed for the system.

5. Identify Leverage Points and Propose System Improvements

When proposing improvements, the researcher must adopt the farmer's perspective on the problem and help the farmer improve on the strategy he is already following. Leverage points are points in the system where there is scope for increasing productivity in ways that are likely to be acceptable and feasible for the farmer. Possible leverage points in the crop sub-system include the method and timing of a cultivation operation and the type of inputs, varieties and enterprises. At leverage points, a problem exists and there are potential solutions to the problem, e.g., by using a new input, changing the timing or method of an operation, or introducing a new enterprise.

This analytical approach is used to examine farming systems in Middle Kirinyaga in this study. The results are presented in Chapters 4 and 5. Proposals for system improvements are discussed in Chapter 6.

2.3. Theoretical Contributions from Managerial Decision Theory

FSR and the analytical approach used in this thesis both highlight an understanding of farmers' decisions. Several sets of concepts from managerial decision theory (Johnson, 1961) provide a useful perspective for examining farmer decision-making processes. These sets of concepts are (1) information classifications for decision-making, (2) steps in the decision process, and (3) knowledge situations.

The first set of concepts presented here is useful for classifying information people use in making decisions. Three information areas may each be broken down into two information types: (1) normative information--information on values, i.e., goodness or badness and (2) positive information--non-normative information, i.e., information on what is or what will be. Further, each information type may be broken down by tense--information on the past, present or future. Thus, information used in making decisions can be categorized in a 3 x 2 x 3 matrix.

The decision maker draws upon information from this matrix to make prescriptions on the rightness or wrongness of an action or goal. A right action or goal is the "best" action or goal, best meaning "that indicated by the value beliefs involved in view of what the factual beliefs involved indicate is possible" (Johnson, 1961). Prescriptions are always a function of both normative and positive information.

The set of concepts on how decision makers perceive reality implies a rational model of decision-making but does not rule out irrational or inconsistent concepts, goals and actions. Moreover, no restrictions are placed on how beliefs about normative and positive information are formed. The model is useful because it instructs us that we must collect both normative and positive information if we are to develop an understanding of farmer decisions. It also shows us that information on farmer prescriptions is useful for understanding how the farmer uses normative and positive information to formulate opinions on the rightness or wrongness of an action. Of course, whether or not the farmer

takes the action that he prescribes is a function of his intentions and many other factors in the farmer's environment--constraints he faces, his own personal initiative, and chance circumstances.

The breakdown of the decision process into steps is a second development in managerial decision theory for examining farmer decisions. The steps include problem definition, observation, analysis, decision, action, and acceptance of responsibility. Indeed, the very process of generating recommendations for farmers is an attempt to reduce the cost to the farmer of several of these steps, especially problem identification, observation and analysis (Harrington, 1980).

A third useful concept in managerial decision theory is that of knowledge situations. Managers acquire information to arrive at decisions, as stated previously. Increments of information have increasing marginal cost and decreasing marginal value; thus some point exists at which marginal costs and returns are equal. The following five states of knowledge explain alternative situations managers face in making decisions:

1. Certainty: The manager considers his present knowledge adequate for making a decision. He has no interest in acquiring further information.

2. Risk: The manager regards present knowledge as adequate for making a decision and the cost of additional knowledge is equal to its value.

3. Learning: The manager feels that he does not yet have enough information to make a decision. The value of learning additional information exceeds the cost of obtaining that information.

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4. Inaction: The manager feels that he does not have enough information to make a decision and that the cost of additional information exceeds the value of that information. Therefore, no action is taken.

5. Forced Action: The manager would be in some other knowledge situation if it were not for some outside force which made it necessary for him to reach a decision.

The recognition of knowledge states requires us to include the acquisition of information in our model of decision-making. For example, in a case where farmers know about a maize variety and 20 percent of the farmers are using the variety, we might conclude that 20 percent of the farmers have decided to use the variety and 80 percent have rejected it. This analysis may be correct, but some users may be in the certainty state, others may be in the risk state, and still others in the forced action state. Those not using the variety could be in any of the five states. Which states farmers are in will have important bearing on our technology planning. For example, if most non-users are in the certainty or risk states, the variety is not appropriate for these farmers. However, if most non-users are in the learning or inaction stage, the problem may be an extension problem. Thus, the concept of knowledge states enriches our understanding of the reasons behind farmer decisions and strategies.

2.4. Some Practical Considerations in Selecting Methods for Data Collection

Research institutions generally face a number of constraints in planning experimentation--most notably, lack of trained manpower, budget limitations, and the time period available to report survey results. Therefore, it is necessary to design a program of data collection to accommodate these constraints. Clearly, the planning team must seek to collect the minimum amount of data needed to plan experimentation which will likely provide benefits to the client population. Further, the data must be collected and analyzed in the most efficient manner possible, minimizing the use of trained manpower, budget costs, and time. Ideally, researchers continue collecting data until the marginal returns of collecting additional data are equal to the marginal cost.

A holistic, multidisciplinary FSR approach appears to be inconsistent with efforts to minimize costs and accommodate manpower and financial constraints. However, empirical findings on how farmers adopt changes limits the scope of the objectives of an FSR program, and thus its costs (Byerlee, Harrington and Winkelmann, 1982). Small farmers, characterized by capital scarcity, risk aversion and possessing a healthy degree of skepticism, generally change in relatively small steps, adopting one or a few relatively minor changes at a time, rather than seeking to transform their system of farming all in one step (Mann, 1977; C. Gladwin, 1979; Gerhart, 1975).[1] Therefore, the objective of the FSR approach in the short run should be to develop a few system improvements which require relatively small degrees of change on the part of the farmer. To accomplish this, researchers should use data collection procedures which help them to efficiently identify a few worthwhile changes and develop a sufficient understanding about the farming system and

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[1]This is not to denigrate the "package" concept in technology diffusion. Indeed, the issue of package recommendations versus the single recommendation approach is a red herring; the issue is the degree of change implied by a single recommendation or set of recommendations, not the number of changes (Collinson, Personal Communication).

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A sequential approach to collecting data, in which data collection at each stage is increasingly focused on priority problems, is more efficient than setting out from the start to collect a complete data set on stocks and flows of inputs and outputs. Researchers using a sequential procedure begin by developing a broad overview of the farming system and then focus on a few variables at leverage points. At each stage, an iterative procedure is followed: researchers collect and evaluate data to decide what additional data are required. Thus, at each stage, data are used to refine one's understanding and establish hypotheses which in turn are used to further focus data collection and eliminate issues and topics which are not relevant. Throughout the exercise, researchers are weighing the value of additional information against the costs of obtaining that information (Byerlee, Harrington and Winkelmann, 1982).

Two other practical considerations are also important in selecting FSR planning methods. First, the methods should be conducive to multidisciplinary team work, that is, they should be readily comprehensible to all team members so that each can play a role in contributing to the objectives of the FSR exercise. Second, the methods should be readily comprehensible to policy makers; if they can understand the process by which results were obtained they will have greater confidence in those results.

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2.5. A Review of Approaches to Modeling Farmer Decision-Making

Thus far, we have described the principal aspects of FSR, presented an analytical approach for identifying system improvements, and discussed some theoretical and practical considerations for developing an understanding of farmer decisions and the farming system. In this section, we review broad approaches to modeling farmer decisions and select an approach suitable to meet our objectives. In the following sections, we present specific issues we will address in using this approach for developing our understanding of the farming systems and identifying system improvements.

Broadly, there are three different approaches to understanding farmer decisions which are found in farm management literature on developing countries. The three approaches and examples from each are presented below.

1. Multivariate analysis approach. Adoption and diffusion studies commonly use multivariate analysis to examine farmers' decisions. In these studies researchers correlate the outcome of a decision to characteristics of individual or groups of adopters (e.g., age, zone, access to extension, characteristics of village leaders), usually using multiple regression. Exploring the association between specific characteristics and adoption is useful for identifying the factors which promote and inhibit adoption. Examples of multivariate analysis studies include Gerhart's study of hybrid maize adoption in Western Kenya (Gerhart, 1975) and comparative diffusion research by Rogers, et al. (1970). Scientists from a variety of disciplines--geography, economics, communications--use multivariate analysis for explaining farmer decisions.

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2. Behavioral Approach. Researchers using this approach establish a choice criterion, such as maximization of profit subject to a number of constraints, and test the hypothesis that farmers make decisions which are consistent with the outcomes of these models. Further, behavioral models are also used to identify constraints, evaluate the impact of new technologies and policy changes on the farming system, and identify and evaluate farmer management strategies (Eicher and Baker, 1982). Behavioral models are used most often by economists and particular methods include response functions (Wolgin, 1975), utility function analysis (Walker, 1980), linear programming (Heyer, 1972) and systems simulation (Crawford, 1982).

3. Cognitive Anthropological Approach. Advocates of this method assume that the farmer's own perspective of the world around him is the best starting point for model building (H. Gladwin, 1979). Intensive, informal interviews are used to develop an understanding of the criteria farmers use in making decisions and the management strategies they pursue. Greater emphasis is given to collecting normative and prescriptive information than in the other two approaches. Examples of the cognitive anthropological approach include participant observation (Hill, 1972), hierarchial decision modeling (C. Gladwin, 1976) and repertory grid (Baldwin, 1977). The CIMMYT diagnostic survey procedures also rely heavily on this approach.

For the purpose of developing an understanding of farmer decisions and management strategies and using this information for planning production research, the third approach, the cognitive anthropological approach, is the most useful.

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Multivariate analysis studies are important for gaining a broad overall view of adoption patterns. Furthermore, they often are able to pinpoint strong associations which may be used to understand why adoption does or does not take place. For example, Gerhart found a strong correlation between climatic zone and adoption of hybrid maize in Western Kenya. Using supplementary rainfall and experimental data he showed that available hybrids were simply not suitable for certain areas. But regression studies investigate association of farm and farmer characteristics with adoption, not causation of adoption. Therefore, they cannot generally be used to explain the reasons why farmers take particular decisions, reasons which may be fairly complex. For example, education is a common variable in regression equations to "explain" adoption. But lack of education is rarely ever a reason for non-adoption; rather it is a proxy for other possible causes of non-adoption: inability to read instructions, less willingness to experiment, less exposure to media, etc. In fact, there is usually a very weak link between independent variables and dependent variables in regression equations which "explain" adoption. Certainly, we are in the dark about which policy measures would be most effective if we do not know the actual causes of non-adoption.

Regression equations are especially poor in explaining adoption when independent variables are used as proxies for farmer attitudes, such as risk. For example, Gerhart sought to associate the area planted to some well known insurance crops (cassava, groundnuts, sorghum and millet) with the decision to adopt hybrid maize, in order to test the importance of risk in inhibiting adoption. The proxy is questionable, as Gerhart acknowledges, since the insurance crops may be grown for a variety o

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variety of other reasons, many yield differently in different areas, etc. Furthermore, Gerhart points out that even if the proxy is acceptable, the association tells us nothing about the nature of the risk farmers perceive--losing their seed investment in a drought year, exposing themselves to more variable returns, etc. Thus, information from multivariate studies is not sufficient for developing an understanding of farmer decisions and management strategies necessary for identifying potential system improvements.

Behavioral models, seeking to confirm whether farmer behavior is consistent with certain choice criteria, also oversimplify the actual decision criteria farmers consider when making a decision. Expected utility modelers, for example, derive utility functions for farmers which establish the farmers' preferences of tradeoffs between risky high-paying options and more stable, low-paying ones (O'Mara, 1971; Walker, 1980). Disregarding the host of measurement problems encountered (Petit and Dijon, 1980; Young, et al., 1979), the model tells us little about sources of risk and other factors besides risk which affect decisions.

Other behavioral model approaches have similar pitfalls. Some researchers use production functions to compare existing resource allocation with optimal allocation, and infer that the difference is due to risk aversion (de Janvry, 1972). The problem in this case is that a multitude of other factors may be involved (Young, et al., 1979). Linear programming and systems simulation may be useful, if costly, methods for modeling the system and testing the effects of including new technologies or enterprises in existing farm systems. However, these models are based on, and are not substitutes for, an understanding of the fa

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of the farming system. How this understanding is obtained is not often made clear; "understanding" generally appears to come through ex-post analysis based on farm modeling (Byerlee, Harrington and Winkelmann, 1982). In any case, behavioral models tend to sidestep examining the actual reasons which farmers have for making decisions and instead, test whether the outcome of the decision is consistent with certain general behavioral choice criteria.

Researchers using behavioral models are generally guided in their data collection efforts by the input-output framework. As comprehensive as this approach may appear it is often found lacking. Informal methods of intensive interviewing and observation are needed to penetrate the relationships and patterns of activities which lie beneath the surface of input-output data (Haugurud, 1979). Researchers using the cognitive anthropological approach emphasize understanding the logic behind production decisions rather than gathering facts about production. "Knowledge of farmers' reasoning is as necessary an input to a successful rural development project as is agronomists' or economists' reasoning from a distance" (C. Gladwin, 1979).

An understanding of "farmers' reasoning", the key element in the analytical approach adopted for this study, can best be developed using the cognitive anthropological approach.[1] For example, farmers in Middle Kirinyaga are divided over the issue whether the best time to plant maize and beans is before or after the rains begin. The agronomist may have his own opinion, but he needs to understand the farmer's perspective

[1]However, we do not contend that the cognitive anthropological approach is always useful for explaining farmers' reasoning. Indeed many actions and decisions may not be subject to analysis using any approach. For example, farmers may not be able to explain why they plant in a particular manner or why they use a particular variety.

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and the flexibility farmers have in order to decide whether time of planting is a leverage point and what research opportunities are associated with it. Farmers in Middle Kirinyaga point to many advantages and disadvantages to planting at each of the two times--before or after the rains begin. Some of the disadvantages can be characterized as risks, whereas others are fairly certain results of planting at a particular time. When the farmer actually does plant is a function of when he intends to plant and any external forces which interfere with his intentions. Sifting through the various criteria he regards as important and understanding the reasoning he uses, cannot be accomplished using a multivariate or behavioral model. These models can indirectly provide important clues of association or possible outcomes of alternative decision paths, but they are not substitutes for the informal, analytical approach for developing an understanding of the farmer's perspective and using this understanding to identify research opportunities.

2.6. Issues Concerning the CIMMYT Diagnostic Survey

The principal method selected for this study is the CIMMYT diagnostic survey, outlined in Chapter 1. The diagnostic survey has several practical advantages:

1. It is relatively inexpensive to implement in terms of time, finances, and manpower. A team of researchers, two at a minimum, can identify recommendation domains and complete an informal survey in one to two months. A formal survey can be completed and data analyzed in an additional two to four months.

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2. The method uses a sequential data collection procedure to focus on important issues as described in Section 2.4. During the informal survey, researchers evaluate the data collected and reformulate data needs on a daily basis. By the end of the informal survey, leverage points are identified and system improvements are proposed.

3. Interview procedures are informal and data collection and analysis techniques are easy to learn. Thus, the method is conducive to multi-disciplinary teamwork and can be easily understood by policy makers.

Examples of diagnostic surveys being used for planning experimentation include: International Maize and Wheat Improvement Centre (1979), and Shumba (1981). Successful results, measured in terms of farmer adoption of technologies proposed in diagnostic surveys, are reported in Moscardi (1982).

Three important issues concerning the CIMMYT diagnostic survey are presented below. The first two issues concern the methodological objectives of this thesis: (1) the collection and analysis of normative and prescriptive information in the CIMMYT diagnostic survey and (2) the advantages and disadvantages of including an RD-identification exercise and a formal survey in the CIMMYT approach. The third issue, that the CIMMYT approach is relatively less holistic than many other FSR approaches, is presented in order to qualify the problem-solving results of this thesis, that is, the adaptive research program developed for Middle Kirinyaga.

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2.6.1. Collecting Information on Farmers' Values and Decisions

A key issue in mounting a CIMMYT-style diagnostic survey is how to collect the relatively large amount of normative and descriptive information--information on farmers' values and decisions--which is required. The call for more emphasis on these kinds of information for understanding decision processes in farm management is by no means a new one.[1] However, farm management and farming systems research in LDC's still emphasize collecting positive data on inputs and outputs, from which normative and prescriptive information are extrapolated. The reasons behind this tendency are not difficult to ascertain. First, farm management work in the U.S. and Europe tends to be positivistic and this approach has been transferred to LDC's. Second, rewards in terms of salaries and prestige among peers are earned on the basis of using the most sophisticated quantitative methods, often with little consideration as to their role in solving problems. Third, communication is difficult between researchers (whether expatriate or local) and farmers, and it is easier to "measure" than to communicate. Fourth, conceptual and semantics problems, which seriously affect the collection of positive data, are even more troublesome in the collection of normative and prescriptive data. Fifth, many agricultural economists seek to mimic the positivistic approach to research which they observe among other agricultural scientists. Thus, they shy away from the study of values, objectives, decision processes, and prescriptions, labeling such studies as "unscientific".

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[1] See, for example, Johnson, 1961.

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The CIMMYT approach and other similar approaches, e.g., Hildebrand (1981) and Bartlett and Umearokwu (undated), use informal, direct interview methods for developing an understanding of farmer values, prescription and the reasons behind farmer decisions. Farmer responses are corroborated by direct observation, and intensive reasoning is used to piece together why farmers do what they do. Unfortunately, the approaches provide little systematic direction on how to identify and evaluate the criteria which farmers use in making decisions. At preliminary stages of the assessment of the farming system, supplementary tools for investigating farmer decisions are probably not necessary. But once leverage points are proposed, researchers need a fairly detailed understanding of farmers' reasoning behind the decisions they make concerning the leverage point. For example, maize variety is a proposed leverage point in this study, as discussed above. Using the CIMMYT approach, researchers would ask the farmer why he plants the varieties he plants as opposed to other alternative varieties. They may also ask about the farmer's past experiences, and test hypotheses on relationships between varieties planted and other variables of the system, e.g., farm size, income level, etc. However, a host of problems may confront the researcher at this point. A farmer may give more than one reason for why he plants or does not plant a particular variety and if a list of possible reasons is presented to him to consider, the number of reasons would certainly increase. Second, two farmers may give the same reasons for planting different varieties; that is, they disagree about some positive characteristic of the varieties. Moreover, constraints and chance occurrences may prevent farmers from planting the variety they want to plant. Unless a fairly uniform set of responses

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responses is obtained, the situation can become quite confusing. It is in these cases that it would be useful to have easy-to-understand, systematic tools for rapidly assembling the information on values and prescriptions and for modeling the decision so as to better understand the farmer's reasoning.

This thesis will use and evaluate two methods, Repertory Grid and Hierarchical Decision Models, as supplements to the CIMMYT Diagnostic Survey, for eliciting and evaluating normative and prescriptive information on farmer decisions. These methods come from the disciplines of psychology and anthropology, respectively, which have relatively more experience in collecting and evaluating such information than does agricultural economics. The theoretical underpinnings and proposed contributions of the two methods are discussed below, in Section 2.7.

2.6.2. The Utility of an RD-Identification Exercise and a Formal Survey

Utility of the RD-Identification Exercise

During the initial stages of an investigation, researchers are interested in gathering preliminary information about farmers in order to demarcate RD's, to develop a preliminary understanding of farmer circumstances in each RD, and to identify appropriate data collection methods to use in ensuing stages. Few farming systems studies use primary data collection methods to meet these objectives. Rather, most researchers rely on secondary information and "reconnaisance surveys", i.e., informal discussions with farmers and persons knowledgeable about the area. Formal data collection exercises at this stage are shunned because they are expensive and time consuming, and because in initial stages o

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stages of an inquiry the researcher does not know enough about the area he is interested in to develop a suitable questionnaire.

However, Collinson used a single-page questionnaire survey of extension agents to identify RD's in Central Province, Zambia (International Maize and Wheat Improvement Centre, 1979). He concluded that the method is a low-cost and effective, albeit preliminary, means of identifying RD's and providing information about them. However, no formal technique was used to arrive at this conclusion. In this thesis, we compare the information obtained in the exercise identifying RD's with the information obtained in the formal survey which followed. We assume that if the information and RD's based on the formal survey are similar to those developed in the RD-identification exercise, then the exercise is an effective means of gathering preliminary information about RD's.

Utility of the Formal Survey

The role of the informal survey in farm management investigations in developing countries has increased in importance in recent years, relative to the formal survey. Shaner, Philipp and Schmehl (1982), comment at length on the advantages and disadvantages of informal methods. The principal advantages are that it promotes free and in-depth discussion of problems and issues and that it helps the researcher to get acquainted with local words, concepts and ideas. On the other hand, its principal disadvantages are that it is non-random, and that because questions are not standardized, quantification is difficult and results are less reliable. The authors conclude that researchers must be "cautious in generalizing from informally collected data." Thus,

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they seem negative about using informal surveys as a basis for planning experimentation, except in special cases when problems and opportunities are so apparent that formal methods of data collection are unnecessary.

Other farming systems researchers view the informal survey as being a generally effective and sufficient measure for gathering information about farmers to plan agricultural experiments. They argue that, whereas a formal survey may increase the accuracy and precision of information, the increased costs, measured in terms of time as well as resources, outweigh the value of the increased benefits. Hildebrand's Sondeo (Hildebrand, 1981) and Gathee (1979) provide examples of using an informal survey to plan experimentation.

Collinson occupies a middle ground between those arguing that only the informal approach is required and proponents of the formal survey. On the one hand, the informal survey is the "pivotal" step in the diagnostic approach, but on the other hand, he generally advocates mounting a single-visit formal survey to verify the information gathered in the informal survey (Collinson, 1982).

Little work has been done to formally compare the information and implications for research from informal surveys with those of the ensuing formal survey for the same group of farmers. Indeed, if the formal survey exercise does not lead to significant improvements in the accuracy of information and the design of experiments appropriate for farmers, one can argue that it is superfluous. In this thesis we compare the data and the proposed experimental program developed in the informal survey with those developed from the formal survey in order to examine the utility of mounting a formal survey.

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2.6.3. Holism

A principal weakness of the CIMMYT approach, as practiced in Eastern Africa, is that it tends to be less holistic than certain other FSR and farm management approaches. Typically, multi-disciplinary teams mounting CIMMYT diagnostic surveys include only agricultural scientists and economists, excluding sociologists, rural non-farm enterprise specialists and others who have expertise on rural development. Thus, it is not surprising that leverage points in these surveys almost exclusively involve agricultural production inputs or operations. Moreover, relatively little attention is given to such topics as household-firm interactions, marketing and credit networks, and other factors influencing the farming system.

The approach used in this thesis is subject to the above weaknesses. The team was composed of an economist and an agronomist, with only limited input from other agricultural scientists. Leverage points were heavily weighted towards experimentation on maize and beans, the area's two principal crops. The researchers sought to analyze how household processes influenced production processes but certainly lacked the expertise of rural sociologists or human ecologists in addressing such questions.

In our case, a more holistic approach was an ideal towards which we strove but which we were prevented from fully attaining by three principal considerations. First, skilled researchers are in scarce supply in Kenya, making it difficult to recruit researchers to participate in survey exercises. Second, logistics and financial constraints limited the size of the team. Third, we had no formal access to policy makers outside of production research so we chose to limit our proposals to

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to those concerning production research. However, we believe that there were sufficient incremental benefits to mounting an FSR exercise with only two team members and focusing only on agricultural production research to warrant the costs of the exercise. Ideally, we recognize that the make-up and focus of the team should be much broader than it was in our case.

2.7. The Repertory Grid (RG) Technique and Hierarchical Decision-Tree Models (HDM)

In this thesis, we evaluate the incorporation of two techniques, RG and HDM, into the CIMMYT diagnostic survey for assembling and analyzing data about farmer values and decisions. These techniques are described in detail below.

2.7.1. The Repertory Grid Technique

Repertory grid is a method from cognitive psychology which seeks to elicit and measure people's perceptions of their environment. The method was developed by clinical psychologist G. A. Kelly in the 1950's as a therapeutic procedure, based on his human "personal constructs" theory.[1] This theory holds that individuals build conceptual models, based on their own experiences, which are used to guide their future actions. In these models, an individual arranges features of his perceived environment, called "elements", by discriminating on the basis of attributes into bi-polar scales which express meaningful contrasts. These scales are called "personal constructs".

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[1]A detailed presentation of Personal Construct Theory is beyond the scope of this paper. A brief sketch is given here only to acquaint the reader with its basic precepts. A summary of the theory is found in Bannister and Mair (1968).

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For example, an individual may perceive a set of elements called "bean cultivars" because they have a set of similar attributes which separate bean cultivars from other sets of phenomena. He evaluates them through his own personal constructs, with bi-polar scales for each attribute, e.g., high yielding-low yielding, good tasting-bad tasting, etc. How these constructs are built into mental models is the subject of further work (Bannister and Mair, 1968).

Repertory grids are matrices of scores for a set of elements across a set of constructs. Elements and constructs are generally elicited from individuals themselves to minimize interviewer bias. Elements are rated on each construct using a consistent procedure. The resulting matrix describes an individual's repertory of feelings about a set of elements. An example of a repertory grid for evaluating farmer opinions of alternative bean cultivars is shown in Table 2.1.

Table 2.1

Sample Repertory Grid of Important Attributes of Bean Cultivars[a]

	Cultivar 1.	Cultivar 2.	Cultivar 3.
Yield in Season of Sufficient Rainfall	4	4	3
Yield in Season of Low Rainfall	1	1	2
Storing (Without Insecticide)	3	3	4
Taste	5	3	5
Price	2	2	4
Disease Susceptibility	1	3	1

[a]Ratings: 5 = excellent, i.e., variety performs very well.
1 = poor, i.e., variety performs poorly.

Source: Data are hypothetical.

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Repertory grids have been used by researchers in a number of fields other than clinical psychology, e.g., market research (Hudson, 1974) and urban geography (Harrison and Sarre, 1975). This author knows of two applications of this technique to agricultural development in less developed countries. Townsend (1975) examined how farmers in a Colombian settlement project perceived of their own farms in contrast to other farms, such as the "best" farm they knew, a particular neighbor's farm, etc. Floyd (1977) used a similar approach in Trinidad. Both researchers reported that the method is useful for developing an understanding of how farmers view the circumstances they find themselves in and the priorities they have for improving their situations. Further, Baldwin (1977) examined the perceptions of English tomato growers towards past technological improvements in tomato production. Solving farmers' problems was not the objective of any of these three applications of repertory grid to agriculture. Rather, the researchers were concerned with using the technique to understand how farmers perceive their world around them.

In this thesis, repertory grids will be constructed to identify the criteria farmers use in deciding among selected technological alternatives concerning leverage points. In the early stage of the field work, four potential leverage points were selected where it appeared that repertory grids could be useful in obtaining farmers' appraisals of available technological alternatives at these leverage points. Repertory grids were constructed using samples of 5 to 15 farmers and the important aspects concerning the set of alternatives were elicited from the farmers themselves. During the formal survey the grids were c

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constructed for randomly selected farmers, using the aspects identified in the formal survey.

2.7.2. Hierarchical Decision-Tree Models

The hierarchical decision-tree model (HDM) is the second method to be tested in this study as a supplement to the CIMMYT diagnostic survey. HDM's present the decision process in a tree form, with decision criteria at the nodes, or branching points, of the tree. HDM's are used by researchers in a number of disciplines, including anthropology, psychology, and economics, to model decisions made by individuals.

The underlying theory behind HDM is that "people in choosing alternatives, do not make complex calculations of the overall utility of each alternative. Rather, people tend to use procedures which simplify their decision-making calculations," due to their inability and/or unwillingness to process all information available to them (C. Gladwin, 1979). Indeed, social scientists are becoming increasingly concerned with the simplifying procedures which individuals use in making decisions. For example, in a review of behavioral decision research across a number of disciplines, Slovic, Fischoff and Lichtenstein (1977) claim that

> . . . whereas past descriptive studies consisted mainly of rather superficial comparisons between actual behavior and normative models, research now focuses on the psychological underpinnings of observed behavior.

Researchers examining simplifying procedures in decision-making include Tversky (1972), Simon (1969), and Abelson (1976).

HDM is an important approach to modeling the simplified decision process which individuals use. The model is built in the following manner. First, intensive interviewing is used to elicit decision criteria from r

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from respondents. Farmers who have not yet made a decision, i.e., are in the "learning" or "inaction" knowledge state, are excluded from the analysis. The criteria are then grouped into three categories:

1. Orderings of alternatives on some attribute (e.g., "in a season of sufficient rainfall, is the yield of variety 'a' greater than that of variety 'b'?");

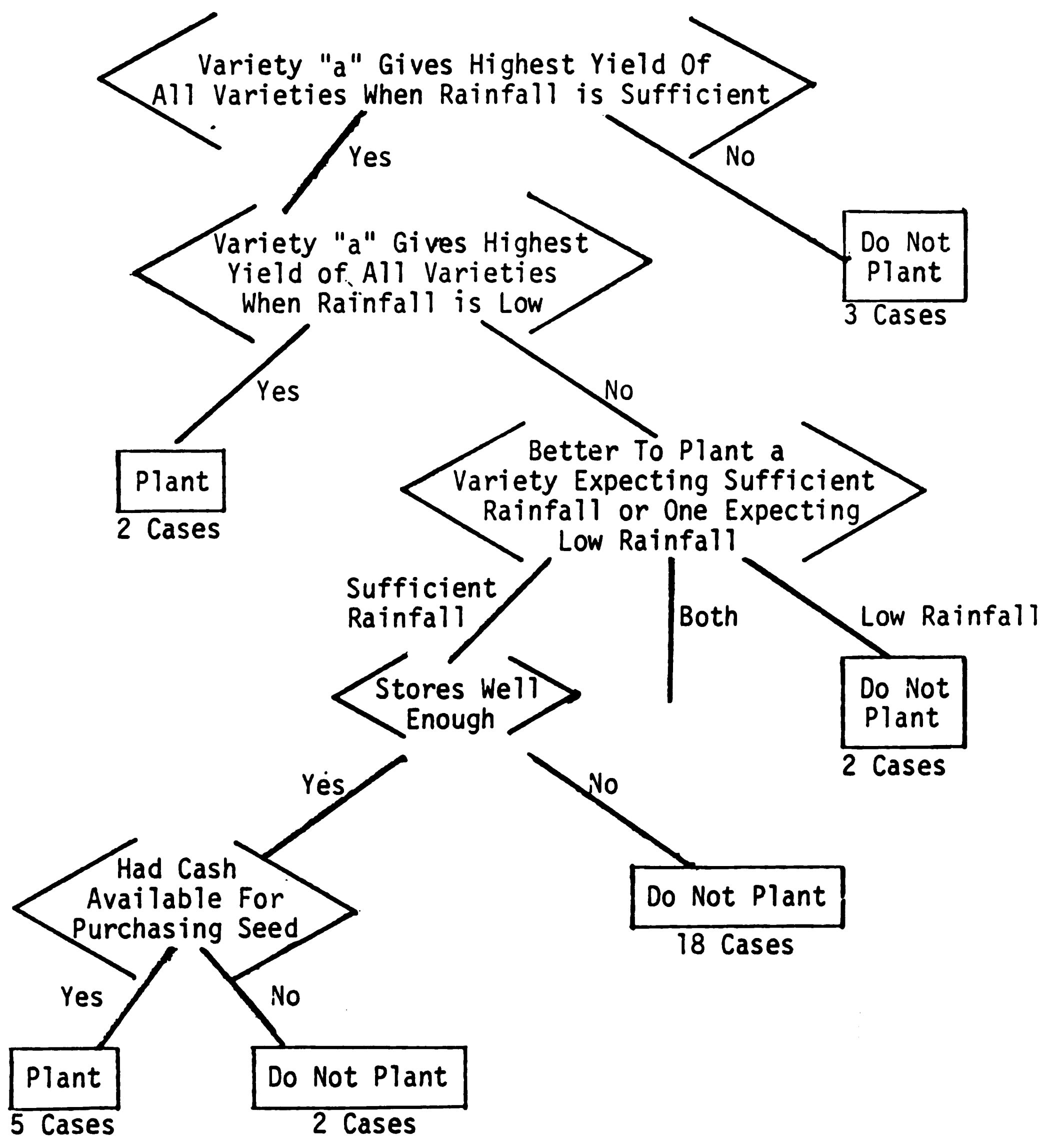
2. Explicit choices that performance on one attribute is more important than performance on another attribute (e.g., "you say that variety 'a' yields better than 'b' when rainfall is sufficient but that 'b' yields better when rainfall is low. So is it better to plant a variety expecting low rainfall or one expecting sufficient rainfall?");

3. Constraints which must be passed or satisfied (e.g., "did you have cash available for buying variety 'a' seed?").

Once a set of criteria are identified, they are arranged in a flow chart in a logical manner. For example, the hypothetical tree, shown in Figure 2.2, summarizes the decision criteria which an assumed group of 32 farmers consider in deciding whether or not to plant variety "a". Yield is the first criterion because it is the most important criterion to farmers in the group interviewed. Since yield in sufficient rainfall was a more important criterion than yield in low rainfall, the former precedes the latter. The criterion involving the trade off between the two yield criteria follows directly after the two yield criteria. The storage issue follows the yield criteria because farmers who test a variety for the first time and find that it has very low yields will not know, or care, much about storage characteristics anyway. "Not having cash for seed" is a constraint and is therefore listed in the tree after the intention to plant variety "a" has already been established.

Figure 2.2

Hierarchical Decision Tree Model: Decision to Grow Variety "a" (Model is Hypothetical)



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In any case, the ordering of the criteria on the tree does not affect a farmer's outcome, as long as the researcher has obtained the principal reason why the farmer does not plant the variety. For example, if a farmer answers no to the first question, "does variety 'a' give the highest yield of all known varieties when the rainfall is sufficient?" but later says that his reason for not using "a" is because it doesn't store well, it would be incorrect for the researcher to let the farmer "get off" the tree at the top box, "do not plant", because variety "a" does not give highest yield when rainfall is sufficient. Rather, one of two problems has occurred. Either the information obtained from the farmer does not represent the farmer's opinions on the issue or, more likely, the tree needs further development to accommodate a person who (1) feels that variety "a" does not yield higher than other varieties when rainfall is sufficient and (2) claims that poor storage is the reason he does not use the variety.

The tree shows the relative importance of criteria in a particular farmer decision. For example, in the hypothetical example of Figure 2.2, 60 percent of the farmers do not plant Variety "a" because it stores poorly. Thus, it is implicit that storage is the most important criterion and that yield and cash availability are less important considerations. Furthermore, the tree can be used to show how farmers explicitly weigh the relative importance of any two particular criteria. For example, Figure 2.2 shows that farmers feel that it is more important that a variety performs well when rainfall is sufficient than that it performs well when rainfall is low.

The use of decision tree models to explain farmer decisions is relatively new. Roumasset (1974) used decision trees to estimate the

risk of alternative fertilization techniques on rice in the Philippines. C. Gladwin (1977, 1980) has used HDM in Mexico, Guatemala, and Alabama to model farmer decisions on the adoption of new methods and inputs and for decisions on which crops to plant. Her earlier work involved using HDM for ex-post evaluation of recommendations to provide feedback to project planning. More recently, she has used HDM for ex-ante research planning. For example, her work on cropping choices in the Altiplano of Guatemala indicated that the least cost method of promoting cash crop production was to improve yields of the subsistence crop, corn (C. Gladwin, 1980). Further, she has reported using HDM's in two "sondeos", multi-disciplinary survey exercises similar to CIMMYT informal surveys, for helping to plan experimentation. However, the models used were not developed during the sondeos; they were refinements of a previously developed model on cropping decisions in a neighboring area.

This thesis builds on Gladwin's use of HDM in FSR for guiding technology planning. However, one departure from her use of the method was made. Gladwin develops an HDM from interviews with 20 to 30 farmers and then tests the model for its ability to explain the decision among another 20 to 30 farmers. Further, she attaches considerable importance to the ability of the model to "predict the decisions of a new, different (if possible, random) sample of decision makers." Thus, a high "success rate" (rate of prediction) is an important objective of this exercise. In this thesis, HDM's are developed by researchers interviewing a small number of farmers, 10 to 15, during an informal survey. The questions underlying the model are then included in a formal survey to a random sample of farmers. The objective is not to test, per se, the model developed in the informal survey by examining the prediction v

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rate. Rather, the objective is to use the model to develop appropriate questions for the formal survey so that decision trees can be reconstructed, based on formal survey responses, which represent the decisions of randomly selected farmers. Thus, we do not presume that the model developed in the informal survey is accurate enough to predict decision outcomes; nor do we have any qualms about adding to or changing the model developed in the informal survey, in order to incorporate individuals from the formal survey who do not "fit" into the original tree.

2.8. Summary of Methods

The cognitive anthropological approach involves intensive interviewing to develop an understanding of the logic behind farmer management strategies and practices in order to develop an understanding of the farming system. Thus, the approach requires normative, positive, and prescriptive information about farmer decisions. Three particular methods will be used to develop this understanding: (1) the CIMMYT diagnostic survey, which is the overall approach for developing the understanding of the system and (2) and (3) the repertory grid technique and hierarchical decision-tree model, which are used for examining particular farmer decisions.

The first step was to select a study area and identify recommendation domains. Next, an informal survey was undertaken together with an agronomist. During the informal survey, we identified system leverage points and used RG and HDM to obtain more information about farmer decisions concerning the leverage points.

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A formal survey was then mounted to verify the information from the informal survey and quantify selected parameters useful for planning experimentation. The questions used for developing RG's and HDM's in the informal survey were incorporated into the formal survey. Thus, the RG's and HDM's constructed from formal survey data may be compared with those developed during the informal survey.

RG and HDM will be evaluated on the contributions they make as supplements to the CIMMYT diagnostic survey for developing an understanding of particular farmer decisions. Unfortunately the exercises could not be carried out completely independently of each other. However, in general, the results from a particular exercise can be compared with results from another exercise.

Two secondary methodological objectives are to compare the quality of information gathered at different stages of the survey sequence. The effectiveness of the exercise to identify recommendation domains is evaluated by comparing the data obtained with data obtained in the formal survey. The utility of carrying out a formal survey, in addition to an informal survey, is evaluated by (1) comparing the data obtained with those obtained in the informal survey and (2) assessing the implications which the formal survey results have on changing or refining the proposed research and extension program planned following the informal survey.

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CHAPTER 3

DATA COLLECTION PROCEDURES

This chapter examines the survey procedures--sampling methods, interviewing techniques and fieldwork procedures--employed for developing an understanding of the farming systems in the study area. First, the reasons for selecting Middle Kirinyaga as the study area are presented. Next, the exercise for identifying recommendation domains is examined. Finally, methods and procedures for the informal survey and formal survey are discussed.

3.1. Selection of Middle Kirinyaga as Study Area

Middle Kirinyaga was selected for this project because it was felt that an adaptive production research program could offer substantial benefits to local farmers, as well as contribute to several of the Kenya government's policy objectives. The specific reasons for selecting Middle Kirinyaga are discussed below.

First, Middle Kirinyaga is made up of mostly low-income, small scale farmers, and does not have any important cash crops, such as coffee, tea, or cotton. As stated in Chapter 1, the Kenya government places a high priority on increasing incomes in low-income, small farmer areas (Government of Kenya, 1979a).

Second, supplies of maize and beans, the area's two most important foods, are frequently exhausted. There is potential for stabilizing

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farmers' food supplies and turning Middle Kirinyaga into a surplus food area, since the physical and climatic conditions of Middle Kirinyaga are suitable for producing both maize and beans. In the aftermath of food shortages of 1980-81, Kenya has placed high priority on achieving self-sufficiency in maize and bean production (Government of Kenya, 1982).

Third, maize and bean production levels are very low and adoption rates for recommended inputs and practices are also low. The reasons for non-adoption are not clearly understood. A diagnostic survey could help researchers understand the reasons behind non-adoption and make appropriate policy recommendations. Revised research recommendations based on on-farm experiments could contribute significantly to increasing production.

Fourth, the institutional environment appears to be favorable, relative to other areas in Kenya. For example, transportation and access to input and output markets are adequate and research and extension services in the area are fairly well developed.

3.2. Identifying Recommendation Domains

The next task was to identify recommendation domains (RD's) in the study area and to delineate the farmer groups to be studied. Two separate tasks were required. One was to identify geographical, or across-area, differences among farming systems. Across-area differences are generally caused by physical factors--e.g., climate and altitude--but may also be a result of historical or socio-economic differences--e.g., ethnic group or government settlement schemes.

The second task was to examine within-area differences in farming systems, that is, to check whether two or more farming systems may be interspersed in a particular ecological zone. The principal causes of within-area differences in farming systems are often socioeconomic and historical factors such as ethnic group, income, or participation in a government credit program.

A critical issue in identifying RD's concerns whether a particular difference between two groups of farmers is an important enough difference to justify separating the groups into different RD's. If the differences among two groups of farmers are significant enough that we will likely require different sets of experiments to meet their needs and circumstances, then the two groups of farmers belong in separate RD's. Thus the objectives of the survey become the benchmark for evaluating the importance of differences among farmers.

The exercise to identify RD's in Middle Kirinyaga took approximately two weeks and involved three methods. First, secondary data on the area were assembled. Unfortunately, these proved to be of limited use because they were averaged across several dissimilar areas within Kirinyaga. Second, researchers, government officials, and local leaders familiar with the area were informally interviewed about across-area and within-area differences. Next, a short, two-page questionnaire was administered to extension workers and local officials in each sublocation, the smallest administrative unit in Middle Kirinyaga.[1] The questionnaire covered principal characteristics of the farming systems which were likely to vary between farms and across areas. Individual

[1]The questionnaire is presented in Appendix A. Sublocations in Middle Kirinyaga range from 50 to 150 square kilometers and have 500 to 4,000 inhabitants.

questions concerned such aspects as physical environment, cropping pattern and practices, livestock, and sources of income.

The interviews were conducted by the researcher; each interview lasted about 40 minutes. Twelve questionnaires covering 15 sublocations in Middle Kirinyaga and adjoining areas were completed in one week. Data tabulation and analysis took another three days. The results of the exercise are reported in Franzel (1981). The methods delivered a rapid, low-cost, preliminary identification and description of RD's in the area.

Map 1 presents the boundaries of Middle Kirinyaga, based on the exercise identifying RD's.[1] The boundaries represent fairly distinct changes in the eco-climatic and socio-economic environment. For example, as one moves north, out of Middle Kirinyaga, altitudes and rainfall increase and temperature and solar radiation decrease. Coffee and dairy are important enterprises and there are higher cash incomes and higher population densities.[2] Maize takes much longer to mature and only one crop is grown per year whereas in Middle Kirinyaga, two crops are grown.

The southern boundary of Middle Kirinyaga is marked by a change in soils, from light, red loam to heavy, black clay. The black soils area is characterized by somewhat different crops, significant differences in the cropping calendar, larger farms, and greater numbers of cattle. To

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[1]The boundaries were revised slightly following the informal survey exercise. Boundaries shown are those from the final assessment of RD's in Middle Kirinyaga.

[2]In fact the northern boundary of Middle Kirinyaga is the 4,300 meter countour, the line below which farmers are forbidden from growing coffee. However, this edict has not been enforced since the coffee boom of 1978.

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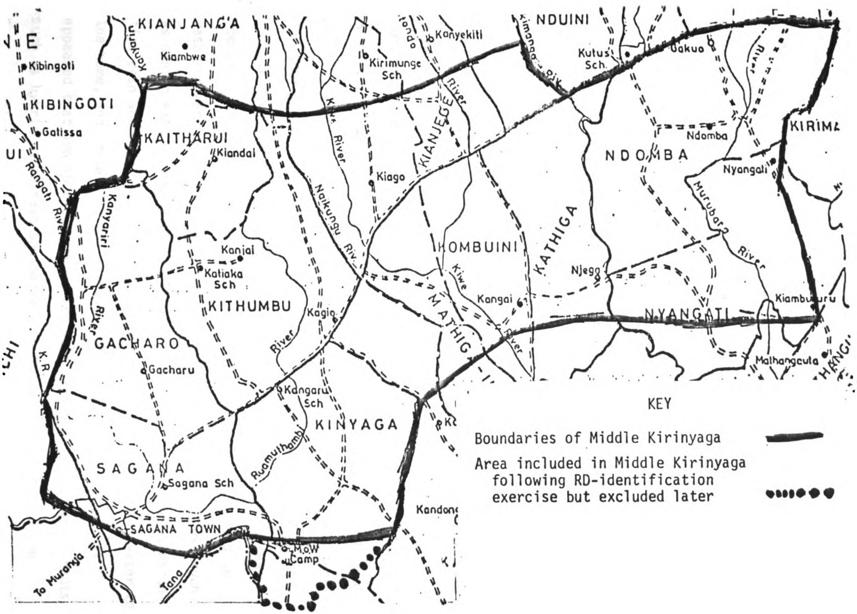

Map 1. Middle Kirinyaga

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the east and west of Middle Kirinyaga are dry, hilly areas with relatively poor road access. These areas have less fertile soils, lower population density and much uncultivated land.

The task of assessing within-area differences among farmers in Middle Kirinyaga was more difficult than identifying across-area differences. Two factors were considered in the investigation:

1. Characteristics of the Farming System: We sought to identify whether there were important differences in the way farmers operated their farms--their priorities, the resources they used, their constraints, and the strategies and practices they employed to use available resources to best meet their priorities.

2. Potential for Change: Second, we were concerned with the relative potential for change among farmers in the area. Two farmers may be operating their farms in the same manner, but have different potential for change because of different resource availabilities. Researchers may divide a homogenous, dryland cropping system, adjacent to an unused flooded swamp area, into two RD's: one with the potential for growing irrigated rice and the other without this potential.

In Middle Kirinyaga, it appeared that access to cash income was an important determinant of the farming system. For example, access to cash influenced whether the farmer undertook certain enterprises, such as owning exotic-breed cattle. Managing these cattle requires substantial cash and other resources for purchasing feed, transporting water to the home, and protecting the animals against disease. Further, it appeared that low income farmers made much less use of purchased inputs such as hybrid maize seed and maize insecticide than higher income farmers. Also, high income farmers tended to own oxen or were able to mir

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hire oxen as soon as the rain started, thus taking full advantage of the brief rainy periods for growing their crops. On the other hand, fewer low-income farmers own oxen and those without oxen tended to plant late, relying on social contacts rather than cash payments to secure an ox-plow team.

We also hypothesized that income level was associated with many other aspects of the farming system aside from enterprise choice and crop husbandry. For example, food security appeared to be an entirely different problem for each of the two groups. Nearly all high income farmers appeared to obtain a regular flow of cash from a non-farm enterprise or a farm enterprise such as dairy; therefore cash was always available for purchasing food when required. However, low income farmers were forced to hire out their labor when their food supplies ran short.

These differences in the way farmers operate affect the type of experiments to be planned for the two groups. For example, maize experiments should incorporate differences in non-experimental variables, e.g., time of planting, variety, and plant population, for the two groups. Further, the number of and range in experimental variables can generally be greater for high income farmers, since low income farmers lack cash for purchasing improved inputs.

Two further issues concerned the number of income groups to establish and how to draw lines between them. We decided to classify farmers into two groups--those who could afford modest investment in their farms and those who could not, because it was thought that this division would cover most of the variation among farmers in the ar

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area.[1] A set of proxies for income were drawn up to differentiate high income farmers from low income farmers for the informal survey. The proxies for high income farmers included grade cattle ownership, house type, past land purchases, and type of off-farm income. A subjective weighting of these variables was used to allocate farmers between the two groups. In only a few cases, was there any uncertainty as to which group a farmer belonged.

3.3. The Informal Survey

The informal survey lasted about five weeks and was carried out by the author and an agronomist who spent two weeks in the study area.[2] The procedures followed correspond closely to those outlined in Byerlee, Collinson, et al., 1980. Two to three farmers were interviewed each day at their farms and about 60 farmers were interviewed, overall. Researchers spent about the same amount of time evaluating the information as in visiting the farms.

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[1] Wealth is often used as a means of stratifying farmers in farm management studies. However, this approach is not appropriate for our purposes for two reasons. First, high income and low income farmers did not appear to have appreciable differences in the more common measures of physical wealth, such as land or number of cattle. Second, one of the most important questions concerning the planning of experimentation is who has money for purchasing inputs and who does not. Certainly, cash income is more closely associated with this distinction than is the fairly lumpy resource base.

[2] The agronomist needed substantially less familizarization time than the economist since he was of the same ethnic group as study area farmers, and he had lived and worked in an area just outside the study area. A sunflower agronomist, maize breeder and bean agronomist each spent 1 to 2 days in the field and were consulted on a number of issues during the course of the survey.

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3.3.1. Who to Interview

Before proceeding too far with the informal survey, it was necessary to define "farmer" and "farm" in the context of local circumstances. Middle Kirinyaga was settled by families who were given title deeds for pieces of land in the late 1950's. Since that time, many farmers have subdivided their farms among their wives, children, or other relatives. In this study, a farmer is defined as a person or group of persons who manages a farm, that is, makes the decisions concerning the allocation of resources on the farm and controls the output from the farm. In the typical case of a husband, wife, and children, the husband and wife share the decision-making function, with the husband making the more general cash-related decisions, e.g., when to plow, which seed to use, when to sell, and the wife making the more detailed day-to-day decisions, e.g., how to thresh, how to space the crops, and when to harvest. Many other systems of management and family organization were found in Middle Kirinyaga and it was not always clear whether one was dealing with an individual farm operation. For example, it was common for a man to divide his land among one or more children, particularly his sons. In general, if the son was not married, the division was in name only and decisions were made in common. However, if the son was married, it was likely that he was operating separately from his father. Polygamous marriages also presented complex situations. If the husband was living on the farm, it was likely, but not always true, that the farm was managed as a single unit. However, if the husband was working away from home, it was likely that there was little if any coordination between the wives; they represented different farms though ea

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each may have been receiving assistance from the same spouse. Another common arrangement was for a farmer to give an acre of land to his mother to manage for herself.

We decided that any person(s) managing a unit of land and its output independently from others was suitable to be interviewed, with one exception. We did not interview elders who were living with their children and had been allocated a small piece (usually one acre) to farm because (1) they represent a very small fraction of total production and (2) they are not a target group for change agents or research services proposing system improvements. We also made an effort to interview the husband and wife together when it was apparent that management was shared between them.

3.3.2. Interview Guidelines

We began farmer interviews by asking a short set of screening questions as shown in Appendix B, Part 1. These questions were used to (1) identify a particular household and the farm area associated with it, and (2) determine which RD this household belonged to.

Two types of interview guidelines were used in the informal survey. The first set, a general overview of important subject areas for developing an understanding of the farming system, is outlined in Appendix B, Part 2. The guidelines are adopted from Collinson, 1980 and 1982, and are divided into seven broad topics. Generally, each topic was covered in a 1 to 1-1/2 hour visit with a farmer. Researchers interviewed one to four farmers in each RD on each topic. The more complex a subject area and the greater the variation in responses, the more farm interviews were required to cover that area.

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The second set of guidelines, developed after the informal survey had begun, is presented in Appendix B, Part 3. As researchers develop an understanding of the farming system, they identify leverage points and draw up guidelines for gathering more information about them. These guidelines help the researcher to assess farmer preferences using repertory grids, to model selected decisions using hierarchical decision-tree models, or to simply gather more information about a particular topic. RG's received first priority because a detailed understanding of farmer preferences among alternatives is useful for identifying particular farmer decisions to model and for constructing the HDM models themselves. Repertory grids were constructed to evaluate farmer preferences among:

1. Alternative maize varieties
2. Alternative bean varieties
3. Alternative times for planting maize
4. Alternative times for planting beans

Hierarchical decision models were constructed to explain the following farmer decisions, based on an evaluation of farmer preferences from RG's:

1. Decision to plant Katumani variety for early maize
2. Decision to plant Katumani variety for main stock of maize
3. Decision to plant hybrid 511/512 for main stock of maize
4. Decision on the time of planting for maize and beans.

Each RG and HDM was constructed from a sample of seven to twelve farmers.

3.3.3. Sampling Methods and Reporting of Results

Sampling in the informal survey was purposive and efforts were made to interview farmers at different income levels, farmers at different locations within the survey area, and farmers living along roads as well as

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as those living at a distance from roads. Simple methods to reduce sampling bias, such as to interview the "nth" farmer on the left along a particular path, were also used.

While the survey was still continuing, results were written up corresponding to the topics listed in each of the guidelines. Repertory grids and hierarchical decision tree models were also developed. The survey results and proposed areas for experimentation were summarized in Franzel and Njeru (1981), issued about two weeks after the survey was completed.

3.4. The Formal Survey

3.4.1. Stratification and Sample Size

The farmer sample was stratified on the basis of income level, the variable which differentiated the two recommendation domains. Determining the sample size was a difficult problem, since no data were available for the target groups on the standard deviations of critical variables, e.g., farm size, enterprise choice, income, farmer practices, etc. However, there appears to be a consensus among many farm management practitioners that 20 to 30 farms in an independent stratus are adequate for producing reliable estimates for each stratum and for making comparisons between strata (Upton, 1972; Lynch, 1976; Bernsten, 1979). Since there was no basis for claiming that the standard deviation for critical variables was greater for one target group than for the other, it was proposed that the sample size be the same number for each strata. Forty-five farmers were selected from each stratum, to allow for the possibility of having to exclude the questionnaires of non-cooperating

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farmers and farmers who did not fall in either RD. The target sample size was thus 90 farmers.

Fortunately, a relatively accurate sample frame exists for Middle Kirinyaga. In the mid-1950's, all land in the area was demarcated by the colonial government and accurate records are kept on all title deed holders. Further, the government stipulates that all land transactions purchases be officially approved and this law is strictly adhered to.

3.4.2. Selection of Sample Farmers and Organization of Fieldwork

Several problems remained in selecting a random sample: logistical constraints, the fact that the stratum of individual farmers was not known, and irregularities in the sample frame. The following three sections describe each of these problems and outline the manner in which they were resolved.

Accommodating Logistical Constraints

Logistical problems had to be taken into account, since our resources for mounting the survey were limited. Our workforce was composed of four enumerators,[1] two supervisors and one vehicle. Further, locating sample farmers would require a local contact. Therefore, clustering seemed to be the most appropriate method.

Determining the size and number of clusters for each group was the next step. The questionnaire was to be administered in two visits, and it was decided that visits were best scheduled on consecutive days at the same time each day. This way, the likelihood of the farmer forgetting

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[1]We selected two female interviewers, since women play such an important role in farming in Middle Kirinyaga.

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the second appointment was minimized and enumerators were able to remember details from the first interview for use in checking the consistency of responses in the second interview. Four enumerators, interviewing two farmers per day, could complete eight farms per two days. We decided to add a full extra day to each cluster to allow for missed interviews, questionnaire checking, and reinterviewing.

We selected a multi-stage sampling method as the most efficient way to meet the requirements of randomness given the logistical constraints. Sampling was carried out in three stages:

1. Selection of sublocations to study. Map 1 shows that parts of sixteen sublocations are included in the study area. Sublocations were randomly selected giving greater weight to those sample units with higher population.
2. Selection of areas within each sublocation. Each sublocation consists of five to fifteen portions, each of which is contained on a separate cadastral map. Sublocation-portions, consisting of 25 to 150 farms, were selected to further cluster the sample.
3. Selection of sample farmers. Finally, twenty farms were selected from each map using a random number table. Twenty was believed to be the minimum number of farmers required to give at least five high income farms and five low income farms.

Classifying Farmers into Income Strata

Because there were many more low income farmers than high income farmers in Middle Kirinyaga, a simple random sample would have given us more low income farmers and fewer high income farms than we required.

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Thus, we needed a method for stratifying farmers into income groups before selecting our farmer sample. We decided to use the assistant chiefs, who each preside over a sublocation, to obtain this information. The assistant chiefs were asked to obtain information on the income proxies listed in Section 3.2 for each farmer: house type and number of zinc roofs, number of grade cows, number of oxen, off-farm jobs, and whether the farmer had ever purchased land. No single proxy was sufficient to establish the income group of a farmer. However, when information on each proxy was assembled and evaluated it was usually clear which income group the farmer belonged to. In many cases, the researcher or a supervisor was able to discuss the grouping procedure with the assistant chief and verify the classification of each farmer.

This procedure also had secondary benefits. First, it permitted us to estimate the ratio of high income farmers to low income farmers in the study area. Second, our sample size, and thus level of precision, was increased. Fortunately, it was relatively easy to test the quality of information provided by the assistant chief by comparing his data with data obtained from the survey. Where important differences existed, we consulted the chief and/or the farmer to resolve which was correct. Thus the method was also useful for checking the validity of the data.

Table 3.1 compares the classification of farmers into income groups based on information obtained from assistant chiefs with classifications established after examining the completed questionnaires. Seventy-seven percent of the initial classifications were correct, assuming of course, that the final assessment based on survey data, was correct. Errors were not biased in any particular direction. Moreover, many of the errors were not errors in classification but errors in the sample

Table 3.1

Comparison of Two Methods for Classifying Farmers into Income Groups: Classifications Based on Information Supplied by Assistant Chief and Classifications Based on Evaluation of Survey Questionnaires, Middle Kirinyaga, 1981

	Number of Farmers[a]
Data from Assistant Chiefs agrees with data from survey	64 (77%)
Farms classified as high income, based on information from chiefs, which were found to be low income in survey	11 (13%)
Farms classified as low income, based on information from chiefs, which were found to be high income in survey	8 (10%)
Total	83 (100%)

[a]Four additional farmers interviewed were not classified by assistant chiefs.

Source: Survey data.

frame. For example, in several cases, a high income title holder was selected but a low income relative farming on the title-holder's farm was interviewed.

Once the groupings were completed, the first five high income farmers and the first five low income farmers were selected for interviewing. If a farmer was unavailable for interviewing, the next farmer on the list from his income group was selected. Of the 90 interviews conducted, 3 were discarded because of suspicion that false information was given. Of the 87 remaining questionnaires, 49 were for low income farmers and 38 were for high income farmers. Low income farmers were

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greater in number primarily because the quota of five high income farmers could not be obtained from sample lists in two of the sublocations and because the three rejected farmers were all high income farmers.

Table 3.2 shows that 72% of the high income farmers and 84% of the low income farmers interviewed were sample farmers, that is, farmers selected from the sample list. Most of the remaining farmers interviewed were also listed farmers, who replaced sample farmers not available to be interviewed.

Table 3.2

Sample Status of Farmers Interviewed in Formal Survey, Middle Kirinyaga, 1981

	High Income Farmers		Low Income Farmers	
	Number	Percent	Number	Percent
Sample Farmers	29	72	37	84
Replacement farmers from sample list	11	27	5	11
Other farmers	0	-	2	4
Total	40	100	44	100

Source: Survey data.

Irregularities in the Sample Frame

There were two additional problems with the sample frame. First, some high income farmers have more than one title deed; they appear in the sample frame more than once and thus have a greater chance of being selected. However, since only six high income farmers and no low income fa

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farmers in our sample were in this category, no adjustments were made in sample selection. However, adjustments were made in calculating the ratio of high income farmers to low income farmers, since the number of high income farmers on the list was biased upwards.

The second problem with the sample frame, referred to above, was that some farmers had given a piece of their land to a relative, usually a son, who operated independently from the title deed holder. These relatives did not appear on the sample frame list, therefore some names on the list actually represented two or more farmers. We decided not to devise a system for randomly choosing a farmer under these circumstances; the choice would have had to be made by the enumerator himself after arriving at the farm and could have created ill feelings between him and the farmer. Therefore, the enumerator interviewed whoever was willing to be interviewed on arrival at the farm. This system appeared to work well; in some cases title deed holders were interviewed and in other cases, relatives farming independently were interviewed.

3.4.3. Execution and Analysis

The formal survey was carried out during a five-week period coinciding with the long rains maize harvest, August through September, 1981. The survey was preceded by a three-week period of enumerator training and questionnaire pretesting. The questionnaire was translated into Kikuyu, the native language of the area. Data tabluation began immediately after the survey was completed and most farmers were revisited to check or clarify some of their initial responses. The preliminary survey results and proposals for experimentation were summarized in Franzel and Njeru (1982).

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CHAPTER 4

DESCRIPTION OF FARMING SYSTEMS IN THE STUDY AREA

The objective of the following two chapters is to describe the farming systems of Middle Kirinyaga and to examine farmers' management strategies, as a basis for proposing experiments for developing system improvements. In this chapter, natural and socio-economic features of Middle Kirinyaga are presented. Next, overall system management is described in a series of sections on farmer objectives and sources of income, management of the farming system, and resource use and system constraints. Finally we outline the system leverage points, those areas of the system where opportunities for improvement appear brightest. In Chapter 5, we focus on farmers' practices concerning the leverage points as a prelude to presenting proposals for a production research program in Chapter 6.

4.1. Physical and Socio-Economics Features

4.1.1. Physical Features

Kirinyaga District extends from the summit of Mt. Kenya in the north to low-rainfall lowlands in the south. The area selected for this study, Middle Kirinyaga, is an area of flat to mildly sloping terrain at an altitude of 1,200 to 1,350 meters (see Map 1). Soils are red, friable clays of volcanic origin, high in humic content (3.7 percent carbon in the A-horizon) and well-drained [Government of Kenya, 1970].

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Rain falls in two seasons: the "long rains", March through May, and the "short rains", October through December, as shown in Figure 4.1. Average rainfall in the long rains is 590 mm whereas the short rains average 341 mm. The figure also shows the brevity of each season. In the long rains, rainfall is over 20 mm per ten-day interval for a period of 80 days; in the short rains the rain lasts only about 50 days.

Figure 4.2 presents average monthly rainfall and the probabilities of receiving lower amounts in some years. The data highlights the unreliability of rainfall in Middle Kirinyaga. For example, in four years out of ten, rainfall is below two-thirds of the average in four of the six highest-rainfall months, March, May, October and December. In two years out of ten, rainfall is below one-third of the average in three of these months. The figure also shows that the starting point of each rainy season is more variable than is the ending point. For example, although the long rains season never extends into June, it is not certain whether the rains will begin in March or April.

Approximately 14 percent of the long rainsseasons over the past 28 years had less than 400 mm and may be characterized as poor seasons. The corresponding number for the short rains is 56 percent. In the last six years, two long rains seasons and three short rains seasons have been poor, according to this definition.[1]

Table 4.1 shows the monthly moisture requirements of maize, Middle Kirinyaga's principal crop, relative to the moisture available in

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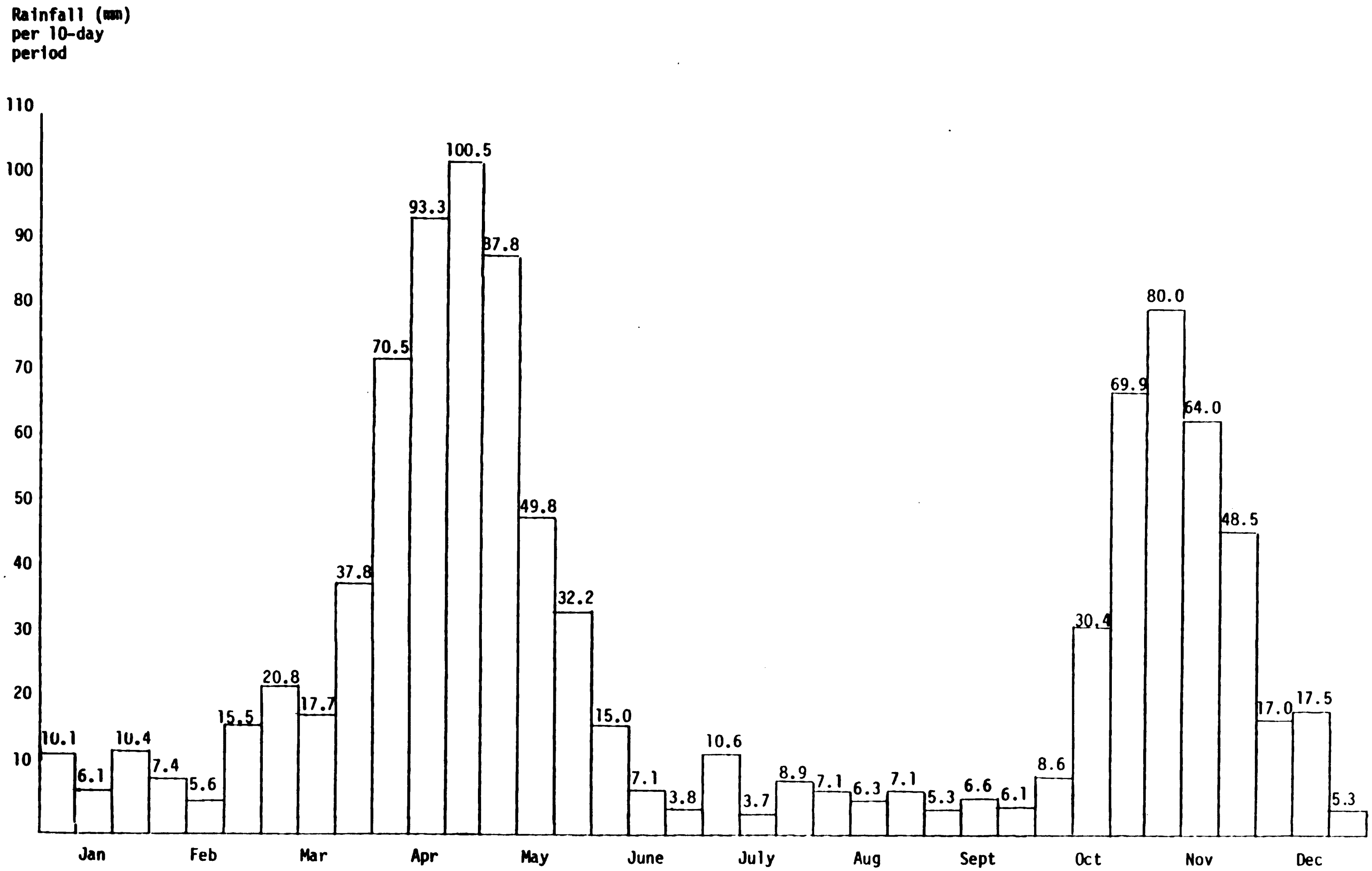
[1]In fact, the quantity of rainfall is a necessary but not sufficient condition for high crop yields since it ignores the distribution of the rainfall. Therefore, the measure used here probably underestimates the number of seasons when rainfall is "poor".

Figure 4.1 Average Rainfall in Middle Kirinyaga, 1953-81 (mm. per ten-day period)



Source: Data for 1953-76 from Ndomba Government Farm. Data for 1977-81 from Mwea/Tebere Cotton Research Station

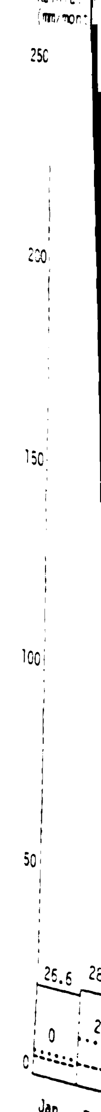


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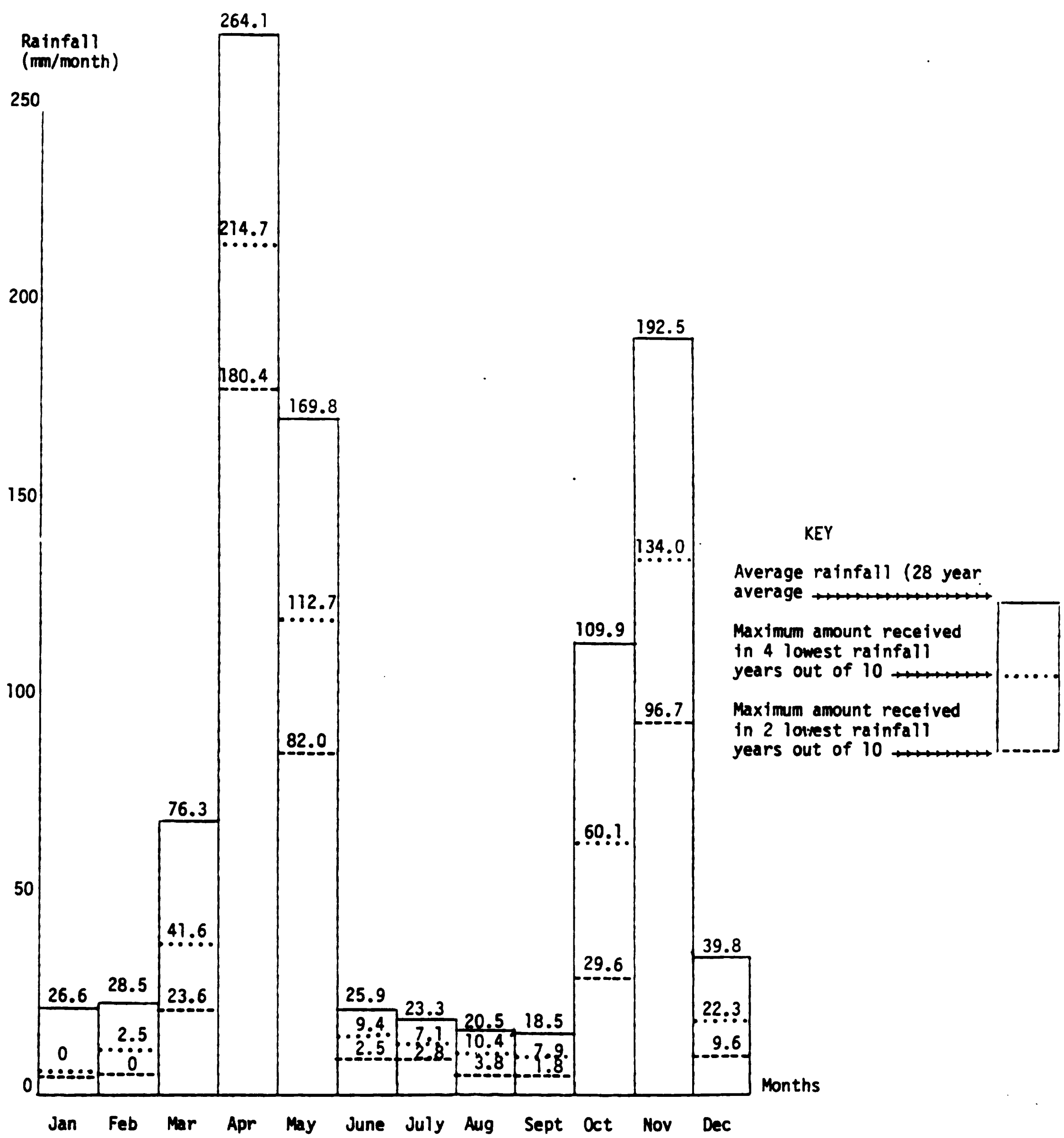
Figure 4.2 Average Montly Rainfall and Probabilities of Receiving Lower Amounts of Rainfall, Middle Kirinyaga, 1953-81



Source: Data for 1953-76 from Ndomba Government Farm. Data for 1977-81 from Mwea/Tebere Cotton Research Station.

Table 4.1

Table 4.1

Rainfall Requirements for Maize and Probabilities of Receiving Lower Amounts of Rainfall, Middle Kirinyaga, 1953-81

	mm./month						
	Rainfall Required for Maize			Rainfall			
Month	Long Rains	Short Rains	Potential Evaporation	Average	Current[1]	Less Than This Amount is Received in 2 Years Out of 10	Less Than This Amount is Received in 4 Years Out of 10
January	-	155	192	26	0	0.0	0.0
February	-	88	198	28	3	0.0	2.5
March	86	-	191	76	12	23.6	41.6
April	82	-	164	264	100	180.4	214.7
May	107	-	139	169	185	82.0	112.7
June	120	-	120	25	0	2.5	9.4
July	84	-	112	23	0	2.8	11.0
August	61	-	135	20	22	3.8	10.4
September	-	-	178	18	3	1.8	7.9
October	-	95	211	109	51	29.6	60.1
November	-	84	153	192	240	96.7	134.0
December	-	147	178	39	0	9.6	22.3

[1]During year preceding survey, 1980 long rains (March-August) and 1980-81 short rains (September-February).

Source: Rainfall requirements for maize are based on percentage of potential evaporation required. These percentages by month are extrapolated from Brown and Cocheme, 1969.

Data for potential evaporation are from Mwea Tebere.

Rainfall data are from Figure 1.

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Kirinyaga. The perils involved in the high unreliability of the rainfall now become apparent. In the long rains, rainfall is quite sufficient in late March, April and May, but falls below requirements from June to August, even in normal years. However, the generally deep soils allow the maize to take advantage of residual moisture during this period. The situation is much more precarious during the short rains. October and November rainfall are sufficient in normal years, but October rainfall falls far below requirements in four years out of ten. Rainfall in December, January, and February is normally far below requirements.

Table 4.1 also shows rainfall in Middle Kirinyaga during the 1980-81 year preceding the survey. Rainfall was considerably below normal; thus data on production and income may be somewhat unrepresentative. Nevertheless, the high degree of unreliability in rainfall--when the rains will start, when they will finish, and how much rain will fall--coupled with the general insufficiency of rainfall in all but the first two months of each season cause grave problems to the farmers. Crop failures occur and late planters, of course, are the most susceptible. Hence, farmers seek to plant their crops as close as possible to the start of the rains.

4.1.2. Population and Settlement

Middle Kirinyaga, as defined in this study, covers an area of approximately 170 square kilometers and has a population of about 35,000, giving a population per square kilometer of about 200. Before the mid-1950's Middle Kirinyaga was practically uninhabited and was used by Kikuyu farmers living on the slopes of Mt. Kenya for cattle grazing. In the late 1950's the area was demarcated by the colonial government and plc

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and plots ranging from 2-6 ha. were given to farmers, mostly Kikuyus from the crowded upper areas of Kirinyaga. These farmers migrated down to Middle Kirinyaga to settle.

A single family was sometimes able to secure several plots, one for each son in the family. Since demarcation, many of the farmers have sub-divided their land among children and other relatives, who manage their farms separately from that of the original title deed holder.

A continuous flow of farmers from upper Kirinyaga and other districts have come to settle in Middle Kirinyaga, purchasing land from those who obtained land during demarcation. Survey data show that approximately 15 percent of the farmers have lived in the area for less than ten years.

Household size is approximately 5.5 persons and most households consist of a man, his wife(s) and children. However, about one-third of the households are headed by women, because the husband is deceased or is working away from home.

Farm size is approximately two to four hectares per household[1] and most farmers have only one piece of land, at their homestead. About 30 percent have another piece of land away from the homestead which they are renting, borrowing or owning. This piece may be in the farmer's own home area or even outside the area--in lower or upper Kirinyaga.

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[1] A household is defined as a group of people who join together to make decisions about the management of the farm and the disposal of the produce. Throughout this paper, decisions are attributed to "the farmer" or "he". In fact, these decisions are more likely to be collective decisions of the household or of the females alone, since they are more active in farming than their husbands.

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4.1.3. Transportation and Marketing

Transportation is excellent throughout the area. A tarmac road passes east-west linking the zone with Nairobi, 100 km. to the south, and Embu, 30 km. to the north. Feeder roads are also numerous and well-kept but some are closed during periods of heavy rainfall.

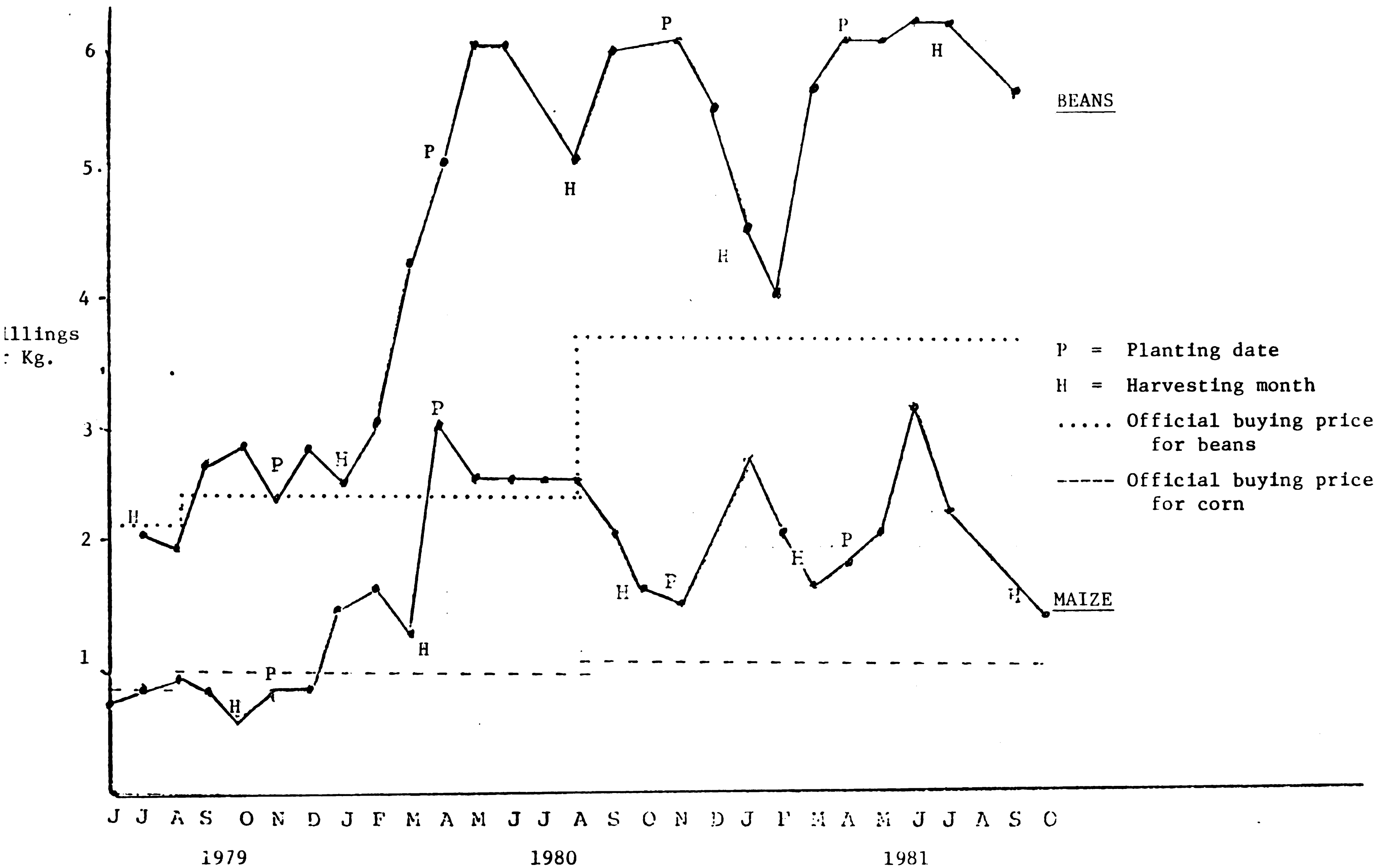
Market centers for purchasing inputs and selling produce are numerous and nearly all farms are located less than 10 km. from a market center. At these centers, a wide range of inputs are available, such as fertilizer, improved maize seed, chemicals, and tools.

Overall, Middle Kirinyaga is a grain exporting area, but grain imports are necessary in times of drought. Crops are bought and sold in local markets and in addition, most grains and legumes may be bought from or sold to National Produce Board Agents. Board agents are found in all major market centers and Board prices are officially fixed by the government. However, the prices at which the agents buy and sell products often fluctuates in accordance with trends in the open market. Food grains are not permitted to enter or leave a district, except through official Board channels, at official prices.

Figure 4.3 shows market prices and official buying prices for maize and beans over 1979-81, and highlights the market price fluctuations which occurred over the period. Produce price increases range from 50 to 350 percent as measured from harvest time up to the "hungry" season which precedes the next harvest. In fact, such wide fluctuations are not atypical. For example, the 1979 long rains crop harvested from July through October was quite satisfactory and prices of maize and beans were relatively low. However, the following three seasons were very poor

Figure 4.3 Maize and Bean Price Trends in Middle Kirinyaga, 1979-81

Figure 4.3 Maize and Bean Price Trends in Middle Kirinyaga, 1979-81



Source: Prices are for Kagio Market, and were collected by the Divisional Agricultural Office, Ndia Division, Baricho.

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for both Middle Kirinyaga and Kenya as a whole and prices fluctuated severely. Moreover, policy factors exacerbated the national maize supply situation during this period of poor harvests.[1] The result was a severe shortage of maize in Kenya throughout 1980; maize was not available in many cities and towns through many months of the year, and prices increased accordingly. The price vagaries and supply uncertainties demonstrate the importance of providing food from one's own home stock.

4.1.4. Cooperatives, Credit, and Government Agricultural Institutions

Cooperative activity is very low in the area, with only a few farmers belonging to cotton or dairy cooperatives. In fact, few farmers pursue either of these enterprises on a commercial basis.

Credit is available from commercial banks, the Agricultural Finance Corporation, and from the Ministry of Agriculture's Seasonal Credit Scheme. However, very few farmers have access to credit. For example, a farmer is required to have two hectares under pure stand maize in order to qualify for the Seasonal Credit Scheme. Moreover, the only collateral most farmers have is their land and they are understandably not willing to risk losing their land should they default on their loans. Thus, the only farmers taking advantage of loan facilities are a very small number of high income farmers who have extensive holdings to

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[1]A permanent secretary of the Office of the President blamed the food shortages on "poor planning" [Daily Nation, March 13, 1982]. For example, the government continued to export maize, even after it was clear that a supply shortage was imminent, until strategic reserves were depleted. Further, credit supplied to farmers for maize production was severely curtailed, due to institutional bottlenecks in the newly formed Seasonal Credit Scheme.

cushion them from the effects of loan default [District Agricultural Officer, Kirinyaga, District, 1981, Personal Communication].

The agricultural extension service is active in Kirinyaga District with one to two extension workers per sub-location (about 400 to 600 farmers). Survey data show that about one-half of the farmers in Middle Kirinyaga have been visited by the extension staff, and that about one-third had received visits during the 18 months preceding the survey.

Several agricultural research stations or sub-stations are found in or near Middle Kirinyaga: a cotton research station at Mwea Tebere, a sunflower station at Wanguru, and a sub-station of the Embu general-purpose station at Murinduko.

4.2. Farmer Objectives and Sources of Income

High income farmers and low income farmers, the two proposed recommendation domains in Middle Kirinyaga, make up approximately 40 percent and 60 percent of the population, respectively. The levels of cash income earned by farmers are shown in Table 4.2, broken down by income group. Median cash income for high income farming is in the 10,000 to 20,000 Shillings (Shs.) range, whereas median income for low income farmers is in the range of 1,000 to 3,000 Shs.[1]

A principal distinguishing factor between high income and low income households is access to regular income from an off-farm business, salaried position, or a dairy enterprise. Eighty-seven percent of the high income households had such income whereas the corresponding number of low income households was only 20 percent.

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[1]At the time of the survey, September 1981, $1.00 U.S. = 10 Kenya Shillings.

Table 4.2

Cash Income Levels of Households in Middle Kirinyaga, July, 1980 to June, 1981

	High Income Households		Low Income Households	
Shillings	Number	Percent	Number	Percent
0-1,000	0	0	9	19%
1,000-3,000	0	0	17	37%
3,000-5,000	0	0	15	33%
5,000-7,000	6	18%	3	6%
7,000-10,000	6	18%	1	2%
10,000-20,000	11	32%	1	2%
20,000-30,000	3	9%	0	0
30,000 +	8	23%	0	0
Not Available	5	-	2	-
Total	39	100%	48	100%

[a]Percentages shown are percentages of households for which income could be calculated. Data on income were collected in a single visit survey and are thus subject to a wide margin of error. It is likely that underestimation of income due to omission of some sources is a greater problem than overestimation.

Source: Survey data.

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Two other characteristics also set low income farmers off from high income farmers. First, the median age of low income farmers is about ten years higher than for high income farmers. Whereas one-quarter of the low income farmers were over 65 years of age, only one sampled high income farmer was over 65. Second, low income farmers have considerably less education than high income farmers; over two-thirds of the high income farmers, but only one-quarter of the low income farmers, had three or more years of formal education.

The principal objective of farmers in Middle Kirinyaga is to provide food for the family; to a great extent this is true for both low and high income households. Low income farmers depend on their farms for their food needs and sell surplus food to acquire cash for purchases. Table 4.3 shows that their total incomes, cash plus subsistence, are about 5,000 Shs. Most of the low income farmers' cash income comes from their farms with crop and livestock sources providing about equal proportions.

In fact, rainfall and thus crop sales were very low in 1980-81, the year in which the survey was conducted. It is likely that in normal years income from the farm and in particular from crops is a much higher percentage of the low income farmers' income than during the survey year. This is so because in years of normal rainfall, crop earnings are greater. Moreover, livestock and off-farm income are also lower since there is less of a tendency to sell livestock or sell family labor to meet urgent cash needs.

Casual labor is the most important source of off-farm income for low income farmers; about one-half of the farmers hired out labor during the previous year. Cash from relatives, businesses (mostly illicit

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Table 4.3

Sources of Income for Farmers in Middle Kirinyaga, July, 1980 to June, 1981[a]

	High Income Group				Low Income Group			
	% Farmers	Shillings	Percent		% Farmers	Shillings	Percent	
Cash Farm Income								
Crops	90	2423	(37%)		95	825	(50%)*	
Livestock	72	4158	(63%)		67	823	(50%)*	
Total	97	6581	(100%)	37%	96	1648	(100%)	55%
Cash Non-Farm Income								
Salaries	38	7027	(64%)		12	372	(28%)*	
Business	56	3166	(29%)		23	239	(18%)*	
Casual Labor	10	25	(0%)		44	270	(20%)*	
Plowing	23	184	(2%)		10	82	(6%)	
Cash From Relatives	5	174	(2%)		21	144	(11%)	
Other	-	394	(3%)		-	238	(18%)	
Total	77	10970	(100%)	63%	90	1345	(100%)*	45%
Total Cash Income		17551	(86%)	100%		2993	(60%)	100%
Subsistence Farm Income[b]	100	2753	(12%)		100	1953	(40%)	
Total Income		20304	(100%)			4946	(100%)	

[a]Asterisks (*) note significant difference between income groups using t-test ($\alpha = .05$).

[b]Subsistence farm income includes only maize and beans, the area's two main staple foods plus 10 percent of this value to account for other foods consumed from home production. The crops are valued at their average market prices for the months up to the following harvest.

Source: Survey data.

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sale of traditional beer), and plowing are each cash sources for 15-20 percent of the farmers. Only 6 percent are working away from their home area and about 20 percent have access to a regular flow of income throughout the year from a business, salary or farm enterprise such as dairy.

High income households have an average income of 20,000 Shs. About two-thirds have salaried jobs or businesses and off-farm income accounts for almost two-thirds of total cash income. For most households with salaried or business income, the farm is important as a source of food for the family rather than for cash generation. Supplying food is especially important, since about 40 percent of high income farmers are working in towns and cities where food shortages may be frequent.[1] About one-third of the farmers have made important investments in their farms in cash-earning enterprises such as dairy or tobacco. One-quarter of the high income farmers have no off-farm income sources; their earnings come primarily from these and other farm cash-earning enterprises. Income from livestock is significantly higher than income from crops for the high income farmers because of the importance of dairy for about one-fifth of the farmers.

Maize and beans are the most important food crops for both income groups; they are boiled and mixed together to form <u>githeri</u>, the area's most popular dish. The importance of maintaining a stable supply of maize and beans is reflected by the area allocated to the two crops,

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[1] The importance of providing home-produced food was clearly demonstrated in 1980 when maize, the area's staple food, was unavailable in Nairobi and many other towns during most of the year. Figure 4.3 shows that the maize price in 1980 rose to Shs. 3 per kg., over three times the official price.

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which are most often intercropped. Low income farmers allocate 91 percent of their cultivated area in the long rains to maize and 78 percent to beans. The figures for high income groups are almost as high, 80 percent and 71 percent, respectively.

In conclusion, both income groups depend on their farms for a steady and reliable supply of food throughout the year. Low income farms also obtain most of their cash income from their farms. Most high income farmers, on the other hand, obtain most of their cash income from off-farm enterprises. For most of these households, the farm is viewed primarily as a source of food for the household and not for generating cash.

4.3. Management of the Farming System

4.3.1. Enterprise Pattern and Land Use

Long Rains Crops

Farm size and land use in Middle Kirinyaga are shown in Table 4.4. Low income farms average 2.4 ha., with 1.4 cultivated, whereas high income farms average 3.8 ha., with 1.8 cultivated. Low income farmers cultivate nearly all of their arable land, whereas high income farmers leave a significant portion under grass and a few leave large areas under bush.

Table 4.5 shows that 68 percent of the cultivated area of high income farmers and 77 percent of that of low income farmers is under intercropped maize and beans. Most of the maize and beans not grown together are planted inside tree crops. Further, some low income farmers grow maize in pure stands because they had run out of bean seed.

Table 4.4

Land Use and Average Farm Size in Middle Kirinyaga, 1981[a]

	Average Farm Size	
	High Income Households ha.	Low Income Households ha.
Cultivated Land		
Own cultivated land	1.8	1.3*
Cultivated land rented or borrowed	0.4	0.1*
Total cultivated land	2.2	1.4*
Farm Size		
Own cultivated land	1.8	1.3*
Swamp area	0.2	0.3
Homestead	0.2	0.2
Grass	1.2	0.2*
Rented out	0.0	0.2
Other	0.4	0.2
Total farm size	3.8	2.4*
Median Farm Size	2.9	1.9*
Size of Titled Farm (includes subdivisions)	4.1	3.2*

[a]Asterisks (*) denote significant differences between income groups using t-test (α = .05).

Source: Survey data.

Table 4.5

Principal Crop Combinations in the Short Rains and Long Rains Seasons, Middle Kirinyaga, 1981[a]

	Long Rains				Short Rains			
	High Income Farmers[a]		Low Income Farmers		High Income Farmers		Low Income Farmers	
	ha.	Percent	ha.	Percent	ha.	Percent	ha.	Percent
Crop Combinations								
Maize and Beans[b]	60	(68%)	55	(77%)	54	(63%)	44	(69%)
Other Maize[c]	11	(12%)	10	(14%)	11	(12%)	7	(10%)
Other Beans[c]	3	(3%)	1	(1%)	7	(8%)	10	(13%)
Coffee	5	(6%)	2	(3%)*	5	(6%)	2	(3%)*
Banana	4	(4%)	5	(7%)	4	(4%)	5	(7%)
Bullrush Millet	0		0		4	(4%)	13	(19%)*
Other Crops	10	(11%)	3	(4%)	9	(10%)	1	(2%)
Total Area[d]	88	(100%)	71	(100%)	87	(100%)	69	(100%)

[a]Asterisks (*) denote significant differences between income groups using t-test (α = .05), tc compare area per farmer under cash combination.

[b]Fields where maize and beans are intercropped. There may be another intercrop on the field but this occurs in less than 10 percent of the maize and bean fields.

[c]"Other" means maize (beans) alone or intercropped with a crop(s) other than beans (maize).

[d]Percentages sum to more than 100 because coffee and banana are sometimes intercropped with maize or beans; thus, these fields are recorded twice.

Source: Survey data.

Bananas and coffee are the only other crops of any general importance. Bananas are grown mostly for food and are very low yielding, relative to other areas. They account for 4 to 7 percent of total cultivated area for both income groups. Middle Kirinyaga is outside of the officially designated coffee zone, yet farmers have begun planting coffee since the coffee boom of 1978. Ministry of Agriculture officials predict poor results due to the high temperatures and low rainfall in the region. Although production will no doubt be low compared to coffee zone areas, farmers hope that returns will be higher than for their only present alternative--maize and beans. One-half of the high income farmers are growing coffee, on plots average 0.2 ha., whereas one-quarter of the low income farmers grow coffee, on plots averaging 0.1 ha. Differences between income groups are significant (α = .05) for both numbers of farmers and areas allocated to coffee.

Several other cash crops exist in Middle Kirinyaga but are grown by less than 5 percent of the farmers. Tobacco is grown by farmers near Sagana in a closely supervised British-American Tobacco Co. scheme. The area cultivated has not increased in several years, due to a shortage of firewood for curing. Some farmers with swampy areas grow vegetables, such as tomatoes, kale, carrots and onions. A few farmers grow cotton, a crop which was very popular in Middle Kirinyaga in the 1960's. Cotton production decreased because of low profitability and poor marketing and grading arrangements.

Farmers in Middle Kirinyaga grow a wide range of minor crops, planted on tiny plots of less than one-eighth of an acre or, more often, scattered among the maize and beans. Ninety percent of all farmers grow bananas and cowpeas. Over one-half grow cassava, pigeon peas, pumpkins, tomat

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tomatoes, sorghum, onions, sweet and English potatoes and mangos. Other minor crops grown by over one-quarter of the farmers include arrow-root, sugar cane, kale, and napier grass. There does not appear to be any significant differences in the percentage of each income group growing each crop, with the exception of napier grass which is grown more frequently by high income farmers.

Short Rains Crops

The short rains cropping pattern is very similar to that of the long rains. Total cultivated area, 2.2 ha. for high income farmers and 1.4 ha. for low income farmers, is identical to the area cultivated by each group in the long rains. The total area under maize is slightly lower in the short rains for both income groups, as some farmers, particularly low income farmers, substitute bullrush millet for some of their maize. Almost half of the low income farmers and 13 percent of the high income farmers planted bullrush millet, a crop not found in the long rains. Bullrush millet is drought resistant, early maturing, and is used primarily as a porridge drink in the morning hours. Minor crops cultivated in the short rains are similar to those of the long rains season.

4.3.2. Livestock

Livestock serve numerous functions for farmers in Middle Kirinyaga. Table 4.6 shows the breakdown of livestock ownership by high income and low income farmers. About 70 percent of the farmers in each group own sheep and goats, 3-5 per family. They are raised primarily for security and are sold when cash is needed. Two-thirds of all low income farmers

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Table 4.6

Livestock Ownership and Uses, Middle Kirinyaga, 1981

	High Income Farmers		Low Income Farmers	
Livestock	% Having[b]	Average No. Owned[a]	% Having[b]	Average No. Owned[a]
Sheep/Goats	74	4.3	64	3.0
Cattle	92	6.9	62†	3.0*
Grade Cattle	56	1.8	2†	0.0*
% Selling Milk	36	-	4†	-
% with Oxen	43	-	27	-
% Using Manure on Fields	84	-	49†	-

[a]Asterisks (*) denote significant differences between income groups using t-test (α = .05).

[b]Crosses (†) denote significant differences, using Chi-square test (α = .05), between income groups concerning whether or not farmers have a particular livestock type/operation. Thus each row represents a different Chi-square test.

Source: Survey data.

own cattle, averaging about three animals per family. Cattle are kept for plowing, for milk for home consumption, for security and for manure, which is applied to fields. Only one low income farmer possessed an exotic-breed[1] cow, although some had bought them in past years and then sold them. Major reasons for not owning exotic breeds include lack of water supply or means of carrying water, fear of disease problems and lack of feed.

[1]The most common exotic-breed cattle in Middle Kirinyaga are Guernseys, Ayrshires, Friesian, and Jerseys.

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Over 90 percent of the high income farmers own cattle and over one-half own exotic-breed cattle. The average family owns five local cattle and two grade cattle. Local animals are kept primarily for plowing, whereas grade cattle are kept to provide milk for home consumption or for sale. Over one-third of the high income farmers sold milk in 1980-81 and for many, milk is a major cash earning enterprise.

Keeping cattle, whether exotic-breed or local, is a labor-intensive enterprise. Local animals are grazed outside of the homestead, at roadside and swamp areas, by men or children for most of the daylight hours. Grade animals are kept at the homestead, so as to control diseases, and therefore must have food and water carried to them.

4.3.3. Crop Calendar and Management of Food Supplies

Table 4.7 presents the cropping calendar for farmers in Middle Kirinyaga. Farmers plant their maize and beans in late March-early April, just as the long rains season begins. Beans are harvested in July and maize in August and each crop is harvested "green" from the field during the month before the final harvest. Harvest periods are rather extended because both early-maturing and late-maturing varieties are planted. The pattern of the short rains season extending from October to February is similar to that of the long rains season. Crops mature more quickly during the short rains because there is greater solar radiation.

The availability of food staples and substitutes from farms throughout the year is shown in Table 4.8. Running out of home produced food is a common occurrence for both groups of farmers. About 40 to 50 percent of the high income farmers and 80 percent of low income farmers run

Table 4.7

Cropping Calendar for Maize and Beans, Middle Kirinyaga, 1981[a]

	January		February		March		April		May		June		July		August		September		October		November		December	
Weeks	1-2	3-4	1-2	3-4	1-2	3-4	1-2	3-4	1-2	3-4	1-2	3-4	1-2	3-4	1-2	3-4	1-2	3-4	1-2	3-4	1-2	3-4	1-2	3-4
Maize																								
Planting				10	44	101	34	12	3								7	12	48	92	15			
Weeding								X	XX	XX	XX										X	X	X	X
Harvesting (green)	28	33	6							6	24	47	30	37	7								10	33
Harvesting (final)	7	15	23	39	16	7								11	34	68	20	11						
Beans																								
Planting				3	27	80	44	14	2								2	10	31	90	18	2		
Weeding								X	XX	XX	XX										X	X	X	X
Harvesting (green)	11	2							12	35	28	19	11										32	37
Harvesting (dry)	25	40	8	10							5	35	24	42	6	6								13
					Start of Long Rains														Start of Short Rains					

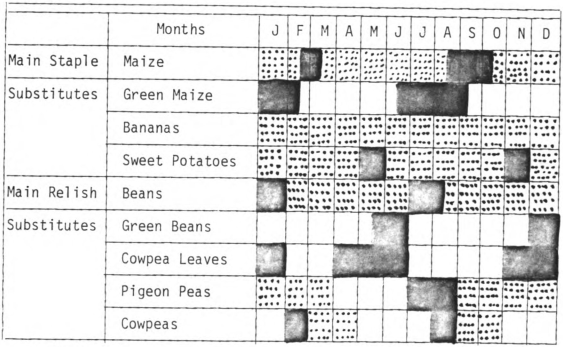
[a]Numbers shown are fields for which a particular operation was carried out by sample farms during a particular two-week period. There were no significant differences in cropping calendar between income groups. Hence, figures are aggregated over the income groups.

Principal periods for carrying out operations are shown by underlining. Data on weeding was not collected; "X's" denote primary weeding times based on subjective assessment.

Source: Survey data.

Table 4.8

Food Availability Calendar for Middle Kirinyaga Farms, 1981



[a]Food availability: – always available; – uncertain depends on season; and – never available.

Source: Informal survey.

out of maize and beans in "most years" or "some years". The situation is even more precarious with respect to beans.

Long rains maize is harvested in August and September and in most years, the quantity harvested is sufficient to last until the short rains harvest in February. However, short rains maize production is meager and supplies are often exhausted well before long rains green maize is ready for harvest in late June or July. For example, in 1981, about one-half of the farmers in both income groups ran out of maize before green maize was rea

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was ready; April and May were the most frequently mentioned months for running out. The principal maize substitutes, bananas and sweet potatoes, are not in reliable enough supply to ensure an adequate diet for the family. Besides, they are considered to be far less acceptable as food than is maize.

The supply of beans more or less parallels that of maize. Few farmers run out after the ample long rains harvest, but over one-half of the farmers in both income groups exhausted their supplies after the short rains harvest in 1981, before green beans were ready in June. However, the availability of substitutes for beans is somewhat better than for maize. Cowpea leaves are always available soon after planting in late March-early April, and reliable supplies last up to three months. Pigeon peas and cowpeas may also be available.

In addition to being the area's most important food crops; maize and beans are also important sources of cash for many farmers. About 60 percent of the farmers in both groups sold maize and beans following the long rains, 1981 harvest and 40 percent sold following the previous short rains harvest. The survey data also show that approximately one-third of the low income farmers and one-fifth of the high income farmers had sold produce from their home stock before running out. Thus, exhausting home-produced food supplies is not simply a problem related to low levels of production; rather, it is exacerbated by competing demands from the household for cash.

How do farmers manage to secure food when home supplies of maize and beans are exhausted? Over 90 percent in both groups stated that they purchased maize and beans; obtaining food from relatives or eating food substitutes were mentioned by less than one-third of the farmers.

Table 4.9

Sources of Cash for Purchasing Maize when Supplies of Home Stocks Were Last Exhausted, Middle Kirinyaga, 1981[a]

Sources	High Income Households		Low Income Households	
	Number	Percent	Number	Percent
Casual labor	3	(9%)	24	(56%)
Livestock sales	11	(32%)	16	(37%)
Off-farm salaries and businesses	21	(62%)	6	(14%)
Sell cowpea leaves	7	(20%)	1	(2%)
Other	5	(15%)	8	(19%)

[a]Many farmers named more than one source. Therefore, percentages do not sum to 100.

Source: Survey data.

Table 4.9 shows that high income farmers relied primarily on cash from off-farm jobs and businesses for purchasing maize and beans, whereas low income farmers obtain cash from casual labor, primarily weeding. Both groups also sell livestock in order to purchase food.

The most difficult time for food supplies then is the three to four months before the long rains harvest. Both income groups are hurt when they run out of food; high income farmers are affected because they often live outside the area, where maize and beans are expensive or not even available. Low income farmers suffer even more--they are forced to search for casual labor which may not be available, and to disinvest from a tiny stock of cattle, sheep, goats and poultry. Stabilizing food supplies is a crucial priority to all farmers in Middle Kirinyaga, hence our emphasis on the two major food staples in this study.

4.4. Resource Use and System Constraints

4.4.1. Land

Land Tenure, the Land Market and Land Constraints

As a result of land adjudication in the late 1950's and early 1960's, land tenure in Middle Kirinyaga is quite secure and land disputes are few. Land titles are available for a small fee from the District Land Office, but most farmers do not bother to obtain them. When a farmer subdivides his land among children or other relatives, he rarely legitimizes the subdivision with the government. However, the government stipulates that all land sales and purchases be officially approved and this law is strictly adhered to.

An active rental market exists for land in Middle Kirinyaga; fees range from 250 to 400 Shs. per ha. per season. During the long rains season, 1981, 31 percent of the high income farmers rented land whereas only 6 percent of the low income farmers did so. The principal reason for not renting land, among low income farmers, was lack of cash, which is needed to pay for rent, plowing and seeds. High income farmers not renting land cited lack of labor or lack of desire to increase their cultivated area. Fourteen percent of the low income farmers and 11 percent of the high income farmers rented land out to other farmers. Most farmers felt it was easy to both rent in land and rent out land in their area.

Although farm size is small, the land constraint does not appear to be particularly severe for most of the farmers in either income group. The rental market appears to be competitive and finding land to rent is fairly easy. Moreover, 90 percent of the farmers in both groups expressed a preference for using scarce cash to invest in their existing farms rather then renting out land.

However, there appear to be two important trends in the system which point towards a serious land constraint in the near future for low income households. First, they have a greater tendency to subdivide their farms among relatives; 69 percent of the sample low income farmers were living on a farm which had been subdivided whereas the corresponding number for high income farmers was only 51 percent. Low income farmers are less able to send their children to secondary school or secure jobs for them; hence, the children remain on the land and are given pieces to manage themselves.

Second, and perhaps even more ominous, is the sale of land from low income farmers to high income farmers as shown in Table 4.10. Thirty percent of the high income farmers have bought land whereas only one low income farmer had done so. The sales trend is reversed, with 13 percent of the low income farmers having sold land and only 5 percent of the high income farmers having done so. These latter figures are probably biased downwards since farmers who have sold all of their land are obviously not included. Moreover, the sale of land is an extremely sensitive issue and it is likely that some of the sample farmers had sold land but declined to give this information.

Table 4.10

Farmers Who Have Bought and Sold Land, Middle Kirinyaga, 1981

	High Income Farmers		Low Income Farmers	
Bought land	9	(23%)	1	(1%)
Sold land	2	(5%)	6	(13%)
Neither bought nor sold land	28	(72%)	41	(85%)
Total	39	(100%)	48	(100%)

Source: Survey data.

Land prices range from 25,000 to 40,000 Shs. per hectare and are increasing rapidly. The buyers are generally speculators[1] or landless urbanites who desire land for their families. The actual value of the land has little relationship with its productive value. For example, the present value of an annual rental fee of 400 Shillings per hectare paid annually, assuming a 20 percent interest rate, is only 2,000 Shillings or one-twentieth of the actual price of a hectare of land. The difference represents the non-pecuniary importance associated with land ownership, per se, as opposed to temporary control over the production of the land.

Poor rural families with small farms are obviously hesitant to sell their land. However, the temptation for selling is high given that the price per hectare is over ten times the government's minimum annual wage

[1] The government has forbidden companies whose purposes are speculative from purchasing land in the area.

in the area. Recently, the Lands Department began to review land transactions to prevent land sales from poor household heads who cannot show how they will support their families.

Soil Fertility and Structure

Although land area, per se, is not an important constraint, soil fertility and structure are extremely limiting constraints on nearly all farms in Middle Kirinyaga. Until the late 1950's, the area was used almost exclusively for cattle grazing. When farmers began cultivating in the early 1960's, they found the deep, loam soils to be highly productive. But most farmers have now cultivated the same land for 10 to 20 years continuously, growing intercropped maize and beans twice per year without fallow, rotation or fertilizer. Thus, the fertility of the soil has become increasingly exhausted. Continous cultivation has also had a severe impact on soil structure. A well-structured soil retains moisture well and this is particularly important in Middle Kirinyaga given the brevity of the rainy season. Thus, following an early end to the rains, crops on well-structured soils may have adequate yields while crops fail on poorly-structured soils.

Poor soil fertility and inadequate moisture retaining capacity are perceived problems; many farmers claim that they are the main causes of low yields on their farms. Many farmers apply cattle manure to their soils but the quantities used are generally insignificant.

4.4.2. Labor

Labor Use, Peak Season Labor and the Labor Market

High income families have about seven persons per household, whereas low income farmers have 5.5, as shown in Table 4.11.[1] The composition of families is similar for the two groups; families consist of 1 adult male, 1.5 adult females and 3 to 4 children.

High income families have 3.6 full-time adult equivalents available for working on their farms, whereas low income families have only 2.5, as shown in Table 4.11. However, low income families have smaller farms, so adult-equivalents per ha. cultivated are roughly equal for the two groups: 1.6 and 1.8. Females provide most of the available workforce in both groups; twice as many full-time farm workers are female as male.

Division of labor along sexual lines is pronounced though there is some degree of flexibility for each task. Men have primary responsibility for plowing, planting tree crops and looking after the livestock. Women plant annual crops, weed, harvest, conduct post-harvest operations, and milk the cows. Most of the marketing is done by women, though men are also involved in making marketing decisions. Both sexes sell out farm labor for hire.

Table 4.12 shows that there is almost unanimous agreement among farmers of both groups that April and May, the period of weeding maize and beans, is the busiest period of the year. About 15 percent of the farms in each group cited planting in March and April as their busiest

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[1]According to the 1979 census, average family size in Middle Kirinyaga is 5.5 [Government of Kenya, 1981].

Table 4.11

Household Composition and Workers Available for Farm Work per Household, Middle Kirinyaga, 1981

	High Income Group			Low Income Group		
	Persons Living in Household	Persons Available for Work	Full-time Adult Equivalents[a]	Persons Living in Household	Persons Available for Work	Full-time Adult Equivalents[a]
Full-time						
Men	1.1	0.6	0.6	1.1	0.6	0.6
Women	1.5	1.3	1.3	1.4	1.2	1.2
Children 10-15 years	2.1	0.0	0.0	1.3	0.0	0.0
Children under 10 years	2.3	0.0	0.0	1.7	0.0	0.0
Part-time						
Men	-	1.0	0.5		0.3	0.15
Women	-	0.9	0.4		0.4	0.2
Children under 15 years	-	2.7	0.7		1.8	0.45
Total		-	3.6		-	2.5
Full-time adult equivalent/ha. cult.			1.63		-	1.78

[a]It is assumed that a part-time worker provides one-half as much labor as a full-time worker and that a child under 15 provides one-half as much labor as an adult. Primary education is compulsory in the area; thus, no children are available for full-time work.

Source: Survey data.

Table 4.12

Farmers' Opinions on Their Busiest Months and Activities During Their Busiest Months, Middle Kirinyaga, 1981

	High Income Group		Low Income Group	
	Farmers	Percent	Farmers	Percent
Busiest Month and Activity				
April-May, weeding maize and beans	31	(82%)	37	(79%)
March-April, planting maize and beans	6	(17%)	7	(15%)
Other	1	(3%)	3	(6%)
Second Busiest Months				
Oct.-Nov., weeding maize and beans	15	(45%)	22	(50%)
Aug.-Sept., harvesting maize and beans	9	(27%)	10	(23%)
Oct.-Nov., planting maize and beans	0		9	(20%)
March-April, planting maize and beans	2	(6%)	3	(7%)
Other	7	(21%)	0	

Source: Survey data.

activity; these were farmers who planted by hand as opposed to planting with oxen. The second busiest time for most farmers was short rains weeding; other farmers cited long rains harvesting or short rains planting.

An active labor market exists in Middle Kirinyaga and high income farmers hire labor much more frequently than do low income farmers.

Table 4.13

Use and Cost of Hired Labor Among Farmers in Middle Kirinyaga, 1981[a]

	High Income Group		Low Income Group	
	% Using	Average Shillings Paid Per Household	% Using	Average Shillings Paid Per Household
None	26	-	83†	-
Casual labor	74	393	17†	37*
Permanent labor	24	545	0†	0*
Total		938		37*

[a]The data do not include the hiring of ox-plow teams to plow land. Asterisks (*) denote significant differences between income groups using t-test (α = .05). Crosses (†) denote significant differences between income groups using Chi-square test (α = .05).

Source: Survey data.

Table 4.13 shows that 74 percent of high income farmers hire labor while only 17 percent of the low income farmers do. Long rains hirings were almost twice as high in value as were short rains hirings and over 70 percent of the hirings in both season were for weeding maize and beans. Most hired workers are paid for on piece-rate basis. Daily wages range from 10 to 15 Shillings per day but many workers are able to earn even more than this on piece-rate wages.

The supply of labor appears to be more than adequate to meet the demand for hired labor as three-quarters of the farmers hiring labor said that it was easy to find workers when they needed them. About one-half of the farmers selling labor say they sometimes have difficulty finding work; they cite the harvesting season as the most difficult time. Few had difficulty finding work during the weeding season.

About one-quarter of the high income households employ permanent laborers, usually one per household. Permanent laborers are generally hired from outside the survey area and wages are about 200 Shs. per month, plus room and board.

Labor: A Constraint to Developing the System?

Numerous studies in both Kenya and other African countries have pointed to the importance of the labor constraint and particularly peak-season labor as being a critical constraint on increasing production (Gathee, 1980; Rukendema, Mavua and Audi, 1981; Eicher and Baker, 1982). However, we reached the opposite conclusion in Middle Kirinyaga; labor is not a particularly important limiting factor. Three findings illustrate this point.

First, improving the efficiency of labor or increasing its supply will not increase the area cultivated. Except in a few exceptional cases, farmers are not prevented from cultivating more land because they lack labor. Table 4.1 shows that low income farmers cultivate nearly all of their own land and in fact, much of their uncultivated land is not arable. Few low income farmers rent in land but their principal reasons for not doing so are that they lack cash, not labor.

About 40 percent of the high income farmers rent in land. Satisfaction with their present farm size,[1] not lack of labor, is what keeps

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[1]The response to the question, "why not rent land," was frequently, "I have enough land now." This can best be interpreted as "there are better things I can do with my available resources than renting land."

most of those not renting out of the rental market. Further, those farmers in both groups who are renting out land are not doing so because they lack labor, but primarily because they have an urgent cash need or do not have enough cash to farm their land. Only three of ten farmers renting out land cited lack of labor as a reason for renting out land.

Second, improving the efficiency of labor or increasing labor supply during the peak period would not appreciably increase output. The principal activity during the peak period, weeding, is completed with a high level of efficiency. During our informal survey, which was conducted during the weeding season, we noticed that most fields were quite clean and that it was not likely that poor or untimely weeding had caused a significant drop in yield. Indeed, over three-quarters of the low income farmers and nine-tenths of the high income farmers felt that they had the resources to do their required weeding.

Third, farmers themselves do not place a high priority on reducing their peak season labor bottleneck or improving their overall weeding efficiency. For example, we asked farmers how they would spend 200 Shillings if it was given to them in March, the planting month. Only 9 percent of the low income farmers and 14 percent of the high income farmers cited weeding, which is normally done in April and May, as a possible use for the cash.

In conclusion, labor availability does not limit production except in a few households where the land/labor ratio is very high and cash for hiring labor is lacking.

4.4.3. Cash

Both high and low income farmers use relatively few purchased inputs on their farms. Table 4.14 shows that total expenditures on farm production in the 1980-81 year was Shs. 2,947 for high income farmers and Shs. 527 for low income farmers. High income farmers spend cash primarily for hiring labor, a land extensive input, whereas low income farmers spend most of their cash on basic production inputs, e.g., purchasing seed. Purchases of livestock and expenditures on maintaining livestock accounted for about 35 percent of the farm cash expenses for both groups.

The cash constraint prevents many low income farmers from purchasing even the most basic production inputs. For example, 25 percent of the low income farmers did not have enough bean seed for planting in the 1981 long rains; one-half of them accommodated this problem by spreading their bean seed very thinly across their fields while the other one-half concentrated their few seeds on particular fields. Further, 21 percent of the low income farmers were forced to plant a part, or all, of their fields without plowing because they lacked cash to hire a plowing team. On the other hand, all high income farms prepared their fields with plows and had enough bean seed for planting.

Lack of cash was an important reason for not using other "non-essential" purchased inputs, as well. For example, 56 percent of the low income farmers and 27 percent of the high income farmers cited lack of cash as the principal reason for not using fertilizer. Further, 38 percent of the low income farmers and 12 percent of the high income farmers claimed they did not use hybrid maize seed because they lacked cash. It should be noted that "lack cash" is often a catch-all reason

Table 4.14

Farm Expenditures of High and Low Income Farmers, Middle Kirinyaga, September, 1980-August, 1981[a]

	High Income Farmers		Low Income Farmers	
	Shs.	Percent	Shs.	Percent
Cash Income	17,551		2,993*	
Expenditure				
Crop inputs[b]	432	15%	193*	37%
Hired labor	938	32%	37*	7%
Renting plow	433	15%	101*	19%
Livestock purchases	628	21%	93*	18%
Livestock expenses	422	14%	89*	17%
Renting land	94	3%	14*	2%
Total	2,947	100%	527*	100%
Agricultural expenditure/ income		17%		18%

[a]Asterisk (*) denotes significant difference between income groups using T-test (α = .05).

[b]Does not include tobacco inputs, which are received on credit by 6 high income farmers.

Source: Survey data.

which farmers give when they want to transfer blame for non-adoption from the technology itself to themselves. This will be discussed further in Chapter 7. However, not withstanding this point, it seems apparent that "lack cash" is an important reason for non-adoption of purchased inputs.

The most difficult time for cash for low income farmers is March through May, as shown in Table 4.15. Their most important cash need

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Table 4.15

Most Difficult Months of the Year for Cash,
Middle Kirinyaga, 1981[a]

High Income Farmers		Low Income Farmers	
Month	% of Farmers	Month	% of Farmers
May	47	May	40
January	44	April	38
April	37	March	30
September	25	November	24

[a]Farmers were permitted to name more than one month as being their most difficult. Hence percentages do not sum to 100.

Source: Survey data.

at this time is for purchasing food; other needs include paying school fees and local harambee taxes. For high income farmers, the most difficult months for cash are January, May, and September, the months when secondary school fees are due. April is also important because of plowing, seed, and weeding expenses.

Table 4.14 shows that total farm expenditures make up the same proportion of total cash income, 17 to 18 percent, for both income groups. This is somewhat surprising; however, two observations help explain why this is so. First, the 1980-81 year was a poor year for crops; thus income from crops was depressed. However, low income farmers must spend a certain amount of cash, especially for purchasing seed and hiring ox-plows, merely to maintain their productive capacity. This helps explain why their expenses, relative to their incomes, are as high as they are. Second, high income farmers appear to be averse to spending money on their farms and in particular, their crops; they prefer to invest a larger percentage of their income in their off-farm enterprises, which they feel are more profitable. This helps explain why the farm cash expenses of high income farmers are so low.

Indeed, the spending preferences of both groups of farmers appear to be oriented away from agriculture and in particular, away from crop production. Beyond spending a minimum on seed and plowing, low income farmers are not willing and/or are unable to invest in their farms. How do they prefer to spend their scarce cash? Survey data shows that 76 percent claimed that it was more important to spend money educating their children than to invest in their farms. Spending preferences are explored in greater detail in Table 4.16, which shows the responses to an open-ended question on how farmers would spend an extra 200 Shillings if it were given to them in March, the planting month. It should be noted that responses are likely to be biased towards agricultural uses for two reasons: (1) because the question concerned cash needs at a time when agricultural expenses are very demanding, and (2) because respondents were aware that the survey was being administered by representatives of the Ministry of Agriculture. Nonetheless, the number of low income farmers who indicated they would spend the cash on agricultural pursuits was surprisingly low, only 44 percent. Predictably, seed was their biggest concern. A further 44 percent said they would keep the cash "for security" or invest in small livestock, ostensibly for the same purpose. A further 19 percent would use the cash for consumption or other non-farm purposes. The spending preferences of

Table 4.16

How Farmers Would Spend an Extra 200 Shs. if They Received It at Planting Time (March), Middle Kirinyaga, 1981

	Low Income		High Income	
	Farmers	Percentage	Farmers	Percentage
Security				
Goat, Sheep, Poultry	9	(21%)	6	(17%)
Keep the cash for security	10	(23%)	5	(14%)
Total	19	(44%)	11	(30%)
Agriculture				
Weeding	4	(9%)	5	(14%)
Seed	7	(16%)	3	(8%)
Insecticide/Fertilizer	4	(9%)	2	(6%)
Plowing/Planting	2	(5%)	7	(19%)
Other	3	(7%)	2	(5%)
Total	17	(39%)	18	(50%)
Non-farm				
Household consumption	5	(12%)	3	(8%)
Other	3	(7%)	6	(17%)
Total	8	(19%)	9	(25%)
Total Farmers	43	(100%)	36	(100%)

[a]Farmers were permitted to select more than one item, therefore percentages do not sum to 100 percent.

Source: Survey data.

high income farmers do not appear to differ greatly from those of low income farmers.

In conclusion, the cash constraint affects each of the two groups in a somewhat different manner. Low income farmers often lack cash for the most basic of inputs--indigenous seed and hiring plows--much less for other improvements such as improved seed and fertilizer. Cash expenses are not high in an absolute sense; however, they come at a time when food is scarce and farmers' cash balances are particularly unfavorable. Further, their priorities in spending cash are directed more towards security and education than towards agriculture. For high income farmers, the cash constraint is much less binding. They are able to provide basic production inputs--seed, plowing and even hired labor for weeding and a grade cow to provide milk for home consumption--but most are reluctant to spend additional cash for improving their farms. They appear to be more interested in investments off the farm and in education, since their greatest source of income is from off-farm sources. Moreover, since about 40 percent of the household heads actually live away from the farm it is doubtful that they take farm investment very seriously. Thus whereas low income farmers are averse to investing in agriculture because they lack the resources, high income farmers avoid investing in agriculture because they feel opportunities are better elsewhere.

4.4.4. Access to Draught Power

Most farmers in Middle Kirinyaga prefer to plow and plant their maize and beans in a single operation: they broadcast their beans, open up furrows with a moldboard plow, and plant their maize seed in lines in the furrows. As the plow opens up a furrow the maize and bean seeds in the adjacent furrow are covered.

Tractors and hoes (jembes) are rarely used for land preparation. Tractors are few and most farmers dislike them because they compact the soil, thus sharply curtailing the soil's capacity to retain moisture. Hoes are used for preparing land only in small swampy portions of fields where plowing is not possible. Farmers who are unable to plow their fields, because they lack access to oxen or the cash to hire them, plant their maize and beans with a machete (panga) without first preparing the land.[1] However, they dislike planting in unprepared soil, citing decreased ability of the soil to retain moisture, more weed problems, and slower crop growth.

Most farmers in Middle Kirinyaga prefer to plant their long rains crops as soon as the rain begins, usually in mid-March. Thus, this is the time when ox-plow teams are in greatest demand. Plow teams are generally made up of four oxen, a driver, and another person to keep the oxen in line. The teams plow about 0.4 ha. per day, working for about 4-5 hours. However, if a field is very wet, plowing will take longer and the plow owner may refuse to plow altogether.

Table 4 17 shows that 46 percent of the high income farmers and 27 percent of the low income farmers own ox-plow and oxen. Although high income farmers have the finances to purchase oxen and ox-plows, many feel that hiring teams is a more cost-effective means of getting their fields plowed. Hiring a plow team costs the same during both the long rains and short rains, 120 Shs. per acre (0.4 ha.) plus about 20 Shs. worth of refreshments. Nearly all high income farmers, but only half of low income farmers, own oxen and plows or had cash for hiring them.

Table 4.18 shows that most farmers not owning oxen were unable to get their fields plowed during their desired period--before the rains,

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[1]Oddly enough, the hoe is the traditional tool for land preparation among the Kikuyu. For Middle Kirinyaga farmers, the incremental returns associated with hoe cultivation apparently do not compensate for the costs, particularly in terms of drudgery.

Table 4.17

Ownership of Oxen and Ox Plows, Middle Kirinyaga, 1981

	High Income Farmers		Low Income Farmers	
	Numbers	Percentage	Numbers	Percentage
Own oxen and plow	17	(43%)	13	(27%)
Own a plow and no oxen	8	(20%)	2	(4%)
Own neither	14	(36%)	33	(69%)
Total farmers	39	(100%)	48	(100%)

Source: Survey data.

Table 4.18

Desired Time of Plowing/Planting Compared to Actual Time of Plowing/Planting for Farmers not Owning Oxen, Middle Kirinyaga, Long Rains Season, 1981[a]

	High Income Farmers		Low Income Farmers	
	Numbers	Percentage	Numbers	Percentage
Yes, entire farm plowed when desired	8	(38%)	8	(27%)
Yes, part of farm plowed when desired	4	(19%)	4	(14%)
No, none of farm plowed when desired	9	(43%)	17	(59%)

[a]The "time" of plowing/planting is divided into three periods: before the rains begin, during the first ten days of rainfall and later. Thus, "farm plowed when desired" means the farm was plowed during the period which the farmer desired.

Data for six low income farmers who lacked cash for hiring a plow are not included in the table.

Source: Survey data.

during the first ten days of rain, or later. This problem is especially acute for low income farmers who tend to pay for plowing by providing labor services in place of cash, or rely on relatives who own oxen. They have little leverage for obtaining the oxen when they need them.

In the short rains season, the draught power problem is also precarious. On the demand side, farmers know that due to rainfall risk, they must get their crop in as soon as the rains begin. Many prefer to plant before the rains. On the supply side, many more tractors are available; they come from farms in the Rift Valley, where no short rains crops are grown. Overall, the balance of supply and demand is roughly the same as in the long rains.

It is likely that the difficulties in gaining access to oxen will worsen in the future. Farm size is decreasing, grazing areas are shrinking, and the cattle population is declining. For example, over one-half of the farmers in both groups claimed they had fewer cattle presently then they had had ten years ago; less than one-third said that their number had increased. Nearly all low income farmers and over one-half of the high income farmers cited urgent cash needs as the reasons for the decrease in number of cattle. Other causes, such as cattle deaths, labor shortages, and grazing problems were relatively unimportant. As draught power in Middle Kirinyaga declines, the area planted late will also likely increase, further depressing yield levels.

4.5. Leverage Points in Middle Kirinyaga

As discussed in Chapter 2, the diagnostic survey is characterized by a sequential approach to data collection in which each stage is increasingly focused on more specific priority problems. Here, we present the focii, or leverage points, we developed in the informal survey in Middle Kirinyaga.

As stated in Section 2.2, leverage points are points in the system where there is scope for increasing productivity in ways that are likely to be acceptable and feasible for farmers. The three principal leverage points we identified in the informal survey are:

1. Method and timing of land preparation and planting. Most farmers, particularly low income farmers, are unable to get their fields plowed when desired. Thus, they are unable to take full advantage of the brief period of rainfall available.
2. Soil fertility and structure. Most farmers cultivate continuously, twice per year, with no rotation and no fertilizer or manure.
3. Maize variety. Farmers frequently exhaust their home supplies of maize, their principal food staple. Maize varieties recommended by the Ministry of Agriculture are not widely used.

All three leverage points are relevant to both income groups; however, it is important to maintain the distinction between income groups because solutions relevant to one group may not be relevant to the other group.

The discussion of short rains management is much briefer than the discussion of long rains management for three reasons. First, short rains management was not given much priority for planning experimentation, because the high probability of low rainfall sharply reduces the potential for developing improvements to help farmers. Second, the survey took place during the long rains season. Therefore, the quality of data on short rains management is much lower because the recall period was much longer and because we were not able to use observations to support our findings. Third, it appears that maize and bean management in the short rains closely mirrors management in the long rains.

We focus on maize and beans for several reasons. First, stabilizing food supplies is a key objective of Middle Kirinyaga farmers and maize and beans are the two most important food crops from a production and consumption standpoint. Second, government policy strongly promotes the local production of maize and beans to substitute for imported maize and beans. Third, as noted in Chapter 2, farmers change in small steps, and it is thus more likely that research services can help by assisting farmers to improve the crops they are currently growing, rather than introducing new ones. Fourth, yield levels for maize and beans are fairly low and there is much potential for substantially increasing them.

We emphasize maize somewhat more than beans in Chapter 5 for three reasons. First, it is evident that maize is a much more important foodstuff to farmers in Middle Kirinyaga than are beans. Second, no ready consumer substitutes are available for maize while several exist for beans. Third, government policy places more emphasis on increasing maize production (Government of Kenya, 1982).

In the following chapter we analyze farmer practices at the leverage points. In Chapter 6, we propose solutions to farmers' problems which are likely to increase productivity and be acceptable and feasible to farmers.

CHAPTER 5

ANALYSIS OF SELECTED MAIZE AND BEAN PRACTICES

The purpose of this chapter is to analyze farmers' practices concerning identified leverage points as a basis for proposing experiments in the following chapter. At several of these leverage points, we use repertory grids and/or hierarchical decision tree models to aid in developing an understanding of selected farmer decisions. Furthermore, we elaborate on several practices not related to the priority areas, e.g., weeding, harvesting, and plant protection. It is important to document these practices because they comprise the non-experimental variables in our experimental program. In experiments to formulate recommendations for farmers, we fix the non-experimental variables at farmers' levels, so that the response to the experimental variable approximates the response the farmer will obtain.

The three principal leverage points identified in the informal survey are: (1) the method and timing of land preparation/planting, (2) maize varieties, and (3) soil fertility and structure. In this chapter, we highlight the first two areas because farmer practices at these points are particularly complex and, at first, baffling. For example, there were several different land preparation and planting methods and planting times, for which the rationale was not clear. Concerning maize varieties, most farmers grow at least two of the five available varieties and the reasons for accepting or rejecting any particular one were quite varied. On the other hand, farmer practices and attitudes concerning soil fertility and structure were fairly uniform and relatively simple to explain.

5.1. Long Rains Management

5.1.1. Maize Variety Choice

Embu Agricultural Research Station has carried out extensive work on maize varieties both on-station and at various sites within Middle Kirinyaga. In the long rains, H-511, a 150-day hybrid, is recommended north of the Embu-Sagana Road (see Map 1), and Katumani, a 120-day composite, is recommended south of the road. In fact, the border is somewhat arbitrary and both varities have been found to perform about equally well at sites throughout Middle Kirinyaga.

Farmers in both income groups have experimented considerably with available maize varieties.[1] High income farmers have tried an average of 3.7 different varieties, and low income farmers have tried 2.6 varieties. The average farmer in both groups grows 1.9 different varieties. These figures clearly refute the often-heard maxim in the area that small farmers are "conservative" and refuse to try varieties other than their own traditional variety, called "Local."[2]

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[1]We were greatly impressed by the amount of experimenting farmers did with varities. One farmer we found was growing a field of pure, purple maize--he had managed to select out a parent of H-512, a purple variety from South America. He liked this variety because of its milling quality and because chickens did not eat the maize, they mistook it for beans!

[2]"Local," also called Kikuyu or Muratha, is actually a mixture of local and second generation hybrids. Nevertheless, local has readily definable characteristics which are recognizable to the farmer, e.g., thicker husk cover, better storing qualities and longer maturity period (about 165 days) than H-511.

Table 5.1 summarizes information on variety use in Middle Kirinyaga. Local is the most important variety, grown by 59 percent of the high income farmers and 77 percent of the low income farmers. Katumani is grown by one-half of the high income farmers and two-thirds of the low income farmers but the total area per farm for both groups is very small, one-third of the area per farm under Local. H-511 and a similar hybrid, H-512, are grown by 36 percent of the high income farmers but only 8 percent of the low income farmers. Twenty to 30 percent of both groups grow second-generation hybrids.[1]

Table 5.1 also shows "rejection" rates, that is, the percentage of farmers who have tried a variety in past years but are not presently planting it. Four varieties, H-512, Katumani, Local and H-511, have each been rejected by over 25 percent of the farmers. Two varieties, H-511 and Local, have been tried and rejected by at least 20 percent of the low income farmers.

What accounts for the complex pattern of variety use, acceptance and rejection, and the area allocated to each variety in Middle Kirinyaga? The repertory grid presented in Table 5.2 shows farmers' ratings of five varieties across eight criteria.[2] Farmers were asked to evaluate only varieties which they were currently growing or had grown in the past. Column 1 shows evaluations on earliness of maturity. As expected, Katumani is rated the best and Local the worst. Column 2

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[1]Second generation hybrid seed is seed originating from a field of hybrid seed. Second generation seed has very heterogenous characteristics and has lower yield potential than first generation hybrid seed.

[2]There were few significant differences between the evaluations of high income farmers and low income farmers. Therefore, data are aggregated across income groups for convenience of presentation.

Table 5.1

Maize Varieties Grown in the Long Rains Season, Middle Kirinyaga, 1981

Variety	High Income Farmers					Low Income Farmers				
	Percent Farmers Planting	Percent Farmers tried and Rejected in Past Years	Area (ha)[a]			Percent Farmers Planting	Percent Farmers Tried and Rejected in Past Years	Area (ha)[a]		
			Pure Area	Mixed Area	Total Area-equivalent			Pure Area	Mixed Area	Total Area-equivalent
Local	59	28	24	14	30 (41%)	77	19	28	16	33 (51%)
Katumani	49	31	6	12	10 (14%)	69	8	11	13	16 (26%)
H-511	28	28	13	1	13 (18%)	8	21	2	0	2 (3%)
H-512	15	41	3	0	3 (4%)	2	12	0	0	1 (2%)
Second generation hybrid	28	8	11	13	15 (21%)	21	6	9	10	12 (18%)
Other	8	31	1	1	1 (1%)	6	4	1	1	1 (0%)
Total			57	14	71 (100%)			50	16	65

[a]"Pure" refers to an area grown to a single variety of maize, which may or may not be intercropped with another crop such as beans. "Mixed" means two or more maize varieties are mixed together in the field. Where data on seed rates were available on mixed fields, the areas planted to each variety were extrapolated and the figures are included under "Pure". Total is calculated by adding "Pure" plus one-half or one-third of "mixed" depending on whether the mixture is of two or three varieties.

Source: Survey data.

Table 5.2

Repertory Grid Showing Farmers' Ratings of Selected Maize Varieties Across Criteria They Consider Important, Middle Kirinyaga, 1981[a]

	Earliness			Resistance to Dog Damage			Yield (Sufficient Rainfall)			Yield (Low Rainfall)			Profitability			Resistance to Weevil Damage in Field			Storeable Without Chemicals			Storeable With Chemicals		
Varieties/Ratings	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
	(Number of Farmers)																							
Local	4	29	40	63	15	0	32	39	6	3	46	29	33	43	9	67	6	1	55	17	2	21	0	3
Katumani	61	3	2	8	12	51	4	29	39	64	6	3	3	16	50	5	23	42	0	11	60	20	0	9
H-511	11	18	4	26	7	3	25	8	1	9	16	7	19	10	3	2	12	19	1	7	25	18	0	3
H-512	3	17	3	19	5	0	23	4	0	3	15	8	15	9	1	0	11	15	0	4	22	10	0	2
Second generation hybrids	8	23	7	33	6	1	30	11	0	9	24	7	27	9	2	9	18	17	3	17	23	13	0	3

[a]Ratings are as follows: 1 = good, 2 = fair, 3 = poor.

Source: Survey data.

shows the susceptibility of varieties to damage by dogs. Katumani is the only susceptible variety; it is ready early, its stalks are relatively short and thin, and its ears are close to the ground. Thus, it is easy for dogs to tear down the stalk to get at the ears.

Yield ratings are presented in Columns 3 and 4. Hybrid varieties have the highest yield ratings for seasons of sufficient rainfall, and, surprisingly, second generation hybrid receives as many high ratings as first generation hybrids.[1] Local also receives high marks by many farmers but has a few more "fair" than "good" ratings. Katumani is clearly the lowest rated variety. However for seasons of low rainfall, Katumani receives almost unanimous "good" ratings whereas other varieties receive mostly fair or poor ratings. Curiously, farmers' own opinions that Katumani yields less than Local in seasons of sufficient rainfall are contrary to research trial results. It is likely that a difference between researcher and farmer practice concerning plant population, soil fertility, or intercropping accounts for this. Also, some farmers feel that there is no difference in yield between the hybrids and their own variety. Once again, differences in one or more of the above management variables may have caused different outcomes between farmers' own experience and research trials.

Ratings on profitability, weevil damage and storing with and without chemicals are presented in Columns 5 to 8. Profitability ratings pertain

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[1]Many farmers planting second generation hybrid have never tried hybrid varieties and many hybrid planters have never planted second generation hybrid seed. Therefore, the results do not imply that <u>most</u> farmers believe that hybrids and second generation hybrids give similar yields. However, a substantial percentage of farmers, approximately one-quarter, claimed that the yields are similar.

to yield in sufficient rainfall, with the hybrids highest and Katumani lowest. Katumani and the hybrids are very susceptible to weevil damage in the field, whereas Local has no weevil problem. Farmers noted that, in the field, Katumani and hybrid ears are often exposed whereas Local has uniformly well covered husks; the results on storing without using chemicals are very similar to those for weevil damage in the field. Katumani is by far the worst and the hybrids also rate poorly, whereas Local stores very well without chemicals. The last column shows that most farmers do not have problems storing maize with chemicals, but where problems occur they are most likely to be with Katumani.

The grids thus show the favorable and unfavorable aspects of each variety from the farmers' point of view. However, the repertory grid tells us nothing about the trade-offs which farmers make among objectives, nor about the resource constraints or chance occurrences which may prevent them from carrying out their intentions. We therefore decided to build hierarchical decision tree models (HDM) of the variety choice process in order to develop an understanding of the reasons farmers had for selecting the varieties they do. The informal survey showed that farmers actually make two separate decisions on maize varieties:

1. Which variety, if any, to grow for early maize. Because pre-harvest food shortages are so critical in the system, most farmers are interested in planting a variety which is ready early. The area allocated to this variety for this purpose is normally 0.4 ha. (1 acre) or less.
2. Which variety to grow for the main stock of maize. The main stock is stored and is used for consumption and periodic

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sales whenever cash is needed. The area for the main stock is residual, generally 1 to 2 ha.

HDM's were developed to model three decisions on variety use, one concerning the variety to grow for early maize and two concerning the variety to grow for the main stock:

1. Grow Katumani for early maize
2. Grow H-511/H-512 for main stock of maize
3. Grow Katumani for main stock of maize

These three decisions are discussed in detail in the following sections.

Grow Katumani for Early Maize

Over two-thirds of low income farmers and just under half of high income farmers grow Katumani for early maize, as shown in Table 5.3, which summarizes the decision tree in Figure 5.1. Those farmers not growing Katumani for early maize cite low yield, damage by dogs, or their own disinterest in early maize.

Even though Katumani is perceived to be much lower yielding than other available varieties, the fear of exhausting home-produced food supplies before harvest time is so high that most farmers are willing to grow at least some Katumani. Low income farmers have more of a propensity to grow Katumani for early maize because they lack regular sources of income, and thus have the most to fear if they run out of food.

Planting Katumani makes sense for high income farmers also; between August, when Katumani is ready to harvest, and September, the principal month for harvesting, maize prices typically fall 20-30 percent

Table 5.3

Farmers' Decisions on Whether or Not to Grow Katumani for Early Maize and for Main Stock: Reasons for Rejecting and Accepting, Middle Kirinyaga, 1981[a]

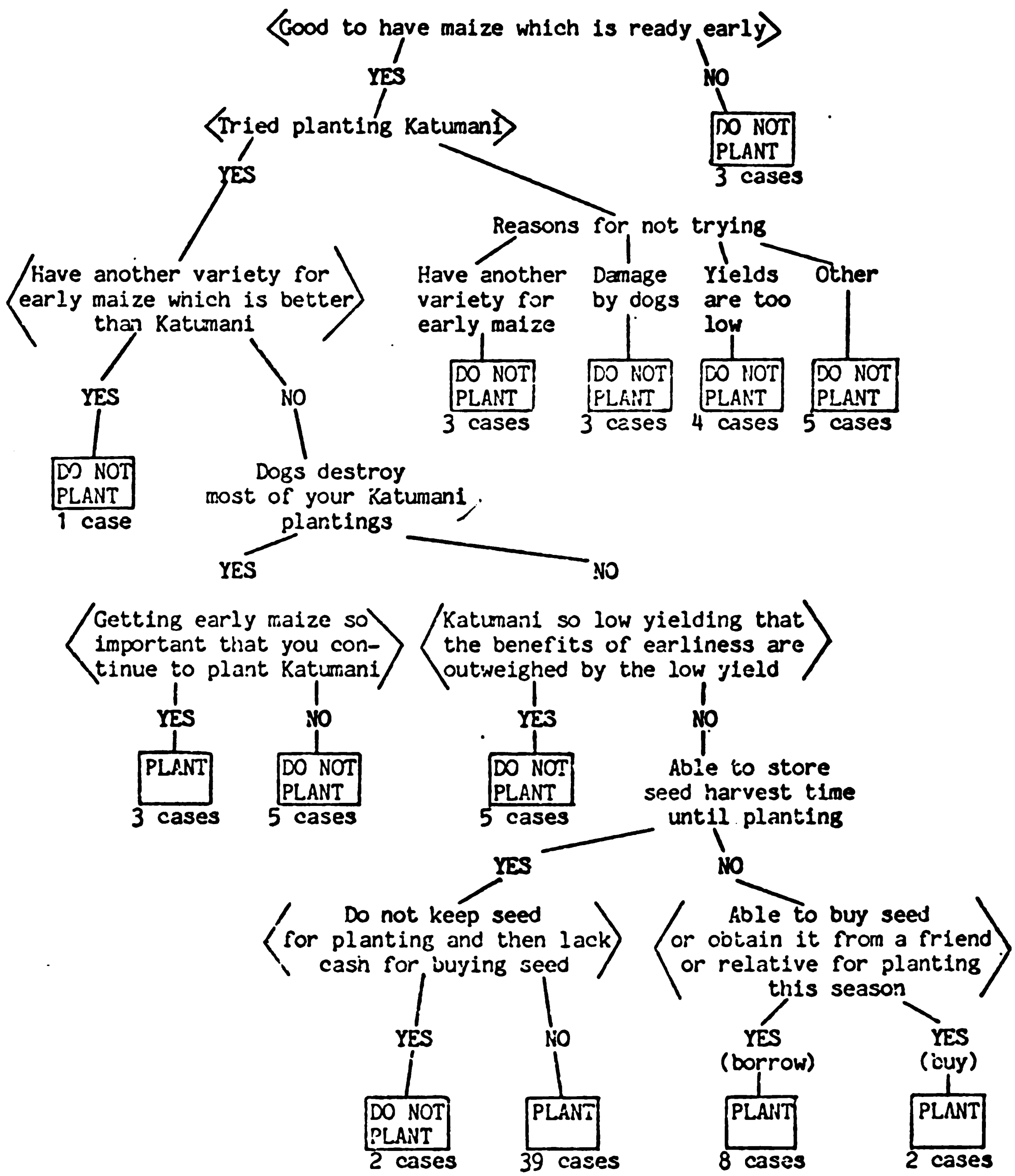
	Decision to Grow Katumani for Early Maize						Decision to Grow Katumani for Main Stock					
	High Income Farmers		Low Income Farmers		Total		High Income Farmers		Low Income Farmers		Total	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Rejectors' Reasons for not growing:												
Not interested in earliness	3	(8%)	0		3	(8%)	-		-		-	
Have better early variety	2	(5%)	2	(4%)	4	(6%)	-		-		-	
Low yield	6	(16%)	4	(8%)	10	(11%)	17	(43%)	18	(37%)	35	(40%)
Dog damage	4	(10%)	5	(10%)	9	(10%)	6	(15%)	4	(8%)	10	(11%)
Storage difficulty	2	(5%)	0		2	(2%)	7	(18%)	10	(21%)	17	(20%)
Other[b]	4	(10%)	5	(10%)	9	(11%)	2	(6%)	4	(8%)	6	(7%)
Subtotal	21	(53%)	16	(33%)	37	(42%)	32	(82%)	36	(75%)	68	(78%)
Adoptors' Reasons for Growing												
Good for early maize	18	(47%)	32	(67%)	50	(57%)	-		-		-	
Good for main stock	-		-		-		3	(8%)	6	(12%)	9	(10%)
Good because am planting late	-		-		-		3	(8%)	3	(6%)	6	(7%)
Other	0		0		0	(0%)	1	(3%)	3	(6%)	4	(4%)
Subtotal	18	(47%)	32	(67%)	50	(57%)	7	(18%)	12	(25%)	19	(22%)
Total	39	(100%)	48	(100%)	87	(100%)	39	(100%)	48	(100%)	87	(100%)

[a]Includes all six cases not included on the trees in Figures 5.1-5.2. For these cases, the farmer gave a specific reason for using Katumani but the information given was inadequate or contradictory. Therefore they are included in the "other" categories under reasons for growing or reasons for not growing.

[b]Includes those who have not made a decision, i.e., do not know enough about Katumani to make a decision.

Source: Survey data. Summary of Figures 5.1 and 5.2.

Figure 5.1 Decision Tree on
Whether to Plant Katumani Variety for Early Maize



N=81, 6 cases not included due to inadequacy of data.

as shown in Figure 4.3. It is likely that the cost savings from growing Katumani, in terms of not having to purchase maize during August, outweigh its yield disadvantage. The decision tree shows that only five farmers who had tried Katumani felt that its yield was so low as to outweigh the benefits of earliness. It is significant that all five of those farmers were high income; since they have access to cash for purchasing food whenever necessary, they are less concerned with the benefits of earliness than are low income farmers.

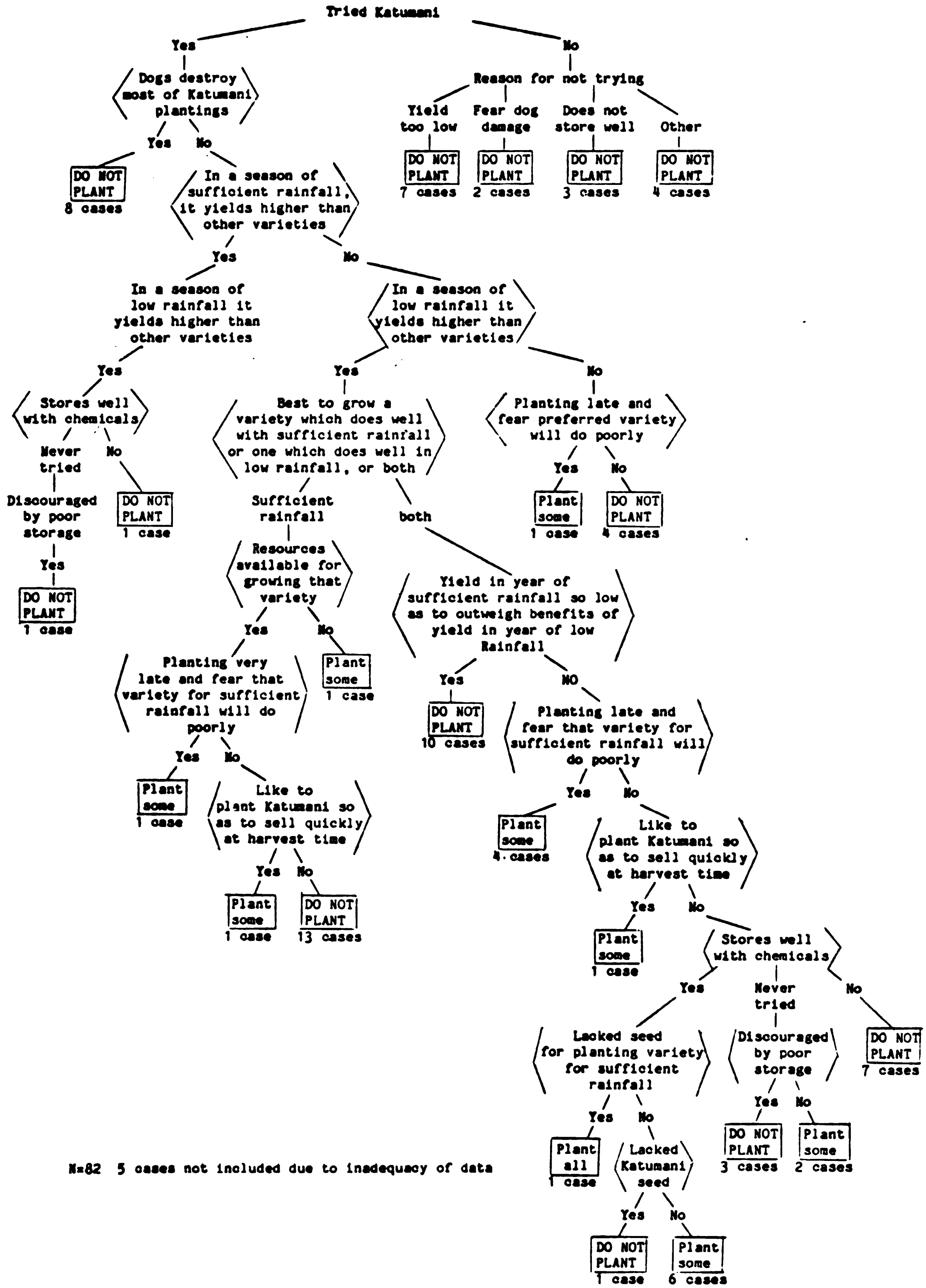
The tree also shows that ten of the farmers who have tried Katumani (11%) are unable to store seed from harvest time until planting time, a period of about three months. However, all ten of these farmers plant Katumani; they borrow seed from other farmers (who presumably use storage insecticide) or purchase commercial seed in stores. Eight of these ten farmers were low income; this lends further support to the finding that low income farmers are strongly committed to growing Katumani.

Grow Katumani for Storage and Sale

Figure 5.2 presents the decision tree on whether or not to grow Katumani for one's main stock of maize. The results are summarized in Table 5.3. Only 25 percent of the low income farmers and 18 percent of the high income farmers plant Katumani for their main stock of maize. Less than half of these farmers are planting Katumani because they think that it is a generally good variety for that purpose. For example, six of the nineteen planted Katumani because they happened to plant very late and were worried that their preferred, late-maturing varieties would not perform well. Others planted Katumani because they wanted to sell

Figure 5.2

Decision Tree on Whether to Grow Katumani to Store for Later Sales and Consumption



N=82 5 cases not included due to inadequacy of data maize quickly at harvest time or because they were prevented from planting their preferred varieties for other reasons.

Table 5.3 also shows that farmers' main reasons for rejecting Katumani are low yield and poor storing. These problems are examined in greater detail:

1. Low Yield. The repertory grid in Table 5.2 showed that nearly all farmers felt that Katumani gave the highest yield during seasons of low rainfall, but that other varieties gave better yields during seasons of sufficient rainfall. Farmers contacted during the informal survey were divided over whether to plant only a variety which does well with sufficient rainfall or whether to supplement this variety with one which does well in low rainfall, presumably to hedge one's risk. There was some tendency for low income farmers to prefer planting varieties for both possible situations whereas high income farmers were evenly split on this issue. In any case, it is clear that farmers who prefer to plant only a variety which does well in sufficient rainfall were not likely to plant Katumani for their main stock of maize. In fact, the tree shows that 14 of 16 farmers preferring varieties for sufficient rainfall did not plant Katumani for their main stock. Further, the tree also shows that 10 of the 35 farmers who had tried Katumani and preferred to plant both types of varieties still rejected Katumani because of its low yields. Thus, it appears that for over half of the farmers--those preferring varieties for sufficient rainfall and those who prefer varieties for both situations but still reject Katumani--the cost of hedging against risk, in terms of lower expected yields, was so high that they rejected Katumani.

During the informal survey, we had hypothesized that more high income farmers than low income farmers would reject Katumani for their main stock because of its low yield. Since low income farmers appear to have more to lose from a crop failure, it seemed reasonable that they would discount the disadvantage of low average yield in favor of the advantage of higher production in years of low rainfall. Moreover, we expected farmers' recent experiences to encourage this tendency since rainfall had been very low in the previous long rains season.

However, the data do not support this hypothesis; nearly the same percentage of farmers in each group, 43 percent of high income farmers and 38 percent of low income farmers, rejected Katumani because of low yield.

2. Poor Storing. About 20 percent of the farmers in both income groups reject Katumani because it does not store well. In the informal survey, farmers indicated that poor storage of Katumani is due to two factors:

(a) Poor husk cover. Some farmers claimed that their weevil problem actually began in the field, because the cobs were exposed, and

(b) Weevil preference for Katumani. Several farmers indicated that when they store Katumani in the same way and in the same store with local, they encounter weevil problems only with Katumani.

About three-quarters of the high income farmers use storage insecticides whereas only one-third of the low income farmers do so.

The repertory grid in Table 5.2 shows that Katumani, unlike Local, keeps poorly without chemicals. Moreover, one-third of those farmers who had tried, claimed it stored poorly with chemicals. About half of the farmers who rejected Katumani because of poor storage characteristics had not even tried to store it with chemicals; these farmers grow mostly Local, which keeps well without treatment, and they do not want to be bothered by having to treat maize in the store. At first, this appears unreasonable, since the cost of storage chemicals (Malathion 2 percent) is very low, only 6 Shs. to treat 3 bags (270 Kg.). However, farmers were able to keep Katumani only four months on average with a single application of insecticide. Therefore, a second application would be required during weeding season, when cash is most scarce. Thus, many farmers appear to be unwilling to use a variety which requires periodic cash outlays for storage insecticide, especially when there is considerable risk that the application will be ineffective.

It appears that poor storage methods may be partly responsible for farmers' dissatisfaction with the storage quality of Katumani. If the period of the effectiveness of chemicals can be increased to six months, through improved storage practices, farmers will need to buy chemicals only once per season. Assured of their ability to store Katumani and hybrid with only one application, more farmers will adopt them.

Unfortunately, we were unable to identify specific farmer storage practices which need to be changed. For example, we found that only 16 percent of those farmers who had used and then rejected storage insecticide had used one of two selected incorrect methods: applying insecticide to unhusked cobs or not mixing insecticide among cobs. It thus appears that other factors such as unclean stores, contamination from untreated maize, low application rates, low quality insecticide, or late applications may be responsible for the poor performance of some storage insecticide.

Grow Hybrid 511/512 for Main Stock of Maize

Approximately 85 percent of the high income farmers and 40 percent of the low income farmers have tried H-511 or H-512. Presently, 36 percent of the high income farmers and 8 percent of the low income farmers grow hybrids. About one-third of the hybrid growers grow hybrids exclusively, one-third grow mostly hybrid and one-third grow one acre or less. Farmers' reasons for planting or rejecting hybrid 511/512 are explored in the decision tree in Figure 5.3 and are summarized in Table 5.4.[1] The tree is more complex than those for Katumani because farmers' perceptions of hybrid yield performance are more varied than for Katumani. The principal reason why low income farmers do not grow hybrid maize is lack of cash; other important reasons include low yield/no profit, poor storage, and belief that second generation seed gives the same production as new hybrid seed. Those high income farmers not growing hybrid cited poor storage, lack of cash, or that second generation seed gives the same production as new seed.

The tree shows that farmers who have tried hybrids are split into three groups on the question of whether new seed is different than second generation seed. First, about one-quarter believe that there is no differences; these farmers did not plant hybrid except for two who received hybrid seed as a gift. Second, 12 percent believe there is a difference, but note that new seed is superior only because it is treated

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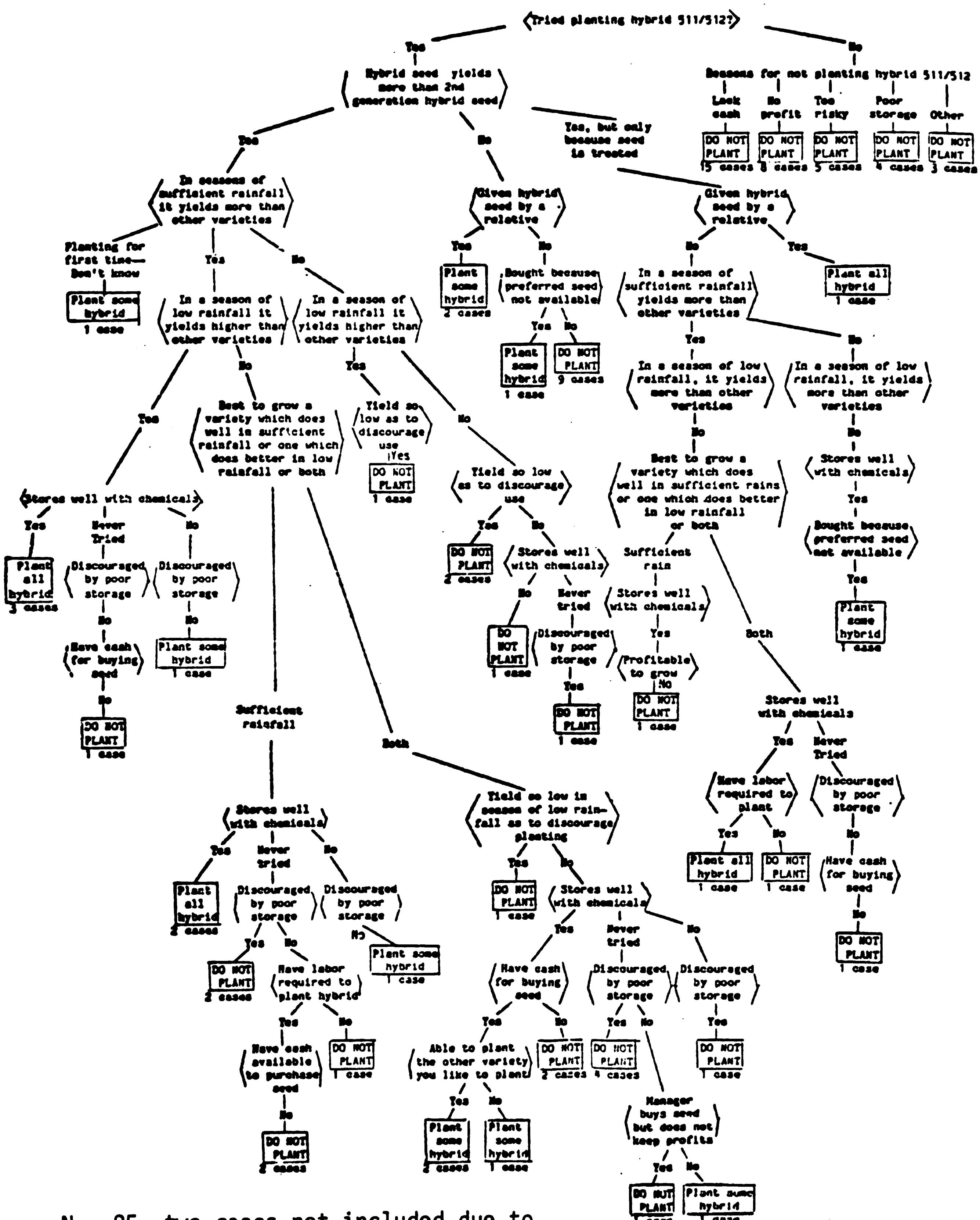
[1]Since hybrid 511 and 512 have very similar characteristics, both varieties are included in the same decision tree. Separate analysis of the 13 cases of 512-use and 29 cases of 511-use showed no discernible differences in reasons for adoption or rejection. 512 is currently unavailable in Middle Kirinyaga; 511 is recommended over 512 because it has a slightly shorter maturity period and is thus less susceptible to late season drought.

Figure 5.3 Decision Tree on Whether or Not to Grow Hybrid 511/512



N = 85, two cases not included due to inadequacy of data

Table 5.4

Farmers' Decision on Whether or Not to Grow Hybrid 511/512 for Main Stock of Maize, Middle Kirinyaga, 1981[a]

	High Income Farmers		Low Income Farmers		Total	
	Number	Percent	Number	Percent	Number	Percent
Rejectors' Reasons for not Growing						
Low yield/no profit	3	(8%)	8	(17%)	11	(13%)
Lack cash for seed	6	(15%)	15	(31%)	21	(24%)
Too risky	0		5	(10%)	5	(6%)
Poor storage	7	(18%)	7	(14%)	14	(16%)
Believe later generations are the same as new seed	5	(13%)	6	(12%)	11	(13%)
Other	4	(10%)	3	(6%)	7	(8%)
Subtotal	25	(64%)	44	(92%)	69	(79%)
Adoptors' Reasons for Growing						
Good variety for main stock	8	(20%)	3	(6%)	11	(13%)
Seed is treated	2	(5%)			2	(2%)
Other (gift, trying for first time, etc.)	4	(10%)	1	(2%)	5	(6%)
Subtotal	14	(36%)	4	(8%)	18	(21%)
Total	39	(100%)	48	(100%)	87	(100%)

[a]The case not included on the tree is included in this table for similar reasons for those given in footnote to Table 5.3.

Source: Survey data. Summary of Figure 5.3.

with anticide. Ant damage of newly planted seed is a common problem in Middle Kirinyaga. About half of these farmers plant hybrid seed. Third, the remaining 65 percent of those farmers who have tried hybrid seed claim that it gives higher yields than second generation seed. Nearly all of these farmers feel that hybrids give them higher yields in seasons of sufficient rainfall than other available varieties; since all prefer to plant a variety for sufficient rainfall in the long rains, all may be characterized as potential users. This group consists mostly of high income farmers, as many more high income farmers than low income farmers have tried hybrid. The two most important constraints preventing these farmers from adopting hybrid seed are poor storage and lack of cash.

1. Poor storage. Most farmers who have used chemicals on hybrid in the store encountered no problem. Indeed, most of those citing storage problems as the reason for not growing hybrid had never tried insecticide. Their reasoning was similar to many of those who cited storage problems in growing Katumani--they did not want to be bothered with storage risks and costs when they could continue growing Local, which stored without problem from harvest to harvest. However, certain farmers with storage problems still grow some hybrid; they sell and/or consume it soon after harvest.

2. Lack of Cash. Hybrid seed sells for 50 Shs. per 10 Kg. (suitable for 0.4 - 0.8 ha.) and thus represents a substantial investment at planting time. Some farmers are unable to spare cash for purchasing seeds and thus plant an alternative variety such as local, which they may have in their store or which is available at less than half the price of hybrid in the local markets.

The decision tree and summary table also show that only 60 percent of those farmers growing hybrid do so because they feel it is the best variety to grow. The two other principal reasons are because the seed is treated against ants, and because the seed was given to the farmer by a relative.

In summary, farmers in Middle Kirinyaga have extensive exposure to the two recommended long rains varieties, Katumani and Hybrid 511/512, but over two-thirds of the area of both income groups is planted to Local or second generation hybrids. Most farmers, especially low income ones, plant a small area of Katumani, in spite of its low yield, to obtain some early maize. However, few farmers in either group are willing to plant it for their main stock of maize, even though it does well when the rains are insufficient. Low yield, storage, and susceptibility to damage by dogs are the principal reasons for rejecting Katumani. Hybrids are rejected by over two-thirds of high income farmers and nearly all low income farmers because of lack of cash for buying seed, poor storage and because they believe there is no difference between new and second generation seed.

5.1.2. Bean Variety Choice

A wide range of bean cultivars are grown in Middle Kirinyaga; 13 different cultivars were found among sample farmers and the average farmer grows two to three different ones. No improved seed is available in Middle Kirinyaga; all seed comes from farmers' stores or is purchased in the market from other farmers. Table 5.5 presents the principal cultivars, their seed characteristics, the percentages of farmers growing and rejecting each cultivar, and areas allocated to each. The

Table 5.5

Bean Cultivars in Middle Kirinyaga, 1981: Seed Characteristics, Percentages of Farmers Growing, and Area Grown

	Description of Seed Size, Shape, Color	High Income Farmers				Low Income Farmers			
		Percent Farmers Growing	Percent Farmers Rejecting[a]	Area (Ha.)[b]		Percent Farmers Growing	Percent Farmers Rejecting[a]	Area (Ha.)[b]	
Canadian Wonder	Large, Kidney, Deep Red, Violet	80	3	37	(58%)	73	6	31	(55%)
Mexican 142[a]	Small, Oval, White	23	41	4	(6%)	31	19	8	(14%)
Mwezi Moja	Large, Kidney, Violet	26	15	8	(12%)	12	14	3	(5%)
Rosecoco-oval	Small, Oval, Pale Red/White Stripes	41	8	6	(9%)	31	6	6	(11%)
Mwitemania	Medium, Kidney, Beige, Mottled	10	0	1	(1%)	10	0	5	(9%)
Canadian Wonder (small)	Small, Kidney, Deep Red, Violet	23	15	4	(6%)	4	10	1	(2%)
Other	-	-	-	5	(8%)	-	-	3	(4%)
Total				64	(100%)			57	(100%)

[a]"Rejecting" refers to farmers who have grown the cultivar in the past but do not grow it at present.

[b]Area refers to either intercropped or pure stands of beans. Farmers mixed two different bean cultivars on approximately 15% of their fields; in these cases each cultivar was assigned half of the area planted in the statistics.

Source: Survey data.

repertory grid in Table 5.6 shows how farmers rate alternative cultivars over criteria they feel are important, and thus contributes to explaining the relative importance of each cultivar in the area. Canadian Wonder is by far the most important cultivar; it is grown by over three-quarters of the farmers in each income group on over half the area planted to beans. Farmers give Canadian Wonder the highest ratings over nearly all important criteria. Canadian Wonder yields well in sufficient rains and heavy rains and is relatively early-maturing, maturing in about four months. Moreover, it has excellent taste quality, good color, high price, and does not interfere with maize when intercropped.[1]

Mexican 142 is the second most important cultivar for low income farmers, grown by about one-third of them. Mexican's high rejection rates can be explained by a recent sharp drop in prices due to a reduction in demand for this cultivar, which is excellent for canning. The repertory grid shows that Mexican has four important disadvantages: (1) it is late-maturing, (2) it has a very poor taste, (3) it has the lowest price of any variety, about 30 percent lower than Canadian Wonder, and (4) it interferes with the growth of maize when intercropped. However, Mexican yields fairly well under all levels of rainfall and, most importantly, its small seed size and low price make it by far the cheapest seed to plant. Thus, the cash constraint at harvest time forces many farmers, especially low income ones, to turn to Mexican even though they would otherwise prefer not to plant it.

Rose-coco oval is the third most important bean cultivar, on the basis of area planted, for both groups. Grown by about 40 percent of

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[1] One woman stated that she liked Canadian Wonder because she could put just a few beans into her Githeri and because of its deep red color, guests would think her very generous for giving them a dish full of beans!

Table 5.6

Repertory Grid Showing Farmer Ratings of Selected Bean Cultivars Across Criteria They Consider Important, Middle Kirinyaga, 1981[a]

	Yield (Sufficient Rain)			Yield (Low Rain)			Yield (Heavy Rain)			Earliness			For Githeri[c]			Compatibility With Intercrops			Color			Price		
Cultivars[b]/Ratings	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
	(Number of Farmers)																							
Canadian Wonder (Gitune Loan)	56	9	3	31	33	6	39	27	5	56	13	2	67	9	0	62	7	2	69	1	0	66	3	0
Mexican 142 (Gacheru)	23	11	6	17	6	8	18	15	9	1	4	37	0	2	40	4	1	37	23	11	8	2	1	39
Mwezi Moja (Kibuu Loan)	16	13	1	11	16	5	9	20	3	21	9	2	9	19	3	22	7	3	13	16	2	9	19	3
Rosecoco Oval (Gikora-Kabumbu)	18	13	2	18	12	3	12	16	4	17	15	0	21	12	0	21	7	4	19	12	2	13	17	0
Canadian Wonder (small size-Gitune Traditional)	9	5	2	2	7	6	5	8	2	2	4	9	7	8	0	1	0	14	11	3	0	8	6	1
Rosecoco Traditional (Gikara Traditional)	10	14	6	3	10	17	8	14	6	2	7	20	4	22	4	0	4	26	16	13	1	4	23	1
Gacheru Traditional	11	3	3	7	5	5	9	5	3	2	2	12	0	1	16	0	3	19	5	5	7	0	1	16
Pinto (Muitamania)	10	0	0	8	2	1	6	4	1	9	3	0	11	2	0	9	4	0	3	6	3	4	7	2
Mwezi Moja (small size-Kibuu Traditional)	4	5	2	3	4	4	2	6	3	3	6	1	3	4	4	4	1	2	3	4	2	2	3	2

[a]Ratings are as follows: 1 = good, 2 = fair, 3 = poor. The local names of each are included next to the more well known, generic name.

[b]Local names of cultivars are shown in parentheses.

[c]Githeri is the main dish in Middle Kirinyaga.

Source: Survey data.

high income farmers and 30 percent of low income farmers, Rose-coco oval is most noted for its ability to produce well in seasons of low rainfall. It obtained fair ratings on price and yield in heavy rains and good ratings on intercropping and taste.

Mwezi moja, the second most important cultivar for high income farmers, is the earliest maturing cultivar available. However, it does not yield well in seasons of heavy rainfall and has only fair taste, price and color characteristics. It is not clear why it is grown by many more high income farmers than low income farmers. Earliness in beans is not as crucial a characteristic as is earliness in maize because cowpea leaves, a home-produced substitute for beans in the diet, are readily available during the period before beans mature.

In summary then, most farmers prefer to plant Canadian Wonder and one to two other varieties: Mexican if there is a cash constraint at planting time and stored seed is lacking, Rose-coco oval to hedge against the risk of low rainfall, or Mwezi Moja for early food.

5.1.3. Method and Timing of Land Preparation and Planting

Most farmers in Middle Kirinyaga prefer to plant their maize and beans as a single operation, as described in Section 4.4.4. Table 5.7 shows that over 60 percent of farmers in both income groups prefer to plant during the first ten days of rain.[1] Only a few, about 13 percent in each group prefer to plant dry, before the rains begin. About 10 percent prefer to plant their maize dry and their beans later; these are farmers who (1) do all of their planting by <u>panga</u> and thus incur no

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[1]Rainfall during the first ten days of rainfall averages 106 mm. (Standard deviation = 55.1), or nearly one-sixth of the long rains total.

Table 5.7

Farmers' Opinions on the Best Time to Plant Maize and Beans, Middle Kirinyaga

Best Time to Plant	High Income Farmers		Low Income Farmers	
	Number	Percent	Number	Percent
During First Ten Days of Rainfall	23	(64%)	36	(75%)
Before the Rains	5	(14%)	6	(12%)
Maize Before the Rains, Beans During the Rains	3	(8%)	5	(10%)
Other (at Different Times or Later than the First Ten Days of Rainfall)	5	(14%)	1	(2%)
Total	36	(100%)	48	(100%)

Source: Survey data.

extra costs by planting at two different times or (2) weed their maize using oxen and plant beans during the weeding operation.

Farmers in Middle Kirinyaga prefer to plant at the safest time, that is, the time which presents the least danger of losing their crop. Farmers face a myriad of hazards at any possible planting time; these hazards and the perceived degree of danger they present are shown in the repertory grid in Table 5.8. The grid shows that farmers consider planting dry to be extremely risky, especially for beans. The most important hazards affecting beans, and the percentages of farmers who feel the hazards are a "big problem" are:

Table 5.8

Repertory Grid Showing Perceived Hazards of Planting Maize and Beans at Various Times, Middle Kirinyaga, 1981

	Maize						Beans					
	Big Problem		Some Problem		Not a Problem		Big Problem		Some Problem		Not a Problem	
	Number Farmers	Percent	Number Farmers	Percent	Number Farmers	Percent	Number Farmers	Percent	Number Farmers	Percent	Number Farmers	Percent
Hazards of Planting Before the Rains												
Insects eating seed	30	(34)	23	(26)	34	(39)	46	(53)	14	(16)	26	(30)
False start of rain	37	(42)	36	(41)	14	(16)	54	(63)	23	(26)	9	(10)
Seeds not germinating	22	(27)	30	(37)	30	(37)	39	(47)	24	(29)	20	(24)
Heavy rain spoiling seeds	23	(26)	39	(45)	25	(29)	50	(57)	29	(33)	8	(9)
Bean flowers spoiled by rain	-	-	-	-	-	-	48	(56)	30	(35)	8	(9)
Seeds buried by soil clumps	14	(17)	41	(49)	29	(34)	21	(25)	35	(42)	27	(32)
Seeds buried too deep	9	(11)	41	(49)	34	(41)	19	(23)	34	(41)	29	(35)
Difficult to get plow	19	(29)	7	(11)	39	(60)						
Hazards of Planting During First 10 Days of Rains												
Bean flowers spoiled by rain	-	-	-	-	-	-	18	(23)	42	(53)	19	(24)
Heavy rain spoiling crop	14	(16)	43	(50)	29	(34)	21	(25)	45	(53)	19	(22)
Difficult to get plow	32	(37)	14	(16)	41	(47)	-	-	-	-	-	-
Rain ending early	8	(9)	36	(41)	43	(49)	10	(11)	33	(38)	44	(51)
Hazards of Planting Later												
Heavy rain spoiling crop	22	(26)	20	(23)	43	(51)	23	(27)	16	(19)	46	(54)
Rain ending early	66	(76)	19	(22)	2	(2)	61	(70)	22	(25)	4	(5)

Source: Survey data.

1. False start of the rain (63 percent). The rain may start, thus triggering the germination process, and then stop for a period, causing seeds and young seedlings to die.
2. Heavy rain spoiling seeds and/or seedlings (57 percent).
3. Bean flowers spoiled by rain (56 percent). If a farmer plants early, he risks having his beans flower before the period of heavy rains has ended. The rains may knock the flowers to the ground, thus sharply curtailing yields.
4. Insects eating seeds (53 percent). This is a localized problem affecting farmers with anthills in or near their fields.
5. Seeds not germinating (47 percent). Seeds left too long in the hot soil may lose vigor.

Farmers note many fewer problems with planting maize dry than with planting bean dry. Only two hazards, false start of the rain and insects eating seeds, were mentioned by over 30 percent of the farmers. Farmers' views on the relative vigor of dry-planted maize seed and bean seed have a sound agronomic basis.

Planting during the first ten days of rainfall is relatively trouble-free; the only problem is in obtaining use of a plow, since most farmers prefer to plant at this time. The principal problem with planting later than the first ten days is the risk that the rains will end early, sharply curtailing yields.

Farmers' preferences for planting as closely as possible to the start of the rains are well justified. Experiments at the Embu Agricultural Research Station show maize yield decreases of up to 50 percent if planting is delayed two weeks after the rains begin. The cause of the decrease is (1) drought stress, since the rain falls over only a brief period, (2) a decrease in soil temperature after the rain begins which retards plant growth and (3) leaching of nutrients by the rain (Allan, 1980). The Ministry of Agriculture recommends planting maize dry and beans just after the rains begin, or if intercropping, both just after the rains begin.

In Section 4.4.4, we noted that most farmers, particularly low income farmers, were unable to plant their fields during the period they desired--before the rains, during the first ten days of rain, or later. Table 5.9 shows that half of the high income farmers' area was planted during the first ten days of rain, with about one-third planted before the rains and only 20 percent later. On the other hand, 36 percent of the area of low income farms was planted later than the first ten days.[1]

Farmers' decisions on the method and timing of land preparation and planting for the 1981 long rains season are explained in the decision tree in Figure 5.4. The decision tree is extremely complex because of the diversity of constraints which farmers face. Farmers deal with these constraints by making sub-decisions which aim to avoid or minimize the effect of the constraints. It is not practical to summarize the decision outcomes of the tree in a single table. Tables 5.10-5.13 highlight the principal results of the exercise.

First, the tree shows that in 88 percent of the cases, the farmer's safest time to plant--the time at which he feels that there is the

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[1]Based on observation of farms at planting time, it is likely that the area planted late was underestimated. Some farmers' statements may reflect the time they would like to have planted rather than the actual time they planted. More realistic estimates are perhaps 33 percent late for high income farmers and 50 percent late for low income farmers.

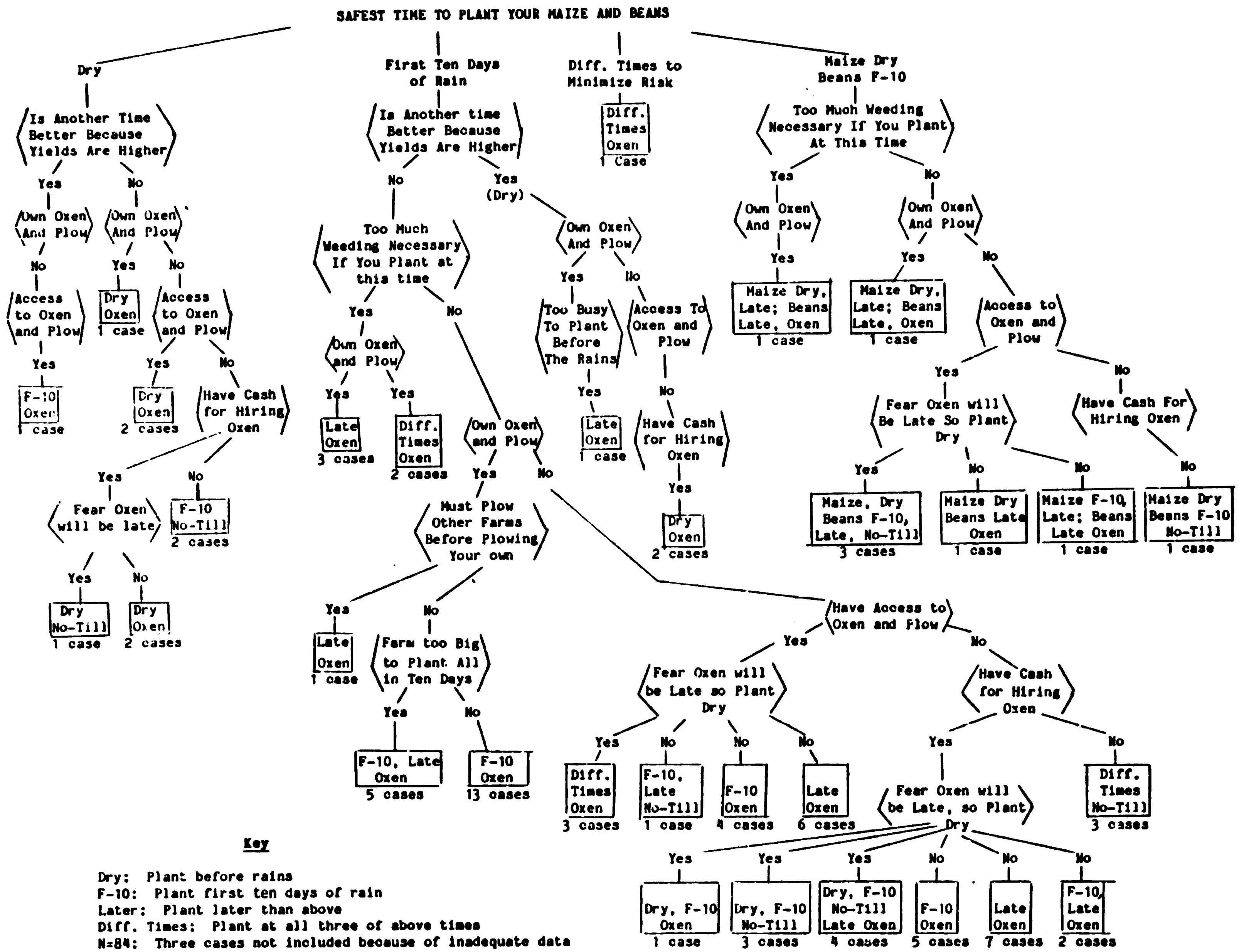
Table 5.9

Timing and Area of Maize and Bean Plantings, Middle Kirinyaga, Long Rains Season, 1981

	High Income Farmers			Low Income Farmers		
	Area Planted Before Rains	Area Planted First Ten Days of Rain	Area Planted Later	Area Planted Before Rains	Area Planted First Ten Days of Rain	Area Planted Later
Maize-Beans (ha.)	13	27	9	5	19	21
Maize (ha.)	2	0	2	1	2	0
Beans (ha.)	1	1	1	0	0	0
Maize; Beans at a Later Time (ha.)	3	0	0	6	6	0
Total	18 (31%)	28 (49%)	12 (20%)	13 (21%)	26 (43%)	22 (36%)

Source: Survey data.

Figure 5.4 Decision Tree on the Time and Method of Land Preparation and Planting



Key

Dry: Plant before rains
F-10: Plant first ten days of rain
Later: Plant later than above
Diff. Times: Plant at all three of above times
N=84: Three cases not included because of inadequate data

least danger of losing his crop--was also his desired time to plant. Those farmers desiring to plant at times other than their safest time did so because

1. They preferred to plant late, after the first ten days of rain, in order to minimize their weeding. After a ten-day period following the start of the rains, weeds have germinated and begun to surface. A farmer planting with oxen at this time will, in effect, be weeding and planting at the same time. Thus, whereas over three-quarters of the farmers stated that a farmer planting during his first ten days must weed his farm twice, they claimed that a farmer planting later will have to weed only once.

2. They preferred to plant at a time which they felt would give them a higher yield, even though the risks were higher. Whereas over two-thirds of the farmers claimed that the first ten days were the safest time to plant, over 40 percent claimed that their yields would usually be higher if they planted their maize before the rains. Nearly all of these farmers chose to plant during the first ten days. The data thus support the hypothesis that safety is a more important consideration in determining when to plant than obtaining high yields or minimizing weeding.[1]

The tree also shows that high income farmers had significantly greater success than low income farmers in plowing/planting their farms at their desired times, as shown in Table 5.10. Approximately 60 percent

[1]That so few farmers plant late to minimize weeding lends further support to our finding in Section 4.4.2 that the peak season labor supply is not an important constraint.

Table 5.10

Farmer's Success at Plowing/Planting at the Time They Desired, Middle Kirinyaga, Long Rains Season, 1981

	High Income Farmers						Low Income Farmers					
	Plow/Plant at Desired Time						Plow/Plant at Desired Time					
	Yes		No		Total		Yes		No		Total	
	Number Farmers	Percent	Number Farmers	Percent	Number Farmers	Percent	Number Farmers	Percent	Number Farmers	Percent	Number Farmers	Percent
Desire to Plant During First 10 Days of Rain												
Own oxen and plow	4	(50)	4	(50)	8	(100)	9	(82)	2	(18)	11	(100)
Have access to oxen and plow	2	(67)	1	(33)	3	(100)	2	(17)	10	(83)	12	(100)
Have cash for hiring	2	(18)	9	(82)	11	(100)	5	(45)	6	(55)	11	(100)
No cash for hiring	0	(0)	0	(0)	0	(100)	0	(33)	3	(100)	3	(100)
Total	9	(41)	13	(59)	22	(100)	16	(43)	21	(57)	37	(100)
Desire to Plant Dry												
Own oxen and plow	2	(67)	1	(33)	3	(100)	0	(0)	0	(0)	0	(100)
Have access to oxen and plow	1	(50)	1	(50)	2	(100)	1	(20)	4	(80)	5	(100)
Have cash for hiring	3	(75)	1	(25)	4	(100)	1	(50)	1	(50)	2	(100)
No cash for hiring	0		0		0	(100)	0		3	(100)	3	(100)
Total	6	(67)	3	(33)	9	(100)	2	(20)	8	(80)	10	(100)
Desire to Plant Late or at Different Times												
Own oxen and plow	6	(100)	0	(0)	6	(100)	1	(100)	0		1	(100)
Total	21	(57)	16	(43)	37	(100)	19	(40)	29	(60)	48	(100)

Source: Survey data. Data from Figure 5.4.

of the high income farmers and 40 percent of the low income farmers were able to plant their fields at the time they desired. Table 5.11 also shows the varied success rate which farmers with different means to secure oxen and plows had in planting at the time they wanted. Most oxen owners were able to plant when they wanted; some failed because their farms were too big to complete the task in the required time. On the other hand, most farmers intending to hire oxen were unable to get them when they needed them. Simply having "access" to oxen, from a relative or in exchange for a service, was particularly unreliable. For example, only 17 percent of the low income farmers who had access to oxen and wished to plant during the first ten days were able to do so. Evidently, they had to wait while the owners were planting their own and, perhaps, others' fields. For similar reasons, having cash for hiring did not insure being able to plant at the desired time.

Over two-thirds of the farmers felt that the first ten days following the rains is the busiest time for plowing and over half of the oxen-owners stated they would do more plowing for cash before the rains if there was increased demand for dry plowing. Therefore, it seemed reasonable to hypothesize that those farmers wishing to plant dry would be more successful at planting at this desired time, since the demand for plows at this time is low. Pooling data from both income groups, two-thirds of those farmers wishing to hire oxen to plant dry, but only 32 percent of those wishing to plant during the first ten days, were able to plow/plant at their desired time. The data thus support the hypothesis that the first ten days of rain is a busier time for planting than before the rains.

Table 5.11

Method of Plowing/Planting for Farmers Not Owning Oxen Who Were Unable to Secure Oxen at the Time They Needed Them, Long Rains Season, Middle Kirinyaga, 1981

Methods of Plowing/Planting	Desire to Plow/Plant First 10 Days				Desire to Plow/Plant Before Rains				Total			
	High Income Farmers		Low Income Farmers		High Income Farmers		Low Income Farmers		High Income Farmers		Low Income Farmers	
	Number of Farmers	Percent	Number of Farmers	Percent	Number of Farmers	Percent	Number of Farmers	Percent	Number of Farmers	Percent	Number of Farmers	Percent
Oxen before rains	2	(22%)	2	(10%)	-	-	-	-	2	(18%)	2	(8%)
Oxen first 10 days of rain	-	-	-	-	1	(50%)	1	(20%)	1	(9%)	1	(4%)
Panga	4	(44%)	10	(53%)	0		4	(80%)	4	(36%)	14	(58%)
Oxen after first 10 days of rain	8	(80%)	11	(58%)	2	(100%)	0		9	(82%)	11	(46%)
Total	10	(100%)	19	(100%)	2	(100%)	5	(100%)	11	(100%)	24	(100%)

Source: Survey data. Data from Figure 5.4.

Table 5.11 shows the measures farmers use to plow/plant when they are unable to plow/plant at their desired time. These measures include:

1. Plow/plant dry. Only two farmers in each income group took this option. It appears that for most farmers, the risks of planting late were less then the risks of planting dry.
2. Plant using a panga without plowing. Over half of the low income farmers and one-third of the high income farmers began planting by panga, fearing that oxen would not be available until a very late date.
3. Plow/plant late with oxen. This measure was used by nearly all high income farmers and almost half of all low income farmers.

The data thus show important differences in how high and low income farmers react when they are unable to plow/plant at their desired times. Low income farmers have low opportunity costs of labor. Thus they are willing to plant part or all of their fields by panga, whereas high income farmers tend to wait for the oxen teams to arrive. Also the costs of planting late and running out of food are considerably higher for low income farmers than for high income farmers.

Table 5.12 shows that 27 percent of low income farmers planted their entire farms by panga. About half of these farmers lacked cash for hiring oxen whereas the other half feared the oxen would arrive too late. Only one high income farmer planted his entire farm by panga.

A few farmers in the sample have alternative methods of planting not previously discussed. About 23 percent of high income farmers and

Table 5.12

Farmers Planting Without Preparing Their Fields, Long Rains Season, Middle Kirinyaga, 1981[a]

	High Income Farmers		Low Income Farmers	
	Number	Percent	Number	Percent
Preparing all Fields	35	(90%)	33	(69%)
Preparing Some Fields	3	(8%)	2	(4%)
Not Preparing Any Fields	1	(2%)	13	(27%)
Total Farmers	39	(100%)	48	(100%)

[a]Only areas which the farmer would like to prepare with oxen are included in this table. Thus, areas normally planted with panga, e.g. fields with tree crops, swampy areas, etc. are not included.

Source: Survey data. Data from Figure 5.4.

13 percent of low income farmers plant relatively small portions of their maize and/or beans using a panga, following the plowing operation. These farmers seek to obtain a higher, more efficiently spaced plant population. Another alternative planting method involves planting maize using oxen and then, two weeks later, weeding between the maize rows with a moldboard plow. At the same time farmers are weeding they are also planting beans; beans are broadcast on the field before the weeding operation begins. However, most farmers claim that this method is not practical because it requires (1) oxen to cultivate twice during one season, and (2) very wide maize rows so that the oxen can pass between the rows without disturbing the maize.

In summary, most farmers in Middle Kirinyaga seek to plant during the first ten days of rainfall, because they consider this to be the safest time. High income farmers, who mostly own oxen or have cash for hiring them, tend to be able to get their farms plowed at the time they like. Low income farmers rely more on borrowing oxen from relatives or gaining access to oxen by exchanging services. Most low income farmers are unable to get their fields plowed at their desired time.

Plant Population

The Ministry of Agriculture recommends that intercropped maize and beans be grown in rows; maize rows should be 75 cm. apart with two bean rows between them (Government of Kenya, 1979b). However, farmers do not feel that it is worthwhile to plant beans in plow furrows; indeed, we did not find a single farmer doing so. Rather, farmers feel that the only way to plant beans in rows is to use a panga and as stated above, farmers prefer not to plant by panga.

Farmers' actual plant populations are compared with the Extension Services' recommended plant populations in Table 5.13. Recommended maize populations are 40,500 plants per ha, over one-third higher than those of high income farmers and over 60 percent higher than those of low income farmers. However, farmers' low rates may be justifiable, due to low soil fertility. Low income farmers' maize populations were 20 percent lower than those of high income farmers; because low income farmers use fertilizer and manure less frequently than high income farmers, their soils may be less able to maintain a high plant population. Moreover, low plant populations also provide some protection against a complete crop failure in times of drought.

Table 5.13

Plant Population for Maize and Beans, Long Rains Season, Middle Kirinyaga, 1981

	Row Width (cm)	Space Between Plants (cm)	Plant Population[a]	Farms Sampled
Maize: high income farmers' practice	108	31	29,700	18
Maize: low income farmers' practice	110	37	24,900	24
Ministry maize[b] recommendation	75	30	40,500[c]	-
Beans: farmers' practice	Broadcast	Broadcast	162,000	8
Ministry beans[b] recommendation	25 Between Maize Rows	15	180,000	-

[a]Differences in plant population between income groups are significant using the t-test ($\alpha = .05$).

[b]Ministry recommendations are for intercropped maize and beans: from Government of Kenya, 1979b and Kenya Seed Co., 1979.

[c]Allowing 10% loss.

Source: Figures from survey data except where otherwise stated.

Farmers' bean population was 162,000 plants per ha., only 10 percent lower than the recommended level. Our estimates are comparable to those of Schunherr and Mbugua (1976) who estimated a median density of 150,000 to 200,000 for Eastern and Central Provinces but much lower than Van Eijnatten (1975), who estimated 250,000-300,000 for Middle Kirinyaga.

Although our sample of observations is small, the data supports our finding during the informal survey that the cover of bean vegetation is rather dense. Evidently, broadcasting of beans does not result in large empty patches in fields as one might expect.

5.1.4. Maintenance of Soil Fertility and Structure

Farmers in Middle Kirinyaga have been continously cropping maize and beans twice per year with no rotation or fallow for periods of 10 to 20 years. In such a system, the issue of maintaining soil fertility and structure is important.

Current fertilizer recommendations for maize and beans in Middle Kirinyaga are to apply 60 Kg. Nitrogen and 90 Kg. P_2O_5 per hectare at planting time (Government of Kenya, 1979b). An application of 20-20-0 to achieve this level on one hectare would cost the farmer 2,430 Shs., omitting the cost of capital, application labor, transportation, etc. Thus the cost of the nutrients alone for one hectare amounts to over 10 percent of the high income farmers' annual cash income and over 80 percent of the low income farmers' cash income.

During the 1981 long rains season, less than one-fifth of sampled high income farmers and only a single sampled low income farmer used fertilizer, as shown in Table 5.14. Five of the eight users applied fertilizer at an average rate of one bag per four hectares--this can hardly be said to be using fertilizer. Most of the users indicated that they did not know the recommended rate.

The table also shows that over one-third of high income farmers and one-fifth of low income farmers have tried fertilizer and rejected it. Reasons for not using fertilizer are significantly different among the

Table 5.14

Fertilizer and Manure Use on Maize and Beans, Long Rains Season, Middle Kirinyaga, 1981

	High Income Farmers		Low Income Farmers	
	Number	Percent	Number	Percent
Fertilizer Use				
Currently use	7	(18%)	1	(2%)
Tried in past and stopped	13	(33%)	10	(21%)
Never tried	19	(49%)	37	(77%)
Total	39	(100%)	48	(100%)
Reasons for Not Using Fertilizer				
Lack cash	8	(29%)	27	(57%)
Lack information	5	(21%)	13	(27%)
Not profitable	11	(33%)	6	(13%)
Other	3	(6%)	2	(4%)
Total	27	(100%)	47	(100%)
Other Means of Fertilizing				
Livestock manure	32	(82%)	25	(52%)
Maize stover	7	(18%)	19	(42%)

Source: Survey data.

two groups: high income farmers cite low profitability and lack of cash whereas low income farmers cite lack of cash and lack of information. The allegation of low profitability is particularly intriguing given the high response to fertilizer shown in local research trials. Three explanations are possible:

1. The fertilizer is applied incorrectly.
2. Non-experimental variables on the research plots were fixed at levels far different from conditions on farmers' fields. Thus, the apparent high response to fertilizer is due to differences in these non-experimental variables, rather than to the effect of fertilizer alone.
3. Investment in fertilizer gives a "high" rate of return but farmers have alternative uses for their money which they feel give them a higher rate of return.

It appears that all three reasons are involved in explaining farmers' opinions that fertilizer is not profitable. Moreover, since the cost of fertilizer is high relative to farmer incomes, lack of cash is also an important reason why most farmers do not use, and have not tried, fertilizer.

Two other methods of maintaining soil fertility are mentioned in Table 5.14. Over 80 percent of high income farmers and half of low income farmers apply livestock manure on their fields. Manure from cattle, sheep and goats is commonly used but the effects of manure use are likely to be very small for two reasons. First, since herd size is small and most animals graze most of the day, quantities applied are very small. Second, treatment of the manure is poor; most farmers leave their manure unshaded so leaching by rainfall is severe.

The second method, leaving maize stover on the field, is used by 42 percent of the low income farmers and 18 percent of the high income farmers. Most farmers prefer to feed their stover to their livestock.

5.1.5. Other Production Practices and Use of Purchased Inputs

Weeding

Nearly all Middle Kirinyaga farmers weed with pangas; only a few farmers weed with oxen as discussed above. Farmers begin weeding in April or May, starting when maize plants are about 30 cm. high. About half of the farmers in both income groups do one weeding and half do two weedings.

For farmers who plant using oxen, planting time is an important determinant of how many weedings are done. About 60 percent of the farmers planting before the rains weeded twice, whereas 80 percent of those planting after the first ten days weeded only once. Those farmers planting during the first ten days of rainfall were evenly divided between one weeding and two.

Farmers' second weedings are generally done when maize plants are about 90 cm. high, but about 10 percent of the farmers do their second weeding when the crop is 150 cm. high or higher. This weeding does not affect the yield of the current crop; rather, farmers claim that weeding late will curtail weed growth for the following crop.

Several farmers complained of severe problems with couch grass (Sangari) which can only be controlled by dry plowing or by using herbicides. In any case, weed growth is not an important production constraint for most farmers.

Pest Control

In most seasons, pests pose only minor problems to maize and beans in Middle Kirinyaga. However, during the 1981 long rains season, stalkborers did extensive damage to maize in certain areas. About one-quarter of the high income farmers and none of the low income farmers purchased DDT dust to control them. Unfortunately, dusting plants with DDT is not of much use after an attack has begun and the stalkborers have already penetrated the stalk. The cost of DDT is very low; about 20 Shs. is sufficient to treat one hectare. However, few farmers use DDT because (1) farmers lack cash during April when applications are required, (2) April is a particularly difficult month for labor (3) many farmers are unfamiliar with DDT, and (4) many farmers are reluctant to expend cash and labor each season to prevent a problem which occurs only infrequently.

Bollworms and semi-loopers also caused extensive damage to maize and beans in a few areas in 1981, but no control measures were taken by farmers. Other insects causing occasional problems include black flies (beans), cutworms (maize) and army worms (maize). Ants often damage untreated seed when seeds are planted dry, as discussed previously. However, only one farmer applied anticide at planting time.

Use of Purchased Inputs

High income farmers spend over three times as much as low income farmers on crop inputs, as shown in Table 5.15. Expenditures on material inputs, i.e., seed, fertilizer, and chemicals, are dominated by seed expenses and, in particular, beans. Bean seed purchases accounted for

Table 5.15

Farmer's Use of Purchased Crop Inputs for the Long Rains Season, Middle Kirinyaga, 1981

	High Income Farmers		Low Income Farmers	
	Percent Farmers	Shillings/ Farmer[a]	Percent Farmers	Shillings/ Farmer[a]
Purchased Material Inputs				
Maize storage insecticide	67	12	14	2
Bean storage insecticide	69	22	29	4
Maize seed	36	27	10	6
Bean seed	31	60	56	64
Fertilizer/chemicals maize-beans	26	14	2	2
Other seed	31	20	35	13
Inputs for coffee and tomatoes	31	44	21	6
Other Inputs	-	47	-	16
Total purchased material inputs	87	245	81	115
Other				
Casual hired labor	74	238	17	31
Permanent hired labor	24	272	0	0
Hired oxen	19	215	15	50
Total other inputs	-	725	-	81
Total Purchased Inputs	-	970	-	196

[a]Averaged over all sample households in the income group.

Source: Survey data.

over half of the material input expenses of low income farmers and over one-quarter of those of high income farmers.

The gap between income groups is even greater for non-material input expenses such as hired labor and oxen services than for material input expenses. Neither income group finds it profitable to purchase material inputs, except to purchase seed when stocks of home-produced seed are exhausted. However, high income farmers find it profitable to purchase hired labor at weeding time to reduce the peak season labor bottlenecks. They are also more willing to spend cash on hiring oxen for plowing, since hiring is a more reliable way to get one's farm plowed promptly than is relying on relatives or the exchange of services for getting oxen.

5.1.6. Harvesting and Production

In seasons which are preceded by bad harvests, harvesting begins as soon as the crops have reached an edible stage. Thus green beans are harvested in June and green maize in July. Final or "dry" harvests normally take place one month later for beans and two months later for maize. However, many farmers exhaust a large portion of their crop before the dry harvest begins and a few may even consume their entire crop green.

Women have primary responsibility for harvesting. Beans are harvested by uprooting the entire plant, and the plants are then piled at the homestead and beaten with sticks for threshing. The beans are then bagged and put in the store. To harvest maize, farmers pick ears and pile them in the store, usually with the husk still intact. They are then shelled as needed, by hand or by placing them in a bag and beating the bag with a stick. Farmers store their maize and beans in a raised, wood structure with walls of sticks and roofs of grass.

Production data for the long rains seasons, 1980 and 1981, obtained through farmer interviews, are shown in Table 5.16. Data are also shown for 31 plots selected at random during the short rains season, 1980-81 where maize yields were measured. Harvests were poor during both long rains seasons for which data were obtained: 1980, because of lack of rainfall, and 1981, because flooding and insect damage ravaged crops. Accordingly, recorded yields are very low. Yields were much higher during the short rains season, 1981, as climatic conditions were relatively favorable.[1]

Yields per ha. of maize and beans harvested dry were significantly different (level of significance = .05) between the two income groups, during all three seasons shown in Table 5.16. During the long rains seasons, 1980, high income farmers harvested above 280 kg. maize and 220 kg. beans per ha.; low income farmers harvested about 100 kg. maize and 90 kg. beans per ha. Maize yields per ha. during the short rains season averaged about 1,300 kg. for high income farmers and 750 kg. for low income farmers. Farmers reported during the informal survey that in a "good" season they expect about 1,200 kg. maize and 360 kg. beans per ha.

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[1]Yield per hectare here is defined as the quantity of maize or beans produced on a hectare of intercropped maize and beans. The figures are for all maize and bean areas, whether mixed with other crops or not. About two-thirds of total maize and bean area is planted to only maize and beans, without any other important crop. For the long rains seasons, data are obtained from interviews shortly after the 1981 long rains crops were harvested. Data are likely to be more reliable for beans than for maize since (1) the recall period for beans was shorter, and (2) beans are stored in containers such as kerosene tins or gūnny sacks whereas maize is simply heaped in the store.

Table 5.16

Production, Yields per Hectare, and Sales of Maize and Beans, Middle Kirinyaga, 1980-81

	Maize		Beans	
	High Income Farmers	Low Income Farmers	High Income Farmers	Low Income Farmers
Dry Production (kg.)				
Long rains 1980	503	299	244	101
Long rains 1981	-	-	276	76
Dry Yield per ha. (kg.)[a]				
Long rains 1980	279	221	152	92
Long rains 1981	-	-	172	66
Short rains 1981/82[b]	1303	752	-	-
Expected Yield per ha.[c] in a Good Season	1200	1200	360	360
Sales (kg.)				
Long rains 1980	180	59	127	45
Percent of farmers selling	62%	56%	62%	52%

[a]Includes all areas, whether mixed with other crops or not. Does not include quantities eaten green.

[b]Data are from 20 plots on 10 low income farms and 11 plots on 6 high income farms. Plots were 49 sq. meters and were selected at random. Harvest losses (10%) and moisture loss (0-10% depending on a subjectively assessed moisture level) were subtracted from measured yields. Fields where maize had been removed for consumption while "green" were excluded from the sample.

[c]From informal survey, not from formal survey data.

Source: Survey data unless otherwise stated.

5.2. Short Rains Management

As stated earlier, long rains and short rains maize and beans management are very similar. Thus, our description of short rains management will be brief, highlighting (1) the differences in management and (2) those similarities which are somewhat surprising, given the high probability of low rainfall during the short rains season.

5.2.1. Maize Varieties

There is almost no difference in the area allocated to available varieties between the two seasons. In the short rains, one might have expected that more farmers grow Katumani, the variety which nearly all farmers feel gives the highest yield when rainfall is low. However, as in the long rains, most farmers grow Katumani only for early maize; they are not interested in growing it for their main stock of maize because of its low yields, poor storage and susceptibility to dog damage.

5.2.2. Time and Method of Planting

As stated in Section 4.4.4, the balance of supply and demand for oxen during the short rains is roughly similar to that of the long rains. Indeed, the timing of plantings by high income farmers was nearly identical to the timing during the long rains as shown in Table 5.9. But whereas in the long rains, high income farmers established their crops earlier than low income farmers, in the short rains the trend was reversed. Low income farmers planted nearly half of their fields before the rains, half during the first ten days of the rains and only 8 percent late. The risk of low rainfall is much greater during the short rains

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and many low income farmers accommodate this risk by planting before the rains. In the long rains, we concluded that most farmers felt that the risks of planting dry are greater than the risks of planting late. However, in the short rains, more farmers, especially low income farmers, prefer planting before the rains to planting late in fear of the high probability of low rainfall.

5.2.3. Use of Purchased Inputs

During the short rains, both groups of farmers spend about one-third less on purchased inputs than during the long rains. The lower expenditures, no doubt, reflect the higher probability of low returns to investments due to drought.

5.3. Farming Systems in Transition: A Summary of Chapters 4 and 5

This section summarizes the principal features of farming systems in Middle Kirinyaga. Further, we review the principal constraints on improving agricultural productivity and draw implications for identifying research priorities.

Nearly all of the cultivated area of both high and low income farmers is under maize and beans, the area's two principal food staples. Low income farmers obtain most of their cash from their farms; they also earn cash working on the farms of high income farmers. On the other hand, high income farmers earn most of their cash from off-farm enterprises, particularly from businesses and salaried positions. Both groups keep cattle, sheep and goats, primarily to provide milk for the family and as a form of security. Rains are often unreliable, especially during the short rains seasons, and both groups frequently run out of home-produced food. Thus, stabilizing food supplies is a principal objective for both high income and low income farmers in Middle Kirinyaga.

Few, if any, purchased inputs are used in maize and bean cultivation. Most farmers in both groups grow Local maize for their main stock and most, particularly low income farmers, also grow a small area of early-maturing Katumani. Over one-third of high income farmers grow hybrid; most farmers reject hybrid because they lack cash for seed, do not consider its yield to be high enough, or because of its poor storage characteristics. Principal reasons for rejecting Katumani include its low yield and poor storage characteristics.

Six different bean cultivars are each grown by at least 10 percent of the farmers; Canadian Wonder is the most popular and rates well on all important characteristics. Mexican 142 is also popular, particularly among low-income farmers because it is so inexpensive to plant. However, Mexican 142 has poor taste qualities, a low sale price, and interferes with maize growth when intercropped.

Most farmers plow and plant in one operation. The preferred time is just after the rains begin. However, many farmers, especially low income ones, are forced to plant late because they lack oxen or cash for hiring them. Fewer farmers prefer to plant before the rains citing the risks of dry planting, especially for beans.

For maize the plant population is less than two-thirds of the recommended level; for beans, it is about equal to the recommended level. The maize plant population is significantly higher for high income farmers than for low income farmers.

Most farmers use livestock manure on their farms but the quantities applied are too low to have a significant impact. Reasons for not using fertilizer include lack of cash and low profitability. Maize and bean yields are extremely low and production methods during the short rains closely mirror methods used in the long rains.

Table 5.17 summarizes farmer practices in cultivating maize and beans. The table shows that the income groups differ on four variables: time of planting, maize plant density, and maize varieties for main stock and for early maize. The income groups are similar on eight variables: seed treatment, method of land preparation/planting, bean cultivar, weeding, plant protection, fertilizer use, manure use, and fallow/rotation.

Lack of cash for purchasing inputs, poor soil fertility and structure, and lack of access to draught power are the most important constraints limiting farm productivity. The cash constraint is especially important for low income farmers who may not have cash for even the most basic inputs: purchasing seed and hiring ox-plows. High income farmers may have cash available for farm investment but they prefer to invest in off-farm enterprises. Soil fertility and structure are eroding rapidly for both groups as fields are continuously cropped, twice per year, to maize and beans. Access to draught power is a particularly important constraint for low income farmers, who are often forced to plant late, because they do not own oxen or have the cash necessary for hiring them. Moreover, as grazing areas shrink and more oxen are sold off due to cash needs, fewer farmers will be able to have their fields plowed just after the rains begin. More will be forced to

Table 5.17

Farmer Practices in Cultivating Maize and Beans, Middle Kirinyaga, 1981

Practice/Operation	High Income Farmers	Low Income Farmers
Time of Planting	Five days after the rains begin	Ten days after the rains begin
Seed Treatment	None	None
Method of land preparation/planting	Oxplow, maize in rows beans broadcast before plowing	Same
Maize plant density	Row width-108 cm. Between plants-31 cm. Plant pop.-29,700	Row width-110 cm. Between plants-37 cm. Plant pop.-24,900
Bean plant density	Plant pop.-160,000	Same
Maize variety for main stock	Local or H-511	Local
Maize variety for early maize	Katumani or none	Katumani
Bean cultivar	Canadian Wonder	Same
Weeding	One or two times if needed. Weed control is effective.	Same
Plant protection	None	None
Fertilizer	None	None
Manure application	None in last year	None in last year
Fallow or rotation	None (previous crop is maize-beans intercropped)	Same

Source: Survey data.

plant late and many may turn to dry planting as an alternative to planting late.

Land is not an important constraint in the short run. However, land will likely become an important constraint for low income farmers in the near future as population increases, farms are subdivided, and land sales from low income to high income farmers continue. Land will not be an important constraint for high income farmers who are more successful at obtaining education and off-farm employment for their children and who have cash for buying or renting land.

It is difficult to predict the effect that the increasingly severe constraints--cash, soil fertility, draught power, and land--will have on the way low income farmers manage their farms. For example, one might forecast that the land constraint, together with the cash and oxen constraints, may cause low income farmers to turn to hoe cultivation. However, we did not find even one farmer who used a hoe to cultivate his land.[1] Therefore, it appears that the above constraints will result in more no-till or infrequently-tilled cultivation rather than a change to hoe cultivation.

Nevertheless, there are several implications for establishing research priorities to help low income farmers. First, research efforts should assist farmers to take full advantage of the limited amount of rainfall available, and/or to accommodate their production methods to limited rainfall. Second, research efforts should help farmers to upgrade the quality of their soils. Third, other efforts to improve productivity should not conflict with the three principal

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[1]Hoes are only used in particular situations, such as preparing land in a swampy area where oxen cannot work, or in areas infested with couch grass.

constraints farmers face: cash scarcity, soil quality, or their inability to plant at their desired time.

The constraints which high income farmers face are similar to those of low income farmers but there are important differences in degree. The cash constraint for high income farmers is much less severe, and stems more from competing investment opportunities than low cash incomes. Draught power and land are less important constraints for high income farmers, because they have cash for hiring oxen and renting land. Soil fertility, on the other hand, is as important a constraint for high income farmers as it is for low income farmers. Since high income farmers face fewer and less severe constraints than low income farmers, there is more latitude for solving their problems than there is for low income farmers.

CHAPTER 6

PRIORITIES FOR ADAPTIVE PRODUCTION RESEARCH

In this section we identify the priority areas for adaptive production research, emphasizing maize and beans. First, we present some advantages and disadvantages of mounting experiments on farmers' fields as opposed to on research stations. Next, production research priorities and farmer practices are outlined. Finally, each research priority is reviewed in greater detail and proposed experiments are discussed. Recommendations for extension programs are also made where it is felt that lack of knowledge is the principal reason behind non-adoption.

Two qualifications are necessary. First, as stated in Section 2.6, the objective of this study is to develop short and medium term production research programs which accommodate existing environmental and infrastructural constraints. Our proposals are weighted towards the improvement of crop production; they do not extend into other areas of rural development such as livestock, marketing, prices, or land tenure. Second, it is rare that there are quick, easy answers to agricultural development problems. It takes a long time to develop appropriate technologies for farmers. The approach used in this thesis aims to develop such technologies in a more effective and timely fashion than other approaches.

6.1. On-Farm and On-Station Experimentation

In recent years, researchers in many countries have come to recognize the importance of carrying out research experiments on farmers' fields as well as on experiment stations. The soil type and structure, labor availability, pest problems, and other agronomic and economic conditions of a small farm are often far different from the conditions found on station fields. Therefore, technologies developed on farmers' fields will generally be more appropriate to the farmers' circumstances and adoption will be more likely. Moreover, on-farm experimentation allows technologies to be developed and tested across a large number of locations, increasing the validity of the recommendations. Finally, on-farm experimentation provides an opportunity for the farmer to participate in developing and appraising the new technology. On-farm research also encourages dialogue between the farmer, the extension worker, and the researchers. Researchers can use a better understanding of the farmers' assessment of experimental results to tailor technologies to the farmers' circumstances.

We are not, of course, arguing that all research should be done on farmers' fields. Experimentation is best mounted on stations when (1) new materials are being tested in the early stages of their development or when (2) close monitoring and/or control is required in order to make needed adaptations. Moreover, in the short run the costs of mounting experiments on farmers' fields may be prohibitive.[1] However, in most

[1]These costs are primarily for increased transport, night allowances and researchers' time in transit. In the long run, however, total research costs may decrease as on-station fixed costs (buildings, equipment, labor, etc.) are reduced.

cases, research experiments for formulating recommendations for farmers are best mounted under farmers' own conditions in their fields.

The analysis in this report focuses on two recommendation domains (RD's)--high income farmers and low income farmers. In Chapters 4 and 5 it was shown that there are important differences between the two groups in their priorities, resources, constraints and management practices. Thus, the two groups have somewhat different researchable problems and different development opportunities. Most notably, high income farmers have regular cash incomes and will thus be able to afford purchasing inputs which help them to better meet their objectives. However, many of them are averse to spending cash on their farms as they feel returns are higher elsewhere. Therefore, agricultural research must offer them technologies which are substantially more profitable than existing farm investments in order to get them to increase investment in their farm. On the other hand, low income farmers often lack cash for even the most basic inputs. Thus, they are less likely to be able to afford purchased inputs. The challenge here is to offer them low-cost technologies which lead to substantial increases in productivity and better help them to meet their objectives.

Of course, it is possible that two different RD's can have the same problem, and that a proposed solution to the problem is appropriate for both groups. Thus, some of our research priorities and proposed solutions relate primarily to one RD whereas other are appropriate for both RD's.

6.2. Outline of Research Priorities

The priority research areas, or leverage points, are selected over other possibilities because:

1. Improvements in these areas offer substantial potential for assisting the farmers of Middle Kirinyaga to increase productivity and to better meet their own priorities in accordance with national policies, and
2. Potential innovations arising from production research in these areas are likely to be acceptable to the farmers and feasible for them to adopt.

Two priority areas for maize/bean production research stand out over the others in order of importance:

1. Improving soil fertility and structure.
2. Easing the draught power bottleneck to enable farmers to plant earlier.

Soil fertility and structure were selected because they are critical constraints and because it appears that technologies available for solving these problems are effective and within the means of many farmers.[1] Easing the draught power bottleneck was selected because time of planting is perhaps the most important variable for increasing crop productivity. Although we have no quick and easy solution to this problem, we propose several avenues by which the bottleneck may be reduced, permitting farmers to plant earlier.

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[1]Two factors explain why soil fertility was selected as a critical constraint although relatively little attention was given to it during the survey. First, it was much simpler to develop an understanding of farming practices concerning soil fertility than it was, say, to describe and explain maize variety use or timing of plowing/planting. Second, as no potential, feasible solution to the soil problem was identified until relatively late in the survey exercise, the topic was not given much importance during the early stages.

Three other research areas are given secondary priority:

1. Improved maize varieties.
2. Improved bean cultivars.
3. Maize storage improvement.

These areas each offer substantial potential for increasing productivity. However, improved maize varieties and bean cultivars will have limited effect without changes in other variables such as time of planting, plant population, and soil fertility. Maize storage also receives secondary priority because, as one woman admonished us, "How can you talk to me about storage when I never have anything to store!" Moreover, most farmers prefer to use a variety which stores well without chemicals, or use chemicals and do not encounter problems.

Before discussing these five priority research areas in greater detail, it should be noted that non-experimental variables form the context in which experimental variables will be studied. For experiments designed to formulate farmer recommendations, non-experimental variables will normally be fixed at current farmer practices as shown in Table 5-19.[1] Thus, researchers will be able to test the response of an innovation(s) under farmers' own conditions.

6.3. Improve Soil Fertility and Structure

Farmers in Middle Kirinyaga have been planting maize and beans continuously, two times per year, for 10 to 20 years with no fertilizer and only minimal quantities of manure. Many have tried fertilizer but

[1]In some cases, it may be preferable to allow the farmer to fix non-experimental variables at levels he deems suitable (Kirkby, 1981).

most of these have stopped using it, citing lack of cash, low profitability, or lack of knowledge about how to use it. Several different strategies may be pursued to try to improve soil fertility and structure in Middle Kirinyaga.

6.3.1. Use of Coffee By-Products as Manure for Maize and Beans

The Sagana Coffee Factory currently produces about 1,000 lorry-loads per year of coffee husks[1] which it contracts out to a private trucker to dump. These by-products are high in nutrient content; and the Coffee Research Foundation (CRF) has found them to be useful as both a mulch and a manure on coffee.

Table 6.1 presents the costs and returns of alternative measures to increase soil fertility through fertilizer and coffee husks, and the yield increases required to pay for the costs. Coffee husks appear to compete very favorably with fertilizer for the following reasons:

1. The partial budget in Table 6.1 shows a positive net benefit to applications of coffee husks. The cost per Kg. of nitrogen and P_2O_5 in the coffee husks is about one-third of the cost of the nutrients in 20-20-0 fertilizer. Soils in Middle Kirinyaga are deficient in both nitrogen and P_2O_5. The total cost of applying the husks (cash, labor and cost of capital) is only 40 percent of the cost of applying fertilizer.

[1]The husks are approximately three-quarters husk and one-quarter pulp by weight. Production began in 1981 and is expected to double in 1982 as the factory makes better use of its capacity. At a rate of one lorry-load per year per farm, the factory could serve 2,000 farmers in 1982, about one-third of all farmers in Middle Kirinyaga.

Table 6.1

Estimated Costs and Returns to Alternative Measures for Increasing Soil Fertility, Middle Kirinyaga, 1981

	Control (no application)	Fertilizer	Coffee Husks/Pulp
1. Treatment			
Quantity applied per ha.	0	150 Kg.	1 lorry load (3.5 tons)
Nutrient level application ($N-P_2O_5-K_2O$)[a]	0	30-30-0	39-27-146
2. Returns per ha.			
Maize yield[b]	750 Kg.	1,000 Kg.	1,000 Kg.
Beans yield[b]	300 Kg.	400 Kg.	400 Kg.
Value of Production[c]	3,000 Shs.	4,000 Shs.	4,000 Shs.
3. Variable money costs per ha.			
Nutrients[d]	0	780 Shs.	0
Transport[e]	0	30 Shs.	275 Shs.
Total variable money costs	0	810 Shs.	275 Shs.
4. Variable Opportunity Costs per ha.			
Application labor (man-days)	0	2	5
Cost/person-day[f]	0	15 Shs.	10 Shs.
Application labor cost/season[g]	0	30 Shs.	25 Shs.
5. Cost of Capital[h] per ha.	0	420 Shs.	225 Shs.
6. Total Cost per ha.	0	1,230 Shs.	500 Shs.
7. Net Benefit[i] per ha.	-	-230 Shs.	+500 Shs.
8. Approximate Maize Yield per ha. Increase Needed to Pay for Total Costs[j]	-	615 Kg. or 6.8 bags per ha. for one season	125 Kg. or 1.4 bags per season for each of two seasons

[a]Analysis of coffee husks and pulp is from Qureshi, 1977. Fertilizer type is 20-20-0.

[b]Yields in control group are based on survey data. Yields under fertilizer and coffee husks/pulp treatments are based on researchers' estimates.

[c]Prices are averages over 2-year period (see Figure 4.3): Maize: 2.0 Shs./Kg. Beans: 5.0 Shs./Kg.

[d]Approximate cost of 20-20-0 in the area = Shs. 260 per 50 Kg. Coffee husks are available for free from Sagana Coffee Factory.

[e]Fertilizer transport costs = 50 Shs/bag. Husks delivery costs range from Shs. 200-350 lorry depending on distance travelled.

[f]Application costs per man-day are less for coffee husks since they may be applied in the slack season.

[g]The costs of applying coffee husks are spread over two seasons.

[h]50% for fertilizer, 75% for husks since benefits are spread over two seasons.

[i]Coffee husks likely have further benefits not accounted for in this table: increased moisture retention due to improved soil structure and mulching, and suppression of weeds.

[j]The benefits of coffee husks are spread over two seasons, since they release nutrients at a much slower rate than does fertilizer.

2. Coffee husks improve soil structure, enhancing moisture and nutrient retention. Moisture retention is particularly important for Middle Kirinyaga farmers, given the brevity of the rainfall. On the other hand, fertilizer does not enhance soil structure.

3. In case of drought, the investment in fertilizer is wasted. However, coffee husks release nutrients over a period of two seasons; thus, the farmer can spread his risk over two seasons instead of one.

4. Coffee husks are much less susceptible to problems of leaching and incorrect placement than is fertilizer.

5. The coffee husks may be applied during the slack season before planting, when labor is available. On the other hand, fertilizer must be applied at planting time, when labor may not be available.

6. Coffee husks serve as a mulch, reducing weed growth and preserving moisture.

Proposed Experiment for Low Income Farmers

The object of the coffee husks experiment is to evaluate the response of maize and beans to coffee husks and to compare it to the response to fertilizer, on farmers' fields. The experiment has two experimental variables, maize plant population and soil fertility.

The levels for maize plant population are 25,000/ha. (farmer level) and 35,000/ha. (improved level). Row width is maintained, but plant spacing within the row is increased by planting 2 seeds every 40 cm. instead of 1 seed every 30 cm.

The levels for fertilizer are 0 and 30-30-0 (150 Kg. of 20-20-0 per ha.), applied at the rate of 8 grams per seed position. The levels for coffee husks are 0 and 4 lorry-loads (approximately 14 tons) per ha. spread on the field just before plowing.

If a significant yield response to coffee husks is observed, as expected, this experiment will be followed by a "levels" experiment to establish the optimal quantity to apply per hectare. In the levels experiment, we would be particularly interested in assessing the yield response to low levels of application, affordable to low income farmers. Furthermore, the experiment should be mounted on-station as well to monitor the long-term effects of husks.

Proposed Experiment for High Income Farmers

Same as above except with a third treatment: maize variety. Two maize varieties will be included, Local and H-511. Plant population is 30,000/ha. (farmer level) and 40,000/ha. (improved level).

6.3.2. Training Farmers on Conservation and Use of Livestock Manure

Most farmers graze their animals during the day, and keep them in an enclosed area at night. Manure piles up in the enclosed area, and after harvest, usually one time per year, the farmer spreads the manure over a portion of the farm. Several weeks later the farmer plows and the manure is turned under. Farmers need to be instructed that this manure should be heaped and covered with grass when fresh, to minimize the leaching of nitrates by rainfall.

6.3.3. Training Farmers on Correct Method of Fertilizer Application

Few farmers use fertilizer, and many apply it at rates that are so low that its effects are negligible. Moreover, some farmers stated that they did not know which fertilizer to apply nor now to apply it. These are clearly problems for the extension service to address. Farmers need to be instructed about kinds of fertilizer to use and how to apply them. If farmers can afford only small quantities of fertilizer, they should use it on small portions of their farm and not spread it over a large area. However, training farmers on the correct method of applying fertilizer will help a relatively small number of farmers only. Survey data indicated that lack of cash and low profitability are more important constraints than lack of knowledge in explaining non-adoption of fertilizer.

6.4. Ease the Draught-Power Bottleneck to Permit Earlier Planting

As soon as the rains begin, farmers rush to plow and plant their maize and beans. However, a large number of farmers in both groups plant their farms late. Late-planted fields give low yields and are prone to complete failures if the rains end early. A number of avenues may be pursued to ease the draught-power bottleneck.

6.4.1. Make Dry Planting More Attractive to Farmers

Although farmers like to plant early, most prefer not to plant before the rains begin, citing the risks of (1) seeds germinating and dying due to a false start of the rains (maize and beans), (2) ants consuming seed (maize and beans), (3) seeds not germinating due to warm soil conditions (beans), and (4) bean flowers being destroyed by rainfall because flowers form before heavy rains cease. Research must focus on minimizing these problems. Enhancing the attractiveness of dry planting would serve two purposes:

1. Easing the draught-power bottleneck which occurs after the rains begin. Farmers would be able to plant their crops earlier, minimizing the risk of crop losses when the rain ends early.
2. Increasing crop yields since dry planted crops yield higher than wet planted crops. This is so because of changes in soil temperature and nutrient availability which occur when the rains begin, as discussed in Chapter 5.

Several means are available to encourage dry planting and thus reduce the draught-power bottleneck which occurs as soon as the rain begins. We emphasize that it is not our objective to make dry planting risk-free; indeed, no time of planting is risk free. As draught power becomes more scarce and the moisture retaining capacity of soils decreases, dry planting will become even more popular. Our objective is to decrease the risks of dry planting for those farmers who already dry plant, and to make dry planting more attractive to those now planting wet. It is likely that even a modest reduction in the risk of dry planting would considerably help many farmers in Middle Kirinyaga. The following efforts would be useful in this respect:

1. Selecting Bean Cultivars More Suitable for Dry Planting

The required cultivars should be superior to present ones in their ability to withstand dry planting. Their development will be discussed in detail in Section 6.6 on bean varieties.

2. Seed Treatment Against Ant Damage

Effective and inexpensive means are available to treat maize and bean seed before planting. Aldrin 2.5 percent is available in the area, and the cost per treatment would only be about Shs. 6 per ha. However, Aldrin is a persistent and deadly pesticide and care must be taken in recommending its use to farmers. A safe alternative should be identified and extended to farmers.

3. Deep Planting of Maize

Increasing the depth of maize seed from 2.5 cm. at present to 5 cm. would appreciably minimize the risk caused by a false start of the rains. Farmers would have little problem digging deeper furrows; their plows can be easily adjusted. Since dry plowing is less difficult than wet plowing in Middle Kirinyaga, deep,dry planting would not increase the workload over shallow, wet planting.

Proposed Research/Extension Demonstration

The proposed demonstration would seek to extend both anticide and deeper maize planting to farmers. The site selected should already have an ant problem. Half of the plot is planted at 2.5 cm. deep and half at 5 cm. Half of each of these sections is then planted with anticide, the other without. The demonstration will show farmers the benefits of using anticide and planting maize deeply when dry planting. The experiment would be more effective if a similarly treated bean variety for dry planting were available. However, even if it is not available, the proposed demonstration could effectively alter the balance of risks between dry and wet planting for some farmers, encouraging them to dry plant their maize.

6.4.2. Develop Infrequent-Tillage and No-Tillage Systems

Many low income farmers do not plow their fields because they lack cash or because they fear they will not be able to hire or borrow a plow in good time. Experimental work should focus on developing no-till and infrequent tillage systems which maintain or increase yields over farmers' present practices. Farmers who plant without plowing experience two principal problems--an increase in weeds and a decrease in moisture retention. Planting into crop residues left from the previous season may help solve both of these problems. Research efforts should build on the work done at Katumani Research Station, Machakos.

Proposed Experiment for Low Income Farmers

The site would be one which had been plowed the previous season. There are two experimental variables, method of land preparation/planting and quantity of maize stover left on the field.

The land preparation treatments are (1) plow preparation/planting and (2) no preparation/planting by panga. Treatments for maize stover are (1) no maize stover left on the field and (2) all of the maize stover left on the field.

Moisture levels will be monitored by collecting soil samples. Weed counts will also be recorded. The experiment will continue for three years with the same treatments each season.

6.4.3. Encourage Farmers to Stagger Plow/Plant Their Fields

Farmers can hedge against the risks of dry planting by planting some of their fields dry and some after the rains begin. A few farmers are already staggering their planting. Farmers who stagger are also able to complete their weeding on a more timely basis, since weed growth begins later on the wet planted field.

6.4.4. Increase the Rate of Work and Efficiency of Ox-Plow Teams

Ox-plow teams currently plow at a relatively high rate of efficiency--one acre per five hours work per day for a team of four oxen managed by two persons. Farmers indicated that feed was not a particularly pressing problem limiting the rate of work. Upgrading the animals may present some advantages; one farmer we met plowed with two cross-bred oxen which he felt completed more work and ate less food than the four Zebu oxen he had used previously. Increasing the efficiency of equipment may also offer some scope; the moldboard plows used in the area are virtually the same as the ones used 25 years ago.

6.5. Improved Maize Varieties

Most farmers in both groups grow local maize for their main stock of maize and a bit of Katumani for early maize. Evidence from demonstrations and from some high income farmers indicates that hybrid maize outyields Local when accompanied by early planting, improved soil fertility, and increased plant population. Indeed, one-third of the high income farmers plant hybrids for their main stock of maize. On the other hand, farmers were nearly unanimous that Katumani gives a lower yield than Local, except in seasons in which the rain ends very early.

This finding contradicts those research and extension trials which show that Katumani yields more than Local regardless of the level of rainfall. It is likely that the difference in performance is due to a difference between management of the trials and farmer practice. Possible sources of variation include plant population, intercrops, planting method, and soil fertility. Nevertheless, Katumani plays an important role in the farming systems of both groups by providing farmers with early maize at a time when their own supplies are often exhausted.

It would not be economical to establish a breeding or even a selection program for only 7,000 farmers. However, we offer the following proposals for breeding and selection work since it is likely that information on variety use holds for farmers in other parts of Kenya as well.

6.5.1. Main Stock Maize Variety for Low Income Farmers

Neither hybrid nor Katumani are appropriate main stock varieties for low income farmers. Hybrid seed is too expensive for them to buy every year. Katumani is not liked primarily because it is low yielding. Moreover, although farmers recognize that Katumani is drought-avoiding, they do not attach much importance to this characteristic. Also, farmers experience problems storing both varieties with or without using storage insecticide.

A medium-maturity composite with good husk cover and good storage characteristics that yields more than Local and Katumani under farmers' own growing conditions would be readily acceptable to farmers. Local maize has a maturity period of about 165 days in the long rains season. If the composite were slightly shorter, farmers could benefit from harvesting their maize earlier, for either food or for sale.

Proposed Variety Experiments for Low Income Farmers

1. Compare Katumani, Local and H-511 under different levels of soil fertility. The experiment would be carried out on farmers' fields using zero, medium, and high levels of N and P_2O_5. The experiment will identify whether or not there is an interaction between soil fertility and maize variety.

2. Compare Katumani, Local, and H-511 on storage characteristics. Researchers have already established that weevil attacks in the field differ among varieties. However, it is not clear whether hardness of grain or husk coverage is responsible. A laboratory experiment to relate hardness of grain to weevil damage would be useful. Farmer opinion is that both husk cover and grain "taste" are important and that Local outperforms other varieties on both counts.

6.5.2. Varieties for Early Maize

One-half of the farmers in Middle Kirinyaga grow Katumani maize for early maize. Analysis based on the decision tree in Figure 5.1 showed that yield considerations are not very important in the decision whether or not to grow Katumani for early maize. Farmers are more interested in securing some early maize, since they often do not have any maize during the month before harvesting Local and Hybrid. Nor do they have the money to purchase maize, which in any case is available only at high prices. It follows that an even shorter maturing variety than Katumani, say one which matures in 90-100 days, would also be popular among low income and perhaps even high income farmers. Of course, farmers would allocate only a very small portion of their farm to the production of such a variety. Nevertheless, it is likely that many farmers would place a high value on such a variety, since it would provide them with much-needed maize at a time when supplies are scarce. Dryland composite, a 100-day variety currently being tested by Katumani research station for areas with very short rainfall seasons, is a likely candidate.

Proposed Experiment: Farmer Evaluation of Dryland Composite

Establish small blocks on farmers' fields at two different populations--farmers' level and a higher level. Principal management practices will be recorded and farmers' evaluations obtained. If farmers do find the variety useful, it can be introduced on a wider basis.

6.6. Improved Bean Cultivars

Both groups of farmers have strong preferences for Canadian Wonder for reasons of yield, taste, and high sale price. Therefore, improvement should be based on Canadian Wonder whenever possible.

6.6.1. Selecting a Cultivar Which Can be Planted Dry

The required cultivars should be superior to present ones in their ability to withstand dry planting. More specifically, they should be better:

1. Able to germinate after being exposed to a slight amount of moisture. This will minimize the effect of a false start of the rains.
2. More drought resistant in early stages of growth, also to minimize the effect of a false start of the rains.
3. Able to germinate under warmer soil conditions, and
4. Have later flower formation and/or greater resistant to flower destruction by heavy rains.

Achieving these objectives is extremely difficult; all one can probably expect is marginal improvement over the performance of existing varieties. Nevertheless, even some improvement would be useful for promoting dry planting.

Deep planting is an important possibility for minimizing the dangers of dry planting. Deeply planted beans would be less likely to be affected by a false start to the rains, and because of the lower soil temperature at greater depths, less likely to lose vigor. Unfortunately, there is relatively little latitude in changing the depth of a particular bean cultivar. The optimal depth of bean seeding varies with rainfall, seed size, and soil structure. Nevertheless, there appears to be some potential for identifying cultivars which can be planted deep. For example, a larger-seed variety may be planted deeper than a smaller-seed variety.

There also appears to be some variation among cultivars in conditions required for germination and in drought resistance in early stages of growth. It is possible that this variation could be exploited in order to offer farmers varieties which are less susceptible to germination in case of a false start to the rains or which are drought resistant in their first few weeks of growth. Research on the germination process might focus on how seeds can be improved to absorb moisture less rapidly, or not to absorb soil moisture if it is less than a certain amount.

Finally, selecting varieties which form flowers at a later time than currently available varieties is the best measure for avoiding the impact of heavy rainfall. This would appear to be a more effective solution than selecting for strength of flower attachment to stem.

Proposed Experimentation

1. Bean Depth of Seed

This trial would be mounted on station under controlled conditions. Experimental variables are bean cultivars and depth of seed. Cultivars from the area and other promising ones could be tested under a simulated false start of rains. Germination results, drought tolerance over a two-week dry period following initial rainfall, and yield would be monitored.

2. Soil Temperature and Depth of Seed

Another experiment also carried out on station under controlled conditions could focus on the relationship between soil temperature and depth of seed, and how different varieties perform at various temperatures. Germination would be monitored to indicate tolerance to high soil temperatures.

6.6.2. Selecting a Palatable Variety with High Returns to Seed Cost--Low Income Farmers

Most experimental work on beans focuses on increasing yield per unit land area. For some farmers, researchers have argued that returns to planting labor is a more important criteria (Gathee, 1980). It appears that for many farmers in Middle Kirinyaga, especially low income farmers, the most relevant criterion is returns to the cost of seed per unit of land area.

For example, the survey shows that Mexican 142 is generally considered to be an inferior variety--it has poor color, poor taste characteristics, a low price, and no yield advantage over most other varieties. Nevertheless, it is very popular, particularly among low income farmers, because it is the most inexpensive variety to plant. Farmers grow Mexican 142 and sell it after harvesting in order to buy beans which are more palatable. Many farmers have exhausted their bean supply by planting time and lack cash forpurchasing bean seed. Mexican 142 is attractive to these farmers because it has a high number of seeds per kilogram, and because its price is low. Moreover, since the plants throw out a relatively high number of pods per plant, it can be planted at a fairly low density. Table 6.2 shows that Mexican 142 has a price one-third less than Canadian Wonder, and a recommended seeding rate one-half less. Planting a hectare of Mexican 142 costs one-third as much as planting a hectare of Canadian Wonder. Thus, even though Mexican 142 has several unfavorable characteristics, many farmers grow it simply

Table 6.2

Seed Cost per Hectare of Selected Bean Cultivars, Middle Kirinyaga, 1981

	Canadian Wonder or Mwezi-Moja	Rosecoco-oval	Mexican 142
1000 seed weight (grams)	500	350	250
Kg. seed required/ha.	75	50	37
Cost of seed/Kg.	5.5	5.2	3.7
Seed cost/ha. (Shs.)	412	260	137

Source: Adopted from Government of Kenya, 1979b. Data for Mexican 142 from own sample measurements. Seed costs from Kagio market, March 1981.

because they lack cash at planting time and it is by far the cheapest cultivar to plant.

A variety which could compete with Mexican 142 on maximizing returns per cost of seed per hectare should:

1. be small-seeded; have a large number of seeds per kilogram.
2. have growth vigor and be able to yield well when planted at a low density. It appears that there is considerable variation in this aspect among different bean varieties. However, care must be taken that the effect on inter-cropped maize not be adverse.
3. be palatable.
4. yield favorably under the low-fertility conditions found on low-income farms.

6.7. Improved Storage Management for Maize

Malathion (2 percent) is the storage insecticide most frequently used in Middle Kirinyaga. However, some farmers have difficulty storing hybrids and Katumani with chemical insecticide from one season to the next. It appears likely that the method of storage is responsible. The principal causes are probably low application rates, late applications (applying only when problem is noticed), contamination from non-treated maize, and poor sanitation. If farmers can be shown how to apply insecticide correctly, more may adopt Katumani and hybrids. Thus, extension demonstrations of correct and incorrect storage management would be useful.

6.8. Sunflower Research

Our research gave less emphasis to crops other than maize or beans. However, one crop, sunflower, appears to offer substantial benefits to farmers.

Sunflower is currently grown by only a very few farmers in Middle Kirinyaga. However, it appears to be appropriate for a larger number of farmers in both income groups. It is especially attractive during the short rains, because it is less susceptible than maize to drought.

High income farmers can afford to implement the seed-fertilizer-insecticide package offered by the Wanguru Sunflower Research Station (WSRS). Sunflower has a high potential among this group because the area lacks a cash crop, and sunflower can yield well when the rain is poor.

However, as is true for maize and beans, it is likely that most farmers will ignore "high" levels of management, preferring to use their money on off-farm investments or investing in higher return cash farm enterprises like dairy, vegetables and coffee. Further, the unreliability of the short rains is a disincentive towards investing much cash in sunflower during the short rains.

Sunflower is a promising cash crop for many low income farmers as well. The current research recommendations cost about 785 shillings per acre and offer the farmer a profit of about 575 Shillings (Wanguru Sunflower Research Station, 1981). However, these farmers simply cannot afford to spend money on farm inputs required for intensive sunflower production, even if the return appears high. Low-income farmers have less land and are closer to the margin of subsistence. Thus they will be more likely to intercrop their sunflower with maize and/or beans.

How can sunflower research help these farmers? Some interesting research questions are presented below:

1. Is it possible that the recommended varieties under high levels of management, Issanka and Hybrid 301, actually yield less than other varieties, when planted at low levels of management? That is, if selections were carried out at low levels of management, is it possible that one could find other varieties which outperform Issanka and the hybrids at these low management levels? WSRC hybrids have been found to outyield Issanka under high management levels. Would this also be true under low levels of management?
2. If a farmer has only 100 shillings to spend on his sunflower crop, say for one acre, how should he spend it?

(Nitrogen or phosphate, basal dressing or top dressing, etc.? Or insecticide?)

3. Are there good responses to fertilizer when low rates are applied? Are these responses adequate to warrant adoption by farmers?

4. WSRC is currently carrying out maize/soybean/sunflower intercropping trials in recognition of the fact that most farmers prefer to intercrop. It would be useful to compare the treatments with the system the farmers most often use: 1 row of sunflower, 1-2 rows of maize, and beans broadcast throughout before plowing.

CHAPTER 7

EVALUATION OF METHODS

The principal technique used in this thesis is the CIMMYT diagnostic survey, which includes an exercise identifying recommendation domains (RD's), an informal survey, and a formal survey. During the informal survey, repertory grid (RG) and hierarchical decision-tree modeling (HDM) were used to develop a greater understanding of farmer decisions concerning selected leverage points--RG to identify important decision criteria and HDM to examine the decision process. The purpose of the formal survey was to verify the information developed in the informal survey, including data for the RG's and HDM's.

The purpose of this chapter is to address the issues outlined in Section 2.6 regarding the three techniques: the CIMMYT diagnostic survey, the RG and the HDM. In the first section, we evaluate the contributions of RG and HDM to the CIMMYT diagnostic survey for collecting and analyzing normative and prescriptive information about farmer decisions. In the second section, we examine the quality of information gathered at different stages of the diagnostic survey to evaluate (1) the effectiveness of the exercise to identify recommendation domains (RD's) and (2) the contribution of the formal survey towards understanding farming systems and planning an experimental program for farmers.

7.1. Evaluation of Repertory Grid and Hierarchical Decision Modeling

A conceptual model, such as RG and HDM can never be proven to be correct. However, a model can be evaluated subject to selected criteria. Johnson and Zerby (1973) identify four criteria for testing models and other concepts:

1. Coherence. The concept must be logical and internally consistent.
2. Correspondence. The concept must be externally consistent; the models must agree with experience and be applicable in a wide variety of circumstances.
3. Clarity. The concept must be clear, precise, and unambiguous.
4. Workable. The concept must be useful for solving problems; whether practical or theoretical.

7.1.1. Repertory Grid

In this thesis, repertory grid has been used (1) to identify the criteria farmers use in deciding among selected technological alternatives, and (2) to assemble normative data on how farmers evaluate the alternatives using the most important criteria. This information is important to researchers so that they can be aware of (1) all the aspects which farmers consider important in evaluating varieties, and (2) how different varieties perform on each aspect.

In Chapter 5, RG served an important role in developing an understanding of farmers' preferences. For example, early in the informal survey, maize varieties were identified as a potentially important leverage point. We began to build our grids by identifying important criteria farmers use in selecting maize varieties. Informal interviews were mounted in which farmers responded to open questions on the advantages and disadvantages of alternative varieties. About ten farmers were interviewed; this sample served as a basis for designing the formal survey and building a repertory grid for farmers in Middle Kirinyaga. Table 5.3 detailed the criteria farmers consider important when selecting a maize variety, and the favorable and unfavorable aspects of each variety. The discussion of the grid in Section 5.1.1 focuses on how each variety performs on each criterion.

Of course, one may argue that the CIMMYT informal survey can be used to determine farmers' evaluations of alternative technologies. However, RG can contribute to the CIMMYT diagnostic survey by enabling the researchers to approach a particular issue, say advantages and disadvantages of alternative maize varieties, in a systematic manner. Certainly, there is a danger in using systematic methods in an informal survey; open-ended probing is the essence of an informal survey. If systematic methods are what is wanted, why not just use a questionnaire? However, RG can help minimize the problems involved in holding unstructured informal dialogues. For example, the particular questions the researcher asks and the way he asks them may be so different between farmers that variation in questioning methods becomes a more important determinant of responses than actual variation among farmers. Moreover, it is often difficult to distill the results of such a discussion without a framework for organizing the data in a meaningful way. RG provides the researcher with ways of (1) collecting information in an open, yet systematic manner, and (2) organizing and analyzing the data so as to permit quantitative comparisons among alternatives and straightforward interpretation of results.

Furthermore, RG does not add significantly to the time spent in the informal survey. For example, if evaluating farmers' opinions of alternative varieties is important, researchers would be exploring this topic with or without RG. Thus, it is more accurate to view RG as a means of directing interviews and systematizing the results of an informal survey rather than as a supplement to the survey.

Two qualifications to the use of RG must be emphasized. First, the method must be used carefully; there is a very delicate line between systematizing an informal survey and destroying its essence by substituting structure for the informal, probing character of the informal survey. Second, the information which RG generates is of limited use in explaining the actual decisions farmers make, e.g., why farmers grow certain varieties. RG provides information about farmers' beliefs concerning normative and positive information. However, the model is not useful for explaining how farmers use this information to reach decisions.

For example, RG does not explain how the farmer resolves tradeoffs among criteria. In the RG on maize varieties, high yield and early maturity are important favorable characteristics of maize varieties. The grid shows that hybrid yields more than Katumani in seasons of sufficient rains, but Katumani matures earlier. Unfortunately, RG does not help us understand how the farmer resolves this tradeoff. Moreover, the decision may be even more complex, the farmer may be weighing the advantages and disadvantages of several different varieties across a number of criteria.

Furthermore, even if RG were able to offer insight into farmers' intentions, it would not help explain how intentions are translated into actions. For example, the decision tree on maize varieties demonstrated that a myriad of constraints and chance circumstances may interfere with a farmer's intentions to plant a particular variety.

In conclusion, RG provides much useful information on farmers' perceptions about alternative technologies and preferences among them. The model stands up well to the test of coherence and clarity; it is clear, logical, and internally consistent, as shown in Section 2.6. Furthermore, it can be used under a wide variety of circumstances and thus rates well on the criteria of correspondence; people are generally capable of rating alternatives across a range of criteria. However, RG performs less well on the test of workability. An understanding of the advantages and disadvantages of alternatives provides an important base for developing an understanding of farmer decisions. However, the technique does not provide prescriptive information explaining the tradeoffs farmers make among criteria or the intentions and actions of farmers.

7.1.2. Hierarchical Decision Modeling

In Chapter 5, HDM provided a basis for explaining farmer practices at two key leverage points: maize variety use and the method and timing of land preparation and planting. RG was useful for analyzing farmer opinions about normative and positive information bearing on their decisions. HDM is used to assemble this and further information in a systematic manner to show the logic behind farmers' decisions. Further, like

RG, it also plays a role in guiding the interviews toward information required for explaining decisions and outcomes of decisions.

Each decision tree developed in the informal survey was based on interviews with approximately ten farmers. The questions used for developing HDM's in the informal survey were then incorporated into the formal survey. The decision trees were later revised based on formal survey responses. Thus, each tree in Chapter 5 summarizes the actual decisions made by each of 80-plus sample farmers. The trees themselves are rather complex and require careful study. Further, they form the basis for tables which highlight the principal results of the exercise. For example, Tables 5.10-5.13 summarize the principal results of the decision tree analysis on time and method of land preparation/planting.

Specifically, HDM assists the researchers to determine:

1. Which of the criteria identified in the informal survey are important in distinguishing users of a given technology from non-users. For example, the tree in Figure 5.3 shows that the important criteria for determining whether or not farmers grow Katumani for their main stock include ability to store, dog damage, appraisal of its yield with sufficient rainfall, and yield in low rainfall. Other criteria relevant to growing Katumani were mentioned by some farmers. However, with the help of the tree model, the researcher determined that these were not important because performance on these criteria were never important in determining whether or not a farmer grew Katumani. For example, including this criterion in the tree would have been superfluous because in no case was it an important enough problem to inhibit adoption.

2. The relative importance of different factors causing adoption or non-adoption. For example, the HDM on hybrid use shows that lack of

cash is the most important cause of non-adoption, followed by poor storage, low yield/no profit, and belief that second generation seed is the same as new seed. HDM is also useful for identifying the reasons for adoption. For example, the HDM identifies at least five reasons why farmers plant Katumani for their main stock of maize. Only half of those planting are doing so because they feel Katumani is the best variety for their main stock of maize. The other reasons include: (1) because preferred variety is not available, (2) because of delay in planting and fear that preferred variety will perform poorly, (3) because resources for planting the preferred variety are not available, and (4) because of desire to sell maize at harvest time.

3. The tradeoff between criteria in situations where a different alternative is rated best on each of two or more important criteria. The HDM's presented in Chapter 5 include several cases where a tradeoff across criteria is important in farmers' decisions. For example, most farmers claim that Katumani is the highest yielding variety when rains are low but are discouraged by its yield performance when rainfall is sufficient. Most farmers assume sufficient rainfall and thus reject Katumani as a variety for their main stock of maize. Thus, yield in sufficient rain is a more important criterion than yield in low rainfall. In a further example concerning whether or not to plant Katumani for early maize, the poor yield performance in sufficient rainfall is less important than the attractiveness of having early maize. Thus most farmers plant Katumani for early maize, despite its low yield in sufficient rainfall.

4. The effect of removing particular constraints on adoption. For example, improving the storability of Katumani would not increase the

number of farmers growing Katumani for early maize. Even though many farmers are unable to store Katumani seed from harvest to planting season, they are able to obtain Katumani seed by purchasing it or obtaining it from neighbors.

5. The effect of resource constraints and chance circumstances on the ability of farmers to carry out their intentions. Farmers in the "forced action" learning state (See Section 2.3) are forced by outside circumstances to reach a decision. For example, in the time-of-planting HDM, many farmers lack oxen or cash for hiring oxen and are thus forced to plant late. Moreover, even farmers who have cash for hiring oxen may not be able to get them for plowing when they desire.

The above five points show how HDM assists the researcher in developing an understanding of farmers' decisions. Furthermore, HDM is also useful in identifying and checking important information bearing on decision processes. In developing a tree, the farmers' responses form a consistent picture of the decision outcome and its determinants. As shown in the discussion of Figure 2.2 in Section 2.7, internal consistency is an important requirement of the decision tree. When internal consistency breaks down, i.e., a contradiction arises, the researcher knows there is a misunderstanding of the decision process which should be remedied. For example, when asked why she did not grow Katumani, one farmer replied that the reason was that she lacked cash to purchase seed. However, further probing indicated that the farmer knew much about Katumani and that she thought it performed poorly on a number of characteristics, including yield and storage. It became clear that lack of cash was not the reason she did not grow the variety and she confirmed that "low yield" was the principal reason.

This situation is fairly simple and perhaps typical and one can argue that such problems can be solved with a few check questions without constructing a decision tree. Nevertheless, the reasons behind farmer decisions are often complex and in some cases a contradiction in the tree was what alerted the researcher that his information was incomplete, not his own intuition. As another example, a farmer interviewed in the formal survey grew Katumani for his main stock of maize, yet was unable to store it. All other farmers reaching the question "able to store Katumani with chemicals" on the decision tree and answering "no" had rejected Katumani. But here we had a farmer who grew Katumani yet was unable to store it. Two possible explanations were available. First, some information obtained from the farmer might not have been correct, e.g., perhaps he did not really grow Katumani. Second, the information obtained may have been correct but incomplete; that is, some added information existed which made not being able to store Katumani and still growing it part of an internally consistent explanation. In fact, we found that the farmer sold all of his Katumani at harvest time, which was the principal reason he liked growing it. We included him on the tree by adding a new node below the storage node for "grow to sell at harvest time".

In fact, HDM is important for assembling the body of information about a particular decision and directing questioning so as to explain farmer decisions. HDM is used to develop a set of relevant topics and information about a given decision. It is interesting to note that the initial response to the question, "what is the principal reason you do not plant more (any) of your fields to Katumani?", in our formal survey, was revised in approximately one-third of the questionnaires. The principal reason for revision was that the answer was not consistent with other information which the tree process had guided us towards obtaining from the farmer; further probing resulted in a modification in the recorded response. "Running" a farmer through the decision tree following an interview, was a useful means for checking, (1) the internal consistency of our record of the farmer's perceptions, opinions, and actions; and (2) the ability of the tree to model farmers' decisions.

Limitations of HDM

There are several qualifications for using HDM's to examine farmer decisions.

First, farmer decisions can be understood only in the context of the overall farming system--his objectives, his resources and how he uses them, the constraints he faces, and the environment he lives in. Therefore, HDM's should only be used as a part of a more comprehensive farming systems approach such as the CIMMYT diagnostic survey.

Second, alternatives and decision criteria in HDM's must be discrete. For example, whereas HDM could be used to examine the decision whether or not to use fertilizer, it probably could not be used to model the decision on the quantity of fertilizer used, since quantity is a continuous variable. However, continuous variables can often be made discrete if in the farmer's view, there is a logical reason underlying the intervals. For example, time of planting is a continuous variable, but, in Middle Kirinyaga, it is logical to classify planting dates into three intervals: before the rains start, during the first ten days of rainfall, and after the first ten days of rainfall.

Third, where a wide array of choices is available and most farmers select several different alternatives, the usefulness of HDM is limited. For example, in Section 5.1.2, it was noted that Middle Kirinyaga farmers normally plant two to three bean cultivars from a selection of 13 possible cultivars and at least 5 are each planted by over 10 percent of the farmers. Here, the decision on which varieties to plant is too complex to model. However, the decision tree can be used to model the decision to plant any particular cultivar. In the case of bean cultivars, the repertory grid is particularly useful for identifying the favorable and unfavorable characteristics of a wide array of alternatives.

Fourth, HDM is most effective when the available alternatives are known to all or nearly all farmers interviewed. In the discussion of knowledge states in Section 2.3 we distinguished between two kinds of knowledge states: those where present knowledge is adequate for making a decision, and those where it is not. HDM's are most useful when most farmers have enough knowledge to make decisions. For example, most farmers in Middle Kirinyaga have experience planting their maize and beans at each of the three possible times: before the rains, during the first ten days of rainfall, and later. Moreover, farmers who have not planted at a particular time usually have strong opinions about planting at that time because they have learned about the results from friends and relatives who have tried planting at that time. Thus, it is likely that nearly all farmers in Middle Kirinyaga have enough knowledge about the three times of planting to make decisions about them. The same could probably not be said about fertilizer, an input which most farmers have never used. It would be extremely difficult to distinguish farmers in risk and certainty knowledge states--farmers who have made a decision not to use fertilizer--from those in learning or inaction knowledge states--those who are not using it because they lack information about it. This problem may be avoided by dealing exclusively with decisions in which all alternatives are known to all farmers.

Fifth, in certain cases, people may be unable to explain why they do what they do. For example, an action may be taken without considering alternatives, as when a farmer plants in a certain manner because that is the way he was taught to plant. In these cases, no decision, per se, was made.

Two further issues are important in evaluating HDM: (1) its incorporation into the informal survey, and (2) its costs in terms of additional time required.

First, as we argued for RG, developing HDM's is consistent with the openness and informality of the informal survey. HDM can be incorporated into the informal survey to provide guidance on information to be collected and methodical analysis of this information without detracting from the character of the informal survey.

Second, it is necessary to assess the extra costs of HDM, particularly in terms of time. HDM should not involve significantly more interview time since it is primarily a technique for organizing the collection and analysis of information about issues which the informal survey is addressing in any case. On the other hand, the time spent organizing and analyzing the information and building the trees would likely be significant. For this study, it is difficult to assess how much time was required for this since tree-building was done periodically over an extended period of time. However, this author feels that the extra time spent using the tree to help guide interviewing and to explain the rationale underlying farmers' decisions was worth his while.

As a conceptual model, HDM performs well on two criteria and has weaknesses on two further criteria. The model is quite coherent; as shown in Section 2.6, HDM is logical and grounded in a theory of human behavior. However, clarity is sometimes a problem; proponents of HDM insist on using farmers' own concepts and wording, which may be somewhat imprecise. On the other hand, this aspect contributes to HDM's workability; it is a powerful tool for explaining farmer decisions. HDM does not receive high marks on correspondence; there are many particular circumstances in which HDM is not applicable, as shown in this section.

In summary, RG and HDM appear to be useful supplements to the CIMMYT diagnostic survey. RG is important for understanding farmer evaluations of available alternative technologies. However, RG is of limited benefit if not supplemented by other tools for developing an understanding of farmer decisions and actions. HDM serves this function. HDM is useful in aiding the researcher to organize the information-collecting process about selected farmer decisions concerning leverage points and for developing an understanding of decision criteria and the logic underlying farmers' decisions. However, HDM has several important limitations; thus it can only be applied in particular situations.

7.1.3. Use of RG and HDM in the CIMMYT Diagnostic Survey

RG and HDM may be included in both the informal and formal survey of the CIMMYT diagnostic investigation. In the course of the informal survey, researchers may identify particular farmer decisions concerning leverage points which are not readily comprehensible using informal techniques. Therefore, they may decide to build RG's and/or HDM's to improve their understanding. They begin by drawing up exploratory guidelines for examining a particular topic; some examples are shown in Appendix B, Section 3.[1] The guidelines are different from a questionnaire in that they are flexible; probing is essential. Following each interview, the data are assembled in grids and/or trees. The topic guidelines, the trees, and the grids are revised many times during the course of the survey. When the researcher feels he has developed a clear understanding of the decision, he directs his efforts to other areas.

For the formal survey, the researcher may want to transfer the guidelines into questionnaire form. Therefore, he will be able to build a grid or tree based on a representative sample of farmers.

7.2. Quality of Information Gathered at Different Stages of the Investigation

Two secondary objectives of this thesis concern evaluation of the quality of information collected at different stages of the diagnostic survey sequence, as discussed in Section 2.6.2. The first objective is to test the effectiveness of the exercise for identifying RD's. The second objective is to evaluate the quality of data obtained in the informal survey and thus appraise the utility of the formal survey. The results of these two assessments are discussed in the two sections which follow.

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[1] For example, guidelines relevant to building an RG for maize variety use are shown in Appendix B, Section 3.17. Guidelines relevant to building an HDM relevant for time and method of planting are shown in Appendix B. Section 3.2.

7.2.1. Effectiveness of the Exercise for Identifying Recommendation Domains

The evaluation of the RD identification exercise is divided into two parts. First, the quality of data obtained in the RD exercise will be evaluated by comparing data collected in the RD exercise with data collected in the formal survey. Next, the delineation of RD's, based on the RD identification exercise, will be compared with the groupings arrived at following the informal and formal survey.

The method used in this thesis for identifying RD's, described in Section 3.2, took about two weeks and is very similar to that used by Collinson (International Maize and Wheat Improvement Center, 1979). First, we examined secondary information about Middle Kirinyaga and interviewed several persons knowledgeable about agriculture in the area. We used information from these sources to develop hypotheses about RD's in the area and to develop a two-page questionnaire for agricultural extension agents. Twelve questionnaires were administered to extension agents and sub-chiefs[1] representing each sub-location in Middle Kirinyaga.

In order to evaluate the accuracy of the data from the RD exercise in Middle Kirinyaga, we compare the data with those from the formal survey. As shown in Section 3.4, the formal survey was based on sound sampling procedures, hence it is assumed to give accurate estimates of the parameters shown. Before comparing the data from the RD identification exercise with those from the formal survey, we list eight possible sources of error in the RD identification exercise. It is important to

[1]A sub-chief administers a sub-location, the smallest jurisdictional area in Kenya. In Middle Kirinyaga, sub-locations are composed of 1,000 to 4,000 people. The sub-chief is usually a native of his sub-location.

examine these sources so as to understand why some estimates were incorrect and so as to attempt to avoid or correct for these biases in future exercises. Five of the sources stem from the respondents, i.e., extension agents and sub-chiefs, and three from the researchers.

A. Respondent-based sources of error.

1. Bias towards high income farmers.

Respondents tended to frame their answers about farmer circumstances with the high income, "progressive" farmers in mind. They tend to have more contact with such farmers (Leonard, 1977) and, further, when the researcher asked about an average or typical farmer, the respondent interpreted these as meaning "best" farmer. In order to counter these biases in the Middle Kirinyaga RD identification exercise, the respondent was repeatedly reminded of the difference between "progressive" and typical farmers.

2. Bias due to attempt to impress investigators.

It is natural for many extension agents to try to impress an outsider by telling him how many recommended innovations their farmers have adopted. Further, they may feel that the researcher is actually evaluating their work. It is difficult to differentiate this bias from the above one, but both lead to similar results--a bias towards high income, progressive farmers. To counter this bias, respondents were reminded that the researcher's goal was not to evaluate their work, but to understand farmer circumstances. Respondents were also reminded that low adoption rates may be caused by many factors other than poor extension.

3. Inaccurate information due to inability of respondent to deal with percentages.

Many respondents have only primary school education and some, particularly older ones, are not comfortable dealing with percentages. Some progress can be made by rephrasing questions in layman's terms, e.g., "if I were to select ten persons by chance at a village meeting where all heads of household are present, how many would have grade cattle?" Further, a continuum of all-most-half-some-few may be substituted for percentages. However, even these terms may confound the respondent.

4. Inaccurate information due to respondent's lack of knowledge.

Two types of responses may be included in this category. In some cases, respondents may fear telling the investigator that they do not know the answer to a question concerning farmers in their district because it makes them look like they do not know their job. Thus, they hazard a guess and give a false answer. In other cases, the respondent may think he knows the answer to a question but may be mistaken.

5. Bias because answer refers only to area which respondent knows best.

Some respondents may give an answer which applies to the area which the respondent knows best, usually the area around his home. In the RD identification exercise in Middle Kirinyaga, this bias was countered by first identifying on a map the respondent's area of work and various landmarks within it. These landmarks were referred to consistently to try to keep his focus on the whole area and not just the section he knew best.

B. Researcher-based sources of error.

1. Bias due to attempt to compensate for perceived respondent biases.

In some cases, the researcher feels he must discount or alter an extension agent's response because it is inconsistent with the responses of other respondents, other observers familiar with the area, or because it contradicts the researcher's own observation. However, these compensatory biases may be incorrect or may overcompensate for respondent bias.

2. Improper phrasing of question or inappropriate narrowing of possible responses.

This problem occurs for the same reason many researchers avoid primary data collection in the early stages of an investigation--researchers lack enough knowledge about the area to appropriately phrase questions and inadvertently guide answers away from realistic possibilities. For example, in this study, the researcher asked respondents to name the methods which farmers used to prepare their land, e.g., own oxen, hired oxen, tractor, etc., and estimate the percentage of farmers using each method. Unfortunately, the researcher never considered the possibility that some farmers may not prepare their land at all. It is not clear that extension agents were aware that some farmers practice no-till but the manner in which the question was phrased did not encourage them to offer this information.

3. Bias due to incorrect assessment of composition of a particular RD.

Most respondents were asked to give answers to two questionnaires--one for high income farmers, and one for low income farmers. At the time of questioning, the researcher believed that most high income farmers were in-migrants and thus orientated the questions around in-migrants. However, later it became clear that most high income farmers were natives of the area. In-migrants differ from high income natives in some important respects; thus responses concerning such characteristics were biased towards in-migrants.

Evaluation of Data Describing RD's

Table 7.1 presents the data obtained from four sources: (1) questionnaires in our RD identification exercise, (2) the report on identifying RD's, (3) the informal survey, and (4) the formal survey. Data in the RD report differ from data obtained from the RD identification questionnaires because adjustments were sometimes made to compensate for perceived respondent bias. Table 7.2 shows accuracy ratings of the data from the RD identification report and shows the sources and direction of bias in these data. Three levels of accuracy are defined: (1) high, (2) moderate, and (3) low levels, corresponding to the percentage difference between the estimate from the RD exercise and the mean sample statistic from the formal survey. Table 7.3 summarizes the overall accuracy of the RD identification exercise. Over 80 percent of the 25 estimates made for each income group were highly or moderately accurate and about 40 percent of the estimates were highly accurate. Low levels were obtained for only four to five (15-20 percent) of the estimates for each income group.

Surprisingly, the table shows that the breakdown by accuracy-level ratings were nearly identical for each income group. Extension workers tend to have more contacts with "progressive" and high income farmers; thus it had seemed reasonable to hypothesize that the accuracy ratings

Table 7.1

Comparison of Estimates of Parameters at Different Stages of Investigation, Middle Kirinyaga, 1981[a]

	Low Income Farmers				High Income Farmers			
	RD Questionnaire Results	RD Report[b]	Informal Survey Report	Formal Survey Report	RD Questionnaire Results	RD Report[b]	Informal Survey Report	Formal Survey Report
Land								
Farm Size (ha.)	3.0	Same	2.5	2.4	2.5	Same	3	3.8
Area Cultivated Long Rains (ha.)	2.5	Same	2.2	1.4	1.5	Same	2	2.2
Area Cultivated Short Rains (ha.)	2.3	Same	2.1	1.4	1.5	Same	Same	2.2
Crops								
Food Crops	Maize-Beans	Same	Same	Same	Maize-Beans	Same	Same	Same
Cash Crops	1) Maize 2) Beans	Same	Same	1) Beans 2) Maize	1) Maize 2) Beans	Same	Same	1) Beans 2) Maize
Percent of Farmers Growing Coffee	30%	15%	Same	25%	50%	40%	40%	51
Percent of Farmers Growing Sunflower	5%	Same	< 5%	0	5%	Same	Same	3
Percent of Farmers Growing Cotton	< 5%	Same	Same	4%	5%	Same	Same	3
Maize/Bean Husbandry								
Method of Land Preparation	Own ox 50%; Hire Ox 50%; Tractor < 5%	Same	Hire Ox 50%; Own Ox 30%; Access to Ox 20%; Tractor < 5%	Access to Ox 33%; Own Ox 27%; Hire Ox 27%; No-Till 21%	Hire Ox 80%; Own Ox 10% Rent Tractor 10%	Hire Ox 60%; Own Ox 20%; Rent Tractor 20%	Own Ox 60%; Rent Ox 41%	Own Ox 43%; Hire Ox 41%; Access to Ox 13%
Percent of Farmers Not Preparing Soil Before Planting	0%	Same	20%	21%	0%	Same	Same	Same
Percent of Area Planted After First Ten Days	-	-	60%	36%	-	-	20	20

[a] "Same" means estimate is the same as in the previous stage.

[b] RD report results differ from RD questionnaire results because adjustment were sometimes made to compensate for perceived extension agent bias.

Source: Data from exercise identifying RD's. RD report (Franzel, 1981), Informal Survey Report (Franzel and Njeru, 1981), and Formal survey data.

Table 7.1--Continued

	Low Income Farmers				High Income Farmers			
	RD Questionnaire Results	RD Report[b]	Informal Survey Report	Formal Survey Report	RD Questionnaire Results	RD Report[b]	Informal Survey Report	Formal Survey Report
Plant Spacing (Maize)	-	-	130 cm. x 45 cm.	110 cm. x 37	-	-	125 x 40	108 x 31
Plant Population (Maize)	-	-	14,300	24,900	-	-	17,000	29,700
Percent of Farmers Intercropping Maize/Beans	88%	Same	Same	85%	20%	Same	80%	90%
Percent of Cultivated Area Under Maize	90%	Same	Same	91%	80%	Same	Same	80
Percent of Cultivated Area Under Beans	90%	Same	Same	78%	80%	Same	Same	71%
Long Rain Bean Varieties	-	-	Can. Wonder 80% Mwezi Moja 45% Rose. Oval 45% Mexican 142 36%	Can. Wonder 73% Mexican 142 31% Rose. Oval 31% Mwezi Moja 12%	-	-	Can. Wonder 80% Mwezi Moja 55% Rose. Oval 22% Mexican 142 22%	Can. Wonder 80 Rose. Oval 41 Mwezi Moja 26% Mexican 142 23%
Long Rain Maize Varieties	Hybrid 45% Local 45% 2nd Gen Hyb. 19% Katumani 1%	Local 55% 2nd Gen Hyb. 30% Hybrid 5% Katumani 10%	Local 80% Katumani 67% Hybrid 10% 2nd Gen. Hyb. 10%	Local 77% Katumani 69% 2nd Gen. Hyb. 21% Hybrid 8%	Hybrids 67% Katumani 33% 2nd Gen. Hyb. 10%	Same	Katumani 60% Hybrid 40% 2nd Gen. Hyb. 30% Local 30%	Local 59 Katumani 49 Hybrid 36 2nd Gen. Hyb. 28
Short Rains Maize Varieties	Katumani 44% Local 43% Hybrid 8% 2nd Gen. Hyb. 6%	Local 50% 2nd Gen. Hyb. 30% Katumani 30% Hybrid 5%	Local 67% Katumani 67% 2nd Gen. Hyb. 10% Hybrid 0%	Local 71% Katumani 60% 2nd Gen. Hyb. 29% Hybrid 6%	Katumani 90% Hybrids 10%	Same	Katumani 70% Hybrid 30% 2nd Gen. Hyb. 30 Local 30%	Katumani 51% Local 51% 2nd Gen. Hyb. 38% Hybrid 26
Stalk Borer Treatment	-	-	0	0	-	-	20%	27%
Number of Weedings	-	-	1	1-2	-	-	2	1-2
Percent of Farmers Using Fertilizer	< 5	Same	Same	2%	10%	20%	10%	18%

Table 7.1--Continued

	Low Income Farmers				High Income Farmers			
	RD Questionnaire Results	RD Report[b]	Informal Survey Report	Formal Survey Report	RD Questionnaire Results	RD Report[b]	Informal Survey Report	Formal Survey Report
Percent of Farmers Using Manure	10%	Same	30%	49%	10%	30%	80%	82%
Percent of Farmers Using Storage Insecticide on Maize	-	-	25%	14%	-	-	80%	67%
Average Maize Yield (Kg./Ha. in Good Season)	2,000	1,900	Same	1,100	2,500	Same	Same	1,200
Livestock								
Percent of Farmers With Zebu Cattle	71%	Same	50%	56%	80%	Same	Same	69%
Percent of Farmers With Exotic-breed Cattle	14%	15%	Same	2%	75%	Same	Same	56%
Percent of Farmers With Cattle	80%	Same	50%	62%	95%	Same	Same	92%
Income								
Percent Getting Income From Relatives	8%	Same	Same	11%	-	-	-	-
Percent Having Regular Jobs (Salary/Business)	22%	Same	10%	21%	75%	Same	Same	69%
Most Difficult Months for Cash	-	-	March-May	March-May	-	-	January, March-May	January, April-May
Cash Sources	1) Maize/Beans 2) Casual Labor 3) Rent Ox	Same	1) Maize/Beans 2) Casual Labor	Same	1) Off-Farm 2) Milk 3) Maize/Beans	Same	1) Off-Farm 2) Maize/Beans 3) Milk	Same

Table 7.1--Continued

	Low Income Farmers				High Income Farmers			
	RD Questionnaire Results	RD Report[b]	Informal Survey Report	Formal Survey Report	RD Questionnaire Results	RD Report[b]	Informal Survey Report	Formal Survey Report
Labor								
Busiest Months	March-May	Same	May	April-May	March-May	Same	April-May	Same
Activity at Busiest Time	Planting/Weeding	Same	Weeding	Same	Planting/Weeding	Same	Weeding	Same
Percent Using Hired Labor (Not Including for Plows)	20%	10%	Same	17%	90%	Same	Same	74%
Other								
Ranking of Resource Constraints (Short Run)	-	-	1) Cash 2) Ox-Plow 3) Soil Fertility 4) Labor 5) Land	Same	-	-	1) Soil Fertility 2) Land 3) Cash 4) Ox-Plow 5) Labor	1) Soil Fertility 2) Ox-Plow 3) Cash 4) Land 5) Labor
Farmers Who Have Purchased Their Land	0%	0%	0%	2%	-	40%	30%	23%
Percent Who Have Run Out of Maize During Past Year	-	-	60%	53%	-	-	20%	64%
Percent Who Have Run Out of Beans Since 1981 Short Rains Harvest	-	-	60%	55%	-	-	20%	55%
Percent With Zinc Roofs	50%	Same	Same	72%	100%	Same	Same	97%
Principal Distinguishing Factor Between RD's	Never Purchased Land	Full-Time Farming/ No Off-Farm Income	Low-Income	Low-Income	Purchased Land	Part-Time Farming/ Off-Farm Income	High-Income	High-Income
Percent of Farmers in this RD	80%	5%	70%	60%	20%	Same	30%	40%

Table 7.2

Evaluation of Data from RD-Identification Exercise by Comparing Them with Data from Formal Survey, Middle Kirinyaga, 1981

	High Income Farmers			Low Income Farmers		
	Direction of Bias	Accuracy Rating[a] (1 = high)	Source of Inaccuracy[b]	Direction of Bias	Accuracy Rating[a] (1 = high)	Source of Inaccuracy[b]
Land						
Farm Size	Under	2	Composition	Over	2	Progressive, Knowledge, Phrasing
Area Cultivated	Under	2	Composition	Over	3	Progressive, Knowledge, Phrasing
Percent Who have Purchased Land	Over	2	Composition	-	1	-
Crops						
Principal Food Crops	-	1	-	-	1	-
Percent of Farmers Intercropping	Under	3	Knowledge, Composition	-	1	-
Primary Cash Crops	-	2	Knowledge	-	2	Knowledge

[a]This table is derived from Table 7.1. Accuracy means degree of correspondence with results from formal survey. Accuracy categories are defined as follows: 1 = high, 2 = moderate and 3 = low. Three different kinds of parameters were estimated:

1. Percentages of the group with a particular characteristic: Here, 1 means RD estimate was within ± 10% of sample statistic, 2 = within ± 20% and 3 means estimate was beyond this range.

2. Numerical parameters: 1 means RD estimate was within ± 20% of sample parameter, 2 within ± 40% and 3 outside this range.

3. Non-numerical parameters: 1 = estimate is the same as formal survey estimates, 2 = estimate overlaps with formal survey estimate, 3 = estimate is completely different.

[b]Underlined sources originate with researcher, others with respondents who are extension agents and local sub-chiefs. The sources of inaccuracy are discussed in detail in the text.

Progressive = bias towards "progressive" high income farmers
Knowledge = lack of knowledge
Phrasing = poor phrasing of question, e.g., phrasing so as to exclude some possible responses.
Composition = mistaken about composition of RD
Compensate = compensating for perceived respondent bias.

Source: Summary of Table 7.1.

Table 7.2--Continued

	High Income Farmers			Low Income Farmers		
	Direction of Bias	Accuracy Rating[a] (1 = high)	Source of Inaccuracy[b]	Direction of Bias	Accuracy Rating[a] (1 = high)	Source of Inaccuracy[b]
Percent of Farmers Growing Coffee	Under.	2	Compensate	Under	2	Compensate
Percent of Farmers Growing Sunflower	-	1	-	-	1	-
Percent of Farmers Growing Cotton	-	1	-	-	1	-
Percent of Area Under Maize	-	1	-	-	1	-
Percent of Area Under Beans	-	1	-	Over	2	Knowledge, Phrasing
Land Preparation						
Means of Preparing Land	Oxen owners, Under	2	Composition, Phrasing	Oxen Owners, Over	3	Knowledge, Progressive, Phrasing
Farmers not Preparing Land	-	1	-	Under	3	Phrasing, Knowledge
Maize/Bean Husbandry						
Long Rains Maize Varieties	Hybrid Over, Katumani, Local Under	3	Knowledge, Composition	Hybrid OK Katumani, Local Under	2	Knowledge, Progressive
Short Rains Maize Varieties	Katumani Over, Local Under	2	Knowledge, Composition	Katumani, Local Under	2	Knowledge
Fertilizer Use	-	1	-	-	1	-
Manure Use	Under	3	Knowledge	Under	3	Knowledge
Maize Yields	Over	3	Progressive	Over	3	Progressive

Table 7.2--Continued

	High Income Farmers			Low Income Farmers		
	Direction of Bias	Accuracy Rating[a] (1 = high)	Source of Inaccuracy[b]	Direction of Bias	Accuracy Rating[a] (1 = high)	Source of Inaccuracy[b]
Livestock						
Percent with Zebu Cattle	-	2	-	Over	2	Progressive
Percent with Exotic-breed Cattle	Over	2	Progressive	-	1	-
Income						
Percent Getting Income from Relatives	-	1	-	-	1	-
Percent Having Regular Jobs (Salary/Business)	-	1	-	-	1	-
Most Difficult Months for Cash	-	-	-	-	1	-
Cash Sources	-	1	-	-	2	Knowledge, Progressive
Labor						
Busiest Months and Activities	-	2	-	-	2	-
Percent Using Hired Labor	Under	2	Knowledge, Composition	-	1	-
Percent of Farmers in RD	-	2	Compensate	-	2	Compensate

Table 7.3

Accuracy of Estimates of Parameters in RD-Identification Exercise and Principal Sources of Inaccuracy, Middle Kirinyaga, 1981

	High Income Farmers		Low Income Farmers	
	Estimates of Parameters	Percent	Estimates of Parameters	Percent
Accuracy Level[a]				
High	10	38	12	44
Medium	12	46	10	37
Low	4	15	5	19
Total	26	100	27	100
Sources of Inaccuracy[b]				
Respondent				
Progressive farmer bias	2	14	7	50
Lack of knowledge	5	36	10	71
Researcher				
Phrasing	1	7	5	36
Composition of RD's	8	57	0	0
Compensating for perceived respondent bias	2	14	2	14
Total	14	100[c]	14	100[c]

[a]This table is derived from Table 7.1. Accuracy means degree of correspondence with results from formal survey. Accuracy categories are defined as follows: 1 = high, 2 = moderate, and 3 = low. Three different kinds of parameters were estimated:

1. Percentages of the group with a particular characteristic: Here, 1 means RD estimate was within ± 10% of sample statistic, 2 = within ± 20% and 3 means estimate was beyond this range.
2. Numerical parameters: 1 means RD estimate was within ± 20% of sample parameter, 2 within ± 40% and 3 outside this range.
3. Non-numerical parameters: 1 = estimate is the same as formal survey estimates, 2 = estimate overlaps with formal survey estimate, 3 = estimate is completely different.

[b]Sources of inaccuracy are discussed in detail in the text. Respondent based sources originate with the respondents, who are extension agents and sub-chiefs. These sources or inaccuracy include:

1. Progressive farmer bias: biasing estimates towards progressive farmers.
2. Lack of knowledge: lacks knowledge about the information requested.

Researcher-based sources are caused by the researcher and include:

1. Phrasing: poor phrasing of questions, i.e., phrasing so as to exclude some possible responses.
2. Composition of RD's: mistaken about composition of RD's.
3. Compensation for perceived respondent bias.

[c]Sources do not sum to 100, since more than one type of bias may be encountered for a particular estimate.

Source: Data from Table 7.1 and 7.2.

in the RD identification exercise would be higher for high income farmers than for low income farmers. Indeed, extension agents, i.e., respondent-based sources, were responsible for twice as many errors concerning low income farmers as for high income farmers. This result is as expected; extension workers showed a greater lack of knowledge and more progressive farmer bias in responses concerning low income farmers than for high income farmers. However, researcher-based errors were more numerous for high income farmers than for low income farmers because of the researcher's incorrect assessment of the composition of the high income RD. Thus, whereas respondent-based biases were the principal factor lowering the quality of information about low income farmers, investigator-based biases lowered the quality of information about high income farmers. The result was similar levels of accuracy in information concerning both groups.

Two other, less important, investigator-based biases also distorted information about farmers. First, inappropriate phrasing and phrasing questions in a way to exclude certain appropriate responses were more of a problem in asking about low income farmers than in asking about high income farmers. This indicates, not surprisingly, that the researcher knew less about low income farmers' alternative means of carrying out an operation than those of high income farmers. Second, modifying estimates to compensate for perceived respondent bias sometimes decreased the accuracy of the estimate. Five estimates concerning high income farmers and seven concerning low income farmers were revised for such reasons. In six cases the modification improved the accuracy rating; in four cases the modification lowered the accuracy rating; and in two cases there was no change. Two examples typify the advantages and disadvantages of this measure. First, extension agents reported that about half of the low income farmers purchased hybrid seed year in and year out. However, a seed retailer assured the researcher that low income farmers rarely, if ever, bought hybrid seed. In the RD report the estimate was lowered, and formal survey results confirmed that the modification was correct. A second example shows how one can easily make mistakes using the compensatory bias tool. Extension agents estimated that one-half of high income farmers and one-third of low income farmers grew coffee. These figures were revised downward, particularly for low income farmers, because of a perceived progressive-farmer bias on the part of the extension agents. In fact, the extension agents' estimates were quite accurate, as the formal survey confirmed.

A further issue concerns the reasons underlying respondent inaccuracies. In comparing extension agents' biases with formal survey results (Table 7.1), it is difficult to explain why extension agents were accurate on some variables but inaccurate on others. For example, estimates concerning crops, maize and bean husbandry, livestock, labor use, and income sources were generally fair to good. Poor estimates were made on manure use, maize varieties, methods of land preparation, maize yields, and percentage of high income farmers intercropping. Estimates on manure use were poor because of respondents' lack of knowledge; manure use is not part of the extension agents' recommendations to farmers and thus, they were unaware of farmers' manure practices. Progressive farmer bias and lack of knowledge were important sources of bias for the other four variables, and improper phrasing of questions by the investigator contributed to inaccuracy in two of the cases.

Accuracy of RD Identification

As discussed in Section 3.2, two sets of factors, across-area differences and within-area differences, were examined in the process of identifying RD's. Map 1 in Chapter 3 compares the across-area boundaries of RD's in Middle Kirinyaga based on the RD identification exercise with the final delineation based on the verification survey. There are no important modifications of the preliminary set of boundaries, except that a part of Rukanga Sub-location was excluded. There were some apparent differences between Rukanga and the rest of Middle Kirinyaga from the RD identification exercise but it was thought that these differences were incidental. However, when we visited Rukanga during the informal survey, it was apparent that rainfall was lower and farm size and livestock numbers were greater than in Middle Kirinyaga. Thus the area was excluded. As stated in Section 3.2, the boundaries of Middle Kirinyaga represent fairly distinct changes in eco-climatic and socio-economic environment. Thus, it is not surprising that the initial attempt to demarcate boundaries proved to be very accurate.

The attempt to identify within-area differences proved to be more complicated and somewhat less accurate. Preliminary contacts led to a focus on the differences between low income residents who had received land in the late 1950's under land adjudication, and high income in-migrants who purchased land from residents. In-migrants, it was thought, were high income, progressive farmers who generally had off-farm jobs and very different farming practices from resident, low income farmers. These "buyers" were thought to make up a majority of high income farmers. During the RD identification exercise, this finding was refuted; it was found that most high income farmers were residents who had acquired land through adjudication as well. Thus, the report on identifying RD's in Middle Kirinyaga distinguished between two RD's: full-time farmers with limited capital resources, and part-time farmers with off-farm income. The principal feature distinguishing these two groups is the amount of cash they have available for investing in their farms.

Several refinements were added to this distinction following the informal survey. First, the correspondence between full-time farming and low-income was dropped, since some full-time farmers had lucrative operations such as dairy or tobacco and were thus high income farmers. Second, the correspondence between part-time farming and high income was omitted because many low income farmers were found to be farming only part-time; their off-farm activities were not lucrative enough to make them high income. However, the principal distinction made in the RD identification report, that of access to cash resources, was maintained throughout each ensuing stage of analysis.

In summary, the exercise identifying RD's was reasonably accurate in identifying and demarcating RD's and in providing preliminary information about the farmers in each group. This result is somewhat astonishing, since so little time and resources were allocated to this exercise. The primary source of inaccuracies concerning high income farmers were researcher-based biases, whereas respondent-based biases were the most significant source of inaccuracy concerning low income farmers.

By examining the sources of inaccuracy in the exercise, it is likely that the effects of these sources can be minimized in future investigations identifying RD's. Three important lessons arise from our exercise.

First, interviewing local leaders, e.g., sub-chiefs, in addition to, or in place of, agricultural extension agents, may be useful in obtaining more valid information about low income farmers. In our exercise, respondent-based biases were generally caused by extension agents' lack of orientation towards low income farmers. In several cases, sub-chiefs were able to provide better information about their sub-location because (1) they are natives of the area and, (2) they have less of a stake in over-reporting the use of recommended inputs than do extension agents. However, sub-chiefs are generally less educated than extension agents. Thus, many had difficulties with such concepts as estimating the proportion of farmers having a particular characteristic.

Second, more effort should have been made to identify the possible reponses to questions in the questionnaire, particularly concerning low income farmers. Because of the biases towards progressive, high income farmers, there were more phrasing errors concerning low income farmers than high income farmers.

Finally, our exercise highlights the importance of correctly identifying RD's before administering questionnaires. In our case, a more thorough investigation of the composition of the high income RD should have been carried out before administering the questionnaires. If the researcher is uncertain about the make-up of an RD, the data collected may be of little use. In our case, more informal interviews with persons familiar with the area could have contributed to a more accurate assessment of the RD's in Middle Kirinyaga.

7.2.2. Evaluating the Utility of Carrying Out the Formal Survey

The purpose of this section is to compare the results of the informal survey with those of the formal survey so as to evaluate the utility of the formal survey. First, the biases involved in the informal survey are reviewed. Next, the effectiveness of the informal survey and utility of the formal survey are evaluated. Two criteria are used to make this assessment. First, data presented in the informal survey report are compared to data obtained in the formal survey. Second, we compare the proposed research program based on formal survey results with the program based only on informal survey results. Thus, we are able to assess the utility of the formal survey for: (1) refining available information on farmers, and (2) for formulating a research program which is more relevant to the farmers concerned.

The objective of this section is not to provide a definitive solution to the issue of whether a formal survey is necessary. As Shaner, Philipp and Schmehl (1982) point out, the issue concerning which methods to use depends on the particular circumstances encountered. However, by examining the performance of different methods in different sets of circumstances, generalizations can be made about which methods to use in which circumstances. In this section, a judgement will be made on the utility of the formal survey in contributing to the diagnostic approach. Moreover, we will identify particular circumstances in the Middle Kirinyaga context which made it more or less desirable to carry out a formal survey.

As in the previous section, formal survey data set the standards by which the accuracy of other data, in this case informal survey data, are evaluated. Before comparing these data, we detail the sources of inaccuracy in the informal survey. All sources presented are researcher-based. This is not to say, of course, that there are no farmer-based sources of inaccuracy in either the formal or informal surveys. Rather, we do not discuss farmer-based biases because it is likely that these biases do not vary between the informal and formal survey. Thus, they do not influence our comparison. The researcher-based sources of inaccuracy, listed below, differ somewhat from those identified in the exercise identifying RD's:

1. Little Emphasis in Data Collection.

The researchers' estimate of a parameter is incorrect simply because this parameter is given relatively little emphasis in the informal survey.

2. Progressive Farmer Bias.

Here, the researchers' estimate was biased towards the practice of progressive farmers. This may have occurred for several reasons: (a) because he was exposed more to progressive farmers in interviews, (b) because most of his non-farmer contacts--government officials, marketing agents, extension workers, etc.--are biased towards progressive farmers, or (c) because he has preconceptions that farmers in particular RD's--i.e., the high income RD--should behave as progressive farmers.

3. Compensating for Perceived Progressive Farmer Bias

In this case the researcher perceives a progressive farmer bias and seeks to compensate for the perceived bias. However, his estimate is actually less correct than the original estimate. For example, in the informal survey, we estimated, based on observation alone, that 60 percent of the farmers were low income and 40 percent were high income.

However, we assumed our estimate was slightly biased towards high income farmers because their farms were more prominent, and because we assumed that we did not get off the main roads and paths as much as we should have. Thus, we revised our breakdown of the two groups from 60/40 to 70/30. However, the original estimate turned out to be correct.

4. Lack of Knowledge

This category is a residual classification; it includes all incorrect estimates for which no particular bias or source of inaccuracy was noted.

Evaluation of Data from the Informal Survey

Table 7.1 shows the estimates of parameters made following the informal survey and those made following the formal survey. The results of the two surveys are compared in two further tables: (1) Table 7.4, which shows directions of bias, accuracy ratings for each variable and sources of inaccuracy in the informal survey, and (2) Table 7.5, which summarizes these results. The latter table shows that over half of the estimates in both income groups were highly accurate and that high or moderate ratings were obtained for over 88 percent of the estimates overall. As was true for the RD identification exercise, there was little difference in the breakdown of accuracy ratings by income groups. However, as in the RD exercise, there were important differences in the sources of inaccuracy bearing on the two RD's.

The most important bias affecting information on the high income group was the progressive farmer bias, which accounted for over half of the errors on estimates concerning high income farmers. It appears that

Table 7.4

Evaluation of Data from Informal Survey Report by Comparing Them with Data from Formal Survey, Middle Kirinyaga, 1981

	High Income Farmers			Low Income Farmers		
	Direction of Bias	Accuracy Rating[a] (1 = high)	Source of Inaccuracy[b]	Direction of Bias	Accuracy Rating[a] (1 = high)	Source of Inaccuracy[b]
Land						
Farm Size	Under	2	Knowledge	-	1	-
Area Cultivated	-	1	-	Over	3	Knowledge, Emphasis
Percent Who have Purchased Land	-	1	-	-	1	-
Crops						
Principal Food Crops	-	1	-	-	1	-
Percent of Farmers Intercropping	-	1	-	-	1	-

[a]This table is derived from Table 7.1. Accuracy means degree of correspondence with results from formal survey. Accuracy categories are defined as follows: 1 = high, 2 = moderate, and 3 = low. Three different kinds of parameters were estimated:

1. Percentages of the group with a particular characteristic: Here, 1 means RD estimate was within ± 10% of sample statistic, 2 = within ± 20%, and 3 means estimate was beyond this range
2. Numerical parameters: 1 means RD estimate was within ± 20% of sample parameter, 2 within ± 40% and 3 outside this range.
3. Non-numerical parameters: 1 = estimate is the same as formal survey estimates, 2 = estimate overlaps with formal survey estimate, 3 = estimate is completely different.

[b]All sources of inaccuracy are researcher-based.

1. Knowledge = lack of knowledge, no perceived bias
2. Emphasis = information category given little emphasis during informal survey
3. Progressive = progressive farmer bias
4. Compensate = compensating for perceived progressive farmer bias

These sources are discussed in detail in the text.

Source: From Tables 7.1-7.2.

Table 7.4--Continued

	High Income Farmers			Low Income Farmers		
	Direction of Bias	Accuracy Rating[a] (1 = high)	Source of Inaccuracy[b]	Direction of Bias	Accuracy Rating[a] (1 = high)	Source of Inaccuracy[b]
Primary Cash Crops	-	2	Knowledge	-	2	Knowledge
Percent of Farmers Growing Coffee	Under	2	Compensate	Under	2	Compensate
Percent of Farmers Growing Sunflower	-	1	-	-	1	-
Percent of Farmers Growing Cotton	-	1	-	-	1	-
Percent of Area Under Maize	-	1	-	-	1	-
Percent of Area Under Beans	-	1	-	Over	2	Knowledge
Land Preparation/Planting						
Means of Preparing Land	-	2	Knowledge	-	2	Knowledge, Progressive
Farmers not Preparing Land	-	1	-	-	1	-
Percent of Area Planted After First Ten Days	-	1	-	Over	3	Knowledge
Maize/Bean Husbandry						
Long Rains Maize Varieties	-	2	Progressive	-	1	-
Short Rains Maize Varieties	-	2	Progressive, Emphasis	-	1	-
Long Rains Bean Varieties	-	2	Knowledge	-	2	Knowledge
Plant Population (Maize)	Under	3	Emphasis, Compensate	Under	3	Emphasis, Compensate

Table 7.4--Continued

	High Income Farmers			Low Income Farmers		
	Direction of Bias	Accuracy Rating[a] (1 = high)	Source of Inaccuracy[b]	Direction of Bias	Accuracy Rating[a] (1 = high)	Source of Inaccuracy[b]
Treating Against Stalk Borer	-	1	-	-	1	-
Number of Weedings	Over	2	Emphasis, Progressive	Under	2	Emphasis, Compensate
Percent Using Fertilizer	-	1	-	-	1	-
Percent Using Manure	-	1	-	Under	2	Emphasis, Compensate
Percent Using Maize Storage Insecticide	Over	2	Progressive	Over	2	Progressive
Average Maize Yield (Good Season)	Over	3	Progressive	Over	3	Progressive
Livestock						
Percent with Zebu Cattle	Over	2	Progressive	-	1	-
Percent with Exotic-breed Cattle	Over	2	Progressive	-	1	-
Income						
Percent Getting Income from Relatives	-	1	-	-	1	-
Percent Having Regular Jobs (Salary/Business)	-	1	-	Under	2	Compensate
Most Difficult Months for Cash	-	1	-	-	1	-
Principal Cash Sources	-	1	-	-	1	-

Table 7.4--Continued

	High Income Farmers			Low Income Farmers		
	Direction of Bias	Accuracy Rating[a] (1 = high)	Source of Inaccuracy[b]	Direction of Bias	Accuracy Rating[a] (1 = high)	Source of Inaccuracy[b]
Labor						
Busiest Months and Activities	-	1	-	-	1	-
Percent Using Hired Labor	-	2	Progressive	-	1	-
Other						
Ranking of Resource Constraints	-	2	Progressive	-	1	-
Percent who have Run out of Maize During Last Year	Under	3	Progressive, Emphasis	-	1	-
Percent who have Run out of Beans During Last Year	Under	3	Progressive, Emphasis	-	1	-
Percent of Farmers in RD	-	1	-	-	1	-

Table 7.5

Accuracy of Estimates from Informal Survey, Compared to Formal Survey, and Principal Sources of Inaccuracy, Middle Kirinyaga, 1981

	High Income Farmers		Low Income Farmers	
	Estimates	Percent	Estimates	Percent
Accuracy [a]				
High	19	53	23	64
Moderate	13	36	9	25
Low	4	11	4	11
Total	36	100	36	100
Sources of Inaccuracy [b]				
Lack of knowledge	4	23	6	46
Information not emphasized	5	29	4	31
Progressive farmer bias	11	65	3	23
Countering perceived progressive farmer bias	2	12	5	38
Total	17	100 [c]	13	100 [c]

[a] This table is derived from Table 7.1. Accuracy means degree of correspondence with results from formal survey. Accuracy categories are defined as follows: 1 = high, 2 = moderate, and 3 = low. Three different kinds of parameters were estimated:

1. Percentages of the group with a particular characteristic: Here, 1 means estimate was within ± 10% of sample statistics, 2 = within ± 20% and 3 means estimate was beyond this range.
2. Numerical parameters: 1 means estimate was within ± 20% of sample parameter, 2 within ± 40% and 3 outside this range.
3. Non-numerical parameters: 1 = estimate is the same as formal survey estimates, 2 = estimate overlaps with formal survey estimate, 3 = estimate is completely different.

[b] Sources of inaccuracy are discussed in detail in the text. All are researcher-based. They include:

1. Information not emphasized. Parameter given little emphasis in informal survey.
2. Progressive farmer bias: Researchers' estimate biased towards practices of progressive farmers.
3. Compensating for perceived progressive farmer bias.
4. Lack of knowledge: residual classification. Includes all other incorrect estimates.

[c] Sources do not sum to 100, since more than one type of bias may be encountered for a particular estimate.

Source: From Table 7.4.

the major reason for this bias was the researcher's expectation that high income farmers should behave like progressive farmers: use purchased inputs, follow recommended practices, etc. Fortunately, the effect of this bias on overall accuracy was limited, affecting less than one-third of all estimates and in most cases, causing "moderate", not "low", ratings. Other causes of inaccuracy included lack of emphasis and lack of knowledge. Compensating for a perceived progressive farmer bias resulted in only two errors.

For low income farmers, lack of knowledge and compensating for a perceived progressive farmer bias were the most important causes of inaccuracy. Indeed, compensating for a perceived progressive farmer bias caused more inaccuracy than the progressive farmer bias itself. Thus, the researchers' own "corrected" impressions turned out to be less valid than the initial impressions in the first place.

Two major implications arise from this discussion. First, the data in this section show that in Middle Kirinyaga the formal survey contributed relatively little to the accuracy of estimates compared to estimates made during the informal survey. Second, the data show a tendency for the researcher, during the informal survey, to try to force high income farmers to be more progressive than they really were and low income farmers to be less "progressive". Indeed, compensating for perceived biases may be a more important source of inaccuracy than the perceived bias itself.

It is likely that the sources of inaccuracy identified in this exercise are common to most farm management investigations in developing countries. Therefore, some discussion of measures to minimize their effects is warranted.

A greater awareness of the progressive farmer bias and its roots, as discussed above, would have assisted this researcher in minimizing its effects. It is interesting to note that the bias had little effect on data concerning low income farmers because we were aware that researchers often mistake small farmers to be more progressive than they actually are. However, we were less aware that the progressive farmer bias was as potentially great for high income farmers as low income farmers; hence, our error in trying to force high income farmers to be more progressive than they really are.

Our efforts to compensate for perceived progressive farmer bias were subject to similar weaknesses. Among low income farmers, we made more mistakes compensating for the progressive farmer bias than were caused by the progressive farmer bias itself! Our overzealousness was due, perhaps, to an unsubstantiated fear that our efforts in the data collection exercise were not sufficient to do away with this bias. However, it appears that they were indeed sufficient; it only proved harmful to make adjustments in the data because of perceived biases. The data thus show that it may be better to accept one's own data rather than modifying it to account for perceived researcher-based biases.

Contribution of the Formal Survey to the Experimental Program

The experimental program formulated following the informal survey may be evaluated by comparing it to the program developed after the formal survey. The principal issue posed is whether the mounting of the formal survey made an important contribution to the development of an experimental program or whether the same research priorities and experiments were formulated folowing the informal survey. Four areas of information are examined in comparing the two experimental programs. First, we examine the principal constraints and their ranking in importance in the two programs. Second, we compare the principal research areas identified in the two programs. Third, we examine the levels of non-experimental variables to see if they were fixed at the same levels in each program. Non-experimental variables form the context in which potential technological changes are tested, and modifying their levels can significantly affect the results of the experiments. Fourth, we compare the experimental variables to see if there were important changes made following the formal survey.

Principal Constraints

The principal resource and other constraints to farm development identified in the informal and formal surveys are shown in Table 7.6. For high income farmers, the two most important constraints identified in the informal survey are also the most important following the formal survey. These constraints are, (1) the low profitability of crop production relative to off-farm investments, and (2) poor soil fertility and structure. The only important change in constraints for high income farmers between the two surveys concerns access to oxen. Following the informal survey, access to oxen was not considered an important bottleneck for high income farmers since they either owned oxen or had cash available for hiring them. However, in the informal survey, we underestimated the number of high income farmers planting late, after the first ten days of rainfall, and also overestimated the number of high income farmers owning oxen. Thus, formal survey results showed that

Table 7.6

Researchers' Perceptions of the Most Important Constraints Facing Farmers, from the Informal Survey and from the Formal Survey, Middle Kirinyaga, 1981

Ranking	Constraints of High Income Farmers		Constraints of Low Income Farmers	
	Informal Survey	Formal Survey	Informal Survey	Formal Survey
1	Low Profitability of Crops	Low Profitability of Crops	Cash	Cash
2	Soil Fertility/ Structure	Soil Fertility/ Structure	Access to Oxen	Access to Oxen
3	Cash	Access to Oxen	Soil Fertility/ Structure	Soil Fertility/ Structure
4	Land	Cash	Labor	Labor
5	Access to Oxen	Land	Land	Land
6	Labor	Labor		

Source: Franzel and Njeru, 1981; informal survey notes; this thesis.

access to oxen was a more important problem for high income farmers than had previously been thought.

For low income farmers, the ranking of constraints from the two surveys were identical. Cash is the most important constraint, followed by access to oxen and soil fertility/structure. Labor and land were relatively less important.

Principal Research Priorities

The principal research priorities identified after the informal survey and then modified after the formal survey are shown in Table 7.7. As stated earlier, research priorities are established at leverage points where (1) there are important problems to farmers and (2) opportunities exist for solving these problems. For low income farmers, improving soil fertility usurped easing the draught power bottlenecks as the most important research priority following the formal survey. This did not occur because of any change in the data or in our understanding of the two problems. Rather, the priorities were modified because researchers made an almost incidental discovery of a potential solution to the soil fertility and structure problem while the formal survey was being mounted. Several months before the informal survey began, a coffee processing factory was opened in Middle Kirinyaga to process coffee from neighboring upland areas. During the formal survey, we discovered that the by-products, a mixture of coffee husks and pulp, were being dumped as waste at a nearby site. A farmer near this site was applying the husks to his maize and beans. We contacted the Coffee Research Station and were told that the husks were a proven, effective manure for coffee and that they were also likely to be effective as a

Table 7.7

Researchers' Perceptions of the Most Important Research Priorities for Farmers in Middle Kirinyaga: After the Informal Survey and After the Formal Survey, 1981

Ranking	Research Priorities from Informal Survey		Research Priorities From Formal Survey:
	High Income Farmers	Low Income Farmers	Both Income Groups
1	Soil Fertility/Structure	Draught Power Bottleneck	Soil Fertility/Structure
2	Maize Varieties	Soil Fertility/Structure	Draught Power Bottleneck
3	Draught Power Bottleneck	Maize Varieties	Maize Variety
4	Bean Cultivars	Bean Cultivars	Bean Cultivars
5	Weeding Efficiency	Maize Storage	Maize Storage
6		Weeding Efficiency	

Source: Franzel and Njeru, 1981; Informal Survey notes; this thesis.

manure for maize and beans. Previously, our only solution to the soil problem was fertilizer, which was expensive and which in any case had been tried and rejected by many farmers. Identification of a new and potentially more effective solution to the soil problem elevated soil fertility and structure to the primary research priority for low income farmers in Middle Kirinyaga.

Easing the draught power bottleneck is the second most important area and improved maize varieties, bean cultivars, and maize storage retained their ranking as research priorities following the formal survey. There was only one further, fairly minor, change in research priorities for low income farmers. A proposal to increase weeding efficiency was dropped because the formal survey confirmed that weeding labor was not an important system bottleneck.

For high income farmers, soil fertility and structure was already the highest priority research area, even before coffee by-products were identified as a possible solution. This area took on an added importance following the formal survey because coffee by-products appeared to be a useful innovation for high income farmers as well. However, three changes were made in the ranking of research priorities for high income farmers. First, since the draught power bottleneck was found to be of greater importance for high income farmers than had been previously expected, this area was elevated to second in importance, passing maize variety improvement. Second, improving weeding efficiency was excluded from the list for the same reasons noted for low income farmers. Third, maize storage improvement was added to the list. Prior to the formal survey, this had been considered primarily a problem for low income farmers.

Non-Experimental Variables

Table 7.8 shows that relatively few changes were made in the levels of non-experimental variables between the two surveys. For high income farmers, eight variables remained the same, marginal changes were made for three variables, and important changes were made in two cases. Marginal changes were made in maize variety for main stock, maize variety for early maize and number of weedings. Important adjustments were made in maize and bean plant populations, which had been underestimated. The primary reasons for the underestimate of plant populations were, (1) the importance of these parameters was not given sufficient emphasis, and (2) a haphazard sampling and estimation procedure was used.

For low income farmers, the results obtained in the informal survey were also fairly accurate, compared to the formal survey. Nine variables were unchanged, one was changed marginally and three important changes were made due to the formal survey results. Important changes concerned maize population, bean population, and time of planting. A marginal change was made in the weeding regime. The causes of poor estimates of plant populations were the same for low income farmers as were noted for high income farmers. The cause of the poor estimate of times of planting is unclear, since much emphasis was given to this parameter during the survey. As stated earlier, it is likely that farmers' responses in the formal survey were biased towards planting early.

Experimental Program

Table 7.9 presents experimental programs developed following the informal and formal surveys. The two programs are quite similar but

Table 7.8

Levels of Non-Experimental Variables in Maize/Bean Experiments Based on Informal and Formal Surveys, Middle Kirinyaga, 1981

Practice/Operation	High Income Farmers		Low Income Farmers	
	Informal Survey	Formal Survey[a]	Informal Survey	Formal Survey[a]
Time of Planting	Five days after rains begin	Same	Two to three weeks after rain begins	Ten days after rain begins
Seed Treatment	None	None	None	None
Method of Land Preparation/Planting	Oxplow, maize in rows, beans broadcast before plowing	Same	Same	Same
Maize Plant Population	15,000	29,700	14,300	24,900
Row Width (cm.)	125	111	130	110
Between Plants (cm.)	40	30	45	40
Bean Plant Density	100,000	160,000	100,000	160,000
Maize Variety for Main Stock	H-511	Local/H-511	Local	Same
Maize Variety for Early Maize	Katumani	Katumani/None	Katumani	Same
Bean Cultivar	Canadian Wonder	Same	Canadian Wonder	Same
Weeding	Two Times; Effective	One to Two Times; Effective	One time; Effective	One to Two Times; Effective
Plant Protection	None	None	None	None
Fertilizer	None	None	None	None
Manure Application	None in Last Year	Same	None in Last Year	Same
Fallow or Rotation	None	None	None	None

[a]"Same" means level is same as in informal survey.

Source: Franzel and Njeru, 1981; Informal Survey notes; Survey data.

Table 7.9

List of Proposed Experiments and Demonstrations Formulated After the Informal and Formal Surveys, Middle Kirinyaga, 1981[a]

Informal Survey Experimental Program	Formal Survey Experimental Program
1. Soil Fertility	1. Soil Fertility
a. Fertilizer	a. Coffee Husks/Fertilizer
b. Conservation/Use of Manure	b. Same
c. Fertilizer application H	c. Same
2. Ease Draught Power Bottleneck	2. Ease Drought Power Bottleneck
a. Dry Planting	a. Same
1. bean cultivar	1. same
2. seed treatment	2. same
3. deep planting maize	3. same
b. No-Till L	b. Same
c. Stagger Land Preparation	c. Same
d. Improve Equipment	d. Same
3. Maize varieties	3. Maize Varieties
a. Variety x Fertilizer x Plant Population	a.
	b. Medium-Maturity Composite L
	c. Dryland Composite L
	d. Variety x Storage Characteristics
4. Bean Cultivars	4. Bean Cultivars
a. Select for Dry Planting	a. Same
1. deep planting	1. same
2. temperature tolerance	2. same
3. germination	3. same
4. drought resistance	4. same
	5. late flowering
	b. High Returns to Planting Cost
5. Maize Storage Management	5. Maize Storage Management
a. Storage Demonstration L	a. Same H, L
6. Other	6. Other
a. Small Livestock for Manure	a. Sunflower Improvement
b. Dutch Hoe	
c. Maize Spacing on the Square	

[a]"H" or "L" indicates that an experiment is designed with high or low income farmers in mind. Where no H or L is shown, the experiment is designed for both income groups. However, the experiment is not necessarily the same for each group as non-experimental variables and levels of experimental variables are likely to be different for the two groups (see Chapter 6).

"Same" means experiment after formal survey is the same as that planned in the informal survey.

Source: Franzel and Njeru, 1981, and this thesis.

there are a few important differences. For research on soil fertility, the coffee husks experiment was included in the experimental program following the formal survey.

The program to ease the draught power bottleneck did not undergo any modification based on the formal survey. The maize variety program, on the other hand, underwent substantial modifications. One variety x fertilizer x population experiment planned for both income groups following the informal survey was omitted following the formal survey. Three research proposals were added, two involving a medium maturity composite and an early maturing composite for low income farmers, and a variety x storage aspects trial for all farmers. However, none of these proposals developed out of new information in the formal survey.

The research plans for bean cultivars underwent two important modifications. First, the problem of bean flowers being destroyed by heavy rains was found to be more severe than had been thought during the informal survey. Thus, late flowering became a desired characteristic in bean cultivars and particularly for dry planted ones. Second, high returns to planting costs was recognized as an important criterion for choice of bean variety following the formal survey. Thus, a priority for bean research is to select vigorous, palatable, small seeded varieties to replace Mexican 142. Both additions to the research agenda on beans came about because data collected in the formal survey modified the researchers' understanding of the farming system.

The remaining areas are of relatively low priority. Three research priorities changed significantly from one survey to the next. Two proposed weeding improvements, using a new hoe and spacing maize on the square to improve oxen weeding, were excluded from the informal survey because low weeding efficiency was not found to be an important enough problem. Similarly, promotion of small livestock for manure and other purposes was also not found to be important.

Maize storage demonstrations were considered important for farmers experiencing problems storing maize in both programs. Some considerations concerning sunflower development are included in the program following the formal survey but do not reflect any new information gained in the formal survey.

In summary, it appears that the contributions of the formal survey to developing an understanding of the farming systems and an experimental program for Middle Kirinyaga were rather marginal, relative to its costs. The formal survey involved approximately four months of the researcher's time and substantial costs in transport, hiring and training of enumerators, computer and hand analysis, paper and photocopying. However, there were relatively few refinements made in the experimental program following the formal survey and, in fact, most of the changes were not due to information gained in the formal survey. Rather, they were due to:

1. Incidental refinements and additions which researchers informally discovered, such as the potential of coffee husks. This lends support to conducting a more thorough informal survey, or carrying out more frequent informal surveys in the same area, rather than mounting a formal survey.
2. A deliberate acceptance of lower accuracy in some aspects of informal survey method and analysis, likely due to the

fact that the researchers knew that a formal survey would be carried out and thus more precise information would be obtained. The effort to measure plant population reflects this.

It is important to emphasize the danger in over-generalizing from our conclusion that a formal survey was not really worthwhile. Certainly, different methods are appropriate for different sets of circumstances. For example, Middle Kirinyaga has several features which make it relatively easy for researchers to develop an understanding of farming systems without a formal survey. First, the cropping system, composed almost exclusively of maize and beans, is less complex in many senses than cropping systems in other areas. Second, farmers and local officials were exceptionally cooperative. Third, farmers' fields are generally all located at their homestead, making farm visits easier. Fourth, transport and communication is relatively easy within the area.

On the other hand, one can also argue that Middle Kirinyaga has several features which make it more difficult than other areas to study. This lends support to the position that if a formal survey is not useful in Middle Kirinyaga, it will not be useful in most other areas. First, farmers have two cropping seasons per year. This, in effect, doubles the quantity of information needed about cropping practices. Second, two RD's co-exist in the area and it is often difficult to ascertain the relative numbers in each and the characteristics which distinguish them. Third, there appears to be much variation in how certain operations are performed, e.g., land preparation and planting. Furthermore, it should also be noted that the inclusion of the repertory grid and hierarchical decision tree methods in the informal survey made it more effective than it otherwise would have been.

Overall, the data in this section support the hypothesis that the informal survey is an effective and sufficient method for developing an understanding of farming systems and planning experimental programs for farmers. It also suggests that a formal survey may be replaced by (1) a slightly longer and more carefully managed informal survey than would otherwise be mounted, or (2) two or more informal surveys.

CHAPTER 8

SUMMARY AND CONCLUSIONS

8.1. Introduction

This study has two types of objectives: methodological and problem-solving. The methodological objectives concern the use of three techniques, the CIMMYT diagnostic survey, repertory grid (RG) and hierarchical decision modeling (HDM), for analyzing a farming system. The problem-solving objective involves using farming systems research (FSR) methods to plan an adaptive production research program for farmers in Middle Kirinyaga, Kenya.

The methodological objectives are twofold. First, we evaluate the contributions of RG and HDM to the CIMMYT Diagnostic Survey for collecting and analyzing normative and prescriptive information concerning farmer decisions. RG's have been used primarily by psychologists, and HDM's by anthropologists. Second, we evaluate the quality of information at different stages of the survey sequence in order to assess the utility of two exercises: identification of recommendation domains (RD's) and the formal survey.

The problem-solving objective involves describing farming systems in Middle Kirinyaga, identifying priority research areas, examining farmer decisions related to these areas, and planning a detailed program of experiments to develop improved technologies for farmers. An agronomist collaborated with the author both in mounting the farmer survey and in planning the research program.

The farming systems perspective is the overall approach used in this thesis. FSR offers an alternative to a conventional yield-oriented perspective, common among physical and biological scientists. FSR researchers view the farm household and its activities as a system of interdependent components and focus on the interaction of these components in their physical, biological, and socioeconomic environment. An understanding of how this system functions serves as a basis for developing recommended improvements. FSR's other principal characteristics are that it (1) is multi-disciplinary, (2) focuses on solving the problems of particular groups of farmers, or RD's, and (3) involves carrying out on-farm experimentation.

The research reported in this thesis is less holistic and comprehensive than was desired due to two practical limitations. First, the size of the team was limited to two researchers due to scarce manpower and finances. Second, policy changes were not considered among the proposed recommendations because we had no formal links with policy researchers or policy-making bodies.

Three general approaches to modeling farmer management strategies are reviewed: (1) multivariate analysis, e.g., multiple regression, (2) behavioral, e.g., linear programming, and (3) cognitive-anthropological e.g., the CIMMYT diagnostic survey. The latter approach was selected for this study. The first two approaches are criticized in Section 2.5-2.6 for oversimplifying the actual decision criteria farmers use. In general, they do not examine the actual reasons for farmers' decisions and test instead whether the outcome of the decision is associated with particular characteristics or is consistent with selected, behavioral choice criteria. On the other hand, the cognitive anthropological approach attempts to understand the logic underlying farmer decisions and strategies. Informal interviews are the principal method for developing an understanding of the farmers' perspective and reasoning.

The principal data collection method in this thesis is the CIMMYT diagnostic survey. The approach includes the following steps:

1. Identification of RD's, based on a review of secondary data, a rapid survey of local agricultural extensión agents in Middle Kirinyaga, and informal interviews with persons knowledgeable about the area.

2. An informal survey, in which a multi-disciplinary team of researchers use detailed but essentially unstructured guidelines to interview farmers.

3. A formal survey to verify the results of the informal survey. Hence, a questionnaire is administered to a random sample of farmers by trained enumerators.

4. Planning a set of experiments to develop technologies appropriate for farmers.

In addition, data collection for building RG's and HDM's to model selected farmer decisions was incorporated into the diagnostic survey. During the informal survey, data were collected for constructing preliminary RG's and HDM's, and during the formal survey data were collected to extend the use of models to farmers in the random sample.

The CIMMYT approach has several important advantages. First, it is characterized by a sequential approach to data collection in which each stage is increasingly focused on more specific priority problems.

Moreover, the approach is relatively inexpensive in terms of time and resources. The CIMMYT procedures are by no means a fixed recipe for carrying out FSR; rather they are flexible and evolving.

One important weakness of the procedures is that they provide little systematic direction on how to identify and evaluate normative information, farmers' values and beliefs, and prescriptive information, farmers' decisions. We address this problem by testing the incorporation of the RG and HDM techniques into the diagnostic survey for a more methodical analysis of farmers' values and decisions. RG is used (1) to elicit from farmers the criteria they use in evaluating alternative technologies, and (2) to obtain farmers' evaluations on the performance of each technology. HDM is used to depict the decision process farmers use when considering alternative actions, and to focus interviewing on those criteria and issues important for developing an understanding of selected farmers' decisions. In this thesis, these two techniques are used to develop the researcher's understanding of selected farmer decisions concerning "leverage points", areas of the system where there appear to be opportunities for system improvement and where further information about farmer practices is required.

The second methodological improvement addressed in this thesis concerns the quality of information gathered at different stages of the diagnostic survey sequence. First, we test the effectiveness of the RD-identification exercise in (1) delimiting RD's, and (2) providing preliminary information on farmers in the RD's. The RD-identification exercise involves using a short questionnaire to interview extension workers. These results are evaluated by comparison to the results of the formal survey, which is assumed to accurately represent farmer circumstances and practices in Middle Kirinyaga. Second, we evaluate the utility of the formal survey by comparing the information and resulting experimental program to those derived from the informal survey results. If the formal survey does not make an important contribution to understanding farmer circumstances and formulating an appropriate experimental program, one can argue that it is superfluous.

8.2. Developing an Adaptive Production Research Program

This section summarizes the results of the farmer survey and outlines the production research program developed for Middle Kirinyaga farmers, satisfying the problem-solving objective of this thesis.

Middle Kirinyaga is characterized by small farms of two to six hectares, flat to mildly sloping terrain, and an adequate transportation network. Rainfall averages about 1,000 mm. per year and is distributed over two brief, somewhat unreliable, seasons.

There are two recommendation domains, or farmer target groups, in Middle Kirinyaga: high income farmers and low income farmers. The two groups of farmers are characterized by different farming systems and hence have somewhat different researchable problems and opportunities. Nearly all of the cultivated land of both groups is under intercropped maize and beans. Low income farmers earn most of their income from the farm, whereas high income farmers derive most of their earnings from off-farm sources. Most farmers use oxen for plowing and plant maize and beans at the same time plowing is done; maize is planted in rows and beans are broadcast. Few if any purchased inputs are used, with the exception of hybrid maize seed which is used by about one-third of the high income farmers. Yields of both maize and beans are extremely low.

Most farmers in both groups keep cattle, mostly Zebu cows, and about one-third of the high income farmers keep exotic-breed cows for a cash dairy enterprise. Farmers of both target groups frequently exhaust their supplies of maize and beans; hence, maintaining adequate food supplies for home consumption is an important problem for most farmers.

The most important constraints limiting farm productivity are lack of cash for purchasing inputs, lack of access to draught power when required, and poor soil fertility. The cash constraint is especially important for low income farmers who may not have cash for even the most basic inputs: purchasing seed and hiring ox-plows. High income farmers may have cash available for investment but they prefer to invest in off-farm enterprises. Access to draught power is also a particularly important constraint for low income farmers. They are often forced to plant late, because they do not own oxen or have the cash necessary for hiring them. Soil fertility and structure is becoming an increasingly important problem for both groups as fields are continuously cropped, twice per year, in maize and beans. Few farmers apply fertilizer or rotate their crops and manure applications are too small to have much effect.

Our proposals for priority research areas focus on the introduction of new technologies and modifications in the system. These must offer the potential to increase productivity and be both acceptable to farmers and feasible for them to adopt. Emphasis is placed on maize and beans, the area's two most important crops. Separate experiments are planned for each income group in instances where their problems differ or where solutions appropriate for one group are not appropriate for the other group.

The two most important research priorities are:

1. Improving soil fertility and structure. The principal activity in this area is an on-farm experimental program to test the effectiveness of readily available coffee husks as manure and to compare them with chemical fertilizer.

2. Reducing the draught power bottleneck. Several means are suggested for accomplishing this objective. First, dry planting must be made more attractive to farmers. A selection program is proposed to select bean cultivars with superior ability to withstand dry planting. Dry planting can also be encouraged by two further steps: treatment of maize and bean seed against ant damage, and deeper planting of maize seeds. Other means of reducing the draught power bottleneck include the development of infrequent and no-tillage systems, especially for low income farmers, and the improvement of oxen efficiency through improved plowing equipment.

Several research priorities of lesser importance also merit attention. Researchers can help low income farmers by selecting a palatable bean variety which gives a high return per cost of seeds per hectare to replace Mexican 142. Research work on maize storage, particularly the relationship between hardness of grain and resistance to weevils among available varieties, can assist breeders in the selection of varieties which store well. Low income farmers would benefit from a medium-maturing maize composite which stores well and out-yields Katumani and Local at relatively low input levels. A 100-day maize composite would be useful to farmers, particularly low income farmers, by providing a small quantity of much needed early maize. Finally, comments are offered on sunflower production which offers potential for improving the welfare of both high and low income farmers in Middle Kirinyaga.

8.3. Selected Issues in the Evaluation of Methods

8.3.1. Repertory Grid and Hierarchical Decision-Tree Modeling

RG and HDM are both found to be important methods for developing an understanding of farmer decisions concerning practices at leverage points. They are particularly useful for guiding the information gathering process, assembling data concerning farmer preferences and decisions in a systematic and meaningful fashion and for assisting the researcher in developing an understanding of farmers' reasoning in making their decisions.

RG is useful in identifying the criteria farmers consider in selecting alternative technologies and in obtaining farmers' evaluations of how each technology performs on each criterion. For example, in our informal survey we quickly understood that late planting of maize and beans was an important problem for farmers. As few farmers plant before the rains begin, we decided to use RG to examine the advantages and disadvantages associated with planting maize and beans at different times--before the rains begin, during the first ten days of rainfall and at later times. The resulting grid illustrated the principal hazards that farmers face from planting at each time and the relative importance of each hazard. One of the aims of our production research program, as stated above, was to develop methods of planting before the rains which reduce the risks identified in the RG exercise.

RG's provide an important base for developing an understanding of farmers' decisions. The technique may be used in a wide range of situations, whenever farmers face a choice among alternatives. RG's principal limitation is that, used alone, it is not a sufficient method for explaining either the intentions or actions of farmers.

HDM is useful for assembling a body of information from farmer interviews which provides a complete, internally consistent summary of the determinants of farmer decisions as well as a summary of how decisions are or are not translated into action. The information used in the HDM includes opinions about performance on a particular criterion, tradeoffs between criteria, constraints which farmers face, and chance circumstances they encounter which affect the outcome of their decisions. The decision tree summarizes case studies of each sample farmer in a single figure.

For example, HDM is used in Chapter 5 to examine farmers' decisions on which maize varieties to grow. In the informal survey, it was clear that recommended maize varieties were not widely grown in Middle Kirinyaga. We used the decision trees to help explain the criteria that farmers use to select a maize variety to plant, why the recommended varieties are not grown, and why the traditional variety still predominates. In Chapter 6, we use this information to make recommendations on maize variety research for farmers in Middle Kirinyaga.

HDM is a more powerful tool than RG for assisting the researcher in understanding farmer decisions. However, its use is limited in several important ways. First, alternatives and decision criteria must be discrete. Second, the number of alternatives must be limited and farmers should be knowledgeable about all possible choices. Third, in some cases, HDM is not suitable because farmers may be unable to explain their own reasoning.

RG and HDM are found to be suitable for inclusion in the CIMMYT diagnostic survey in the following manner. In the informal survey, a few farmer decisions concerning leverage points were selected for further examination. Preliminary grids and/or decision trees based on a sample of about ten farmers were then constructed to help develop an understanding of these decisions. Next, the key questions required for building a tree or grid were incorporated into the formal survey. Therefore, grids and HDM's were constructed for a representative sample of farmers.

An important issue concerns whether or not RG and HDM would greatly extend the time required to mount the CIMMYT diagnostic survey. It must be noted that RG and HDM are primarily techniques for organizing the collection and analysis of information about issues which the informal survey is addressing in any case. Our informal survey involved eight researcher-weeks and we completed three HDM's and four RG's during that period. RG was not found to add significantly to the time spent in the diagnostic survey. HDM does require additional interviewing and analysis time but we feel that the benefits associated with its use outweigh the extra costs.

8.3.2. Quality of Data at Different Stages of the Investigation

The second methodological objective addressed in this thesis was to evaluate the quality of data in both the RD-identification exercise and the informal survey by comparing them with data from the formal survey.

During the initial stages of an investigation, most researchers use secondary data and informal interviews with farmers and others to develop a preliminary understanding of farmers' circumstances, to stratify the sample, and to identify appropriate data collection methods. However, in the research reported in this thesis, the exercise identifying RD's involves administering a brief questionnaire to extension agents and/or local leaders as well as the more conventional methods. The exercise is found to be reasonably effective for the following:

1. Tentatively classifying farmers into RD's. Few revisions were made in the RD boundaries following the informal and formal surveys.

2. Developing some preliminary information about farmers in the RD's. We estimated 25 parameters for each income group in the RD identification exercise and later measured these parameters in the formal survey. We then established a system of rating the accuracy of the estimates. Over 80 percent of the estimates in the RD identification exercise were moderately or highly accurate.

The primary sources of inaccuracy concerning low income farmers in the exercise were respondent-based; extension agents and local leaders tended to bias their responses towards "progressive" farmers. In other cases, they simply did not know the answers to certain questions about farmers in their area. In contrast, the sources of inaccuracy concerning high income farmers tended to be researcher-based. For example, on a number of occasions, the researcher made mistakes because he had improperly assessed the characteristics of the high income RD.

Next, the utility of the formal survey was evaluated by comparing its results with those of the informal survey. Many survey approaches place emphasis on formal surveys for providing information; others rely on informal surveys. In our research, the formal survey contributed relatively little to our understanding of farmer practices and constraints developed in the informal survey.

For example, over half of the 36 parameters estimated for each income group in the informal survey were highly accurate; about 90 percent were moderately or highly accurate. Here, the principal source of inaccuracy concerning high income farmers was a bias towards progressive farmers on the part of the researcher. Concerning low income farmers, the greatest source of inaccuracy was overcompensating for a perceived progressive-farmer bias. A careful review of the biases and sources of inaccuracy in the different stages of the survey is likely to contribute to greater accuracy in future exercises.

Furthermore, there were relatively few refinements made in our research priorities and experimental program as a result of new information from the formal survey. Therefore, our findings support the hypothesis that the informal survey is an effective and sufficient method for planning experimental programs for farmers. They also suggest that a formal survey may be replaced by either (1) a slightly longer and more carefully managed informal survey than would otherwise be mounted or (2) additional informal surveys.

8.4. Suggestions for Further Research

There is no single, uniform FSR approach; many different approaches and techniques in data collection and problem definition are currently being used in FSR programs. This author believes that FSR in general, and the CIMMYT diagnostic survey in particular, provides great potential for focusing the efforts of agricultural researchers towards solving farmers' problems in an efficient manner. Research is needed to measure the effectiveness of this approach and to improve its performance.

8.4.1. Research on Measuring Effectiveness

Although enthusiasm is currently at a high level, FSR's contributions are quite uncertain. FSR must be evaluated by the ultimate contribution of technologies developed in the exercise to improving the welfare of farmers and society as a whole. In this thesis, we discuss FSR's contribution to developing an understanding of farming systems and planning experiments appropriate for farmers in Middle Kirinyaga. However, ultimately, FSR evaluations must cover the entire research-extension continuum from describing farmer circumstances through planning experimentation to an evaluation of the adoption of new technologies. Of course, at this early stage in FSR's development there are relatively few examples of technologies being disseminated among farmers which were developed in FSR exercises. As these technologies are developed, research is needed to examine their utility and to review the contribution made by the FSR process. Contributions can best be measured using a "with-without" comparison: comparing the costs and returns of an FSR exercise with the costs and returns to research without an FSR component.

For example, in Middle Kirinyaga five to ten years hence, it may be possible to compare the costs and benefits of our FSR program with those of the conventional research effort. For example, the costs and benefits associated with developing coffee husks for improving soils may be compared to those of the program to encourage fertilizer use in the absence of the coffee husks programs. In both cases, research and extension costs would be compared with the net benefits associated with the improved technology.

8.4.2. Research on Improving Performance

Several channels are available for improving the performance of FSR and in particular, the CIMMYT diagnostic exercise. First, research on the cost-effectiveness of alternative methods should be pursued. Specifically, researchers should evaluate the quality of information at each stage of their survey, the factors affecting the quality, and the contributions of each stage to developing the experimental program. In particular, research should focus on (1) measuring the effectiveness of the exercise to identify RD's, (2) comparing the results of informal surveys and formal surveys for the same groups of farmers, and (3) assessing the incremental costs and returns associated with frequent-visit, "cost-route" surveys. A comparison of different researchers' experiences under different circumstances in using these tools can contribute to evaluating their utility and improving those methods which are found to be most useful.

Second, researchers need to identify and analyze the effectiveness of new techniques in strengthening the CIMMYT diagnostic survey, and other similar FSR approaches. Specifically, researchers should evaluate new techniques, such as RG and HDM, for collecting and analyzing information on farmer values and decisions. Research should focus on (1) the versatility of these tools for examining different kinds of decisions and values, (2) the incremental costs and returns of including these tools, and (3) comparison of their role in informal and formal surveys. By testing these techniques in different sets of circumstances, we can better evaluate the contributions which they may make to FSR.

Third, researchers should broaden the focus of FSR beyond production research. Currently FSR teams generally explore possibilities for developing improved technologies while holding other variables fixed, e.g., price policy, infrastructure, and marketing. At least initially, however, all factors bearing on rural development should be subject to analysis and possible change in an ideal farming systems exercise. Of course, broadening the focus of FSR implies broadening the makeup of the team--for example, policy analysts and rural planners could be included on FSR teams along with production specialists and social scientists.

Furthermore, researchers should give greater emphasis in FSR to those activities not normally associated with production but which do in fact have important bearing on the production process. Some of these activities include the production of household goods and services (e.g., food preparation, gathering water and firewood, etc.) and the demand for and consumption of health, education and other services which compete with agricultural production for household resources. FSR cannot really claim to be comprehensive until it addresses all important issues affecting the production process, not just those concerning production methods.

APPENDICES

APPENDIX A

QUESTIONNAIRE FOR IDENTIFYING RECOMMENDATION DOMAINS IN MIDDLE KIRINYAGA

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QUESTIONNAIRE FOR IDENTIFYING RECOMMENDATION DOMAINS IN MIDDLE KIRINYAGA

AREA/RD. ____________ RESPONDENT AND POST. ____________

PHYSICAL.

TOPOGRAPHY. ____________

SOILS. ____________

RAINFALL. ____________

SETTLEMENT AND FARM SIZE.

% NEW SETTLERS AND WHERE. ____________

SETTLEMENT PATTERNS. ____________

FARM SIZE. ____________

AREA CULTIVATED LONG RAINS. ____________

AREA CULTIVATED SHORT RAINS. ____________

LAND AVAILABLE FOR RENT OR PURCHASE. ____________

CROPS.

FOOD CROPS (1, 2, 3).

CASH CROPS (1, 2, 3) AND % GROWING.

FERTILIZER OR MANURE USE (% AND CROPS).

METHOD OF LAND PREPARATION AND % EACH.

BUSIEST MONTHS.

HIRED LABOR (OPERATION/CROP).

COTTON POTENTIAL.

DIFFICULTIES.

MAIZE.

VARIETIES USED (%) IN LONG RAINS.

VARIETIES USED (%) IN SHORT RAINS.

AVERAGE MAIZE YIELD, GOOD YEAR (L.R. S.R.)

PURE OR INTERCROPPED.

CATTLE.

% WITH GRADE (NO.). ______

______

% WITH ZEBU (NO.). ______

______

INCOME.

% WITH MABATI ROOFS. ______

% GETTING INCOME FROM OUTSIDE. ______

% HAVING REGULAR JOBS. ______

% MAN AND WIFE ON FARM. ______

3 MAJOR CASH SOURCES. ______

______

______

ACCESS OTHER. ______

______

APPENDIX B

INFORMAL SURVEY GUIDELINES

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INFORMAL SURVEY GUIDELINES

Informal survey guidelines are divided into three parts:

1. Initial screening questions for identifying the recommendation domain which the farmer belongs to.
2. Guidelines for developing an understanding of the farming system.
3. Supplementary sets of questions developed during the informal survey for explaining selected topics concerning leverage points, in greater depth.

1. Initial Screening Questions

1.1 Establish area of farm, which people belong to it and whether the titled farm has been subdivided among family members. If the farm has been subdivided, establish whether this is more in name or is actual fact:

a) who is responsible for plowing
b) who is responsible for weeding
c) who controls the output
d) does the subdividee and his dependents live/eat with the owner and his dependents?

1.2 Screening questions to ascertain farmers' income group:

1. House type (observe)
2. Did he obtain land through demarcation or did he purchase it?
3. Own cattle? How many? How many grade cattle?
4. Any family members have off-farm employment? Where? What type?

2. Guidelines for Developing a Understanding of the Farming System

The guidelines used in this section were adopted from Collinson, (1980, 1982) with some minor modifications. The guidelines were divided into six sections:

a) Enterprise pattern, output use and system trends.
b) Enterprise calendar, food preferences and food calendar.
c) Causes of output variation and main production methods.
d) Land, labor and cash availability.
e) Maize and bean husbandry.
f) Livestock husbandry.

3. Supplementary Guidelines for Exploring Selected Topics

Five sets of supplementary guidelines were developed during the course of the informal survey to explore the following topics:

a) Maize variety use in the long rains season.
b) Timing and method of land preparation/planting for maize and beans.
c) Use of oxen for plowing.
d) Sunflower husbandry.
e) Bean cultivar use in the long rains season.

Guidelines for the first two topics are shown below:

3.1 Maize variety use in long rains

1. End uses of maize: sales, consumption, feed.
2. Varieties using this season.
3. Source of seed.
4. Year started using each variety.
5. Varieties tried and stopped using in past years
6. Reasons for stopping.
7. Open question pros and cons of each variety they are familiar with (let farmer develop this section when he has finished, go over the points he has omitted, asking if they are important criteria and how the varieties rate on them).

    a) Yield in a year of sufficient rainfall.
    b) Yield in a year of low rainfall.
    c) Which is better to plant, a variety which yields well in a year of sufficient rainfall or one which yields better in a year of low rainfall?
    d) Profitability. Is return worth extra cost of hybrid seed.
    e) Pests in field, especially weevils.
    f) Dogs, rodents, birds eating corn off stalks.
    g) Storeability without insecticide, with insecticide.
    h) Storage methods, from harvest to consumption or sale.

8. Do you change the variety you are planting when you see the rains are late? When you realize that you must plant late?
9. Does the fertility of your soil affect your decision on which varieties to plant.
10. Is F_2 of H511 the same as Katumani?
11. Is hybrid seed from the field the same as hybrid seed from the packet?
12. Is there a market for green maize? Have you ever sold green maize? Which variety? Why that one?

Several topics were deleted because it quickly became apparent that either (1) they were not important or (2) that there was no significant variation among the alternatives concerning these topics. The topics included:

1. Taste in various dishes
2. Size of cob
3. Seed availability

3.2 Timing and method of land preparation/planting for maize and beans (ask questions for planting together or by crop).

1. His time of planting this season.
2. Best time to plant (i.e., if you have your own plow). Ask for maize and for beans. If responses are different, ask when best time is if you are planting them at the same time.
3. Different times of planting you have tried.
4. Open question comparing advantages and disadvantages of alternative planting times (let farmer discuss, afterwords go over points he has not mentioned, ask, if they are important criteria. Rate different times according to each.

    a. risk of losing seeds to insects
    b. risk of losing crop if rains start and then stop
    c. heavy rain, waterlogging
    d. risk of rains finishing early
    e. risk of losing bean flowers to heavy rainfall
    f. risk of not getting plow
    g. pest problems
    h. yield, if nothing bad happens
    i. At which planting time is the farmer taking the biggest risk, which is the least risky time? Which is safer, dry planting or wet planting? (Safety = least risk of losing a large quantity of your harvest.)
5. Weed problem timing? Quantity?
6. Staggering done? If so, why?
7. Is there a problem of seeds being planted too deeply when dry planted?
8. Problem of seeds being covered by clods of soil when dry planted.
9. Do you own oxen? If no, do you have access to oxen?
10. If you plant late is there a chance of the rain falling before you have completed harvesting?

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