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DESFIL
Development Strategies for Fragile Lands

A NATURAL RESOURCES INFORMATION MANAGEMENT SYSTEM
DESFIL'S CONTRIBUTION
A Discussion Paper

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LIST OF ACRONYMS

ANRU	Agriculture and Natural Resources Unit
API	Assessment of Program Impact report
CPSP	Country Program Strategic Plan
DFA	Development Fund for Africa
EDC	Eros Data Center
EROS	Earth Resources Observation Systems
GOS	Government of Senegal
GIS	Geographic Information System
KAP	Knowledge, Attitudes and Practices survey
M&E	Monitoring and Evaluation systems
NR	Natural Resources
NRM	Natural Resources Management
USAID	United States Agency for International Development
USGS	United States Geological Service

SECTION I
PURPOSE OF REPORT

Abundant information exists about natural resources management (NRM) in Africa, notably through USAID Missions-supported program and project activities. Missions, however, are grappling with poorly organized, yet ever expanding data. Poorly organized data hinder not only the systematic analysis of causal relationships in NRM, but also the timely and accurate reporting of Missions' program and project results, for example, in their assessment of program impacts (API). In addition, poorly organized data invite costly "reinventions of the wheel" on one hand, and under-investigation of key missing information on the other.

Several USAID Bureaus and Missions have recently initiated or are contemplating activities to set up improved NRM data management systems. ARTS/FARA has retained the Development Strategies for Fragile Lands (DESFIL) project to spearhead its effort in designing a NRM relational database structured according to the Africa Bureau's NRM Analytical Framework. A NRM relational database serves both as a repository of information and as an organizing tool for analysis of the cause-and-effect relationships among the variables in the progressive levels of the NRM Framework.

This report uses USAID/Senegal's 1992 Knowledge, Attitudes and Practices (KAP) survey to illustrate the design and use of a NRM relational database. It is a working document that will serve as a discussion paper for a workshop in Washington D.C.. The objective of the workshop will be to present the work accomplished to date by DESFIL on organizing NRM data into a relational database, review the analytical methodology used, and to discuss the analytical results, which develop profiles of users and non-users of NRM practices in Senegal.

A. Purpose

The purpose of this report is for DESFIL to inform AFR/ARTS/FARA and USAID/Senegal on the work accomplished on the following specific points:

- Development of a **NRM relational database** structured according to the Africa Bureau's NRM Analytical Framework.
- Proposed **candidate variables** with standardized definitions and suggested codes, whenever possible.
- Identify and test appropriate **analytical tools** to identify associations and/or other causal relationships between the enabling conditions and the adoption of NRM practices.

- Use these **analytical results** to answer, when possible, key questions raised by Bureaus and Missions implementing NRM programs and projects.

- Suggest appropriate **survey instruments/questionnaires** to collect field data on the candidate variables.

B. Report Format

The report comprises ten sections. Section I presents the purpose of this report. Section II provides the conceptual framework within which this activity is defined. Section III discusses DESFIL's approach to the development of a NRM relational database. Section IV describes the source of data of the NRM database: USAID/Senegal's 1992 Knowledge, Attitudes, and Practices (KAP) dataset. Section V discusses the array of NRM practices used by men- and women-headed households in Senegal. Section VI analyzes certain characteristics which contribute to a profile of men- and women-headed households relative to the use or non-use of NRM practices. Section VII discusses manageable determinates that support or constrain the adoption of practices. Section VIII is an attempt to synthesize the cause-and-effect relationship in a logistic regression model. Section IX proposes a list of candidate variables that would be included in a relational NRM database to discern the causal relationships between the enabling conditions/constraints associated with the use/non-use of those practices. Finally, section X draws conclusions based on this analytical activity.

SECTION II
CONCEPTUAL FRAMEWORK

A. The USAID Africa Bureau's NRM Analytical Framework

To better understand the relationships between program inputs and people-level impacts, USAID's Africa Bureau developed a five-level NRM Analytical Framework to organize intermediate indicators in a hierarchical order. As USAID Missions move from projects to programs, the NRM Framework can be used to reason through the long-term process between program inputs and people-level impacts. This use of the framework has resulted in USAID designing monitoring and evaluation (M&E) systems for their projects according to the five levels of the framework. It was noted that one of the most important products of any program or project is the knowledge gained during its implementation -- especially that knowledge gained from the production of unanticipated impacts, whether negative or positive.

The NRM Analytical Framework is designed to help pick up the lessons learned during implementation. At each level, actual outcomes can be compared to those planned or expected to validate the working premises upon which the program and/or project is built. This use of the framework focusses attention on the lessons learned from the implementation of programs and their projects. Instead of being penalized for falling short of specific targets, Missions should receive credit if they can identify why a target was not gained and can add to USAID's collective knowledge about the process of achieving the Development Fund for Africa's (DFA) goal of broad-based and sustainable economic growth.

B. NRM Issues, Questions and Applications

Across most regions, Missions implementing NRM programs and projects are confronted with a common set of crucial issues.

- What NRM practices are used or not used by men and women, where, and why or why not according to these men and women?
- What are the impacts of adoption of these NRM practices, in terms of reducing environmental degradation, increasing the productivity of renewable natural resources, and improving peoples' welfare?
- What are the current policy and other enabling conditions related to the adoption/non adoption of these NRM practices, in terms of the relative importance of various factors which influence land use and resource management decisions at the local level?

- What further policy changes are needed and what other enabling conditions might be established in order to promote more sustainable NRM and land-use practices?

The following seven analytical questions address the different levels of the NRM Analytical Framework. Answers to these questions have practical applications for Missions' NRM programs and projects.

Land-use management practices (Level III)

Question 1. For each agroecological zone, what is the inventory of land-use management practices currently being used at the community and household level? (Locations of observations should be geo-referenced and displayed on a map.)

Answers to this question have the following practical applications:

(a) Establish and update a baseline inventory of NRM practices used by men and women which address specific biophysical problems, such as soil degradation, declining soil fertility, vegetation loss, insufficient forage production, etc.

(b) Identify "best practices," according to users themselves, as well as most innovative farmers.

(c) Produce a map of where various practices have been adapted/adopted in order to facilitate farmer-to-farmer visits.

(d) Produce a map of practices to provide a spatial distribution of practices in order to help identify location-specific as well as common characteristics of users/non users associated with the adoption/non adoption of various NRM practices.

Impacts on the NR base (Level IV)

Question 2. For each practice or set of practices, what are the impacts on the rates of degradation of soil, vegetation, wildlife, and water? (It is best to collect both qualitative and quantitative data.)

Answers to this question have the following practical applications:

(a) Determine which practices are likely to be sustainable. Increases in production cannot be sustained if accompanied by substantial increases in degradation rates.

(b) Provide information about rates of degradation to help users figure out the

prospects for various practices to be sustained.

Impacts on productivity/welfare (Level V)

Question 3. For each practice or set of practices: (a) how do expected yields compare to actual yields, and (b) how do yields using the practice(s) compare with yields of non-users? Do increased yields justify (eventual) additional costs associated with the use of the practice(s)? For each agroecological zone, what is the area that could be expected to hold the practice(s)?

Answers to these questions have the following practical applications:

(a) Yield data from "best practices" compared to "current practices" provide an empirically-based estimate of the potential production increases for each agroecological zone.

(b) Data permit cost/benefit analysis to identify and measure the importance of incentives for adopting the practice(s). This is important to address the concern that the potential for increases in productivity in Senegal are so limited that the prospects for returns on development investments are extremely poor.

(c) Answers to these question and others help governments and development agencies identify those practices that are most promising.

Enabling conditions (Level II)

Question 4 What are the enabling conditions associated with the adoption of those practices?

Answers to this question have the following practical applications:

(a) Governments and development agency programs aim at establishing policies and institutions that provide incentives for men and women farmers, herders, and woodcutters to adopt practices that increase productivity and decrease degradation rates. Analysis that helps identify the distinguishing characteristics of adopters/non adopters of various practices help policy decision makers focus on those factors that make a difference in the broad-based adoption of appropriate practices.

(b) For the Mission's API, this analysis will validate (or lead to modification of) the policies and institutional reforms being supported.

Programmatic Options (Level I)

Question 5. For each enabling condition identified in question four, what are the programmatic options for establishing the conditions? What are the estimated costs to the GOS of establishing the conditions using various program options? (What are the implications of doing nothing?)

Answers to these questions have the following practical applications:

(a) Identify array of programmatic options and provide costs for each. For each enabling condition, there are a number of possible programmatic actions, for example, to increase the level of awareness of rural communities concerning the benefits of using improved land-use management practices; , a program would develop and implement an extensive media campaign to advertize project concepts and catalyze community interest.

Question 6. So what? If, in each agroecological zone, the improved practices become widely adopted, what will be the increases in production and decreases in rates of degradation?

Answers to this question have the following practical application:

(a) Determine the potential "ceiling" on production that could be achieved compared to the current levels of production.

Question 7. Using data from questions two and five, what are the costs and benefits of diffusing various practices? Answer to this question has the following practical application:

(a) If the production potential is substantially higher than the current levels, costs of establishing the enabling conditions about the benefits of wide-spread adoption would provide valuable information to decision-makers.

C. A NRM Relational Database

The NRM database structured according to the NRM Analytical Framework is **multi-dimensional,** as it includes data on biophysical and socioeconomic variables. The NRM database is a **relational database** that facilitates data manipulation and analysis. To establish a relational database, at least one key variable should be common to two files. The greater the number of files that share one common variable, the easier the manipulation of files and analysis of data. Examples of common variables include village locator ID number, household ID number, and practice ID code number. Linking files by practice is necessary to avoid ambiguity in the cause-and-effect relationships. Finally, the NRM database is **dynamic**. Inputting data into the NRM database over time on a yearly basis reflects the

dynamics of users' adoption of NRM practices, and will help monitoring and evaluation of programs and/or projects over time.

In addition to the analytical uses of the relational database discussed above, there are several types of performance indicators that would help USAID Missions track progress. One is the changes in the field attributable to the Mission's program; the other is increased knowledge about critical causal relationships. The measures of the first are easier to quantify while the measures of the second may require qualitative descriptions.

1. Monitoring People-Level Impact

Tracking the direct impacts of a program on people and the land is the first type of monitoring. These would include the following:

a. How broadly spread is the adoption of appropriate land-use management practices? Counted in terms of number of farms, farmers (women and men), hectares, etc., this measure is probably the best proxy for people-level impacts.

b. On lands where the above practices have been adopted, what are the changes in yields compared with (i) yields on the same land in previous years and/or (ii) yields on adjacent lands where practices have not been adopted?

c. On lands where the above practices have been adopted, what are the changes in land degradation rates?

d. What are the changes in the enabling conditions? (e.g., peoples' perceptions about tenure security, local authority, and risk; peoples' access to capital and markets; increases in knowledge; relative reduction in labor requirements)

e. What are the changes in programmatic outputs that establish the enabling conditions? (e.g., policies and institutional changes; people acquiring enterprise management skills; farmers observe and interact with model peers; technologies refined and tested in agroecological zones)

2. Assessing Progress in Gaining Knowledge About Causal Relationships

Many programs are designed with the purpose of gaining greater knowledge about causal relationships in the process that links program inputs with broad-based impacts. These programs support the development and testing of hypotheses about these relationships. They also support the development and refinement of tools to compare expected with actural outcomes. The products of such a system include both the validation of hypotheses and the production of unexpected outcomes that allow decision makers at all levels (farmers, governments, private sectors, and donors) to make more effective use of limited resources.

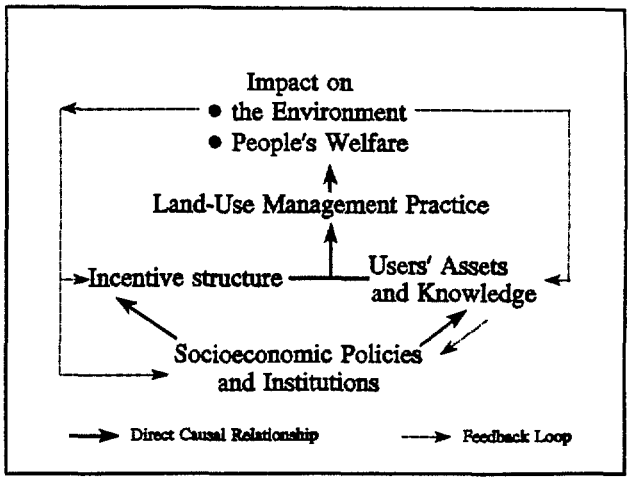
The importance of gaining knowledge about causal relationships is becoming better appreciated as Missions move from focusing on projects to programs that develop long-term strategic objectives.

a. Projects, on the one hand, have objectives that are confined in space and time, in a particular area, so many people will be assisted through project interventions in a very specific way over so many years. There is little concern about how this happens nor is there much conscious effort to use projects to leverage change on a broad scale. The indicators are quantitative: so many households or farms assisted in a particular way.

b. Programs, on the other hand, aim to have broad-based impacts and usually have policy components. Project activities at the village level are used to empirically test assumptions about the determinants of land-use management decisions. The findings inform the decisions of national-level policy makers as well as donors. The indicators are more qualitative: policies tested; assumptions validated or modified; and policies changed.

SECTION III
DESFIL's NRM DATABASE DEVELOPMENT PROCESS

A. Literature Review



An extensive review of the development literature was conducted by DESFIL to determine the extent of information available on the adoption of NRM practices in Sub-Saharan Africa (SSA). One study (Ouedraogo, 1993) was an initial effort to conduct a natural resources policy inventory through a review of the literature limited to five Francophone countries in SSA. It was intended to be the first step in developing the natural resources policy component of DESFIL's taxonomy and analysis framework for SSA. The inventories describe biophysical, socioeconomic, policy, and cultural conditions, which determine the benefits and costs of NRM practices and whether they are likely to be adopted over wide areas. This review identified issues that relate directly to interactions between policy and natural resources management in SSA.

A second study (Fiebig, 1993) discusses interactions between factors or conditions that influence land-use management decisions and the use of NRM practices which are conducive to sustainable agricultural development in SSA. Issues to consider when promoting sustainable agriculture and NRM are identified and certain incentives that contribute to improved resource user participation in the sustainable management of natural resources of fragile lands in SSA are discussed. A technological and socioeconomic framework is proposed which could lead to the design of appropriate strategies for African resource users to sustainably manage their natural resource base through improved agricultural management systems.

Based on the results of the above studies and the personal experiences of DESFIL team members, a concept paper (Ouedraogo and Fiebig, 1993) was developed on the use of the Africa Bureau's NRM Analytical Framework to structure a relational database. The objective of the relational database is to assist USAID Field Missions in organizing and analyzing NRM field data to monitor and evaluate impacts from program and project interventions. The concept paper discusses DESFIL' approach (see following point B), analytical tools and data collection, structural aspects of the relational database, and progress and impact indicators.

B. DESFIL'S Approach to the Use of the NRM Analytical Framework

DESFIL applies the NRM Analytical Framework in its research agenda to provide USAID Missions with clear indicators to monitor and evaluate their NRM programs and projects. DESFIL uses the interactive and iterative nature of this framework in a logical and effective way to fulfil its mandate: to promote the effective participation of local resource users -- men and women -- in the sustainable management of fragile lands. Figure 1 is a schematic representation of the relationships among enabling conditions, incentives, indigenous knowledge, the adoption of practices, and the impact of these practices on the environment and users' welfare.

- **Identification and Characterization of Practices**

DESFIL's analytical point of entry into the NRM Analytical Framework is Level III, the identification of practices currently adopted by natural resource users[1]. The natural resource management practices are identified and characterized within agroecological zones or *terroirs* that are perceived to face problems associated with fragile lands, because DESFIL's mandate concerns fragile lands. This characterization accounts for two important considerations: (i) who uses NRM practices and (ii) where are NRM practices being used.

Within a *terroir*, there may be a large variety of resource users whose purposes of using practices are different and who respond differently to incentives. To capture this heterogeneity, DESFIL categorizes practices according to users' profiles, such as:

- Gender;
- Assets or household resources (land, labor, capital, and knowledge); and
- Sociopolitical status.

A NRM practice, which may be a technical component or a technological package, can be used in different activities that produce different goods and services. For example, a practice may be used to produce traditional food crops, such as cereals or legumes, or non-traditional exports, fruits and vegetables. A practice such as brushfire may be used in range management and possibly in ecotourism to clear tourists' view of wildlife. Therefore, in categorizing NRM practices, it is important first of all to identify the major activities in which practices are used to produce goods and services. Identifying these activities is critical for the later steps of our analysis at levels IV, V, and II of the NRM Analytical Framework.

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[1] An "Inventory of Practices" has been developed by W. Fiebig, DESFIL's Technology Program Coordinator.

- **Analysis of Impact of Practices on Natural Resource Base**

The second step is to analyze the impact of practices on the natural resource base (level IV). Do these practices "maintain or improve the productive capacity of soil, forest, range, water resources, and habitat?" Or do these practices contribute to the degradation of natural resources? A NRM practice can be hypothesized to have a direct, cumulative, impact on the natural resource base. What are the causal relationships? An attempt is made at this stage to diagnose or determine the short-, medium-, and long-term impact of the continued use of these practices on the natural resource base. Whether this impact of practices on the natural resource base is intended or unintended by users is further examined, at a later stage, in the analysis of the incentive structure.

- **Analysis of Impact of Practices on Users' Welfare and the Environment**

The third step is to determine the impact of NRM practices on the socioeconomic activities in which users are engaged. Do these practices contribute to "sustainable increases in yields, [and users' welfare] and the maintenance of biological diversity" (level V). The practices affect users' welfare through the market and social costs and benefits of the goods and services these practices contribute to produce. At this stage, therefore, it is critical to have clearly identified the (major) activities which require the use of practices and the goods and services produced in this process. Clearly, the impact on farm income from the use of compost is different depending on whether compost is used to grow low-priced cereals or non-traditional export-oriented fruits and vegetables. Focusing on the specific major outputs from the use of practices contributes to the development of unambiguous indicators for monitoring and evaluation of NRM programs and projects.

- **Analysis of Users' Incentive Structures Reinforcing Adoption of Practices**

The fourth step is to analyze the incentives that, together with the characteristics of users, determine the choice of practices by natural resource users. The incentive structure is hypothesized to shape and reinforce the behavior of natural resources users, particularly through its effect on both the cost of the practice and the price of the output that this practice produces. Therefore, it is crucial that one clearly identifies the (major) activities that require the use of practices and the goods and services produced in this process. The incentive structure can be viewed as a subset of the "enabling conditions for diffusion of appropriate practices" (level II)[2]. This incentive structure is a complex set of economic, institutional, and other sociological elements:

(i) The economic incentives include expected costs and benefits and perceived

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[2] Erdmann (1992) also categorizes "price/market structures" at level II. Land users' incentives include many factors other than economic, such as socio-political factors, including the community's norms and beliefs.

risks of using NRM practices to generate goods and services;

(ii) The institutional incentives include property rights (land tenure, tree tenure), and local governance; and

(iii) Other sociological incentives include the indigenous community's norms and beliefs that punish and reward members for engaging in certain NRM practices (for example, protection of *bois sacré*).

The profiles of users (gender, assets endowment, managerial capability, level of information, and social/political status), and the incentive structure determine the extent to which the unintended effects of practices are:

- Externalities, for which users feel no accountability;
- "Social traps " or vicious circles, of which users are aware but against which they lack viable alternatives; or
- Cases of users' ignorance of the cause-and-effect relationships.

- **Analysis of Policies Affecting Users' Incentive Structure**

The fifth step is to analyze what and how policy measures support the structure of incentives and reinforce the access of users to resources and knowledge identified previously. This step is also part of Level II of the NRM Analytical Framework. The analysis establishes how policies affect incentives, and in particular, what would be the likely incentive structures if constraining policies (distortions) are removed or enabling conditions introduced. These policies must also reconcile private (individual users or community) incentive with overall societal economic benefit and conservation of the environment. The categorization of enabling and constraining policy conditions will contribute to DESFIL' s taxonomy. Two broad categories of public policies can be distinguished: (a) economic and (b) institutional policies. Together, these policies affect, positively or negatively, the community's norms and beliefs, and thus the incentives they embody.

- **Economic Policies**

Three levels of economic policies affecting NRM practices may be further distinguished:

(i) Macro, or economy-wide level, such as exchange rate, fiscal and trade policies. Such policies, for example, the World Bank/IMF Structural Adjustment Programs, which are often instituted without regard to the environment, may actually negatively affect land users' incentives. For example, foreign exchange policies strongly affect the protection or taxation

facing products, encouraging or discouraging the use of NRM practices to produce these products.

(ii) Sectoral level, such as in pricing of inputs and outputs in crop and livestock production. These policies are often viewed as the most critical to explaining land users' behavior. However, this should be verified through empirical investigations.

(iii) Natural resource-specific policies, such as in pricing of forest products, pricing of ecotourism, and sharing of costs and revenues of reserve management. Although these policies may be considered as part of broad agricultural sector policies, they deserve a particular emphasis. They reflect a conscious effort on the part of government to promote better NRM practices, or to come to grips with the balancing of competing objectives, often involving economic growth and environment conservation.

- **Institutional Policies**

An analysis of the institutional framework is also crucial because institutions establish the "rules of the game" under which markets operate. Changing these rules will alter the incentive structure. For example, changing land tenure regimes may affect land value and output prices; changing the institutional boundaries of rule-enforcing agencies will change transaction costs faced by natural resource users. Enforced new rules of local governance and community participation are important variables affecting land users' behavior.

- **Analysis of Programmatic Actions Establishing Enabling Conditions**

The sixth step is to identify the "programmatic actions that establish the enabling conditions," which are the economic and institutional policies would be analyzed in step five. This is level I of the NRM Analytical Framework.

SECTION IV
DATA SOURCE: USAID/SENEGAL 1992 KAP Survey

Field missions would benefit from the use of a relational NRM database to answer their NRM-related questions. This report illustrates this application by using real data from the 1992 USAID/Senegal KAP survey.

A. NRM Data Sources

Field Missions have several data sources relative to natural resource management issues. For example, landsat and other satellite imagery, aerial photography, and videography provide many Missions with data on changes in the biophysical landscape. Also projects supported by Missions generate a tremendous amount of technical and socioeconomic field data from project monitoring and evaluation (M&E) systems. These sources, especially M&E system and special purpose surveys are data sources for a NRM relational database.

USAID/Senegal has established a process to monitor and evaluate the impact of its development strategy for Senegal, which is defined in the Mission's Country Program Strategy Plan (CPSP). The Mission's M&E system has two components:

- Information from specific project and/or program interventions, usually executed and analyzed by project and GOS staff. These kinds of analyses will be provided by impact monitoring systems, which are (or are being) included in each project or program financed by USAID/Senegal. These systems are expected to provide the detailed socioeconomic analyses relevant to specific interventions.

- The second component of the M&E system is based on information from baseline surveys with a more comprehensive geographic and/or sectorial focus. In this light, the Mission has planned yearly Knowledge, Attitudes and Practices (KAP) surveys. The primary reporting mechanism will be reports such as the USAID/ANRO KAP Survey Report (Kite et al., 1993) and the Annual Program Impact (API) Report.

B. Knowledge, Attitude, and Practice (KAP) Survey

The 1992 KAP survey from the ANRO M&E system is a baseline survey, which was conducted throughout the Mission's zone of intervention. The survey was conducted on a statistically valid, stratified random sample of 1531 households in Central and Southern Senegal. Enumerators interviewed the head of household, with other members of the household present. They administered 64 questions, which after data transformation led to some 800 variables in a huge (over 8 megabytes), flat database.

As would be expected with any source of data, the 1992 KAP data has advantages and disadvantages. One key advantage of the survey is the randomness of the sample. Survey results are representative of the area investigated. Another advantage is the wealth of information collected on issues related to NRM. The disadvantages, however, are also important. The 1992 KAP survey was a baseline survey, rather than a specifically designed NRM survey. Therefore, in an attempt to keep the survey manageable, the survey omitted many questions specific to NRM. Another disadvantage is that most variables are ordinal/nominal (e.g., yes/no) rather than ratio/interval variables (i.e., with continuous measurement). This limits the range of analytical tools one can use to analyze the data.

The advantages, however, far outweigh the disadvantages. The bottom line is that the KAP data, and any other similar dataset, represents readily available information relevant to NRM that should not be bypassed while waiting for a better dataset. To the extent possible, it can be used to shed light on as many NRM questions as possible. Analysis of such a dataset helps a Mission better design future data collection and develop appropriate analytical tools to discern cause-and-effect relationships among variables associated with adoption of NRM practices and their impacts.

The 1992 KAP Survey Report (Kite et al., 1993) offers an excellent profile of the characteristics of the rural population in the regions sampled. This paper provides further analysis, focusing on the profiles of households having knowledge of NRM practices and reporting using them or not.

C. Transforming the KAP data set to a NRM database

Rod Kite (1993) wrote an easy-to-use program intended for basic statistical and graphical analysis of the 1992 KAP data set. For additional analysis, Kite envisioned the extraction of data from the large flat file into files exportable to other software programs. A recent companion program written by Kite (1994) extracts variables in ASCII delimited (PRN) format that all spreadsheet programs can import. The steps for transforming the KAP dataset flat file into to NRM database files for additional analysis are as follows:

- **Categorize KAP variables according to a NRM database framework.** Based on their definitions, KAP variables were regrouped in NRM database files, as discussed above. The KAP dataset is extremely rich in some key areas and not as rich in others. For example, there is a wealth of information about practices, but much less information about the degradation/conservation of the resource base and policy conditions and programmatic actions that can explain users' decisionmaking linked to the use/non-use of NRM practices.

- **Extract KAP1 variable.** Using Rod Kite's extract program, variables (a maximum of 20 at a time) were extracted from the KAP flat file into ASCII delimited (PRN) files.

- **Create DBF files.** Using a spreadsheet program, these ASCII delimited files were retrieved (imported) and then saved as database (DBF) files. These DBF files make up the NRM relational database.

- **Establish Relational Database.** All these DBF files have a common variable or field, in this case, the identification number of the household interviewed. Because of this, the database is relational; files can be linked to one another using this unique household identification number.

- **Manage and Analyze Database Using a Database Management Software.** Using a database management program such as Paradox or FoxPro, different files can be linked and some variables (fields) dropped to create specific working files, for example, revolving around compost. From the database software program, different queries can be run, simple statistical analysis performed, and report tables produced, including graphics.

- **Conduct Additional Sytatistical Analysis Using Other Software Programs.** Further manipulation and statistical analysis can be performed and more graphs produced using other programs, such as Statistica or SPSS/PC+.

D. Approach in Analyzing NRM Database

Kite, Keita, and Thiam (1993) have reported results of the 1992 KAP survey, establishing key elements for baseline data. They analyzed characteristics of the rural population by gender; primary activities of household family members; resources controlled and used by rural households; natural resource management; marketed and marketing with revenues and expenditures. The KAP data is rich and its random nature allows valid and interesting statistical manipulation. Additional analyses can take advantage of the richness and random nature of the KAP data to answer the basic five NRM questions discussed in section II. In the next chapters such additional analyses are conducted to answer these questions and suggest candidate variables to design a NRM database information system. Three steps can be distinguished in the analytical process.

(i) The first step is a descriptive analysis of the village profiles and practices identified by KAP survey.

(ii) The second step may be viewed as a weeding process, in which the set of 800 variables in the KAP set is reduced to a manageable number, and potentially instrumental variables are identified for further analysis. A combination of analytical methods, descriptive as well as regression analysis are used in this step.

(iii) The third step attempts to determine the strength of the relationship among variables to suggest candidate variables for a NRM database development. It

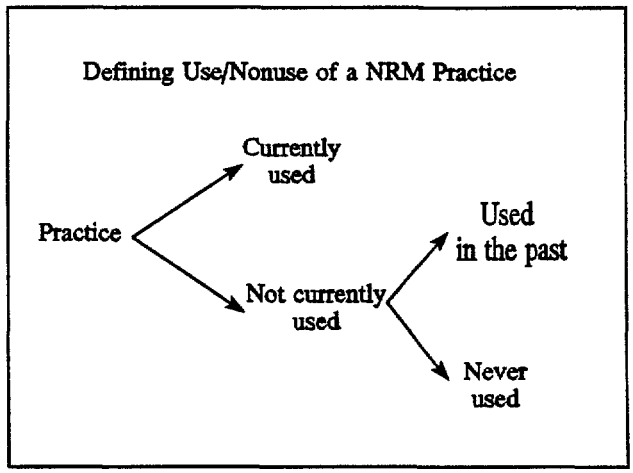
is based on logistic regression to determine the likelihood of the use of practices depending on explanatory variables identified in the previous steps.

SECTION V
ARRAY OF NRM PRACTICES IN SENEGAL

A basic first question of any NRM program is: What is the array of NRM practices being used (in an area of concern)?. A NRM database should provide answers to this and other related questions, such as *where are practices being adopted?* Before addressing these questions, however, there is need for an unabiguous definition of a user and a nonuser of a practice.

A. Definition of a User/Nonuser of a NRM Practice

Who is a user or nonuser of a NRM practice is a simple question only on the surface. The 1992 KAP survey asked about the last time households used a NRM practice. Quite a few households have never used several of the practices identified. For those who had, responses ranged from 1962 to 1992, the survey year. Based on these responses, households may be divided in two categories as users and nonusers. There are different ways of defining a user/nonuser (See box)[3].



Depending on the purpose on hand, the definition of user/nonuser may be more or less restrictive. For practices that imply a short-term investment, such as composting and fertilizer use, restrictive definitions seem appropriate. A user can be defined as one currently using the practice. A nonuser, on the other hand, would be either as one not currently using or one that has never used it. For practices that imply a longer-term investment, such as dam building or tree planting, a less restrictive definition of user may be acceptable. For example, a user could be defined as one that is either currently using the practice or has used it in the (recent) past. There may not be need to plant field trees every year, so that households that have planted field trees in 1992 but did so in recent past (1990 or 1991) may still be considered "users" of this practice. Here, "using field trees" can be interpreted not only as planting, but also including care and maintenance of the trees. Note that 1992 KAP survey did not ask how long households have used the practice. Therefore, it is not known whether those households who have used a

[3] There are other possible definitions of users and nonusers (see appendix ...).

practice(s) were long-time or first-time users.

The box above also shows that this seemingly simple user/nonuser dichotomy may actually mask valuable information. Some households have used a practice in the past, but chose not to, or could not do so presently. Past users of short-term investment practices may be viewed as "quitters." There are households that used a practice then "abandoned" it. An important issue in this survey is the lack of data to explain why they quit using the practice. This identifies a critical variable(s) needed in the relational database to be able to answer the question: *why are past users no longer using NRM practices?*

As a way of standardization, this analysis will be based on the following definitions: we define a user of a NRM practice as that household currently using the practice(s) in 1992. A nonuser is defined as a household that has never used it or is no longer using the NRM practice(s).

B. Typology of NRM Practices

The array of NRM practices identified by the 1992 KAP survey in central and southern Senegal covers 19 NRM practices (Table 1). One may choose to analyze practices individually or grouped according to an appropriate typology. USAID/Senegal, for example, has adopted a commonly-used typology which groups practices as agroforestry, soil and water conservation, and soil fertility enhancement practices[4].

One definition of an agroforestry practice is when farmers use live tree or bush materiel to achieve various purposes on any unit of land area under cultivation of food and/or cash crops. A soil and water conservation practice is one that emphasizes a physical alteration of the natural resource base for the purpose of reducing soil erosion and/or water loss, most commonly using mechanical means (except for grass strips). A soil fertility enhancement practice is one that uses chemical or organic materiel to increase soil fertility.

The classes of this typology are not necessarily mutually exclusive, especially when one accounts for the time factor (short-, medium-, and long-term impacts). In the medium- to long-run, many agroforestry or soil & water conservation practices can contribute to soil fertility enhancement. Likewise, a soil fertility enhancement practice, such as composting, by building a more cohesive soil structure will eventually reduce wind and water erosion, improve soil moisture holding capacity, and improve cation exchange capacities of these soils to improve soil fertility.

The reasons reported by the men- and women-headed households for using or not using the practices are well documented in the KAP survey report (Kite et al., 1993).

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[4] There exists other alternative typologies (for example, involving the use of air, coastal and marine resources), but this appears appropriate for the Mission's concern.

Table 1. Short-, medium- and long-term use of NRM practices in Senegal.

TYPOLOGY	Targeted Biophysical Constraint	TIME HORIZONS		
		SHORT-TERM (< 3 yrs.)	MEDIUM-TERM (3-7 yrs.)	LONG-TERM (> 7 yrs.)
AGROFORESTRY PRACTICES	Deforestation Fodder/Fuelwood Soil/Wind Erosion	Windbreaks Live fences	Windbreaks Live fences Alley cropping Field trees Orchards	Windbreaks Live fences Alley cropping Field trees Orchards
SOIL and WATER CONSERVATION PRACTICES	Soil/Wind Erosion Drought Salinization	Contour dikes Tied ridges Diversion structures Check dams Fall plowing Grass strips	Anti-salt dams Contour dikes Diversion structures Check dams Grass strips	Anti-salt dams Contour dikes Diversion structures Check dams
SOIL FERTILITY ENHANCEMENT PRACTICES	Declining soil fertility Poor soil structure	Manure/parquage Compost Fertilizer Chemical pesticides Improved seeds	Crop rotation Fallow Manure/parquage Compost	Crop rotation Fallow

An important aspect relative to the adoption of NRM practices is the time frame in which the anticipated benefits will occur. It is extremely difficult for limited resource farmers to invest time and resources into the use of practices that may not have short-term payoffs or introduce a risk factor over the long-term. Understanding the time frame question may be of critical importance to NRM planners and decision makers.

As will be seen in the following discussion on the use of NRM practices, there is a significant difference between the number of households using the three types of practices (Table 2). Soil fertility enhancement practices are, by far, the most widely adopted. Some of the reasons for these land-use management decisions can be identified by an analysis of the farming household characteristics, their assets, primary activities, access to technical assistance (information), markets, credit, etc. These factors will be explored in the following sections.

It must be remembered that the 1992 KAP survey was conducted in USAID/Senegal's zone of intervention which includes the southern half of Senegal where rainfall exceeds 450 mm of rainfall during the growing season. The fact that most farming households own animals which provide manure for direct applications or compost production most likely

explains reasons for their strategies resulting in using practices which address their most pressing crop production problem - declining soil fertility, which results in decreasing crop yields under continuous cropping of their land areas. Fallow is a declining practice due to demographic pressures. Therefore, the integration of animal and crop production systems provide rural households the means to develop strategies, given their limited resources, to adopt soil fertility enhancement practices to meet their immediate needs.

Agroforestry practices are the least used, followed by soil and water conservation practices (Table 2). Access to land and land tenure security are candidate variables which would most likely explain this observation. Soil fertility enhancement practices, on the other hand, are used by significantly more men- and women-headed households.

Table 2. Distribution of non-users and users of types of NRM practices disaggregated by gender.

TYPOLOGY	NON-USER		USER	
	FEMALE	MALE	FEMALE	MALE
AGROFORESTRY PRACTICES *	98 (96)	1267 (89)	4 (4)	162 (11)
SOIL & WATER CONSERVATION PRACTICES NS	85 (83)	1249 (87)	17 (17)	180 (13)
SOIL FERTILITY ENHANCEMENT PRACTICES *	59 (58)	474 (33)	43 (42)	955 (67)

Note: Columns are numbers of households reporting use/nonuse of practices, with percent of total households surveyed are in parentheses.
* = Significant at $p<.01$ NS = Not significantly different

The significant differences in the use of NRM practices by men- and women-headed households and what factors are associated with those diffences are the focus of the following analyses. Regional differences in the use of practices are also examined. The variables representing data on the factors which appear associated with the land-use management decisions will be discussed.

C. Location of Practices Used

A NRM database should one to answer the question of not only: *What is the inventory of practices being used*, but also *where specifically are the practices being used*? The practical application of this answer is to develop a map of NRM practices over time to help decision-makers, for example, to know where adoption is occuring, develop plans for farmer-to-farmer visits. The next three tables present data on the use of each type of NRM practices by region. Data on past-users is included to show rates of abandonment by region. Differences are highly significant ($p < .001$) between regions relative to the use of each type of practice.

[Insert map of practices if available]

Table 3. Typology of non-users, past-users and users of agroforestry (AF) practices by region.

AGROFORESTRY PRACTICES (AF)	NON-USER	PAST-USER	USER
Ziguinchor	106 (69)	25 (16)	23 (15)
Tambacounda	219 (82)	36 (14)	12 (4)
Kaolack	328 (70)	57 (12)	80 (17)
Fatick	244 (74)	50 (15)	36 (11)
Kolda	259 (82)	41 (13)	15 (5)

Note Columns are numbers of households reporting never having used the practice, having used it previously, or were currently using the practice in 1992 (percent of all households surveyed are in parentheses).

Table 3 raises questions of why agroforestry practices have lower rates of adoption in the regions of Tambacounda and Kolda than the other three regions. This analysis would suggest data being collected in the other three regions to better understand the reasons for adoption.

The low rate of use of AF practices also highlights the importance of asking past- or non-users what the constraints are. Data on these variables are extremely important to identify programmatic options to establish enabling conditions.

Table 4. Typology of non-users, past-users and users of soil and water conservation (SWC) practices by region.

SOIL and WATER CONSERVATION PRACTICES (SWC)	NON-USER	PAST_USER	USER
Ziguinchor	114 (74)	2 (1)	38 (25)
Tambacounda	249 (93)	18 (7)	0
Kaolack	346 (74)	21 (5)	98 (21)
Fatick	251 (76)	24 (7)	55 (17)
Kolda	286 (91)	24 (7)	5 (2)

Note. Columns are numbers of households reporting never having used the practice, having used it previously, or were currently using the practice in 1992 (percent of all households surveyed are in parentheses).

Table 4 raises questions of why soil & water conservation practices, similar to agroforestry practices, have lower rates of adoption in the regions of Tambacounda and Kolda than the other three regions. This analysis would suggest data being collected in the other three regions to better understand the reasons for adoption.

Here again, although the rates of abandonment SWC are approximately half of AF practices, reasons for not using SWC practices need to be well understood.

Table 5. Typology of non-users, past-users and users of soil fertility enhancement (SFE) practices by region.

SOIL FERTILITY ENHANCEMENT PRACTICES (SFE)	NON-USER	PAST_USER	USER
Ziguinchor	29 (19)	36 (23)	89 (58)
Tambacounda	49 (18)	120 (45)	98 (37)
Kaolack	21 (4)	50 (11)	394 (85)
Fatick	28 (9)	50 (15)	252 (76)
Kolda	25 (8)	125 (40)	165 (52)

Note. Columns are numbers of households reporting never having used the practice, having used it previously, or were currently using the practice in 1992 (percent of all households surveyed are in parentheses).

Table 5 raises questions of why soil fertility enhancement practices have higher rates of adoption in all regions relative to the other two types of practices. Crops on which these practices are being used would also allow one to determine if they are used on cash crops which would offer an economic incentive for using SFE practices.

It would be interesting to know why the rates of abandonment of SFE practices are so high in Tambacounda and Kolda relative to the other three regions. It would also be good to know factors have contributed to the high rates of adoption in the Kaolack and Fatick regions.

D. Gender analysis of the use of practices

The relational database should be set up to answer a question that readily comes to mind when identifying the array of practices being used in a project area: *Are there any significant differences between men's and women's uses/nonuses of the practices?* A disaggregation of data by sex is a basic tool of gender analysis. Table 6 shows the results of a crosstabulation analysis of the use of NRM practices disaggregated by gender and type of users.

Table 6. Typology of NRM practices.

TYPOLOGY	NRM PRACTICES	NON-USER		USER	
		FEMALE	MALE	FEMALE	MALE
AGROFORESTRY PRACTICES	Field trees	102 (100)	1392 (97)	0	37 (3)
	Windbreaks	101 (99)	1361 (95)	1 (1)	68 (5)
	Orchards	99 (97)	1390 (97)	3 (3)	39 (3)
	Live fences	102 (100)	1387 (97)	0	42 (3)
	Alley cropping	102 (100)	1409 (99)	0	20 (1)
SOIL and WATER CONSERVATION PRACTICES	Fall plowing	92 (90)	1284 (90)	10 (10)	145 (10)
	Grass strips	102 (100)	1429 (100)	0	0
	Check dams	102 (100)	1429 (100)	0	0
	Diversion	101 (99)	1418 (99)	1 (1)	11 (1)
	structures	95 (93)	1403 (98)	7 (7)	26 (2)
	Contour dikes	97 (95)	1403 (98)	5 (5)	26 (2)
	Tied ridges	102 (100)	1429 (100)	0	0
	Anti-salt dams				
SOIL FERTILITY ENHANCEMENT PRACTICES	Manure/parquage	67 (66)	673 (47)	35 (34)	756 (53)
	Fallow	95 (93)	1202 (84)	7 (7)	227 (16)
	Compost	92 (90)	1251 (88)	10 (10)	178 (12)
	Crop rotation	80 (80)	799 (56)	21 (20)	630 (44)
	Fertilizer	91 (89)	1056 (74)	11 (11)	373 (26)
	Chemical	86 (84)	1002 (70)	16 (16)	427 (30)
	pesticides	96 (94)	1222 (86)	6 (6)	207 (14)
	Improved seeds				

Note. Columns are numbers of households reporting never having used the practice, having used it previously, or were currently using the practice in 1992 (percent of total households surveyed are in parentheses).

When data has been collected randomly as in the case of the 1992 KAP survey, a cross-tabulation analysis with chi-square statistics allows one to determine if there any

significant difference between men's and women's uses/nonuses of the practices (Table 7).

Table 7. Gender disaggregated data on the use of NRM practices during the 1992 growing season by female- and male-headed households in Senegal.

Practice	Female-headed	Male-headed	Chi-square
Grass strips	0 (0)	1 (.1)	NS
Check dams	0 (0)	3 (.2)	NS
Anti-salt dams	0 (0)	3 (.2)	NS
Alley cropping	0 (0)	20 (2)	NS
Live fences	0 (0)	42 (3)	S**
Diversion structures	1 (1)	11 (1)	NS
Field trees	0 (0)	37 (3)	S*
Windbreaks	1 (1)	68 (5)	NS
Tied ridges	5 (5)	26 (2)	S*
Orchards	3 (3)	39 (3)	NS
Contour dikes	7 (7)	26 (2)	S***
Improved seed	6 (6)	207 (14)	S***
Fall plowing	10 (10)	145 (10)	NS
Fallow	7 (7)	227 (16)	S***
Compost	10 (10)	178 (13)	NS
Fertilizer	11 (11)	373 (26)	S***
Chemicals	16 (16)	427 (30)	S***
Crop rotation	21 (21)	630 (44)	S***
Parquage/manure	35 (34)	756 (53)	S***

Note: Columns are numbers of households reporting having used the practice(s) in 1992 (percent of all households surveys are in parentheses).

Level of significance: NS = Not significant S* = $p < .10$ S** = $p < .05$ S*** = $p < .01$

The top group of practices, even though showing some significant differences between female- and male-headed households, will not be included in this analysis. The number of

households reporting having used the practices have an expected frequency of five or less female-headed households and could lead to certain spurious conclusions.

This table shows that there are significant differences between female- and male-headed households relative to the use of NRM practices. The following sections will consist of an analysis of households using soil fertility enhancement practices, given the low rates of adoption of AF and SWC practices

The analysis of the 1992 KAP data will focus on a number of candidate variables that will enable a discussion of the characteristics of the user/non-user households and lead us to identify certain enabling conditions and/or constraints associated with the adoption/non-adoption of NRM practices.

SECTION VI
PROFILES OF USERS AND NONUSERS BY GENDER

What are the profiles of men and women users/nonusers of NRM practices? Developing the profiles of women and men users and nonusers should help analysts increase their understanding of, and suggest working hypotheses about, the adoption of NRM practices. In previous sections, we saw significant differences in the use of practices by men and women. What characteristics explain these differences? Answers to this question have practical applications for decision makers at several levels (Mission, government, NGO/PVO, and local community). For example, current services and support can be better delivered if targeted to well-defined beneficiaries. Policies and institutions can also be designed to change key elements of land users' profiles to turn non-adopters into adopters of NRM practices.

In analyzing users/nonusers' profiles, one can distinguish their personal characteristics and their assets endowment. In broad terms (to be qualified later), personal characteristics may be viewed as given, while the endowment of asssets may be affected by policy decisions. The analysis can be conducted for all practices. For illustrative purposes, however, this section analyzes the profiles of the men and women users and nonusers of soil fertility enhancement practices, the most commonly used type of practices identified in the 1992 KAP survey.

A. Personal Characteristics

Personal characteristics of men and women include such elements as age, ethnic background, religion, education, and social status. Table 8 presents the personal characteristics of men and women users and nonusers of soil fertility enhancement practices.

Age of heads of households. For the whole sample, male heads of households are significantly older than female, although this mean difference is only about 5 years (see appendix ...). For soil fertility enhancement practices, this difference is even more tenuous (Table 2), particularly for users. It appears then that age plays no important role in the decision for adopting such practices.

Ethnicity. It is well known that ethnic background reflects regional differences in Senegal, particularly in the regions covered by the 1992 KAP survey. Although all ethnic groups, and particularly Wolofs, can be found anywhere in Senegal, Wolofs/Lebous are predominant in Kaolack region; Sereres in Fatick region; Diolas (and also Bassaris and Manjacks) in Ziguinchor region; Mandingo/Bambara in Tambacounda; and Fulahs in Kolda region. For the whole sample (appendix ...), there are significant differences in the ethnic makeup by gender, especially for Diola (twice as more women as men-headed households)

and Serere groups. These particularities are also present for the users and nonusers of soil fertility practices. Serer make up a third of the women using soil fertility practices.

Table 8. Profiles of Users/Nonusers of Soil Fertility Enhancement Practices by Gender: Personal Characteristics

Personal Characteristics	NON-USER		USER	
	FEMALE	MALE	FEMALE	MALE
Average Age (years)	46	51	50	51
Ethnic Background (%)				
Wolof/Lebou	19	13	20	30
Toucouleur/peulh	31	39	18	30
Serere	22	11	33	15
Diola/Bassari/etc	20	22	15	10
Mandingue/Bambara[1]	8	14	14	15
All Others[2]	0	1	0	0
Religion (%)				
Mulsim	92	90	79	94
Christian	8	10	14	5
Animist/other	0	0	7	1
Education Level (%)				
None	92	73	95	94
Primary	5	18	3	5
Secondary	3	7	2	1
University level	0	2	0	0
Social status (%)				
Religious leader	0	0	0	1

Note: [1] Other ethnic groups include Bassari, Balantes, Coonagui, Manjack, the majority of which inhabit Ziguinchor region.
[2] Here others include Mandinque, Bambara, Soce and Sarakhole

Religion. To some extent, religion is related to the ethnic makeup in Senegal. Diola, Bassari, Coonagui, Manjack, Baiouik, and Balante ethnic groups in Ziguinchor region are more likely to be Christian or animists than muslims. Because relatively more women-heads of households are Diola who tend to be Christian or animist, there is also relatively more Christian or animists among women (16 percent) than among men (8 percent) in the whole sample (see appendix ...). Muslims, however, as expected in Senegal, are the overwhelming majority in both sexes and are found among Wolof, Serer, Toucouleur/Peulh, and most other ethnic groups.

Education. As expected, the education level of heads of rural households in the 1992 KAP sample is relatively low[5], with women's education level significantly much lower than men's (appendix ...). One should note, however, education is taken here as a personal characteristic, but it may be affected by policies.

Social status. Social status is another personal characteristic that can shed light on the adoption of practice. Social status includes such traits as religious notability, political leadership, or caste in a caste society. Data on social status was not collected by the 1992 KAP survey, except for religion identified by some male heads of households as their principal activity.

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[5] The 1992 KAP survey shows, however, a significant number of households with members with formal education. These literate members of the household ease the access of others to written information.

B. Household Assets

Personal characteristics can be revealing, but policies have little impact on them, except education[6] as already mentioned. By contrast, access to factors of production can be more readily affected by institutions and policies. Command over, or access to land, labor, capital, and information are hypothesized to determine the capability of adopting/not adopting certain NRM practices. This is one key purpose of policies (another important one is to affect the use of the currently available resources). Table 9 shows the household assets or resources for men and women users and nonusers of soil fertility.

Land. The amount and quality of land in use are critical variables in NRM. For example, the spread of practices in a region can be estimated in terms of area on which each of the practice(s) is being used. Sometimes, land quality by itself can be a valuable proxy for potential productivity of the land. Most land users have a keen knowledge of land quality, although indigenous land typology may be difficult to standardize for comparison across regions. By contrast, the amount of land in use is often more difficult for users to estimate. In the 1992 KAP survey and elsewhere in Senegal, however, households have a good idea of the amount of land in use. The survey zeroed in on area used, total land controlled and for how long. (Other information has to do with land tenure issues.) As would be expected, given other gender differences, men-headed households hold and have access to significantly more land area than women-headed households in the 1992 KAP sample. This is reflective of the general proposition that African women have extremely poor access to land.

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[6] To some extent average age of heads of households, through change in life expectancy can be affected by health policies. Similarly, social status (political leadership) can be affected by democracy and governance policies.

Table 9. Profiles of Users/Nonusers of Soil Fertility Enhancement Practices by Gender: Assets Endowment

Assets Endowment	NON-USER		USER	
	FEMALE	MALE	FEMALE	MALE
Land (average)				
Area controlled (ha)	1.36	3.65	3.21	7.90
Years in control	6	10	16	17
Area used	.41	2.02	2.81	6.13
Labor force (average)				
Actifs (labor force)	4	4	5	6
Labor units	3	4	3	5
Consumption units	5	6	5	7
Number of Members	7	9	7	10
Number of Kids	3	4	3	5
Animals and Equipment (average)				
Animal units	1.67	6.56	2.71	6.84
Animal traction units	.2	.21	.15	.53

Labor. The amount, type (e.g., family or hired labor), and seasonal distribution of labor are assumed important variables in the adoption of most NRM practices. The 1992 KAP provides several proxies of labor stock, including members of household, household size, number of kids, labor units, and consumption units. As will be discussed later in survey design, information need not be gathered on these proxies; some (e.g., actifs, labor units) are just manipulations of data on other variables. Women nonusers or users of soil fertility practices have considerably less control on land than their male counterparts (Table 9). Based on the labor proxies, data suggests that women-headed households have just slightly less available labor than their male counterparts. [REFER TO TABLE ON LABOR AND COMPOST USE FOR HOUSEHOLD STATING THAT LABOR IS A CONSTRAINT.]

Capital. Access to funds and productive assets are another set of factors that affect the ability of land users to invest and maintain NRM practices. Information on market availability, or access to capital includes income from various sources, access to credit, and

other productive assets such as equipment and animals. The 1992 KAP survey is, among other things, an attempt to minimize the burden of collecting detailed and costly information on capital and other economic variables. As proxies for income, the survey provides information on equipment and animals owned, principal household activity, and sources of revenue.

Table 9 shows a striking difference between men's and women's ownerships of animals (weighted average animal units). However, unexpected for soil fertility practices where use of manure is predominant is the fact that nonusers possess almost as many animal units as users.

Information. Information can be considered an asset. Lack of knowledge about a practice certainly hinders its adoption. Farmer-to-farmer visits are an attempt to remedy this lack of information. If one is satisfied that information is appropriately disseminated, the field of investigation narrows considerably. The 1992 KAP survey report (Kite et al., 1993) provides information about knowledge relative to the NRM practices, and its sources, and information on the resons for using or not using the practice(s) (which are not repeated here). The analysis conducted here considers those households who knew of practices but chose to adopt them or not for whatever reason.

(delete this statement??) In the next section, information on users/nonusers' characteristics will be incorporated to identify causal relationships.

C. Activities

An interesting feature emerges from the type of main activities in which men and women are engaged. Users of soil fertility practices report relying more heavily on agriculture than nonusers (comments??). Although the difference between users and nonusers is more dramatic for women than for men, a higher proportion than men reported other activities, for example commerce. Such an observation is supported by households reporting their main sources of income (Table 10). Nonfarm source of income is much more important for women-head of households than for men. Crop revenue is a much more important source for men than for women.

Table 10. Main Activities and Sources of Revenue of Women and Men Users/Nonusers of Soil Fertility Enhancement Practices in 1992.

Primary Activities and Revenue Sources	NON-USER		USER	
	FEMALE	MALE	FEMALE	MALE
Main Activities (%)				
None	28	9	8	2
Agriculture/Livestock	31	56	82	92
Religous leader	0	0	0	1
Civil servant	3	9	0	.5
Commerce	17	5	8	1.5
Other	21	21	2	3
Crops Revenue (%)				
Important source	28	47	73	93
Not important	72	53	27	7
Nonfarm Revenue (%)				
Important source	67	57	56	26
Not important	33	43	44	74

SECTION VII
MANAGEABLE DETERMINATES OF LAND USE

The previous sections identified the types and spread of practices, and analyzed the profiles of users/nonusers according to gender. Important, highly approapriate applications of these analyses include farmer-to-farmer visits, monitoring and evaluation, and better designed programs and projects targeted to well-defined beneficiaries. A lingering concern, however, remains: *What can issions and other decision makers do to affect the adoption of practices that reduce degradation and improve social welfare?* Decision makers use policies and institutions to affect land users' behavior for such a purpose. These factors that decision makers can thus manipulate are also referred to as manageable determinants (McGahuey, personal communication). A well-designed NRM information management system is expected to provide information on critical manageable determinants.

Land users' depend of their access to productive assets and the social and economic constraints and incentives offered to them. Therefore, an analysis of users' assets as well as their prevailing constraints and incentives should preceed and lead the discussion of manageable determinants. Economic constraints and incentives faced by land users include yields, costs, and prices of various crops (and other entreprises); marketing costs of various crops and other products; as well as costs of establishing and operating practices that are used in these various crops or other enterprises.

Section VI B. analyzed users/nonusers' assets endowment. Of particular notice was the limited set of proxy variables for such an important factor as capital (including income, animals, equipment, and access to credit). The 1992 KAP survey data, used for this analysis, also contains little quantitative information about economic constraints and incentives. At the discharge of the 1992 KAP survey, however, such information is better obtained by more targeted surveys because they involve specific sampling and survey methodologies. That is, one should think of obtaining information on economic constraints and incentives from another database.

A. Market Constraints

The 1992 KAP survey, however, collected information about land users' perceived market constraints. Table 11 summarizes responses of male and female users/nonusers of soil fertility enhancement practices. The overwhelming majority of users as well as nonusers report no major market constraints. Only low crop prices appear to be a major concern for both male- and female-headed households, but only for users of soil fertility enhancement practices. It is not known, however, which crops are thought to have lower prices and whether soil fertility practices are used for these crops or not.

Table 11. Market constraints reported by nonusers/users of soil fertility practices by gender.

Expressed Market Constraints	NON-USER		USER	
	FEMALE	MALE	FEMALE	MALE
# Buyers (%)				
No	81	84	83	88
Yes	19	16	17	12
Bad roads (%)				
No	94	90	92	83
Yes	6	10	8	17
Time to markets (%)				
No	86	83	88	82
Yes	14	17	12	18
Transport (%)				
No	83	78	86	81
Yes	17	22	14	19
Storage (%)				
No	92	94	94	90
Yes	8	6	6	10
Enough products (%)				
No	94	90	88	92
Yes	6	10	12	8
Low prices (%)				
No	75	77	46	57
Yes	25	23	54	43
Post-harvest loss (%)				
No	94	96	98	93
Yes	6	4.	2	7
Rent of storage place (%)				
No	100	98	98	97
Yes	0	2	2	3

B. Manageable Determinants

Candidate manageable determinants are policy decisions and institutions hypothesized to affect users/nonusers' profiles, particularly access to productive assets, and constraints and incentives faced by users/nonusers of practices. The Green Book (Johnston, 1992; Johnston et al, 1994; and Ouedraogo, 1993) identifie policies and summarizes lessons learned about their impact on their impact on natural resource management. The 1992 KAP survey report (Kite et al., 1993, pgs 20-25) covers with limited detail the issues of land tenure and extension.

Land tenure: Type of land ownership, mode of land acquisition, and perceived risk or security of land provides some information about land tenure conditions (Table 12). There is a striking difference between non-users and users, regardless of gender, about land ownership and land acquisition. Less than half of non-users compared with more than three quarters of users report that the household owns the land. The data suggests a relationship between land owned by the household and adoption of soil fertility enhancement practices. A similar hypothesis can be formulated for land acquisition, where again less than half of non-users did not inherit the land, compared with more than 70 percent of users who did. The data also leaves us thinking of a possibility of a land market, even if extremely limited, and certainly not official given current laws in Senegal. Here, non-users are more likely to "purchase" land, which would be consistent with the fact that relatively few own land within the family and a few also have inherited land. These suggestions remain tentative, however, because of lack of detail in households' responses to these questions. Surprisingly, however, very few households perceived risk of losing land not currently being used.

Table 12. Land Tenure Issues by Gender:

Land Tenure Issues	NON-USER		USER	
	FEMALE	MALE	FEMALE	MALE
Type of Land Ownership (%)				
Household	33	48	82	80
Community	0	3	4	8
State	0	3	3	3
Nonfamily member	3	5	6	7
Other	64	41	5	1
Mode of Land Acquisition (%)				
Inherited	33	44	73	72
Through community	0	7	9	11
Rented/borrowed	3	9	12	12
Purchased	3	2	0	1
Other	61	38	6	4
Risk of Losing Fallow Land (%)				
No Risk	97	100	100	96
Risk exists	3	0	0	4

Extension: Visits by extension agents can serve as a proxy for valuable services provided to households in their use of NRM practices (Table 13). Relatively few visits to households by extension agents were reported by the households surveyed in 1992 in Central and Southern Senegal. This is a critical factor that can be classed as a manageable determinate and is probably one of the most important aspects which has resulted in the lack of adoption of NRM practices. Information does not expose limited resources farming households to any risk. The men and women can take this information and use it in any way they feel appropriate. Technical assistance provided to back up the information is another critical variable which can greatly influence land-use management decisions. Furthermore, as historically established, women-headed households received fewer visits than men-headed households.

Table 13. Extension and Project Activities Reported by Nonusers and Users of Soil Fertility Enhancement Practices by Gender.

Extension and Project Activities	NON-USER		USER	
	FEMALE	MALE	FEMALE	MALE
Extension Visits to Households (%)				
No visit	97	95	91	81
Visit	3	5	9	19
Project Activities (%)				
None	81	71	80	71
Forestry	3	5	4	10
Literacy/health/water	0	3	3	3
Agriculture/livestock	11	18	13	12
Other	5	3	0	4

Project Activities: Project activities are manifestations of additional resources and services provided to beneficiaries. As mentioned above about extension visits, relatively few households were exposed to information and/or technical assistance by various types of projects in the regions surveyed. This data should be of immediate concern to decision makers, donors, and the NGO/PVO community.

SECTION VIII
LOGISTIC REGRESSION ANALYSIS OF THE USE OF PRACTICES

The underlying premise of this analysis is the realization that it is essential to understand how and why a NRM practice is actually adopted by men and women if the broad-based adoption is to realized (Besley and Case, 1994). Can we synthesize, or summarize in some way, causal relationships in the use of practices? As valuable as can be the expressed reasons of men and women for using or not using practices, an attempt to empirically establish quantitative causal relationships remains highly appropriate. Such an analysis helps identify or validate key indicators for monitoring and evaluation systems.

Underlying this understanding of NRM practice adoption is a choice-based model. One must, however, keep in mind the usual caveat in this proposition. A model, mathematical or otherwise, is an attempt to simplify a reality too complex to grasp in its entirety. Therefore, a model intrinsically aims to uncover as many kernels of truth as possible, rather than attempt to wholly capture reality. Furthermore, models are driven by the reliability of the available data.

A. Studies and Approaches in Understanding Adoption of NRM Practices

In a recent literature review, Besley and Case (1994) summarize various approaches used in different studies of technology adoption.

In time-series studies, one observes and aggregates measures of adoption (e.g., the percentage of farmers employing the new technology at each date), to capture the pattern of time-series diffusion processes, usually modeled as a logistic-shaped function over time. This approach is limited in what it can say about the underlying dynamic process at work.

Cross-sectional studies provide insight into the farm and farmer characteristics associated with accepting the practice, but they remain a snapshot in time and thus remain limited in exploring the adoption process itself.

Panel-data studies answer some of the criticisms raised for time-series and cross-sectional data, but there is still a real question about how these relate to the underlying choices or problems that individuals face.

Studies of dynamic choices without externalities model the probability of observing the value of *state variables* for their impact on choice in the future. State variables include credit availability (current assets available to pay for carrying out the practice); learning (stock of knowledge about the new technology, which evolves through time); and an irreversible investment.

Studies of dynamic choices with externalities recognize the role of externalities in technology-adoption decisions. Examples include marketing infrastructure for a new crop; market power gained by early adopters; learning when a technology is of uncertain profitability and some potential adopters may wait until they observe whether others have fared well by using it. This is an example of learning from the behavior of others.

These different approaches use a wide variety of statistical techniques, most often nonlinear regression techniques. Commonly used nonlinear regression techniques include probit, logit, and logistic models. On one hand, probit and logit models are used to express the relationship between the *proportion of users* responding to stimuli (incentives), where the stimuli (independent variables) are usually measured on a ratio scale (e.g., prices). These models require a transformation of the proportion whose interpretation is not always intuitive (Norusis, M. J., 1993)[7]. On the other hand, logistic regression is used to express the relation between *binary dependent variables* (e.g., use or nonuse) and independent variables measured at various levels (nominal/ordinal and continuous measurements).

B Logistic Regression Model of the Use of NRM Practice

A logistic regression is applied to the 1992 KAP data to illustrate how one can gain more insight into the causal relationships of the adoption of NRM practices. This approach is consistent with the purpose and type of data of the 1992 KAP survey. The survey is concerned about why or why not households use a practice(s). Also most variables of the dataset are binary (yes/no) or categorical (e.g., ethnic group), rather than continuous (e.g., age). The cross-sectional data include information about households' use of practices, characteristics, and opinions, and a few variables relating to conditions (externalities) such as markets, visits, village infrastructure, etc. Nonetheless, one must keep in mind that the 1992 KAP is a baseline, one-shot annual survey covering more than just natural resources management. Therefore, the results of the regression analysis are offered as thought-provoking assessments of the hypothesized causal relationships and suggestions for better survey instruments.

Here, the binary dependent variable "use of practice" contrasts current use (as of 1992) and nonuse (including past use and no use ever). The candidate independent variables hypothesized to determine the adoption of practices can be regrouped in the following main categories: (1) ecological conditions; (2) village physical infrastructure and institutions; (3) household characteristics and assets endowment; (4) economic constraints and incentives; and (5) policy conditions.

Several considerations have guided the choice of independent variables. Not all five

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[7] The Probit transformation replaces each observed proportion with the value of the standard normal curve below which the observed proportion of area is found. In the Logit transformation, requires a logit, the log of the odd of the proportion, where the odd is p/(1-p).

categories of variables are covered in the 1992 KAP survey. For example, there is scant information on economic assets and incentives, and on policy conditions. By contrast, there is a plethora of variables, often highly related, in other categories. To overcome these constraints, proxy variables were identified. For example, village infrastructure is represented by the existence of a market place in the village, and such things as the existence of health units, school, water sources, etc. The ecological variable in the 1992 KAP data is approximated by region (Central and Southern Senegal, going from sahelo-sudanian to sudanian-guinean ecosystems).

The number of variables (a total of 800) was also considerably reduced. Because the logistic regression requires an iterative algorithm for parameter estimation that uses the maximum-likelihood method, the greater the number of candidate independent variables, the slower the process in a given computer configuration. Field experience, lessons learned in literature review, and the analysis conducted in previous sections have guided the choice of candidate variables. If their number remains high, a stepwise, simple regression may be suggested to weed out variables with weak relationships with the dependent variable[8]. One can then run the logistic regression with the remaining independent variables.

Gender can be used as an independent "dummy" variable if one wants to capture gender differentiation in one single equation. However, two distinct gender-specific equations may be run if the gender "dummy" variable proves insignificant contrary to one's expectation or need to show that different variables affect men's and women's uses of practices[9]. Gender analysts usually argue historically that female-headed households are a different cohort, usually among the very poor, so that it is difficult to compare them with male-headed households. [10]Such a comparison, however, can help to show the extent and significance of these stark differences. Also, the gender "dummy" variable may be insignificant because women are so under-represented in the sample that they do not significantly affect the variability of the dependent variable. Appropriate sampling techniques can be used to increase women's representation in order to conduct meaningful statistical analysis. One suggestion is to stratify, ex-ante, the sample by gender. Another, in

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[8] Note that this is just a shortcut to a logistic regression and that no attempt is made at interpreting the linear regression relationship. When the dependent variable can have only tow values (0,1), the assumptions required for hypothesis testing in simple, ordinary least square (OLS) regression are necessarily violated. Furthermore, the predicted values cannot interpreted as probabilities because they are not constrained to fall in the interval 0 and 1 (Norusis, Marija J., 1990).

[9] In such a case, these different variables may still be combined in one single equation. The relevant independent variables will be transformed with the appropriate gender interaction term. Two gender-specific equations, however, may still be easier to interpret.

[10] I am indebted to Mary Hill Rojas, Gender Specialist on the Desfil team, for this comment.

combination or not with the first one, is to make the unit of inquiry not the head of household, but individual (adult) members within a given household. Female members of households are likely to be of equal number as male members.

C. PRELIMINARY Analytical Results

To illustrate, logistic regressions were run on two individual practices (compost and manure) and one type of practices (soil fertility enhancement). The dependent variable was regressed against some 35 independent variables, allowing the model to retain the most significant ones at 10% level of significance[11]. The following results (see appendices ....) of the logistic regression analysis are of particular interest. The likelihood statistic (-2*Log LR) is a summary measure of the goodness-of-fit of the model (the smaller, the better). Another summary measure of goodness-of-fit is the classification table, which compares the model predictions to the observed cases. The coefficient (B) and its exponential, Exp(B), of the independent variable indicate how a unit change of this variable contribute to the prediction of the model. Finally, the partial correlation shows how the independent variables are correlated individually with the dependent variable.

Compost equation. The classification table for compost shows that although the model overall prediction is 88 percent correct, only 14 percent of the current use of this practice is correctly predicted. The variables that most significantly contribute to the model include marketplace (whether the village is a marketplace or not), the use of manure, and to a lesser extent regional difference, the existence of a school, and source of water. As already shown in previous analysis, gender differentiation in the use of compost is extremely weak. There are too few cases of women adopters to run an analysis to suggest what determine this adoption among women.

	Predicted		
Observed	Nonuser	User	Percent correct
Nonuser	1235	18	98.6%
User	161	26	13.9%
Overall (Weighted) Accuracy of Prediction			87.6%

Manure equation. The table of classification is better balanced for the use/nonuse of the practice, but the overall prediction is lower than that of the compost equation. Here again, regional difference plays an important role, along with the use of other practices, such

[11] In previous attempts, a simple regression was used to shorten the number of candidate independent variables. Here, a faster version of SPSS for Windows and a more powerful computer allowed us to include all these variables in the logistic regression run.

as fertilizer and compost. Once again, gender "dummy" variable is insignificant, at least in part for the reasons indicated.

Observed	Predicted		Percent correct
	Nonuser	User	
Nonuser	458	200	69.9%
User	163	619	79.2%
Overall (Weighted) Accuracy of Prediction			74.8%

Soil fertility enhancement practice equation. In 85 percent of the time, the model predicts correctly the use of the practice, but just about half its nonuse. A smaller set of variables is included in the solution, with regional difference still significant. The gender "dummy" variable is also part of the solution. Here, being a female-head household lowers the odds [here p/(1-p)] that the household will use the practice.

Observed	Predicted		Percent correct
	Nonuser	User	
Nonuser	234	220	51.5%
User	145	841	85.3%
Overall (Weighted) Accuracy of Prediction			74.6%

As emphasized at the outset, these results should be interpreted with extreme caution, that is, more as thought-provoking than definite statements of causal relationships. Nonetheless, such a regression analysis shows that given appropriate information, it has the potential to guide monitoring and evaluation and decision making. Appropriate information is key. Indeed, these and previous analytical results serve to point to improvement of data collection and management. Next section discusses variables and data collection to improve NRM data management and analysis.

SECTION IX
CANDIDATE VARIABLES

A. Minimum Dataset Requirements

NRM Issue: How broadly spread is the adoption of appropriate land-use management practices? Counted in terms of number of farms, farmers (women and men), hectares, etc., this measure is probably the best proxy for people-level impacts.

Questions:

1. Date:
   Country:
   Region:
   Dept.:
   Arrond:
   CR:
   Latitude:
   Longitude:
   Village name:
   Household ID #:
   User (man=1, woman=2):
   Practice ID code #:

2. List practice(s) used (by ID code #): e.g., 1100 = field trees (arbres en plein champs)
   (See Fiebig's Inventory 1400 = live fences (haie-vives)
   of practices for codes) 6300 = compost (compostage)

3. For each practice ask - on how much land-area is practice used?
   (proportion/percentage of all land which the respondent cultivates)

4. If they use practice(s), ask why? If they know about, but do not use the practice(s), ask why not?

   WU_ (list practices) = why used (1=improve yields, 2=stop erosion, 3=water conservation, 4=protect/delimit fields, 5=fodder, 6=project requirement, 7=fuelwood, 8=increase revenue, 9=other)

   WN_(list practices) = why not used (1=cost, 2=lack labor, 3=not appropriate, 4=lack seeds, 5=no land to fallow, 6=not my land, 7=lack of plants/seedlings, 8=lack fertilizer, 9=lack equipment, 10=lack of knowledge, 11=other)

NRM Issue: What profiles users of NRM practices?

Questions:

1. User household characteristics :
   - MEM = # members
   - SEX = sex of each member
   - AGE = age of each member
   - HH_AGE = age of household head
   - WIFE = household head: # wives
   - FEM = head of household (0=man, 1=woman)

2. Land assets:
   - L_AREA = land area controlled (hectares)
   - L_YEAR = years controlled
   - L_AQD = how was land aquired (1=inherited, 2=common property, 3=rented/borrowed, 4=purchased)
   - L_USED = land area used in past growing season (% total)
   - L_CHANGE = change in land area used in last three years (0=same,1=up, 2=down)

3. Animals:
   - NO_COW = number of cows owned
   - NO_SHEEP = number of sheep owned
   - NO_GOAT = number of goats owned
   - NO_HORSE = number of horses owned
   - NO_DONK = number of donkeys owned
   - NO_OXEN = number of oxen owned
   - NO_CHICK = number of chickens owned
   - NO_DUCK = number of ducks owned

4. Markets:
   - IN_MRKT = is there a market in the village (0=no, 1=yes)
   - TIME = time to nearest market

5. Equipment:
   - N_PLOW = number of plows owned
   - N_WEED = number of weeding equipment owned
   - N_CART = numbers of carts owned
   - N_SEED = number of seeders owned
   - N_OTHER = number of other equipment owned

6. Other:
   - COOP = member of Coop (0=no, 1=yes)
   - ASSN = member of Assn (0=no, 1=yes)
   - GIE = member of GIE (0=no, 1=yes)
   - VISIT = received field visits (0=no, 1=yes)
   - WHO = who visited fields (1=extension, 2=CER, 3=forest agent, 4=village association agent, 5=ngo, 6=project staff, 7=other)
   - PROJ = type of project association (1=agriculture, 2=livestock,

3=forestry, 4=literacy, 5=water, 6=health, 7=other)

ACT = primary activity of household head (1=agriculture, 2=livestock, 3=civil service, 4=merchant, 5=migrant worker, 6=other)

ETH = ethnicity of household head (1=wolof, 2=puel, 3= serere, 4= diola, 5= mandinque, 6= sarakhole, 7= bambara, 8=other)

NRM Issue: On lands where the above practices have been adopted, what are the changes in yields relative to (i) yields on the same land in previous years and/or (ii) yields on adjacent lands where practices have not been adopted?

Variables:

1. crop(s) grown using practice(s)
2. crop yield changes (up, down, same)
3. yield change due to use relative to non-use in nearby fields

Questions:

1. What crops are grown using each practice?

MIL
SORGHO
MAIZE
MANIOC
NIEBE
PNUT
COTTON
TOMATO
ONION
OTHER

2. For each crop grown using practice, are yields changing?

CY_SAME
CY_UP
CY_DOWN

3. For each crop grown using practice, are yields different relative to the crop grown without use of practice?

Y_SAME
Y_UP
Y_DOWN

NRM Issue: On lands where the above practices have been adopted, what are the changes in land degradation rates?

Variables:
1. changes in vegetation cover
2. changes in soil organic matter
3. changes in soil erosion rates

Questions:

1. On the land cultivated using the NRM practices, have changes occured in the following:

   VEGET = changes in vegetation cover (1=less, 2=same, 3=more)
   SOM = changes in soil organic matter (1=less, 2=same, 3=more)
   ERODE = changes in soil erosion rates (1=less, 2=same, 3=more)

NRM Issue: What are the changes in the enabling conditions?

Questions:

1. What is your perception relative to your *terroir*?

   L_OWN = who owns land (1=household, 2=gov't, 3=other, 4=don't know)
   L_SELL = can you sell land (0=no, 1=yes)
   L_RISK = do you risk losing land control (0=no, 1=yes)

2. What is your perception relative to trees on your land?

   T_OWN = who owns trees (1=household, 2=gov't, 3=other, 4=don't know)
   T_HARV = can you harvest trees on your land (0=no, 1=yes)
   T_SELL = can you sell trees (0=no, 1=yes)
   T_RISK = do you risk losing control of trees (0=no, 1=yes)

3. Marketing problems? (0=no, 1=yes)

MP_BUY = no clients
MP_PRICE = low prices
MP_PROD = no surplus
MP_ROAD = bad roads
MP_STG = no market storage
MP_TIME = distance to market
MP_TRAN = lack of transport
MP_RENT = high storage costs
MP_LOSS = post harvest loss
MP_OTH = other marketing problems

4. Who does the market problem(s) influence most? (1=men, 2=women, 3=both)

WP_BUY = no clients
WP_PRICE = low prices
WP_PROD = no surplus
WP_ROAD = bad roads
WP_STG = no market storage
WP_TIME = distance to market
WP_TRAN = lack of transport
WP_RENT = high storage costs
WP_LOSS = post harvest loss
WP_OTH = other marketing problems

5. Where did you learn about the NRM practice(s)?

SOURCE = source of information
(1=family member, 2=neighbor, 3=extension, 4=travel, 5=NARS, 6=IARC, 7= NGO, 8=farmer conference, 9=field day, 10=farmer-to-farmer visit, 11=other)

6. Access to credit? (0=no, 1=yes) A_CREDIT

7. Other conditions ?????

SECTION X
CONCLUSIONS

By itself, a relational database is an important and improved management tool that conveniently stores data and allows facilitates retrival of this data for analysis. Depending on the availability and richness of data, a wide range of analytical tools can be used to shed light on the cause-and-effect relaltionships in NRM and thus helps firm up policy decisionmaking. The 1992 KAP does not allow the use of spreadsheet-based techniques, such as cost-benefit-analyis and policy analyis matrix (PAM) to investigate the impact of policy conditions on users' incentives to use or not use practices. However, thanks to its abundant data on many important variables and the randomness of its sampling methodology, the 1992 KAP allows simple and even advanced statistical analysis.

Simple descriptive statistics are most appropriate to answer the question of who is doing what and where. Frequencies tables and histograms are used to answer these questions. Mapping of practices would supplement this analysis. Crosstabulations (with chi-squre tests) and t-tests were also used extensively to determine the relative importance of characteristics and differences between men and women users and nonusers of practices. Further analysis was conducted by running a logistic regression. Such an analysis helps one shed light on the importance of candidate proxies or indicator variables.

These candidate variables that have been identified will comprise the core of a minimum dataset that field-based projects and their partners will use in Senegal. The data will be shared between the projects and with the USAID Mission to track progress towards achieving the Mission's strategic objective to increase agricultural productivity in Senegal and to report on the Mission's ANRU program and project performance and impacts.

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