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Development Strategies for Fragile Lands

THE DESIGN AND IMPLEMENTATION OF A NATURAL RESOURCE INFORMATION MANAGEMENT SYSTEM: PROCESS AND TOOLS

A Discussion Paper

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PURPOSE OF A NATURAL RESOURCE INFORMATION MANAGEMENT SYSTEM

The need for Natural Resource (NR) Information Management System (IMS) has been strongly articulated from many quarters (see Hassan, 1994). In broad terms, the goal of a NR IMS is to contribute to better, more efficient decision making to increase people's welfare and reduce the degradation of the natural resource base, the two pillars of sustainable development. USAID Missions and Bureaus need a NR IMS to better track and report the progress and impacts of programs and projects, while reducing their management burden in the long-run. Operationalizing such a NR IMS, however, raises difficult issues.

The design and implementation of a NRM information management system is a process that includes a clear definition of the purpose to be accomplished; identification of specific questions; and an array of "informational" tools needed to answer these questions and fulfil this purpose. This paper discusses key NRM questions and informational tools. The ideas are based on DESFIL's experience and collaboration with AFR/SD/PSGE/NRM (formerly ARTS/FARA) to help USAID Missions develop NR IMS tailored to their needs and requirements.

QUESTIONS-INFORMATIONAL TOOLS MATRIX

The ways and means of tracking and reporting the progress and impacts of NRM programs may be schematically represented by a matrix of key NRM questions and tools (table 1). This matrix forces researchers and decision makers to reflect on the essential components of a NR IMS in a systematic way. Thorny issues can be constructively discussed and options and trade-offs can be clearly presented.

Table 1. Matrix of Questions by Informational Tools

QUESTIONS	INFORMATIONAL TOOLS				
	Sampling Techniques	Data collection	Data Management	Analytical Methods	Dissemination
1. What and where is the inventory of land-use management practices used by men and women in the area of interest?	-Probability sampling[1] -Nonprobability sampling	-Videography -HH surveys -ASF survey -Rapid Appraisal -PRA -Key informant survey -In-depth interview	-Relational databases (RDB) -GIS -Hypertext	-Qualitative analysis (includes literature review) - Descriptive statistics - Graphical analysis (mapping)	-Reports -Hypertext -Maps -Workshops[2] -Radio/TV -Teleconf. /email -Site visits
2. What characteristics distinguish adopters from non-adopters?	As for question #1	-HH survey -ASF survey -Rapid Appraisal -PRA	-RDB -Hypertext	- Qualitative analysis - Descriptive statistics - Statistical hypothesis testing	As for question #1
3. What are the economic outcomes of practices?	As for question #1	-As for question #2 -Experimental design	As for question #2	-As for question # 2 -Regression analysis -Budget analysis	As for question #1
4. What are the environmental outcomes of practices?	As for question #1	-As for question #1 -Remote sensing -Experimental design	As for question #1	-As for question #3 -Graphical analysis	As for question #1
5. What conditions are associated with the adoption/non adoption of practices?	As for question #1	-As for question #2	-Same as above	As for question #3	
6. What are the programmatic options for establishing enabling conditions?	As for question #1	-Same as for question #2	-Same as above	Same as above	As for question #4

Source: Adapted from McGahuey and Ouedraogo

[1] Simple random; Systematic; Stratified; Multistage; Area sampling frame (ASF)

[2] Workshops include seminars and conferences.

Key Questions in NRM

The key questions in NRM structured according to the Africa Bureau NRM Analytical Framework have been well articulated by McGahuey, USAID Missions, and DESFIL. These sets of questions in this matrix strongly reflect a people-level perspective. Annex 1 discusses in more detail these questions and the practical applications of the information generated in answering them.

Informational Tools

In the process of designing and implementing a NR IMS, the following tools are critical: sampling techniques; data collection instruments; data storage and management; analytical tools; and dissemination media. These tools are inter-related. To fulfill the purpose on hand, one follows the steps of choosing a sampling technique, data collection tools, data storage and management instruments, appropriate analytical methods, and means to disseminate the information generated to end users. Therefore discussing one tool involves the others. Yet each tool offers several options, so that depending on information needs, different combinations allow decision makers to identify alternative options. The key points of these tools are discussed below.

SAMPLING TECHNIQUES

Many observers of natural resources management might look at sampling as a luxury and a futile academic exercise far removed from practical considerations. Yet, "most data in the social and political sciences are collected from samples" (Henry, 1990). Sampling is a necessary proposition in research as well as in everyday life because "in science and human affairs alike, we lack the resources to study more than a fraction of the phenomena that might advance our knowledge" (Cochran, 1977). In social sciences, "rarely can a researcher collect data on all the subjects of interest in a particular study. Sample selection provides a practical and efficient means to collect data. A sample serves as a model of the study population" (Henry, 1990).

We always need to put the information generated in perspective. Is the target population for the policy or program the same as the target of study population[1] from which the sample is taken? Have the methods for selecting the sampling units biased the results? Are the results precise enough for the study purpose? The end user remains interested in the target population, not just one part of that population. To generalize study findings to the target population, the sample must be an accurate representation of that population (Henry, 1990). There are instances where such an accurate representation of the population cannot be obtained. Sorting out the advantages and disadvantages of various sampling options is an important element in the design of a natural information management system for monitoring and evaluation and for analyzing the impacts of policy on land users' behavior.

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[1] When the available frame list, from which the sample is drawn, is incomplete, the study population does not match the target population.

Nonprobability vs. Probability Sampling

This old debate is covered extensively in the literature (see for example Casley and Kumar, 1990). The advantages and disadvantages of nonprobability and probability are well known and need only be summarized here. (Annexes 2 and 3 summarize the types of nonprobability and probability techniques.)

It can be argued that a nonprobability sample based on "good" judgement can be just as biased as, or even less biased than, a "poor" probability sample (see Duff, 1993). The main disadvantage of nonprobability sampling, however, is its lack of objective criteria to ascertain whether the sample is an accurate representation of the target or study population. There is often no precision attached to the sample results and any statistical inference is questionable. For example, based on non-probability sampling, a statement such as "the difference is significant" has no objective basis and thus can be misleading. The sample results of non-probability sampling cannot and should not be extended to the target population. Nonetheless, the advantages of non probability sampling are numerous. Nonprobability samples are convenient, quick, and generally less expensive than probability sampling. The results can shed useful insight, dispel long-held but false generalizations, and suggest interesting working hypotheses. The results of nonprobability sampling are most often used in qualitative analysis.

The main disadvantages of probability sampling is the expense incurred in planning, selecting the sample, conducting the survey, managing the data, and conducting the analysis. The advantages of probability sampling are the opposite of the disadvantages of nonprobability sampling. With probability sampling, there are objective criteria to evaluate the bias of the sample, ascertain the precision of the sample results, and generalize the results to the whole population. As with nonprobability sampling, probability sampling also sheds useful insights, dispels false generalization, and suggests working hypotheses, which furthermore can be objectively tested with a stated degree of precision.

In turn, probability sampling techniques have advantages and disadvantages compared with one another. Simple random samples are appealing because they are self-weighing (every units having the same chance of selection), and thus the computation of sample estimates are straightforward. However, the sample size may be too large for the available resources. Other stratified sampling techniques that incorporate stratification are more flexibility while generally reducing the sample size or increasing the level of precision. Their major drawback is their computational difficulty in estimating the sample and the population characteristics. The cost of the survey might also increase.

Estimating the sample size is usually an iterative process because the following elements are involved (Cochran, 1977):

1. A statement from the end user concerning what is expected of the sample, for example, desired limits of error.

2. Some equation connecting the sample size (n) with the desired precision of the sample, that varies with the content of the statement of precision and with the sampling technique contemplated.

3. Estimation of unknown properties of population, contained as parameters of the equation, in order to give specific results.

4. If desired limits are set for subdivisions of the population, separate calculations are made for each subdivision and the total sample size is obtained by addition.

5. If desired precision is prescribed for each characteristic of the sample survey, the calculation lead to conflicting values of the sample size and a method must be found to reconcile these sample sizes.

6. An estimation of the cost (labor, time, and materials)[2] to determine whether the chosen size of the sample is consistent with the available resources.

7. Finally, a decision to trade off higher precision (large sample size) for reduced cost (smaller sample size).

Implications for a NR IMS

The purpose on hand determines the range of sampling techniques to consider. If information is sought on the characteristics for a large population, probability sampling is required to allow us to expand the survey sample results to the target population. Also an indicator such as the proportion of users of a practice in a large project area requires a probability sampling for accuracy. However, if only the presence or not of a characteristic is of interest, a nonprobability, convenient case study may be sufficient to show the existence of this characteristic. (No conclusion can be drawn, however, if this characteristic is not found in the non-probability sampling.) Often, nonprobability sampling is recommended as an exploratory first phase to formulate hypotheses that a subsequent, more rigorous probability sampling would test. This recommendation is justified if the working hypotheses cannot be formulated from the available literature and if the commitment exits to carry on the second phase that uses a probability sampling.

In general, quantitative analysis tends to be associated with a probability sampling survey, and qualitative analysis with non-probability sampling surveys. In practice, however, many sophisticated models (regression, cost-benefit, or linear programming analyses) use data

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[2] Estimating the cost of a sampling technique is an arduous task. For a simple random sample, a simple cost function is $C(n) = c_o + c_1 n$, where c_o is the overhead cost, and c_1 the per unit cost (Cochran, 1977)).With stratified sampling, the simplest cost function is $C = c_o + \Sigma(c_h n_h)$ where the cost per unit c_h may vary from stratum (h) to stratum. If travel costs between units are substantial, the recommended expression is $C = \Sigma(t_h \sqrt{(n_h)})$.

from case studies, which are not entirely based on probability sampling techniques[3]. For example, farm surveys may be based on probability sampling or non-probability case studies, in which "representative or modal farms" are selected (Banta, 1982). Despite the usefulness of the analytical results, the analyst will caution that they should not be generalized to the target population.

Most sample frames are lists (of villages, households or household members) from which a probability sample is drawn. It can be argued that an area sampling frame (ASF), eventually supplemented with a list frame[4], is more accurate than a list frame alone. In natural resource management when we are concerned with a region or the French notion of *terroir*, an area frame has considerable advantages over a list frame. ASF is an effective sampling techniques to collect data on crop yields and degradation rate changes in the region of concern.[5] An ASF, however, requires an heavy initial investment (in satellite imagery, mapping and ground truthing) to pay off in the medium- to long-term.

To resolve the sampling techniques issues, expert statisticians must be involved in the design and implementation of data collection efforts. Any time statistics are used as indicators, one must answer the basic question of the reliability of the data. A statistic is only as reliable as its source. That does not mean, however, that only probability sampling is to be used to collect data. Rather, it serves to lay out the trade-offs in an NR IMS.

DATA COLLECTION METHODS

Numerous social science methods exist to collect and generate information to understand human behavior. These methods can be used to collect two major types of data: qualitative data (text) and quantitative data (numbers). These two types of data can be used separately and in combination to characterize and understand people and their behavior.

Different advantages and disadvantages are associated with qualitative and quantitative data. Qualitative data are relatively easy to collect, provide useful descriptions of human behavior, and allow people to express themselves in their own words. Collecting qualitative data usually includes collecting some quantitative data also, and vice versa; the two types are not mutually exclusive. The main disadvantage with qualitative data is that usually they are collected from nonprobability samples and therefore cannot be generalized to the larger population. Quantitative data usually are collected from probability samples and therefore can

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[3] Households (the sampling units) may be chosen randomly in villages that have been selected for convenience. In this case, the sample is not statistically representative of the target population of the households in the region.

[4] A Multiple Resource Inventory (MRI) and Monitoring scheme, which uses such a multiple sampling frame, was the subject of a recent a seminar sponsored by the Forestry Service of the United State Department of Agriculture (Washington, January 23, 1995).

[5] An area sampling frame "with modifications could appropriately handle environmental monitoring"... "including forested areas, soils, water quality, and agricultural productivity" (AAIC. 1992).

be generalized to the larger population. They can be analyzed with inferential statistics to quantify people's characteristics and behavior patterns.

The end use of the information determines which data collection methods are appropriate to use and which types of data are necessary to collect. The information-user's objectives thus are the key factor in choosing among data collection methods and types of data. His/her resources (time and money) are another key factor. The objective is to match the information requirement with the appropriate data collection methods.

The range of existing data collection methods includes participant-observation, key informant interviews, focus groups, informal surveys (Participatory Rural Appraisals, Rapid Rural Appraisals), and formal surveys that use probability samples and structured questionnaires. Secondary data from national governments is another source of useful data. Participant-observation can range from less intrusive (observation only) to more intrusive (taking pictures or videos, asking questions, participating in an activity). Key informants are people who are knowledgeable about the topic(s) under investigation and available for interviewing. A focus group usually consists of a particular social group whose discussion is focused on a particular topic by the researcher. The characteristics that make a survey "informal" include nonprobabilistic sampling and the use of semi-structured survey instruments such as topical guides. "Formal surveys" generally are based on probabilistic samples, use structured questionnaires, and produce data that are analyzed on a computer.

Research using secondary data sources, such as the gray literature and research documents generally does not use sampling techniques. In a literature review we strive for comprehensive coverage but usually settle for the conveniently available information, which often constitutes a small sample of all existing documents. A reviewer does use some informal methods to survey the literature.

Implications for a NR IMS

To share data efficiently among institutions (for example, a Mission and its collaborators), data must collected and stored in a standardized structure. All data collectors of a NR IMS must agree on a common standardized structure that all can use. This minimum, standardized must be keyed to the lead institution, the Mission program unit, but it must be also relevant to the projects. Even with informal nonprobability sampling, some variables can be collected with the use of structured data collection tools. The challenge is to agree on this minimum structure. This issue is discussed in further detail in the next section.

DATA STORAGE AND MANAGEMENT

The types of data collected influence the options for data storage and management. Reports are obviously an important store of information that is used in analysis. The NR IMS discussed here includes an electronic relational database. Any structured database requires a well thought structured survey instrument (questionnaire) to facilitate data entry and verification. A database can handle numeric and alphanumeric (text, including field memos). A structured database, however, does not handle several paragraph-length text fields well.

Implications for a NRM IMS

A NRM relational database should make the link between the Mission program and projects information needs. Because these projects are funded by the Mission, a common ground must exist between Mission program and projects needs. Somewhat similar to the agricultural information system in the United States, USDA receives the same type of data from each state, but each state collects far more information than USDA requested data, which remains of interest to each state. The state's information is tailored to its need, but its questionnaire is piggy-bagged to the one designed to collect the information needed by USDA.

In the case of Senegal, Figure 1, on the next page, illustrates the position of a project-level MIS in the overall mission context. One of the major goals in establishing project-level databases is to provide a flow of data to the mission level data repository. These data, combined with data from other sources, such as KAP studies, will provide the Mission with a greater number of indicators in evaluating policies, tracking progress, and reporting on performance and impacts.

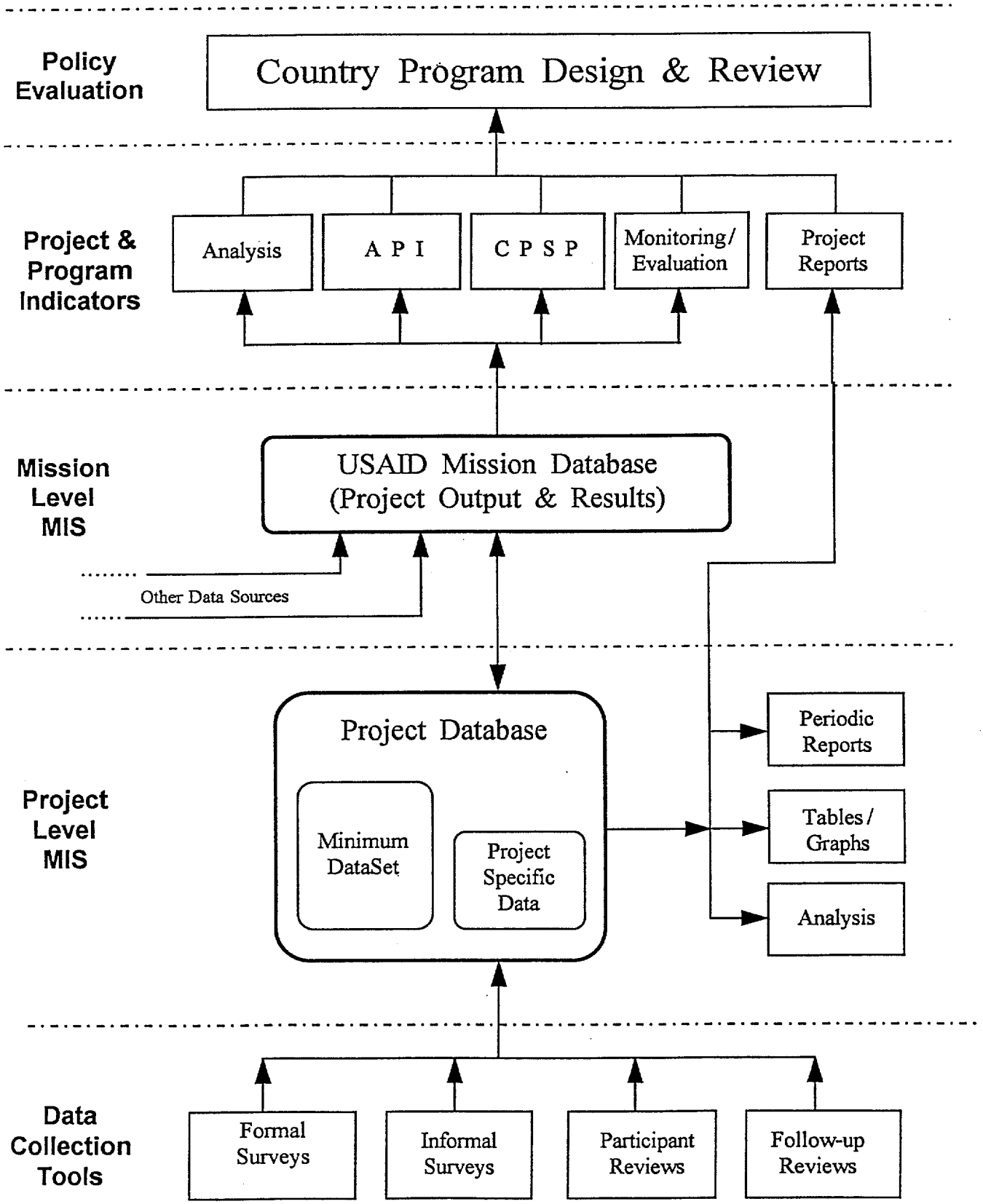
The lower half of the diagram focuses on the position of the project-level databases. Each project will collect and process data for the minimum dataset, a consistently defined set of variables among projects and AID. These data will then also be exported to the Mission after being converted to the standard coding used at the Mission. With a database program in place, the individual projects will be able to easily provide data to AID for use in their periodic reports such as the API. As the databases are established, the Mission will be able to transfer data back to the projects.

The database program will also allow each project to manage data that are specific to their own activities and integrate them with the minimum dataset. These data, as well, can be transferred between projects.

An important aspect of the project-level IMS is the facility to easily disseminate the data in an informative manner. The reports will be used to distribute data at workshops, farmer-to-farmer activities, seminars, etc. The reports provided by the database system will consist of pre-defined queries for reports that are required on a regular basis, and ad-hoc queries for specific analysis.

The data collection tools will include formal surveys, such as KAPs or collection of the minimum dataset. To ensure compatibility with the Mission and among projects, consistent definition of terms will necessary. Data from informal surveys carried out by project staff and their collaborating partners will be integrated into the project-level IMS.

Proposed MIS Components



One particularity of the Senegal case is that the Mission carries out (through a local contractor) a special purpose, baseline random survey. This survey can be used to suggest structured data collection tools.

A data dictionary should be developed to provide recommended variable names, definitions, and codes. This helps establish standardized data collection methodologies to assure that databases relate to each other with minimal data burden. For example, an inventory of practices can be developed to standardize definitions and codes for each practice. This is necessary when sharing information between programs and projects. The analyst, for example, should be able to distinguish data for compost below ground pits and above-ground piles.

ANALYTICAL METHODS

Analysis is a process in which problems are identified and defined, responses formulated and evaluated and courses of action selected, monitored, and revised as needed. Analysis in particular provides insights into complex situations by: elucidating issues; exposing points of sensitivity; identifying relations and opportunities for trade-offs; anticipating impacts of actions, in a probabilistic sense (for quantitative analysis); and organizing information and data to support reasoned decision making (Gohagan, 1980). Here we are particularly interested in the analytical methods or tools. Before one discusses analytical methods, however, we need to discuss types of analysis and correlation vs. causal relationships.

Descriptive, Qualitative, and Quantitative Analyses

Descriptive and qualitative analyses are often contrasted with quantitative analysis.[6] In fact, descriptive analysis should be contrasted with both qualitative and quantitative analysis, and qualitative with quantitative analysis. Descriptive analysis reports the state of a situation without suggesting an inference or underlying cause-and-effect relationship. Both qualitative and quantitative analyses go beyond the simple presentation of facts to suggest relationships in the facts. Some view qualitative analysis as the use of words to describe and explain reality, including human behavior. Other view it as a tool that does not rely on sophisticated model, even if it uses descriptive statistics as opposed to inferential statistics. Quantitative analysis uses quantitative or mathematical models (such as regression, linear programming, and budgeting techniques) to process numeric data[7] in its attempt to describe reality, including human behavior.

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[6] Sometimes, the distinction is between descriptive, diagnostic, and impact analyses (Casley and Kumar, 1990).

[7] Non numeric data can be easily transformed into numeric data by codes. Data are either discrete, nominal (such as red, blue, green or dichotomous in yes/no) and continuous measured on a ratio or difference scale (such as price, income, age in years). Continuous data can be transformed into discrete data, for example, by defining categories of age or income. The term quantitative data often refers to data obtained by measurement or observation as opposed to respondents' perceptions.

The purpose of quantitative analysis is to investigate underlying relationships among variables and test hypotheses. Some descriptive and qualitative analyses make use of only a few numeric data, while others may use quite a few.

Correlation and Causal Relationships

There is considerable debate in the social sciences about using data to show correlation and cause-and-effect relationships. Causation is more stringent test than correlation. It requires not only a correlation between two variables, but also precedence of a change of one variable before another changes in the direction of the correlation and a theory that explains how an independent variable causes the change of a dependent variable. The key arguments of the debate can be summarized as follows.

On theoretical grounds, one key argument is that social scientists cannot demonstrate causal relationships in the strictest sense because they lack the luxury of setting up experimental designs as physical and biological scientists have. For one independent variable that appears to cause the change of a dependent variable, a third factor, unaccounted for, may be in play (Crow et al., 1960[8]). A counter argument is that causal relationships, nonetheless, often guide social scientists when they build theoretical models, imperfect as they may be, and collect data to test them (Hair et al., 1992[9]). One can argue that when researchers set to investigate the "impacts" of programs or the "determinants" of behavior, they implicitly or explicitly assume underlying cause-and-effect relationships (see Birkes and Dodge, 1993[10]). With this argument, "the strength and conviction with which a researcher can assume causality among variables lies not in the analytical method chosen, but in the theoretical justifications presented to support the analysis" (Hair et al., 1992).

Decision makers, such as Congress and USAID, require an indication of causal links between programmatic actions and impact, with some reasonable degree of confidence, before committing resources. In environmental policy making, "before administrators can legislate, they must have established that the thing to be regulated is or can be the cause of the actual or potential cause of harm" (Fienberg, 1989). Perhaps, a pragmatic, constructive resolution of this debate is to accept the following proposition supported by experience: It is acceptable in social sciences to ***investigate*** causal relationships, but one must realize that the analytical results generated ***never establish or demonstrate*** causal relationships. Rather, based on

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[8] "A statistically valid regression is no indication that the independent variable causes the dependent variable to change, as both may be caused to change by a neglected third variable. If the identity of the causation is known..., the regression analysis of appropriate data serves to estimate the constants of the relationships" Crow, Edwin L., Frances A. Davis, and Margaret W. Maxfield, 1960 (p. 148).

[9] "Although in its strictest sense, causation is never found, in practice strong theoretical support can make empirical estimation of causation possible" (p. 127) Hair, Joseph, Ralph Anderson, Ronald L.T. and William C. Black. 1992 (p. 27).

[10] "A regression model can be used to describe associative relationships as well as causative relationships". Birkes, David and Yardolah Dodge. 1993 (p. 10).

theoretical grounds, the data used in the analysis may ***only suggest the existence*** of causal relationships with a certain degree of precision.

Analytical Tools

There is a wide range of tools available to analyze NR data. Techniques applied elsewhere are now being ported to the analysis of natural resources. These include advanced statistics (such as logistic regression analysis (Fiebig and Ouedraogo, 1994), benefit-cost analysis (Pagiola, 1993), Policy Analysis Matrix (Pagiola 1991), and The Green Book policy assessment (Johnston and Lorraine, 1994). The PAM is a improved format of budgetary data initially suggested by Monke and Pearson (1989) to analyze government policy distortions in agriculture. The Green Book is a structured compilation of lessons learned mostly in Central America about the impact of policy on people's welfare and the environment, which provide keen insight on policy decision making. Statistical methods demand probability sampling techniques if the results are to be generalized to the target population. Cost-benefit analysis and PAM are more eclectic: they use data from a wide range of sources and sampling techniques and their results are best viewed as site specific.

Implications for a NR IMS

Good information for decision making can be generated from many types of analyses. In fact, a IMS usually needs and uses information from descriptive, qualitative and quantitative analyses. A sound qualitative analysis may result in information as good as, or better than, a biased or inappropriate quantitative analysis. However, a sound quantitative analysis offers the best prospect to empirically estimate the magnitude of underlying relationships, and to test hypotheses with objective precision criteria.

A key question is how to combine different types of data collected from different sampling techniques. The answer depends on how the information will be used. If the question is about the identification of practices in some region, without any attempt at being comprehensive, data from different sampling techniques may serve the purpose. However, to compare and contrast situations with any degree of precision, data must come from random samples. For example, to statistically test that the adoption of compost in two regions depends on the availability of household labor or/and other factors, researchers must collect similar information in the two region from random samples that accurately represent these two regions. The two surveys may not use the same probability random sampling techniques, although the analysis is much more simplified if they do.

Specific information needs most likely will have to be limited to a few surveys or even case studies because of cost considerations. USAID/Senegal's KAP survey is an example of a specific baseline survey. Similarly, some quantitative analysis such as cost-benefit analysis may be restricted to a few cases. Despite the inherent site-specificity of cost-benefit analysis, one must often "borrow" a missing characteristic from another, but similar situation to complete the analysis (Gittinger, 1982). Inferences made from this analysis are greatly enhanced if the basic conditions of the two situations are well known. This is a strong

reason for collecting information with standardized statistical methodologies such as with multiple resource inventory.

DISSEMINATION

Sharing information benefits all participants involved in NRM. USAID Mission programs and projects, host-country government agencies, NGO/PVOs, and direct land users should be able to share information about NRM interventions with one another within a given country and agroecological zones. There is a wide range of media through which a NRM IMS can disseminate the information to decision makers. The choice of particular media depends on the target audience.

Traditional printed documents reach a wide range of decision makers, but they bypass low-level literate men and women, the bulk of land users in developing countries. Seminars, workshops, and conferences bring together more representative groups of participants. They help to dramatize the importance of the subject by reaching to many participants who are encouraged to engage in a fruitful dialogue. At the village and community level, a form of information dissemination that has proven quite effective is farmer-to-farmer visits, which several NGOs are promoting as their primary extension method.

More sophisticated dissemination media include teleconferencing, internet interaction, and hypertext. These media are heavily dependent on modern communication infrastructure such as telephone lines (teleconferencing and internet) and computers (internet and hypertext). Internet connections, though still expensive, are increasing in many developing countries. International, bilateral, and private agencies have set up bulletin boards that discuss NRM issues, (e.g., the World Bank, the French ORSTOM, and INFORUM, managed by Rodale Institute).

Hypertext is a relative new addition to the panoply of dissemination tools. Hypertext is a way of organizing and accessing information by creating a onlinear, nonsequential electronic document (see Seyer, 1991; Shneiderman and Kearsley, 1989; Ntergaid, 1993). Hypertext (or hypermedia) has the capability to link text to any combination of computer graphics, still photographs, animation, sound, narration (speech), and live video pictures. The information that hypertext works with is contained in "topics," which are interconnected by "links" that give immediate access between linked topics. In hypertext, rather than turning pages to find more information, the document itself is structured so that whether more information exists, it is "linked" off a key word and phrase. This allows the reader to find information and absorb ideas easily and quickly. Hypertext can be viewed as both an efficient repository of large information and a powerful computer-based learning tool. Another clear advantage of hypertext is that documents can be shared across multiple locations/computers, which allows collaboration in both reading and writing documents.

Implications for a NR IMS

Because one key objective of Missions is to track and report progress to Bureaus and Congress, a NRM IMS at the Mission program level should be geared to generate printed documents, including text, tables, and graphics. A NRM relational database with built-in predefined queries as well as user-defined queries is an important element of such a system. In assessing the needs and purpose for a NR IMS, such reporting requirements are important factors in the design and implementation of the IMS. DESFIL is building a NRM relational database with such features.

Ultimately, however, to reach its goal of sustainable development, the information must be made available to the actors directly involved in NRM, government agencies, NGO/PVOs, and foremost the men and women land users. Obviously, the same printed material generated for reporting can serve as a basis for seminars, workshops, and conferences that reach a large public. When directly targeting land users, the information generated should allow farmer-to-farmer visits, which has been proven effective. That is, the data collected should geo-referenced.

With the increased availability of computers, the information generated from the relational database and other sources can ported to a hypertext application for ease of use and learning. For example, NGO/PVO and extension agents can be trained to establish a fruitful dialogue with land users.

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APPENDIX 1

NRM Questions

The following analytical questions were identified during the design of the CBNRM project to address the above issues according to 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 that addresses 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 to facilitate farmer-to-farmer visits.

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

Question 2. What are the profiles of the men and women users and nonusers of the NRM practices of interest?

This question, in an explicit way, shows the people-level concern of the NRM Analytical Framework. Answer to this question has the following applications.

(a) Test hypotheses related to perceived determinants of behavior regarding adoption of NRM practices

(b) Identify significant elements of profiles that enabling conditions could influence to promote adoption of practices, for example, access to information/training and other productive assets.

Impacts on the Natural Resources base (Level IV)

Question 3. 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 determine the prospects for various practices to be sustained.

Impacts on productivity/welfare (Level V)

Question 4. 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 accommodate 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 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 which are most promising.

Enabling conditions (Level II)

Question 5 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 USAID Mission's assessment of program impact (API) report, this analysis will validate (or lead to modification of) the policies and institutional reforms being supported.

Programmatic Options (Level I)

Question 6. For each enabling condition identified in question four, what are the programmatic options for establishing the conditions? What are the estimated costs to the host-country government 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 advertise project concepts and catalyze community interest.

APPENDIX 2

Nonprobability Sampling Designs

Type of Sampling	Selection Strategy
Convenience sampling[1]	Select units of the population based of their accessibility or volunteering for the study
Most likely/most dissimilar units	Select units of the population that are judged to represent similar conditions or, alternatively, very different conditions
"Typical" sample	Select units judged to be "typical" as opposed to extreme, according to the researcher
Critical units (key informants)	Select units that are key or essential for overall acceptance (or assessment)
Haphazard sample	Units taken haphazardly
Snowball sample	Members previously selected in turn identifies additional members to be included in the sample
Quota sample	Sample selected to yield the same proportions as the population proportions on easily identified variables

Sources: Adapted from Henry (1990) and Cochran (1977).

1 As in Participatory Rural Appraisal
2 As in Rapid Appraisal

Note that even if random assignment is used to subdivide the sample obtained in one of these ways, this would not make the sample a random sample. Random sampling applies to the selection of the whole sample. Results obtained with random assignments are still confined to the sample and cannot be generalized to the target population.

APPENDIX 3

Probability Sampling Designs

Type of sampling	Selection Strategy
Simple random sampling	Each unit of the study population has an equal probability of being selected
Systematic random sampling	A random start is designed and units of the study population on the frame are selected at equal intervals
Stratified random sampling	Each unit is assigned to stratum, then a simple random sample is selected from each stratum
Cluster sampling	Each unit of the study population is assigned to a group or cluster, then clusters are selected at random and all units of a selected cluster are included in the sample
Multistage random sampling	Clusters are selected as in cluster sampling, then sampling units are selected from each cluster by simple random sampling. Clustering may be done at more than one stage.
Area sampling frame	The area to be surveyed is divided into homogenous but various sizes land use strata. Each stratum is subdivided into sampling units of similar size. Sampling units are selected that are representative of the strata (larger strata being assigned larger probabilities).

Sources: Adapted from Henry (1990); Cochran (1977); AAIC (1994)